ADMINISTRATION AND SYSTEM OPERATION OF THE COLUMBIA RIVER BASIN PIT TAG INFORMATION SYSTEM PTAGIS

2006 - 2007 Annual Report

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Abstract

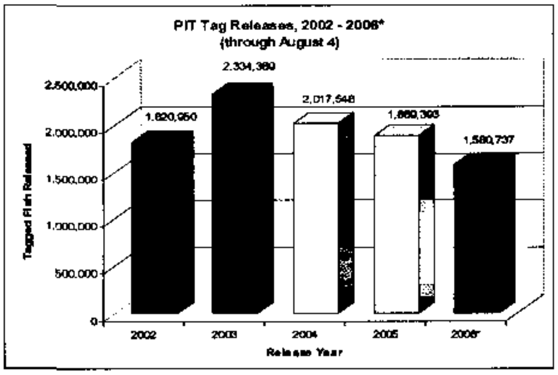
The Columbia River PIT Tag Information System (PTAGIS) is a data collection, distribution and coordination project. The project saw over 1,580,000 juvenile salmonids marked with passive integrated transponder (PIT) tags, for the 2006 out-migration through the Columbia and Snake River systems, compared to over 1,889,000 in 2005 (Table 1). In 2006, over 795,000 tagged fish were detected (Table 3). These fish generated over 9,615,000 interrogation records (Table 4). One fish can generate many interrogation records, depending upon how many interrogation sites or monitors 'saw' the fish.

In 2006, the PTAGIS project, in cooperation with NOAA Fisheries and the US Army Corps of Engineers, completed work on the installation of the Bonneville Corner Collector (BCC) PIT-tag detection system. The Bonneville Corner Collector is the largest PIT-tag antenna in the world and was completed in May 2006. In addition, installation of Adult PIT-Tag detection systems at Bonneville Dam Bradford Island Fish Ladder and Washington Shore Counting Window were completed. All three of these systems are currently on-line for the 2006 fish migration season.

PTAGIS continues to support a number of agencies utilizing the "Separation by Code" (SbyC) system capability. This system has the capability to divert PIT-tagged fish in various directions based upon distinct tag code. The PTAGIS project implemented support for 13 separate Separation by Code projects for various agencies in 2006.

The PTAGIS project continued development of the M4 application, which will replace current interrogation and SbyC applications by summer 2007.

Table 1



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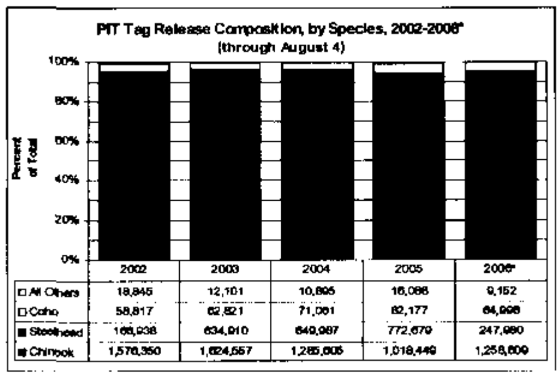

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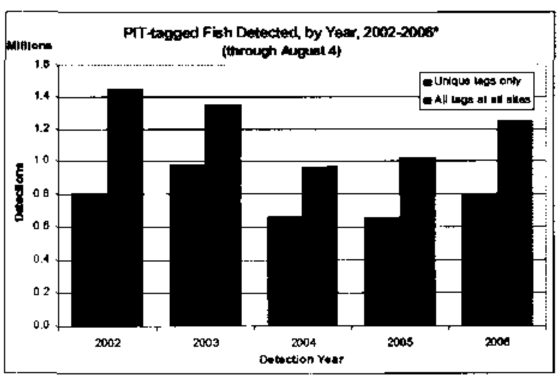

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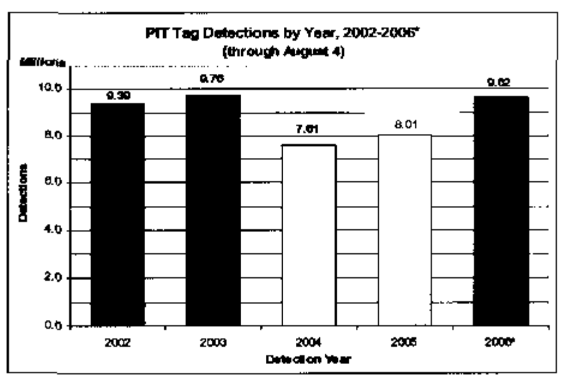


PREFACE

In 1984, Bonneville Power Administration (BPA) entered into an agreement with the National Marine Fisheries Service (NMFS) to research and develop a passive integrated transponder (PIT) tag for use in the Columbia River Basin (CRB) Fish and Wildlife (F&W) Program. The PIT tag system enables large amounts of data to be produced using relatively few tags, compared to traditional tagging and marking systems.

In 1988 and 1989, NMFS contracted with PSMFC to develop and operate a prototype database system to help NMFS meet, in a timely manner, its contractual and verbal agreements involving PIT tag data. The database was designed to meet immediate needs as well as provide a framework for a formalized database system for the Columbia River Basin PIT tag program.

In April 1989, NMFS announced its intention to phase out of the operation, maintenance and management of the PIT tag systems in the Columbia River Basin. Subsequently, BPA contracted with PSMFC because it was the only agency experienced in data management with no vested interest in the interpretation of data generated from PIT tags, while being independent of water or fish and wildlife management responsibilities.

In 1992, NMFS initiated the transfer of field operations and maintenance (O&M) to PTAGIS. This transition was completed in 1995 when the Columbia Basin PIT Tag Information System transitioned from a research and development (R&D) effort into an operations and maintenance effort. Note, however, that R&D efforts by NOAA Fisheries continue in collaboration with the PTAGIS project staff and other contractors.

The PTAGIS project covered by this report has been part of the Northwest Power and Conservation Council's Fish and Wildlife Program funded by Bonneville Power Administration since 1990. The NMFS 2000 BiOp for the Federal Columbia River Power System (FCRPS) includes approximately 15 RPA Actions calling for studies that explicitly include PIT-tags or would likely employ them. The Tagging Studies Technical Committee (TSTC) would help ensure that the numbers of ESA-listed fish proposed for tagging (in the study designs) are necessary and adequate to address BiOp implementation and other needs. Additionally, the NMFS BiOp includes numerous RPA Actions calling for studies that may employ other tagging methods that may benefit from improved integration with PIT-tagging studies.

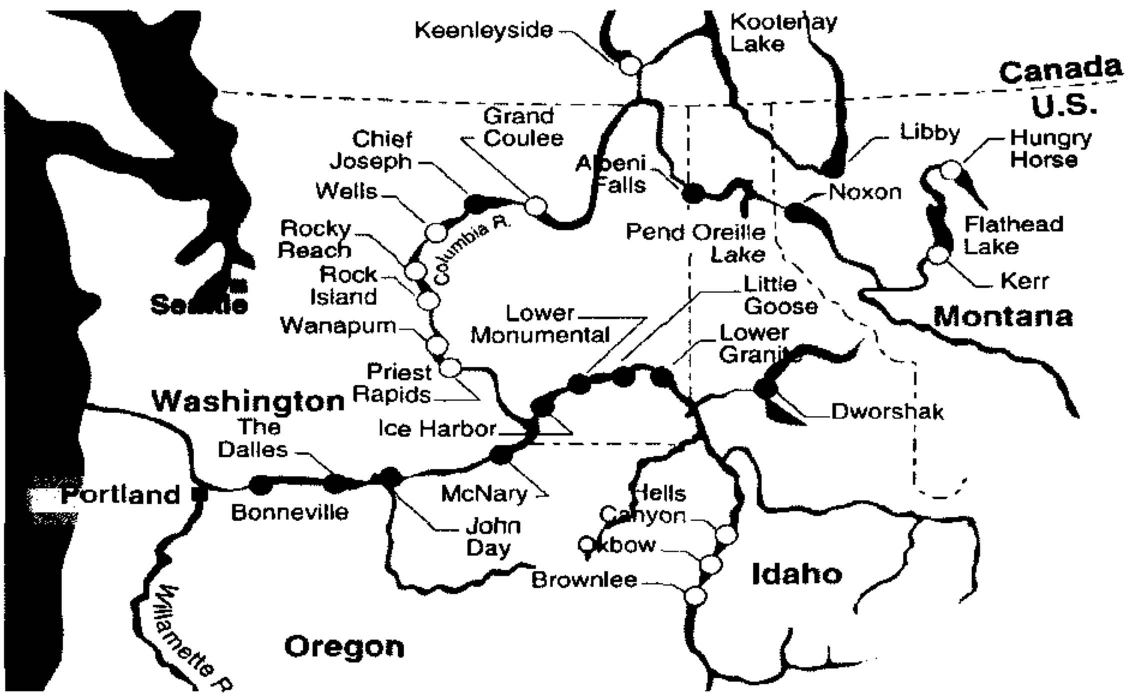
The PTAGIS project is guided by the Columbia Basin PIT Tag Steering Committee (PTSC) which was chartered through an agreement between Pacific States Marine Fisheries Commission and the Columbia Basin Fish and Wildlife Authority in 1993. PTSC representatives are National Marine Fisheries Service, U.S. Fish and Wildlife Service, Tribal Representation through CBFWA Anadromous Fish Advisory Committee, Oregon Department of Fish and Wildlife, Idaho Department of Fish and Game and Washington Department of Fish and Wildlife.

The PTAGIS project is organized into five data systems staff located at PSMFC headquarters in Portland, Oregon and five field operations staff in Kennewick, Washington.

INTRODUCTION

In 2006, PTAGIS operated computer systems to collect and distribute PIT tag information related to various projects in the Columbia River basin. In addition, we operated and maintained (O&M) equipment to assist various entities in efforts to monitor, manage and study the migration of juvenile salmonids at seven dams Federal Columbia River Power System (FCRPS) projects on the Columbia and Snake rivers. These O&M locations are Bonneville Dam (BON), John Day Dam (JDA), McNary Dam (MCN), Ice Harbor Dam (ICH), Lower Monumental Dam (LMN), Little Goose Dam (LGO), Lower Granite Dam (LGR). In addition, we monitor fish migration at the Bureau of Reclamation facilities at Prosser and Yakima Indian Nation acclimation ponds on Yakima River tributaries. We also operate the PIT tag volitional release system located at Rapid River Hatchery.

Figure 1. Hydroelectric projects on the Snake and Columbia Rivers. This figure is reprinted courtesy of the U.S. Army Corps of Engineers, Portland District. Red circles are Corps of Engineers projects, yellow circles are privately owned or Bureau of Reclamation projects.



PROJECT GOAL and OBJECTIVES

The goal of this project is to operate and maintain the Columbia River Basin-wide database for PIT Tagged fish and to operate and maintain the established interrogation systems. The data collected by this system is accessible to all entities.

The measurable goal for the system is to collect 100% valid data[1] and provide that data[2] in "near-real" time with downtime of any system component of not more than one percent as measured during the period of peak out-migration.

[1] Valid Data is defined in the "2004 PIT Tag Specification Document" which is maintained by the Columbia Basin PIT Tag Steering Committee.

[2] This means PIT tag mark, recapture and release information provided by PTAGIS users in addition to interrogation data provided by PTAGIS or other system users.

The PTAGIS project achieved this goal. All data that are incorporated into the PTAGIS database are validated for conformance to format and content based upon rules defined in the 2004 PIT Tag Specifications Document. PTAGS server and web systems performed reliably with down-time limited to less than four hours on few occasions for some system components. PTAGIS supported interrogation equipment was also highly reliable and fully redundant. Any data outages are logged in the PTAGIS event logs which are available at www.ptagis.org.

Operate, Maintain and Enhance the PTAGIS System

This objective relates to our BPA Work Element titled, "A: 160. Create/Manage/Maintain Database." This objective intends to deliver near-real-time PIT tag mark, recapture and interrogation data and tools to allow for the collection and retrieval of that data to all entities. This objective also incorporates BPA Work Element, "I: 119 Manage and Administer Projects," the purpose of which is to provide for the program and project management necessary for the PTAGIS effort.

PTAGIS project headquarters staff and one contractor are organized into three parts to support this objective: O&M Server Systems Development, O&M Client Systems Development and O&M Web Systems Development.

O&M Server Systems Development

This objective addresses a software and computer system in a dynamic environment such as PTAGIS which requires continuous updating and refinements to address new and changing user requirements. Milestones for this aspect of the project include:

- Acquisition and processing of data from remote interrogation sites;
- Acquisition and processing of mark, release and recapture data from researchers;
- Timely updating PTAGIS database with valid data and error notification to users;
- Systems management, including backups, performance tuning, capacity planning, system monitoring, database and operating systems upgrades and other necessary activities.

Tables 1 – 4 in the ***Abstract*** of this report summarize acquisition, processing and update of mark, release, recapture and interrogation data for this milestone. In addition, the PTAGIS computer hardware was upgraded.

Hardware Upgrade

Since 1995, PTAGIS computer hardware and capacity management strategy has been to acquire computer resources on a three year capital lease with purchase option. The benefit of this to the project is that it spreads out the capital cost of hardware acquisition over several years, rather than requiring a very large capital investment when systems become obsolete (and are no longer supported by the hardware vendors), or additional processing or storage capacity is required. In September of 1996, PTAGIS initiated acquisition of a new computer system to replace the last system that was acquired in 2002.

Work was done throughout the fall to port systems and data. Testing was conducted to verify system performance and operations. The initial switch-over to the new hardware occurred on November 29, 2006. However, performance issues lead to the swap of hardware and final transition to the current system environment on February 9, 2007.

The new Sun Solaris based PTAGIS hardware environment includes:

- Database Server Hardware: SunFire V490 System with four, 64-bit, dual core CPU's and 16 GB memory. This is connected to a 1.1 Tera-byte (usable space) Sparc StorEdge 3510 storage array.
- Web Servers: Two, SunFire T2000 with a single, 64 bit eight core processor configured with 16 GB memory and two 72 GB internal disk storage devices.

We would schedule the upgrade of this system in 2010.

Data Modeling

In their 2002 and 2006 Final Review of the PTAGIS Project Proposal, the Independent Science Review Panel (ISRP) indicated their desire to be able to attach some "metadata" concerning "how a given fish has been treated prior to release". They also indicated a desire to "...tie the record (tagging and detections) for each PIT tagged fish to the verified migration path of the fish".

With regards to the first desire of the ISRP, it is outside of the scope of the PTAGIS project to track internal research agency or fish hatchery treatment or brooding records. PIT tags distributed by the PTAGIS project (that is, BPA PIT tag purchases) contain an attribute that associates a given tag with a project number. Should any entity have the desire to link associated records to research or broodstock treatments, it is suggested that they do so by linking to metadata through the project number, tag code or the combination of the two.

With regards to the second desire, the mark, release, recapture and interrogation data collected, keyed by individual tag codes are verification of the migration path of the fish. PTAGIS does this, by design.

The ISRP indicated some frustration that "...the project is lacking a detailed description of the comprehensive data model..." Data definitions, in format, context and content are detailed in the "2004 PIT Tag Specification Document." In addition, further descriptive information is available at www.ptagis.org.

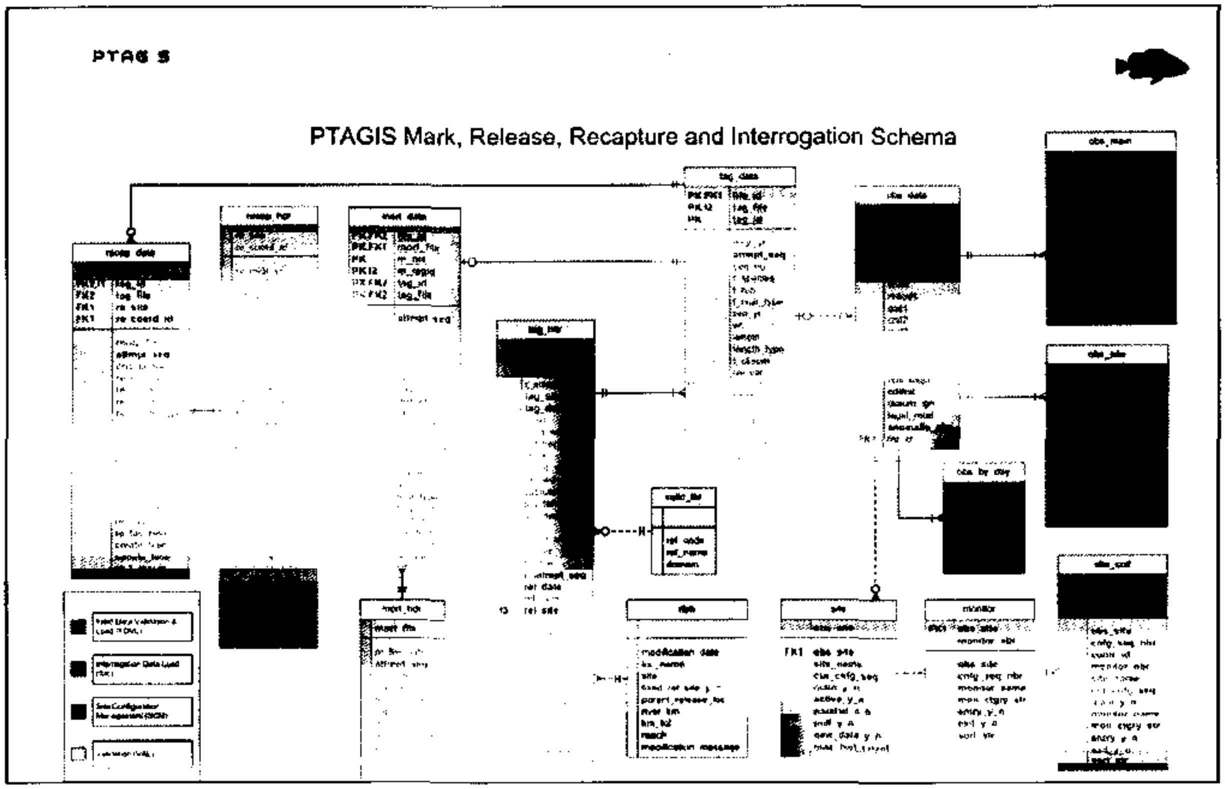


Figure 1: PTAGIS "Core" Data Model

In an effort to enhance the model shown in Figure 1, PTAGIS moved forward into work on the design of a data model that would address the ISRP's concerns related to associating PIT tags with the principle investigators that assigned the marks. They wrote in their ISRP 2002 Final Review, *"...it is our understanding that the initials of the principal investigator responsible for tagging a fish are stored in the record and one must contact that person to obtain required metadata on a tagged fish. This procedure may have been adequate given the short time that PIT tags have been in use, but in the not too distant future the principal investigators are going to retire or die and the required metadata will be lost"*.

Appendix 1 (*PPO Schema: Modeling Organization History*) describes a data model designed to track responsibility of Tag Coordinators or Organizations over time. It should be noted, that the model described is only a model. It will require substantial resources in order to develop the software to populate the model in the PTAGIS database for initial use, a user interface to update the model using a web interface, auxiliary software to integrate the model into the client based tools used by PTAGIS users. Assuming resources are acquired, work on implementation could begin in 2008.

O&M Client Systems Development

This objective addresses software development, maintenance and support for Microsoft operating system client tools used by PIT tag researchers to mark, release, recapture or interrogate PIT tagged fish. The key milestone descriptions are:

- Incorporation of SbyC functionality into client software (M4);
- O&M Support for Minimon;
- O&M Support for P3;
- O&M Support for MobileMon
- O&M Support for client based tag distribution and inventory system.

The following section describes the PTAGIS client tool set.

Client Tools Overview

The key applications that are developed and maintained by the two PTAGIS Software Applications Specialists are listed in the following table:

Application Name	Description
P3	P3 is the third version of the Microsoft operating system client program used when researchers are marking, releasing or recapturing PIT tagged fish. The first version was PITTAG.EXE and ran on the DOS operating system. In 1998 the program was re-written for the Microsoft Windows 95 operating system. P3 was redesigned for easier maintenance and was written in Visual Basic 6.0.
MiniMon	MiniMon is the first version of the Microsoft windows operating system client program used to collect fish as they pass 'passive' interrogation systems. The original version of this program (MONITOR.EXE) was written for the Microsoft DOS operating system in the mid to late 1980's as part of the original NOAA PIT tag research. Minimon does not support the Separation by Code capability.
Multimon	Multimon is the Microsoft DOS operating system client used at the major FCRPS fish transportation and bypass facilities and adult fishways to separate (or sort) fish by code. The program was transferred from NOAA' Research and Development effort to the PTAGIS Operations and Maintenance project in XXXX.
MobileMonitor Mobile Sync Manager	MobileMonitor was written to run on devices that run the Microsoft Pocket-PC operating system. The program is written in C# (Visual Studio 2003). The Pocket PC's are useful in environments where electic power is not readily available. Due to the rapid and continuous changes in this hardware platform and lack of resources, the PTAGIS project in anticipating abandoning this program. The Mobile Sync Manager is a utililty that MobileMonitor users use to take PIT tag data from a Pocket PC device running MobileMonitor and format it for upload to PTAGIS.
M4 (Formerly code named "Mustang")	M4 is being designed as the Microsoft Windows replacement for Multimon. M4 is currently in development. The program is written in C# using Visual Studio 2005.

Application Name	Description
Other Client Tools	PTAGIS has developed other client tools to use to unit test portions of the M4 system. One of the tools is called LoadEmulator. The LoadEmulator was built to simulate data collection at a PIT tag interrogation system at a very busy FCRPS transportation facility. This test is important in order to verify that the M4 program can readily look-up a PIT code, determine SbyC routing and send a signal to a programmable logic controller to control switch gates. Timing latency in the Microsoft Windows operating system is non-deterministic and so this tool allows us to find bottle necks in SbyC processing in M4. Another tool developed was the PLC scraper. This tool takes data off of a PLC in order to deterring throughput timing in SbyC test case scenarios run by the M4 program.

Most of the O&M Client Systems Development effort in 2006 was related to support requests for small modifications to P3, development of new drivers for MiniMon to support new versions of the Digital Angel FS1001-M Multiplexing reader, development of a new driver for Minimon to support the new Digital Angel transceiver used at the Bonneville Corner Collector, and M4 development.

P3 Support and Maintenance

On September 14, 2006 the PTAGIS project released P3 Production Release 1.4.3. This release enhanced the layout of exported tag files, incorporated the Satrorius Combics 1 electronic balance, and added additional support for tag actions.

MiniMon Support and Maintenance

Much of the effort related to MiniMon updates was related to making changes to support the Digital Angel FS1001M multiplexing reader.

During 2006, Digital Angel required special PTAGIS support to update MiniMon in order to support FS1001M version 1.7, version 1.9, version 1.9B and version 1.9D. Coordination between Digital Angel and the PTAGIS project related to the reader firmware changes needs to be improved in the future.

In addition PTAGIS resources were diverted from M4 development in order to create a "one-off" version of MiniMon to support the Digital Angel BCC PIT tag detector. Since the Corner Collector detector is one-of-a-kind, PTAGIS determined that it was best to branch the MiniMon code base and create a separate MiniMon version for this unique application. Since the BCC detector research and development effort has been on-going, new requirements seemed to trickle in as tweaks were made to the detector.

M4 Development

In 2003, the PTAGIS project initiated work to develop a Microsoft Windows replacement to the Microsoft DOS version of the separation by code program, MINIMON.EXE which was developed by NOAA in the mid to late 1990's. The key difficulty in re-writing this application is to guarantee that the time between when a tag code is read, a separation by code action is looked up and when an electronic signal sent to a gate to divert a fish be minimized. Unlike DOS, the Windows operating system takes time to listen to keyboard or mouse movements, update the display or take care of other operating system overhead. This processing time is taken away from our application. MultiMon developers used the standard of 10 milliseconds for the timing of the critical code section listed above. This remains the goal for M4.

Another complexity in the development of the Windows replacement for Multimon is the fail-over mechanism. This means that when the primary data collection computer fails, processing is picked up by a redundant system. In 2004, as a strategic decision, the project team decided to use a Microsoft technology partner (Marathon) product to fill the fail-over requirement. In October, 2006, after working with the Marathon solution for about a year and a half, the team determined that it was a poor solution for our requirements since it was very costly, highly complex, and was still prone to failure. A new draft of the M4 Design Specification (See Appendix 2) was prepared which provided an opportunity for architectural re-design in order to incorporate a custom fail-over solution as part of the M4 Project. Details on M4 development are available on the PTAGIS wiki.

O&M Web Systems Development

PTAGIS web applications infrastructure developed by Scientific Applications International Corporation (SAIC) for the PTAGIS project has proven to be costly and complex to maintain. Web based infrastructure efforts were focused on replacing commercial off-the-shelf (COTS) software with low to no cost alternatives.

Initial priority was to find an alternative to the SiteScape collaboration tool, and remove the HTML frame-sets and Adobe "Flash" web navigation developed by our contractors. The PTAGIS report interface (StyleReport EE from www.inetsoft.com) was upgraded from version 5 to version 7 which improved overall reliability of the web interface.

Separation by Code Support

This objective relates to our BPA Work Element titled, "B: 160. Create/Manage/Maintain Database". This objective intends to deliver a well coordinated and successfully implemented Separation by Code system for use by the research community. Key milestones include updating seasonal database support tables, capturing user requests, implementing user requests and monitoring separation by code passage on a daily or more frequent basis during the migration season.

Although we identified another work element, "C: 158 Mark/Tag Animals" in anticipation of M4 prototype testing of separation by code capabilities, we had to reschedule the activity because of the M4 delay.

We identified a third work element in our statement of work, "D: 70 Install Fish Monitoring Equipment" with the deliverable of providing instrumentation to activate fish routing gates based upon SbyC activity. This work is performed by PTAGIS Kennewick field staff.

SbyC Data Systems Coordination and Support

In addition to providing O&M support in 2006 for most of the PIT tag interrogation sites in the mainstem Snake and Columbia Rivers, the PTAGIS project also coordinated, implemented, and supported all of the Separation-by-Code (SxC) activity conducted at the eight sites with SxC capabilities in the Columbia River Basin. The Separation-by-Code protocol is used to divert specific tagged fish, based on their individual tag codes, away from the general population of tagged or untagged fish. Separation-by-Code was originally developed to allow researchers to identify, divert, and trap specific tagged fish as they were detected in the juvenile bypass systems and adult fish passage facilities at the federal hydroelectric dams. In 2006, researchers used the SxC systems to recapture individual PIT-tagged smolts in the juvenile bypass systems at Lower Granite, Little Goose, McNary, and Bonneville dams. Researchers also used the SxC systems to re-capture tagged adult salmon and steelhead at the Bonneville Dam Adult Fish Facility and in the trap in the Lower Granite Dam fish ladder. See appendix 3, "PIT Tag Detection and Separation by Code Activities at Interrogation Sites Operated by or for the Columbia River Basin PIT Tag Information System 2006 Annual Summary Report" for full details.

The following table summarizes SbyC projects supported by PTAGIS in 2006:

PTAGIS SbyC #: Researcher: Organization	Funding	Study Description
2006001: Jason Vogel, Nez Perce Tribe	BPA 199604300	Johnson Creek Artificial Propagation and Enhancement Project
2006002: Michele DeHart, Fish Passage Center	BPA: 199602000	Comparative Survival Study
2006003: Lyle Gilbreath, NOAA-Fisheries	AFEP	Evaluation of timing and condition of yearling Chinook salmon passing through the Bonneville Dam Second Powerhouse juvenile bypass system transport flume.
2006004: Mary Arkoosh, NOAA-Fisheries	AFEP	Disease susceptibility of hatchery-reared yearling Snake River Chinook salmon with different migration histories in the Columbia River
2006005: Steve Achord, NOAA-Fisheries	AFEP	Migration timing and parr-to-smolt estimated survival for wild Snake River spring/summer Chinook salmon smolts

PTAGIS SbyC #: Researcher: Organization	Funding	Study Description
2006006: Mark Schuck, WDFW	LSRCP	WDFW LSRCP hatchery evaluation project for Tucannon and Tuochet Rivers
2006007: Sam Sharr, IDFG	LSRCP 14110-6-J009	LSRCP releases at Clearwater Hatchery "run at large" treatment
2006008: Doug Marsh, NOAA-Fisheries	AFEP	Transportation studies
2006009: Kent Mayer, WDFW	BPA: 200205300	WDFW Asotin Creek Project
2006010: Steve Lee, ICFWRU	Not provided	Adult fish collection at Bonneville Dam AFF
2006011: Ann Miracle, PNNL-Battelle	Battelle funded internally	Recovery of juvenile spring Chinook in cooperation from the "Extra Mortality Study" conducted by NOAA
2006012: Russell Perry, USGS	AFEP	PIT tags used in conjunction with radio tags to evaluate fish condition of fish surgically implanted with radio transmitters
2006013: Mike Flesher, ODFW	Not provided	Wallowa stock Grande Ronde subbasin hatchery steelhead trout research

SbyC Field System Support
During the migration season, PTAGIS field systems personnel inspect and test separation by code pneumatic, *electrical and mechanical components at each facility on a weekly basis. During these site visits, staff* communicates with Corps of Engineers facility biologists and other researchers at the site. Often time's issues are identified during discussions which take place on site during these visits. In 2006 there were 27 gate related issues between the Lower Granite, Little Goose and Lower Monumental sites. The issues ranged from gates sticking open or closed to gates breaking due to slamming.

In October, 2006, PTAGIS field O&M staff kicked off a project to upgrade slide gates in time for the 2007 migration season. The project included the collaboration of the NOAA Fisheries Pasco shop to provide fortification and mounting modifications to the slide gates. Three optical sensors were added to each gate and the programmable logic (PLC) controllers at the facilities were upgraded to incorporate these sensors as inputs. The PLC logic was updated to incorporate the optical sensor input to prevent gate slamming. In addition, human / machine interfaces and signal lights were installed to notify on-site personnel when a gate problem alarm was issued by the PLC.

Field Operations and Maintenance

This objective relates to the following BPA Work Elements in the PTAGIS Statement of Work:

- "E: 70 Install Fish Monitoring Equipment". This work element provides for milestones (tasks) required to deliver installed PIT tag detection system as required by Action Agencies and approved by Bonneville Power Administration.
- "F: 159 Transfer/Consolidate Regionally Standardized Data". This work element provides milestones (tasks) necessary to deliver high quality, near-real-time PIT tag interrogation data for incorporation into the PTAGIS database.
- "G: 122 Provide Technical Review". This work element provides for development technical documentation, written standard operating procedures, provision of technical assistance and support to the research community related to the design, installation, operation and maintenance of PIT tag interrogation system by other entities engaged in PIT tag detection research activities in the Columbia Basin.
- "H: 119 Manage and Administer Projects". This work element provides for the efforts necessary for planning, organizing work, and directing and controlling efforts to achieve optimal results for PTAGIS field system operations.

Details of the 2006 field systems operations can be found in the PTAGIS Event Logs. PTAGIS field O&M staff utilizes daily operational reports which are monitored multiple times each day during the fish migration season. During the busiest portion of the season, PTAGIS field staff performs a weekly, on-site, standard maintenance check at each facility. In the less busy times, these maintenance checks are bi-weekly.

In additional to the standard operations and maintenance of interrogation systems at FCRPS facilities, PTAGIS field operations staff was involved in several other efforts. Efforts that were conducted by PTAGIS Field O&M staff are described herein.

PTAGIS O&M staff completed efforts to install PIT tag detection systems on the adult fish return flumes on flumes exiting the fish and debris separators at FCRPS juvenile fish transportation sites on the Snake and Columbia rivers.

Administration, Management and Coordination

This objective relates to the following BPA Work Elements in the PTAGIS Statement of Work:

- "I: 119 Manage and Administer Projects". This work element provides for the efforts necessary for planning, organizing work, and directing and controlling efforts to achieve optimal results for overall PTAGIS program and project management.
- "J: 122 Provide Technical Review". This work element provides for development technical documentation, written standard operating procedures, provision of technical assistance and support to the research community related to the design, installation, operation and maintenance of PIT tag interrogation system by other entities engaged in PIT tag detection research activities in the Columbia Basin
- "K: 122 Provide Technical Review". This work element provides for development technical documentation, written standard operating procedures, provision of technical assistance and support to the research community related to the design, installation, operation and maintenance of PIT tag interrogation system by other entities engaged in PIT tag detection research activities in the Columbia Basin.
- "L: 132 Produce (Annual) Progress Report". This work product is this report.
- "M: 185 Produce Pisces Status Report". This work involves updating the BPA contracting data through its "PISCES" Microsoft Windows client application.

Administration and Management

This work consists of developing annual work statements and budgets and monitoring and controlling project activities and resources. The increase in the number of projects that rely on the PTAGIS infrastructure is placing a strain on existing staff resources. The PTAGIS proposal provided for the "FY 2007 F&W Program Project Solicitation" forecasted a need for additional two staff resources to be hired in the 2008 fiscal year.

Coordination

The PTAGIS project serves as a central support center for the region's PIT tag research programs. PTAGIS staff field hundreds of telephone calls each year to answer question related to the complexities of the system.

In 2006, the PTAGIS project initiated an effort to collect and distribute information via Wiki technology through the World Wide Web. The PTAGIS Wiki is proving useful as an easy to use information sharing and collaboration tool.

PTAGIS Field O&M and Data Systems Operations Standard Operating Procedures, data models, definitions, system activities and other technical information are documented and updated in the PTAGIS Wiki.

Half Duplex PIT Tag Coordination

PTAGIS staff worked extensively with University of Idaho and NOAA Fisheries to troubleshoot problems caused by the installation of Half-Duplex (HDX) PIT tag interrogation systems adjacent to the Columbia River Basin PIT tag detection systems at Corps dams. Interference was caused by the HDX systems which were installed as part of one of the Corps Anadromous Fish Evaluation Program (AFEP) projects. The fix to the problems was to assure that the HDX systems were on separate power systems from the production PIT tag systems and to assure that the HDX antenna systems were adjusted to minimize additional interference.

PIT Tag Distribution

During 2006, the PTAGIS project delivered 756,900 tags to over sixty Fish and Wildlife PIT tagging projects funded by Bonneville Power Administration.

Automatic PIT Tag Test System (APTTS)

The APPTS project kickoff meeting was held in December, 2005. The project was motivated by the fact that the resources and time required to qualify, verify and test new PIT tags was very high. For example, two to three staff people would be required to work from three to ten weeks to run a series of tests intended to determine whether or not PIT tags provided by a given manufacturer could be read in the Columbia River Basin PIT tag detection systems.

Construction of the machine progressed through out 2006. The mechanical, vibratory feeder bowl construction, delivery, and integration were on the critical path of the schedule. An antenna system was developed that could eliminate the bias imposed by reading the tag micro-chip end of the tag first, rather than antenna end first. Development of the optical sensor technology that determines the length and diameter of the tags, as well as algorithms necessary to decode the tag and to energize the tag to a known power level, and reject tags out of conformance was time consuming but successful.

The PTAGIS project hopes to use the APTTS to assure quality of PIT tags purchased for distribution to BPA funded projects. Initially, we hope to develop a process to test a 1% sub-sample of all tags delivered. This could be done by 1998. Assuming that sub-sample testing is efficient and effective, a higher percentage sub-sample could be tested. In addition, we expect to be able to study new tags as they are developed for use in the Basin.

We expect the APTTS to be delivered sometime in 2007.

Installation of New PIT Tag Detection Systems

McNary Washington Shore Adult Counting Window PIT Tag Detector

The PTAGIS project worked in collaboration with the Walla Walla District of the Corps of Engineers to complete the installation of a PIT tag interrogation system in the counting window at the Washington shore counting window at McNary Dam.

The PTAGIS project provided the labor for the installation, testing and integration of the new detection system into the adult ladder at the dam. Costs of the electronic components of the system were funded through BPA Fish and Wildlife Program Project Number 2001-003-00.

Bradford Island Adult Ladder PIT Tag Detector

The PTAGIS project worked in collaboration with the Portland District of the Corps of Engineers to design and install a PIT tag interrogation system in the vertical slot portion of the Bradford Island fish ladder at Bonneville Dam.

The PTAGIS project provided the labor for the installation, testing and integration of the new detection system into the adult ladder at the dam. Costs of the electronic components of the system were funded through BPA Fish and Wildlife Program Project Number 2001-003-00 through contract 25703. The antennas and transceivers required for this project were provided by Digital Angel Corp (reference BPA Contract 00002760, Release 00011).

Lower Monumental Dam Full Flow Detector

The PTAGIS project worked in collaboration with the Walla Walla District of the Corps of Engineers to design and install a PIT tag interrogation system on the full flow bypass line at Lower Monumental dam. PTAGIS provided technical services to the Corps and Corps contractors to locate the PIT tag detectors at a reasonable location, to review electrical and mechanical drawings to assure that facilities for incorporating PIT tag electronics met PTAGIS standards.

The PTAGIS project provided the labor for the installation, testing and integration of the new detection system into the juvenile bypass system electronics at the dam. Costs of the electronic components of the system were funded through BPA Fish and Wildlife Program Project Number 2001-003-00 through contract 30318.

Evaluation and testing of this new detection system was performed by NOAA-Fisheries subsequent to the installation.

John Day Dam Full Flow Detector

The PTAGIS project worked in collaboration with the Portland District Corps of Engineers to design and install a PIT tag interrogation system on the full flow bypass line at John Day dam. PTAGIS provided technical services to the Corps and Corps contractors to locate the PIT tag detectors at a reasonable location, to review electrical and mechanical drawings to assure that facilities for incorporating PIT tag electronics met PTAGIS standards.

The PTAGIS project provided the labor for the installation, testing and integration of the new detection system into the juvenile bypass system electronics at the dam. Costs of the electronic components of the system were funded through BPA Fish and Wildlife Program Project Number 2001-003-00 through contract 30318.

Evaluation and testing of this new detection system was performed by NOAA-Fisheries subsequent to the installation.

Roza Dam
PTAGIS field O&M staff consulted with Yakama Nation and Bureau of Reclamation to provide technical information related to the design of a PIT tag detection facility at

Three Mile Falls on the Umatilla River
PTAGIS project designed, constructed and installed a mobile PIT tag interrogation system. The mobile interrogation system was of high quality and met the PTAGIS O&M installation standards. However, detection system antennas, provided by the U.S. Fish and Wildlife Service were sub-standard and not maintainable by the PTAGIS O&M staff.

Eastern Oregon Hatchery
The PTAGIS project consulted with ODFW and Nez Perce on a PIT tag installation at a hatchery project in the Lostine River area. Several phone calls and various other information resources were provided to assist ODFW in scoping out the project.

Sullivan Dam
The PTAGIS project did some reconnaissance, and consulting with ODFW and PGE. ODFW contracted with Biomark to install adult PIT tag detection systems in the Willamette Falls Fishway. ODFW, Biomark and PSMFC collaborated to provide a system that was optimized to be lower in cost, yet meet PTAGIS O&M installation standards.

Support for BCC PIT Tag Detector Research and Development
On April 13, 2006, after several years of research and development, the PIT Tag Detector designed for and installed in the corner collector flume at Bonneville Dam (BCC) for the first time, detected two fish from the Carson fish hatchery. PTAGIS O&M staff was vital to the effort to have this system installed and collecting data to report to the PTAGIS data systems so that it could be available to researchers and river system managers.

PTAGIS O&M staff and project resources provided assistance to Digital Angel and it's contractors for the research, development, testing and installation of the BCC system. PSMFC provided technical direction and consultation for design and installation of the environmental controls for the BCC antenna. In addition, PTAGIS installed sensors to indicate water level in the antenna. Water level, temperature and humidity levels recorded at the BCC antenna are sent to the PTAGIS server system and are available to all entities. In addition, PTAGIS provided telecommunications network support, logistical support and technical expertise in support of the BCC installation project.

Appendix 4 provides additional information about pressure testing and read-range characterization of the BCC system as it was under construction. Data for both of these tests was collected by PTAGIS staff members.

In addition, as previously described, the PTAGIS team developed a specialized version of our MiniMon program so that information collected by the new BCC transceiver system could be collected in the PTAGIS standard format and incorporated into the PTAGIS database and made available to all entities.

PIT Tag Recovery Rewards
In 2006, the PTAGIS project initiated an incentive program to encourage people to report PIT tags found by fishers in the ocean or rivers and tributaries. The PTAGIS project offers a "PIT Tag Recovery Program" ball cap, a PTAGIS test-tag key chain and a reward letter with detailed information and history on the host fish marked with the recovered PIT tag. Details on the PIT Tag Recovery Program can be found on the PTAGIS Wiki.

In 2006, there were 11 PIT tag recoveries reported to PTAGIS in 2006, from sport anglers in the Columbia River and from commercial trollers. Two of the tags were recovered by one troller; this was the first time that a single individual reported two PIT tag recoveries in a single year. This same individual recovered a PIT tag in a previous year.

Annual Report

This report is the 2006-07 Annual Report.

APPENDIX 1: PPO Schema: Modeling Organization History

Pacific States Marine Fisheries Commission
PPO Schema: Modeling Organization History
CONTRACT NO. 06-71 - TASK ORDER NO. 06-08

Doug Clough, SYNERGETICS Engineered Systems
Ver 0.1, 26 Sep 2006

INTRODUCTION

At least twice in the history of the PTAGIS project, organizations performing project roles important enough to warrant their registration in the database have changed in name or structure. For example, WDF and WDW merged to form WDFW, "Washington Department of Fish and Wildlife"; the PIT-tag manufacturer Destron-Fearing was acquired by DigitalAngel.

As of Version 0.4, the PPO logical data model lacks a means for accommodating such changes. This document introduces two new entity-types into the model, in order to represent various kinds of relationships between organizations – for example, superior-subordinate versus predecessor-successor – and to simplify the maintenance of people-specific information when organizational changes occur.

DEFINITIONS

Noun phrases essential to the Data Model discussed in this document are defined in Table 1, below. Notes accompanying a definition provide examples or warn of inconsistencies with legacy implementations of similar concepts.

Table 1 - Definition of Terms

Phrase	Definition	Notes
hierarchical relationship	A *superior-subordinate* relationship between two instances of **organization**. The instance identified as *superior* may be regarded as containing or controlling the *subordinate*.	Hierarchical relationships exist between the US Dept of Commerce and NOAA; between NOAA and NMFS. Note that a hierarchical relationship also exists between an **organization** and its **offices**. However, hierarchical relationships between distinct entity-types are captured intrinsically by the ER notation; no additions to the model are required for this purpose.
temporal relationship	A *predecessor-successor* relationship between two instances of **organization**. The instance identified as *predecessor* ceases to exist upon creation of the *successor*.	Temporal relationships exist between WDF and WDFW; also, between WDW and WDFW.

LOGICAL ERD

The PPO Logical ERD modified to accommodate organizational changes is presented in Figure 1, below.

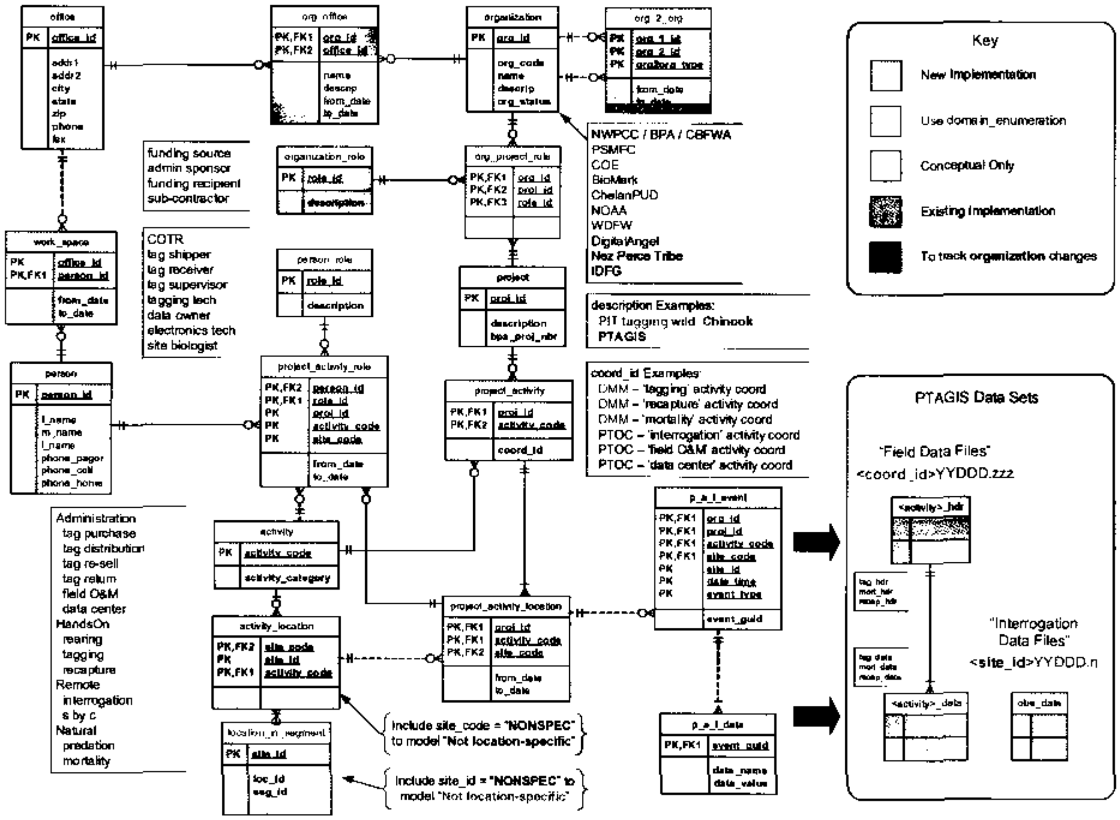


Figure 1 – PPO Logical ERD – Version 0.2.5

Two simple changes fulfill the objectives stated in the Introduction. First, the new associative entity **org_office** enables re-assignment of an **office** to a new **organization** instance, while preserving the history of previous office-organization relationships, in the event of an organizational name change or a structural re-location of one or more offices between organizations.

Second, the new **org_2_org** associative entity enables the modeling of *temporal* and *hierarchical* relationships between **organization** instances, as defined in Table 1, above. Consider the changes that produced the Washington Department of Fish and Wildlife, for example.

Prior to the change two **organization** instances would have existed, representing WDF and WDW. Each of these would have had one or more **org_office** instances, identifying their respective **office** locations.

To model *temporal* aspects of the change, a new **organization** instance would be created, representing WDFW. Two instances of **org_2_org** would be created, establishing *predecessor-successor* relationships – indicated by the *org2org_type* – one between WDF and WDFW; the other between WDW and WDFW. The **org2org**.*from_date* values would be set to indicate when WDW and WDF, essentially, ceased to exist and WDFW was created.

To model *hierarchical* aspects of the change, an **org_office** instance would be created for each of the **office** locations originally belonging to WDF and WDW. These would be configured with the *org_id* corresponding to WDFW, while the original **org_office** instances would be updated with *to_date* values indicating that the relationships they represent are no longer in effect.

More succinct definitions of the **org_2_org** attributes are presented in Table 2, below.

Table 2 – org_2_org Attributes

Attribute	Description	Notes
org_1_id	*org_id* value of the first **organization** instance.	
org_2_id	*org_id* value of the second **organization** instance.	
org2org_type	Specifies the relationship between the first and second **organization** instances: *hierarchical* or *temporal*.	*hierarchical* org_1 is superior, org_2 is subordinate *temporal* org_1 is predecessor, org_2 is successor
from_date	When the relationship came into effect	
to_date	When the relationship ceased to exist	As defined here, a *temporal* relationship exists forever.

-------------------------- END -------------------------

APPENDIX 2: M4 Design Specifications

Directed By Pacific States Marine Fisheries Commission

M4 Design Specifications

Version 1.0

23 January 2007

Prepared for the:

M4 Technical Committee

PTAGIS

PIT Tag Information System

Columbia Basin | ptagis.org

Prepared by:

John Tenney

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1. INTRODUCTION

1.1 *Background*

In late 2002, the PTAGIS project proposed to develop a new application to replace the dated MultiMon and MiniMon programs that performed monitoring and separation-by-code (SxC) processing at various interrogation sites. It was also proposed this application run on a Microsoft Windows PC-based platform with the following objectives:

1. All interrogation data collected by this system will be 100% valid.
2. Interrogation data will be provided to PTAGIS in "near-real" time.
3. 99.9% uptime of all system components.
4. SxC functionality must have as good or better efficiency as MULTIMON.
5. Interface with G2 readers and all legacy hardware.
6. Interface with PTAGIS data management systems.
7. Ease of use.
8. Standard system platform for all deployment scenarios.
9. Monitoring will take precedence over SxC control operations.

The M4 project will replace legacy interrogation software and meet all of the objectives listed above. In August 2006, an alpha version of M4 with limited SxC features was released to a technical committee and upon review it was decided to replace the proposed proprietary fault-tolerant hardware platform with a custom redundant failover solution. A subsequent alpha release will be needed to introduce high-availability features and fully functioning SxC protocols.

1.2 *Scope*

The scope of this document is limited to describing the general architectural and design of the M4 solution which includes:

- Operational and system requirements
- Application architecture: component relationships and communication
- Failover and data recovery schemes
- Integration of client data with PTAGIS
- Target platform and development tools
- Identify key use cases

These features are deemed critical by this author because they have significant scope and effect related to the performance, cost and scheduling for the M4 project.

The site facility described throughout this document will be identified as a large-scale interrogation site with several reader devices, separation-by-code operations and maintained by PTAGIS.

1.3 *Objective*

The objective of this document is to communicate the broad design decisions and assumptions to the M4 Technical Committee (M4TC) for review and approval. This document will be used as a guide for estimating project schedule and costs as well as identifying additional feature requirements. Once finalized and approved by the M4TC, it will provide the basis for developing a subsequent M4 alpha release that includes all functionality outlined in this document.

1.4 *Document Revisions*

1. **Original Draft, 0.1 October 2, 2006**

Version 0.1 is the original draft of this documentation prior to approval. This document will be reviewed, revised if necessary, and approved by the M4 Technical Committee. Subsequent to approval, this document version will be denoted 1.0.

2. **Modified Draft, 0.2 December 28, 2006**

Proofed original version and added some minor edits.

3. **Modified Draft, 0.3 January 04, 2006**

The system architecture was revised to separate the M4 Topology Manager from the M4 Client interface to allow seamless configuration of clustered systems as well as the ability to change the configuration while monitoring.

4. **Modified Draft, 1.0 January 23, 2006**

With the approval of the M4 Committee, this draft includes some minor updates that were suggested during the presentation of this information.

2. M4 DEVELOPMENT TOOLS AND TARGET PLATFORMS

The following development tools will be used to develop M4:

- Visual Studios and C# Programming Language
- .NET Framework 2.0
    - (TBD) .NET Framework 3.0 may be used with Windows Communication Foundation that has just been released.
- SQL Server Express and Standard Versions
- (TBD) Parajet PLC communication library

M4 will be developed for the following platforms:

- Windows XP SP2 or better
- Windows 2003 Server
- Windows Vista
- (TBD) Windows 2000 if .NET 3.0 is *not* used

3. M4 ARCHITECTURE AND SYSTEM COMPONENTS

The following diagram presents the general system component, functional domains and relationships that compose the M4 solution. Topics contained within this section introduce each component identified within the diagram.

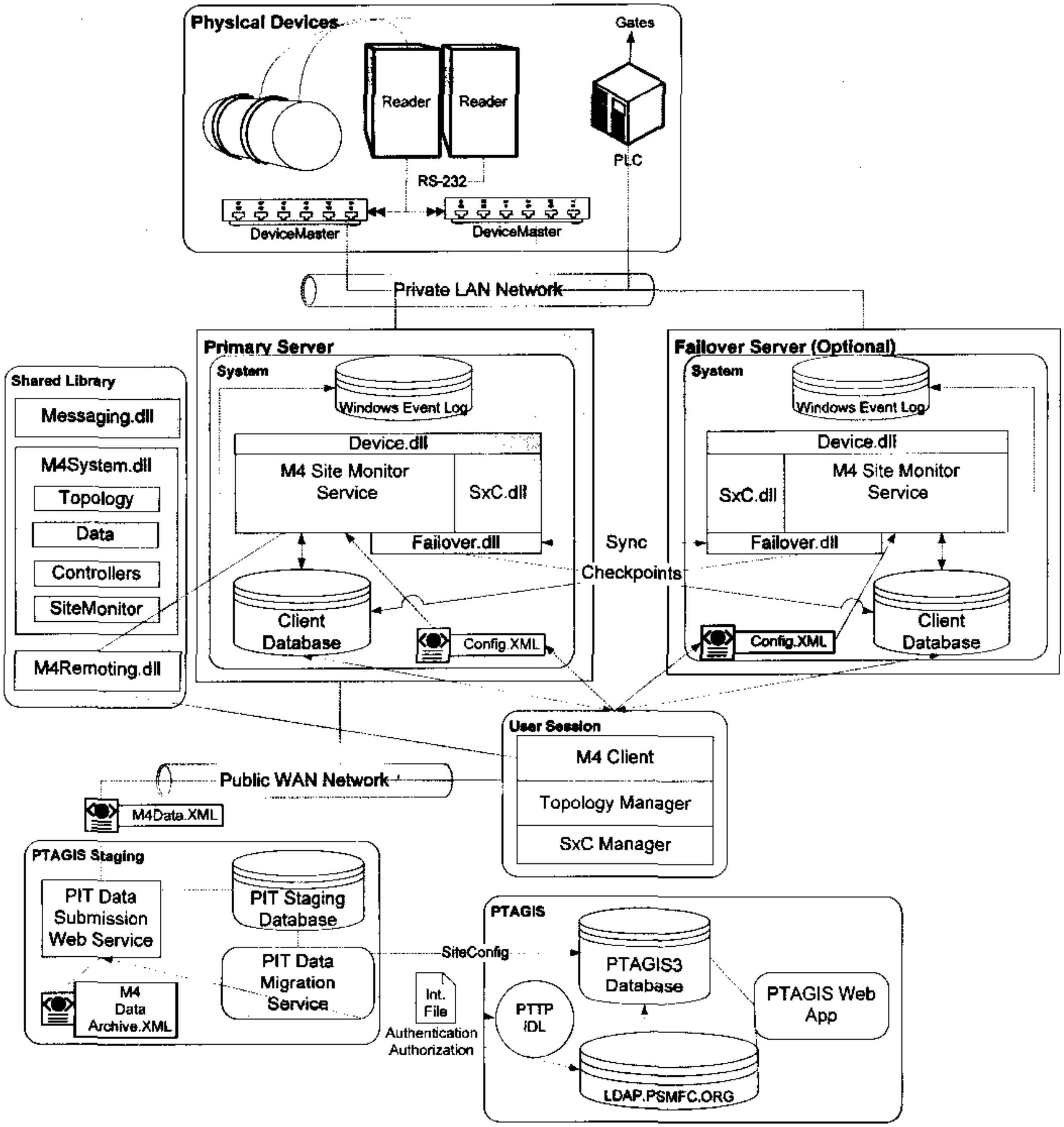

Figure 1 - M4 Conceptual Architecture

3.1 *Physical Device Domain*

This domain includes all peripheral hardware devices used to generate interrogation data, control slide-gates to route fish or provides communication between peripherals and the data collection platform.

3.1.1 Reader Devices

These devices, also known as transceivers, decode PIT tags and transmit data in various protocols usually via serial communication. Users can issue remote commands to change configuration settings or download data stored in an internal buffer. The following types of readers will be supported by M4:

READER	DESCRIPTION	PROTOCOLS	COMMUNICATION
FS2001 ISO	Digital Angel Portable	ASCII	Serial
FS1001	Digital Angel Juvenile Stationary	ASCII/BPA	Serial
FS1001A	Digital Angel Adult Stationary	ASCII/BPA	Serial
FS1001M	Digital Angel Multiplexer	ASCII	Serial
B2CC-G2	Digital Angel B2CC Reader	XML	Serial/Ethernet
FS1001B	Modified Digital Angel Adult Stationary	ASCII/BPA	Serial
In-Stream	Proposed In-stream reader (G2)	ASCII	USB

Table 1: Supported Reader Devices

Interrogation sites can contain any number of these devices, typically in the range of one to 50. The total number of reader devices that can be configured at a site is limited to hardware capacity. At larger sites, two to four inline readers will compose an *antenna-group* (also known as a monitor) to increase system efficiency.

3.1.2 GPS Devices

M4 will support a variety of GPS devices that transmit in a standard NMEA protocol using serial communication. GPS devices have been classified as a *trigger device*, meaning that a GPS position is triggered from this device whenever a tag code is read at an entire site or, optionally, from one of the many subcomponents (readers, antenna-groups) of the site topology. The number of GPS devices that can be configured at a site is limited to hardware capacity.

The typical use for GPS devices are for sites that change location often (pair-trawler for example) or have subcomponents that are frequently moved from place to place (antenna placement at in-stream sites).

3.1.3 Programmable Logic Controllers (PLC)

A PLC is used to control one or more slide-gates for separation-by-code operations at a facility and has the following, typical use case:

- One PLC is used per facility
- M4 sends and receives data from this device using Ethernet communication
- Sites that support separation-by-code will use a PLC device.

3.1.4 DeviceMaster

This product is manufactured by Comtrol Corporation and provides a bridge between serial devices communicating to one or more computers over an Ethernet connection and has the following, typical use case:

- DeviceMaster can support 16 to 32 serial ports per unit
- Large interrogation sites will use this product
- Smaller interrogation sites will use either USB/Serial hubs (such as the Comtrol's RocketPort product line) or native serial ports.

3.2 *Network*

Large interrogation sites that incorporate a PLC or DeviceMaster products will need to supply an Ethernet network to support these devices as well as a public network for management and data submission. These networks have the following typical use cases:

- A private local area network (LAN) will be used to for data collection and PLC communication
  - This network should be reliable and could be redundant with automatic hardware failover.
- A separate, public wide-area-network (WAN) will be used to submit data to PTAGIS and provide remote management.
  - The WAN network can have restrictions if not owned and operated by PTAGIS.
  - In some cases, a Virtual Private Network (VPN) tunnel may be installed between PTAGIS and a site to enhance the performance and reliability of operational management and data submissions.

3.3 *Primary Server Domain*

This domain represents the Primary Server or PC that collects data and optionally controls operation of separation-by-code gates. The term *primary* refers to the possibility that a secondary *failover* system may be placed parallel to this system to maximize uptime potential. Both primary and failover systems will be deployed with identical system components, however each will take on a separate role which is outlined in the Failover Server Domain topic.

3.3.1 M4 Site Monitor Service (M4SMS)

This principal component runs continuously in the background performing data collection and optional separation-by-code operations. This component is implemented in the M4System.dll and is hosted by a Windows service and is intended to be long-running and decoupled from any user session.

The Windows Service hosting M4SMS is disabled by default and can be controlled by the M4 Client component. Controlling M4SMS by extending the following Windows service operational states:

STATE	DESCRIPTION
Monitoring	The Windows Service host is started and instantiates M4SMS into memory. M4SMS performs the following initialization steps: 1. Opens Config.XML and reads in configuration settings. 2. Enables any failover services. 3. Connects to the client database 4. Retrieves the *Active Topology Version* 5. Connects to devices specified in the topology version 6. Enables any SxC operations 7. Processes all incoming messages from system and devices; if a message is a tag and SxC is enabled, the tag message is passed to the SxC library for further processing.
Paused	When Windows Service host is issued a paused command, the M4SMS disconnects from all peripheral devices, including any SxC operations. This state is used primarily for development and debugging. The M4SMS reestablishes connections using a refreshed topology configuration when the service is continued. This allows users to make minor configuration changes without stopping and restarting the M4SMS service.
Stopped	The Windows Service host is issued a stop command and the M4SMS component disconnects from all devices and the database and then is disposed from memory. The Windows Service host is stopped.

Table 2: M4SMS Operational States

Any errors encountered at the Windows Service host are logged to the *Windows Event Log* as well as the client database. The Windows Event Log provides a holistic view of the overall system and will be integrated into the M4 Client.

The following subcomponent libraries are used by M4SMS:

5. DEVICE.DLL

This library provides a common interface to all peripheral hardware devices listed in the Physical Device Domain. It provides standard serial and Ethernet communications as well as regular expression parsing routines that translate raw data from devices to meaningful messages that are passed to the host M4SMS component and logged to the client database.

6. SXC.DLL

This library performs all of the separation-by-code operations. If SxC is enabled, M4SMS initializes this library from configuration information stored in the client database and/or Config.xml. As each tag message is processed from a physical device, M4SMS passes them to the SXC.DLL library for further processing. The details of the SxC are not within the scope of this document.

An important operational requirement: data collection operations function independently of any SxC operations; any initialization or state changes in the SxC library should not affect primary data collection.

7. Failover.DLL

This library is part of a system architecture revision to incorporate failover clustering features into the M4 application. This library is only used if the configuration specifies a secondary, redundant server that will be used for failover purposes.

The Failover.DLL component performs the following primary functions:

- Maintains a primary/failover role between two servers in a clustered environment.
- Synchronizes with a remote component to provide real-time failover for gate controllers within a clustered environment.
- Provides checkpoints to both local and remote database to facilitate data recovery from failovers.
- Communicates failover state to a user session.
- Enforces identical topology versions between redundant systems
- Provides single-point control of two redundant systems

3.3.2 Windows Event Log

The Windows Event Log service enables an application to publish, access, and process events. Events are stored in event logs, which can be routinely checked by an administrator or monitoring tool to detect occurrences or problems on a computer.

M4's M4SMS logs events such as errors, monitoring state changes and data uploads into the Windows Event Log with a unique source identifier under the Application group. M4 events can be filtered using this source identifier or they can be viewed in context of all system event messages.

3.3.3 Client Database

The client database recommended for the M4 solution is Microsoft SQL Server 2005 Express Edition with Advanced Services (SSEA). This database provides the following benefits to this project:

- Free
- Ease of integration and management within the .NET development environment, including XML support
- Simplified administration: automatic tuning and patching.

- File-based deployment
- High performance, high reliability and secure
- Scalable (can scale up to more robust versions if needed without change client code)
- Provides replication, full-text searching and reporting services
- Hosted from a Windows service

3.3.4 Config.XML

This is an XML-based configuration file that is managed by the M4 Client and consumed by the M4SMS service on startup. The user can make minor configuration changes when the M4SMS service is paused and major changes only when the M4SMS service is stopped. However, all configurations take effect the next time the M4SMS server is started or continued.

3.4 *Failover Server Domain*

This domain represents an optional redundant server that the *Primary Server Domain* uses for failover in the case of a system or application fault. This domain only exists if the data collection platform requires high-availability. Ideally, the primary and failover domains will reside on identical hardware platform and they will have identical M4 system components installed. This document dedicates an entire topic to the details of failover, system roles and data recovery.

3.5 *User Session Domain*

This domain provides user interaction with the M4 system components in the *Primary and Failover Server Domains*. The primary objective of this client is to provide a single-application view by making the rest of the complex, distributed architecture of M4 transparent to the end-user. The user session domain is decoupled from the server domain, meaning that a user session can reside and connect to any server domain as long as a valid network connection exists.

The following subtopics present the components within this domain:

3.5.1 M4 Client

This principal component appears as a standard Windows application and allows user to interact with the M4 system components, namely M4SMS, and view the data collected. This component only exists when the user logs into the system and by default, they will be connected to the local M4SMS service. The user may be able to redirect the client to another M4 instance on a remote server (failover server for example).

The client application provides the following basic features:

- Control of the M4SMS service (starting, stopping and pausing).
- Real-time feedback of the state of the M4SMS, connected devices, SxC operations, and any failover operations.
- Data viewing, reporting and System Event Log integration.

- Ability to send remote commands to connected reader devices and control the connection state.
- The ability to submit data to PTAGIS from an M4 installation manually and/or from a configured schedule automatically.
- Configure application settings, site topologies and separation-by-code with separate, but integrated managers.

The M4 Client will integrate the following components into a single application. Each component will be launched into a separate window, but requires the user to complete the task before continuing with other tasks (modal):

3.5.2 Topology Manager (M4TM)

This component, implemented as a separate library, provides instrumented topology configuration related to physical devices and their relationships within a site facility. The topology configuration provides location and other historical context to the data collected, therefore whenever the user makes significant changes to a topology configuration, a new version is created and associated with new data.

Again, a topology version has a one-to-one relationship with the data collected during an activation period. Each topology version will have the following lifecycle states:

STATE	DESCRIPTION
New	The topology version has been created but not activated yet for data collection.
Pending	The next time the M4SMS service is restarted, this topology version will be activated.
Active	The topology version is currently used by the M4SMS service for data collection.
Expired	The topology version provides a historical background for researchers for the data collected during the period it was active. Once expired, it cannot be reactivated.

Table 3: Topology Lifecycle States

In addition to creating and maintaining topology versions, the M4TM component provides the following basic features:

- Automatic discovery and validation of physical devices
- Cloning of existing topologies as new versions
- Importing and exporting topology versions between installations

M4TM shields the M4 Client application from the complexities of instrumented topologies and the rules and procedures for versioning. Since data and topology are related, the following rules must be observed:

- All topology versions are stored in the Client Database
- Topology is exported and imported with corresponding data
- Topology is submitted to PTAGIS and integrated into legacy infrastructure.
- Topology versions must be identical on redundant, high-availability platforms
- Expired topologies cannot be reused. They can be cloned as new versions however.
- Only one topology can be designated as "active" when the M4SMS starts.

When the M4SMS starts up, it uses the M4TM to provide the active topology version to wire-up to the physical world.

3.5.3 SxC Manager (M4SXC)

This component is integrated within the M4 Client to provide a simple interface to the end-user for establishing the configuration of SxC protocols and a lookup database. Since it is dependent upon the active topology configuration, it uses M4TM component to extend physical antenna-groups and gates with separation-by-code logic.

Similar to a topology version, SxC configuration is managed by M4SXC hosted within the M4 Client and consumed by the M4SMS service on startup. And, like the M4TM counterpart, allows for exporting and importing SxC configuration between installations.

3.6 *Shared Library Domain*

A group of .NET libraries that provide implementation for several of the M4 system components that are shared across multiple function domains. This group is comprised of three libraries:

3.6.1 MESSAGING.DLL

This library provides all of the common messages types used by M4 for data collection, process control and persistence:

M4 supports the following types of messages:

MESSAGE TYPE	DESCRIPTION
Real Time Tag	A tag code captured from a device in real-time.
Buffered Tag	A tag code downloaded from a reader's internal storage.
Device Alarm	An alarm message generated from a device indicating a problem.
Device Status	A verbose status report which includes device diagnostics.
Device Message	A generic message created by a device.
System Status	A status message generated by the M4 system.
Error	An error message generated by the M4 system.
Start Monitor	Indicates the M4SMS service has started monitoring.

Stop Monitor	Indicates the M4SMS service has stopped monitoring.
Pause Monitor	Indicates the M4SMS service has paused monitoring.
Continue Monitor	Indicates the M4SMS service has continued operating from a paused state.
Start Monitor Pending	Signals that the M4SMS service is about to be started.
Start Monitor Failed	Signals the M4SMS service failed to start.
Pulse	A scheduled message indicating the continued operation of the M4SMS service over time.
Marker	User driven message to indicate an event outside of the M4 system.
GPS Coordinate	Indicates the location of a site, device or other M4 topology component over time.
Device Noise Report	A report generated by a device indicating antenna signal noise.
Device Bit Counter Report	An operational report generated by a device.
Connection Status	A status message generated by the serial or Ethernet communication layer.
Device Exception Errors	Error generated by a physical device, usually in regards to communication.
Buffered Device Status	A status message downloaded from a reader's internal storage.
Device ID Reset	The user-defined device id supplied in the topology configuration is corrected based upon messages from the physical device. This device message type is deprecated and used for backward compatibility only.
Device Tag Count Reset	The buffer storage within the device has reached a threshold and is being reset.
Sequence Mismatch	Indicates a communication error with the G2-B2CC reader
SxC Message	Base separation-by-code message
SxC Reject	Indicates a problem processing a SxC request
SxC Tag	Provides detail on the processing of a real-time tag message within SxC operations

SxC PLC	Provides detail on PLC operations.
Checkpoint	Used to synchronize two redundant Client Databases
System Failover	Indicates a fault in the Primary Server and the Failover Server is taking control of all gate operations.
Planned Failover	Indicates planned downtime for the Primary Server and the Failover Server is taking control of all gate operations.

Table 4: Message Types

3.6.2 M4SYSTEM.DLL

This library provides all the shared M4 system components used by several domains. The following components are included within this library:

COMPONENT	DESCRIPTION
Topology	A highly-structured set of objects that define logical site topology configurations, such as devices, sites, antenna groups and versioning information.
Data	Provides a common, lightweight data access layer to the Client Database and emphasizes performance over scalability.
Controllers	These are the objects instantiated by M4SMS that represent the physical active topology and maintains connections and structure that process data collected from devices.
SiteMonitor	This class provides the implementation for the M4SMS service.

Table 5: Components in the M4System Library

3.6.3 M4REMOTING.DLL

This library provides common inter-process communication between M4 components distributed in different application domains. It allows a component in one domain to interact with another component in a remote domain as if it were a local object.

For example, this library is used between the M4 Client to issue remote commands to the devices hosted in the M4SMS service. Conversely, the M4SMS service issues real-time alerts to any M4 Clients that might be listening.

TBD: this library may be implemented with Windows Communication Foundation that is part of .NET 3.0.

3.7 *PTAGIS Staging Domain*

This domain is centrally located at the PTAGIS Portland office and provides an adapter layer between M4 interrogation sites and existing PTAGIS legacy infrastructure. The primary focus of this domain is to collect data from various M4 interrogation sites and then periodically load this data into the legacy PTAGIS database. This domain performs this task using the following components:

3.7.1 PIT Data Submission Web Service (WS-PDS)

A standard web service layer that performs data submission into PTAGIS allowing an authenticated HTTPS or TCP connection from M4 systems and performs the following actions:

- Authenticates the caller's identity
- Authorizes the action based upon caller identity
- Validates the data package (M4Data.XML) and type (Interrogation or Tagging)
- Loads the data package into the PIT Staging Database and prevents data duplication.
- Logs the submission to the PIT Staging Database for reporting.

This service will initially incorporate M4 and MobileMonitor 2.0 data, but can be extended to load P4 tagging data as well. It will perform necessary authentication and authorization so only valid data can be submitted to PTAGIS. Data submission will be primarily automated on a user-specified schedule from each site. However, this service supports manual submissions such as data patching due to failover or data collected from MobileMonitor 2.0 sites. The data submission process is required to be in "near real time" with 100% reliability.

This service is covered in more detail in the M4 Data Submission topic.

3.7.2 M4Data.XML

This XML file consists of raw data from an M4 interrogation site for a period of time. Each site will periodically submit data using this file package to WS-PDS. All XML data files are archived (**M4DataArchive.XM**L) as a backup or for future use.

3.7.3 PIT Staging Database

This dedicated database provides a temporary store of data collected from M4 and *MobileMonitor sites using the WS-PDS service and periodically transforms this data to* the legacy PTAGIS database using the PDMS Service. It will have the same schema as the M4 Client Database plus additional schema to support the logging and reporting of data submission and other processing information for each site.

It is recommended this database be SQL Server 2005 Standard for the following reasons:

- Simplifies integration with Client Database and .NET Development Environment with native XML support.
- Can be scaled with native replication for data submission
- Robust, secure, high performance and reliable
- Simplified administration: automatic tuning and patching
- Low TCO; pricing for Standard version supports low connectivity with large data volumes, ideal for our environment
- Hosts native XML Web services (WS-PDS) without the need for IIS.

For optimization, this database may be purged on a set schedule. SQL Server 2005 Standard's is a low connectivity model, therefore it is not recommended to serve data for any web applications.

3.7.4 PIT Data Migration Service (PDMS)

This packaged component is a part of the SQL Server 2005 Integration Services and provides scheduled transformation and loading of M4/MobileMonitor 2.0 data from the PIT Staging Database to the legacy PTAGIS database.

3.8 *PTAGIS Domain*

This domain represents legacy PTAGIS infrastructure that play a significant role in M4 data submission. All of these components are housed within the PSMFC Portland office and have the following relative components:

3.8.1 PTTP and IDL

These server-based components provide the current mechanism for submitting formatted *interrogation text files* into PTAGIS database from legacy interrogation sites. PTTP is also used for tagging data submission.

3.8.2 LDAP.PSMFC.ORG

PTAGIS and the Commission currently use an LDAP directory to store and manage user accounts for the web application and other resources. WS-PDS will use this directory for authentication and authorization purposes during the data submission process.

3.8.3 PTAGIS3 Ingres Database

This is the legacy Ingres database used to house millions of tagging and interrogation records that are made available to researchers via the PTAGIS web site.

3.8.4 PTAGIS Web Application

This application provides researchers with the ability use all of the PTAGIS data by creating customizable queries or standard reports. In addition, it provides O&M personnel with strategic information for managing interrogation sites and equipment.

4. M4 TOPOLOGY CONFIGURATION

Before M4SMS can begin collecting data, a user must specify a valid topology configuration that describes a set of physical devices and their topological relationships to each other for an interrogation site. A topology configuration also provides context to the collected data, therefore, whenever a device or a relationship changes, *a new version of a topology configuration* must be created so that data and topology maintain a one-to-one historical relationship. This topic explains the special features of M4 topology configurations as well as establishing rules and procedures for effective management.

4.1 *Topology Components*

A topology has following hierarchical component structure:

```
[Topology]
```

```
[Site]
    [Antenna Group]
        [Reader Device]
        [Gate]
    [Reader Device]
        [Mux Antenna]
    [Trigger Device]
```

Where:

PARENT COMPONENT	CHILD COMPONENT	RELATIONSHIP
Topology	Site	A topology will contain at least one or more sites.
Site	Antenna-Group	A site can contain zero or more antenna-groups. However, a site must contain at least one reader device somewhere in the hierarchy. For larger mainstem sites, readers will be grouped into one or more antenna-groups.
Antenna-Group	Reader Device	Antenna-Groups must have at least two reader devices grouped together – or at least one multiplexer reader (FS1001M).
Antenna-Group	Gate	One gate can be associated with an antenna-group for SxC operations.
Site	Reader Device	A site can contain zero or more readers independent of any antenna group. This type of topology is primarily used with smaller In-stream sites that do not use antenna-groups.
Reader-Device	Mux-Antenna	If the reader is a multiplexer device, it must contain one or more antennas.
(various)	Trigger Device	Trigger devices can be associated with any of the following components at any hierarchy level: Site, Reader, Antenna-Group, Mux-Antenna.

Table 6: Topology Component Relationships

For example, the following figure displays samples of topology configurations to describe the respective topologies for a large, mainstem and a smaller in-stream site:

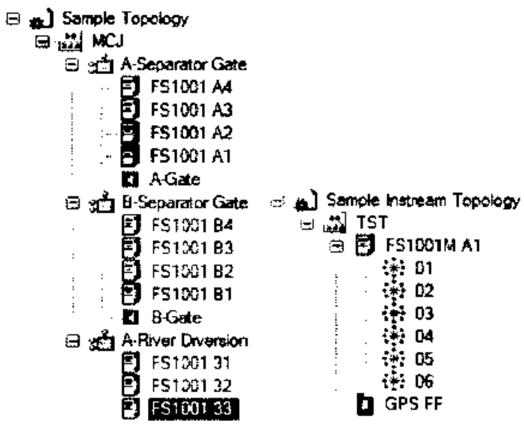

Figure 2 Topology Example Mainstem and In-Stream

Each topology component has these principal configuration features:

COMPONENT	FEATURE	DESCRIPTION
Topology	Description	Provides a detailed description for this topology
	Version*	Major version and revision number, i.e. 1.5
	Created*	Date version was created
	Modified*	Date version was last modified
	Activated*	Date topology was activated (data collected)
	Expiration*	Date topology expired
	State*	Current Topology Lifecycle State: • New • Pending • Active • Expired
Site	Site Code	Three character code assigned by PTAGIS
	Description	Description of interrogation site
	~~Type~~	~~Type of site:~~ • ~~Juvenile (mainstem)~~ • ~~Adult (mainstem)~~ • ~~In-Stream~~
	Location	Optional: Lat/long pair representing location of site
	Supports SxC	True if SxC operations occur at this site (note: a PLC device may be added to a site without requiring SxC

		Operations – used for an input device).
Antenna Group (all settings are mandatory)	Description	Verbose description of a grouping of Readers
	Sorting Sequence	Provides logical sorting in relation to physical layout of antenna groups
	Site Entrance	True if located at entrance of a site
	Site Exit	True if located at exit of a site
	Disposition	Information on fish disposition after leaving antenna group: • Unknown • Indeterminate • River • Transportation • Sample Transportation • SMP
	Location	*Optional: Lat/long coordinate pair.*
Device	Device ID	Two character hexadecimal unique identifier assigned by PTAGIS or other site personnel
	Description	Optional: Verbose description of device
	Enabled	If true, device will be connected when M4SMS starts. Disabling a device is useful for sites that download data from multiple, remote readers using a common serial port.
	Device Type	Type of device: • F1001 • FS1001A • FS1001M • FS2001 • FS1001G2 • GPS • SLC500 • *B2CC*
	Data Protocol	Communication protocols: • ASCII

		• Binary (BPA) • NMEA • SLC500 • XML
	Port Type	Type of communication port: • Serial (RS-232) • UDP • TCP • USB (for In-stream reader)
	Port	Communication port (serial: COM1, TCP: 1599)
	Ethernet Settings	Ethernet communication settings: • Host Name • Remote Port
	Serial Settings	Serial communication settings: • Baud Rate • Parity • Data Bits • Stop Bits
	Location	Optional: Lat/Long coordinates of device
Mux Antenna	Antenna ID	Two character hexadecimal unique identifier assigned by PTAGIS
	Alias ID	Optional: two character hexadecimal site unique identifier to bypass current PTAGIS limitations.
	Description	Optional: verbose description of antenna placement
	Location	Optional: lat/long coordinates of antenna
Gate	Description	Verbose description of gate
	Type	Type of gate: • Two Way • Three Way
	Address	PLC bit-mask address of a physical gate

	Delay Period	Period in milliseconds to delay before opening gate
	Location	Optional: lat/long coordinates of gate

Table 7 Topology Configuration Features

* Settings are Read Only

4.2 *Topology Versioning*

The M4 Client provides features for users to make changes to the existing topology whenever the M4SMS service is stopped or paused. The changes will take effect immediately when the M4SMS service is started again.

The M4 Client (via M4TM) distinguishes between two types of topology changes: major and minor. The M4 Client automatically tracks a topology version number to help maintain the historical relationship of topology configuration and data between – and this relationship is transferred between the M4 application and the PTAGIS server. This version number is in the format of *<major version>.<decimal minor version>* where major changes cause the <major version> number to increment and minor changes cause the <minor version> decimal number to increment. For example, 1.0.5 is the first installed topology version that has five minor change events. Note: minor version is a n.m value to aid in sorting.

Any major or minor change will cause M4 to automatically submit the changed topology version to PTAGIS on the next scheduled upload.

What constitutes major and minor changes are described in the following subtopics:

4.2.1 Major Topology Changes

These types of changes require a new topology version record to be created. End-users of PTAGIS data will be made aware of these changes because of the impact on data collection and context.

The following are considered major topology changes:

- Adding or removing a device, antenna-group, mux-antenna, gate or site component
- Renaming of a device id, mux-antenna id or site code
- Changing the relationship between any of the components, i.e. moving a device between antenna-groups or sites.
- Changing the type of device

Once a topology version is used for data collection it is flagged as *Activated* and no further major topology changes can be made to it. Users must create a new topology version only when monitoring is stopped to make any major configuration changes.

A version number is incremented for each new topology version and the state of the topology (New, Activated, and Expired) is clearly identified in the M4 Client.

4.2.2 Minor Topology Changes

Minor topology changes are those that are not listed as major changes in the previous topic and include:

- Changing a Serial Port or other serial setting for a device
- Changing data protocol or port type for a device
- Changing the description of a component
- Changing any of the gate settings

Users can make minor changes to a topology without making a new topology record. When minor topology changes are saved, the current topology revision number is incremented by one (i.e. 1.0.0 becomes 1.0.1).

Minor topology changes can occur whenever the M4SMS service is paused or stopped.

4.2.3 Revision Notes

Whenever the user creates a major or minor change, they will be prompted with a revision note indicating the reason for the change. This feature will be used as an informal change log. These revision notes will be migrated to the existing PTAGIS Event Log.

4.3 *Topology Rules and Procedures*

This subtopic presents a list of topology rules that must be defined in order to successfully collect data at an interrogation site.

4.3.1 Rule: a valid topology must exist before M4SMS can start

M4 will be installed with a default, empty topology. M4 Client will disable any start actions if the topology is not valid. If an attempt to start the M4SMS from the *Service Control Manager*, M4SMS will fail and log an error to the event log.

The requirements for a valid topology are:

- At least one Site defined
- At least one reader device defined for the Site.
- Any antenna-groups must contain two or more readers
- All mandatory settings for each component are specified and valid.
- Only one device can be enabled for a given port address

The M4 Client will provide a validation feature that allows users to verify if a topology configuration meets the above standards.

4.3.2 Rule: major topology changes require a new topology version

If a topology configuration has been used to collect data, the user must create a new topology version to make major changes.

4.3.3 Rule: minor topology changes updates existing topology version

Users can make minor changes to a topology without forcing the creation of a new topology record.

4.3.4 Rule: two devices cannot be simultaneously read from the same port address

A topology configuration can contain a definition for two or more devices that specify the same serial or UDP port, however, *only one* of these devices can be enabled to connect and read from the port while the M4SMS is running.

This feature allows users that download data from multiple readers on a computer with only one serial port. When a user enables a device for communication, any other device sharing the same serial port will be automatically disabled.

4.3.5 Rule: importing a new topology configuration will create a new topology version.

Users can export and import topology configurations between M4 installations, however, each time a topology configuration is imported, a new record is created and the version number is incremented based upon the destination M4 installation and not the source.

4.3.6 Rule: any device identification transmitted within data is overridden by topology configuration

Some data protocols contain reader identification within tag or status data records. The reader identifier specified in the topology configuration is always associated with data regardless of any transmitted reader id. Therefore a reader id reset to a factory default will not affect data collection.

The M4 Client will have a topology validation utility to detect conflicting reader identification.

4.3.7 Rule: clustered machines must run the same topology version

When two machines are used for failover, both machines must run the exact same topology version. The M4TM utility will enforce this rule such that any time a configuration is changed on one machine it will be transparently updated on the cluster.

M4SMS service will verify that its failover counterpart is running the same topology version, if it is not, it will fail to start and report the error.

4.3.8 Rule: All changes to a topology and configuration take effect the next time monitor is started.

The M4SMS monitoring service must be stopped and a new version created to make *major* changes. For *minor* changes monitoring can be stopped or paused. All changes take effect the next time monitoring is started.

4.3.9 Procedure: Concurrent Reporting and SxC Processing

There is potential for performance degradation of the M4 system when computationally expensive reports are executed from the M4 Client. Any load put on the M4 system can effect real-time SxC operations. To avoid this, users should perform all reporting and other types of analysis on the redundant failover server.

4.3.10 Procedure: Year End Database Maintenance

Each year the end user should purge any unnecessary data from the Client Database to optimize the performance of the system, especially at sites that accumulate a lot of data. This can be easily done using the *Purge Wizard* feature located under the tools menu.

TBD: other database management procedures may also be available, such as compacting and repairing a corrupt database file.

4.3.11 Procedure: Compatibility Issues of Sites with Several Multiplexer Readers

Users must make use of the *antenna alias* setting for multiple FS1001M antenna configurations to ensure compatibility with legacy PTAGIS data structures. This antenna alias will be used to override the existing PTAGIS Device ID field in the legacy database.

5. M4 CLIENT FEATURES

This topic explains key features of the M4 Client from a user's perspective.

5.1 *M4 Icon in the System Tray*

The M4 Client application can be minimized to an active icon within the System Tray of the Windows Operating system. The icon will provide simple real-time display of the M4SMS service state as well as a set of basic menu commands that can be accessed by right-clicking the icon. A user can configure this minimized view of the M4 Client to automatically launch at logon.

5.2 *Opening M4 Console*

The user can launch the M4 Client console (the main viewer window) by:

- Dbl-clicking the M4 Icon in the System Tray
- Right-clicking the icon in the System Tray and select *Open…*
- Dbl-clicking the M4.exe executable from a desktop shortcut or directly from the installation folder.

The M4 Icon is displayed whether the console is open or minimized. The user must close the M4 Client from console.

5.3 *M4 Client Layout*

The M4 Client is divided into two panes. The left-most pane represents the current topology version, called the Topology Viewer. The right-most pane, called the Data Viewer, presents the most current data associated with the selected item in the Topology Viewer. This has a similar layout and functionality as the familiar File Explorer in the Windows operating system.

5.4 *M4 Topology Viewer*

The Topology Viewer presents real-time status of all topology components as well as drill-down navigation for viewing data. Users can right-click any of the components displayed in this viewer and perform tasks from a context-sensitive menu for the selected item. This topic discusses some of the features of the Topology Viewer in more detail.

5.4.1 M4SMS Service Display

The top-most (root) node in the viewer represents the real-time state of the M4SMS service (green=monitoring, red=stopped, or yellow=paused) as shown in Figure 3.

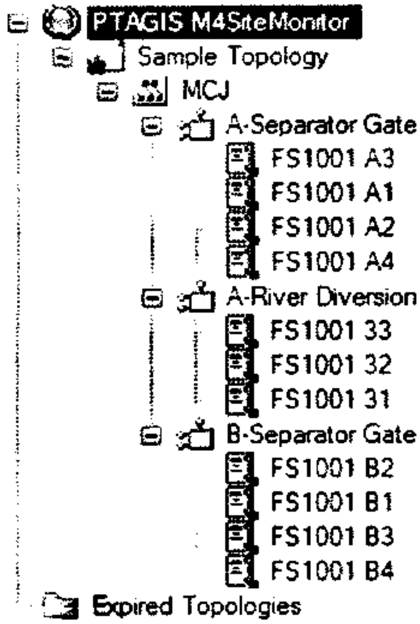

Figure 3 Topology Viewer Pane

When this node is selected, the Data Viewer will display records corresponding to operational events, such as when the service started or stopped and any errors that may have occurred.

Right-clicking the node will allow the user to control the state of the service, similar to *File* menu commands. However, there is a distinct difference when running in a clustered environment: control commands selected from the menu control both clustered services, whereas control commands selected from right-clicking this display node controls only the specific service it represents. This is useful when users want to perform a planned shutdown of one of the clustered servers.

5.4.2 Active Topology Display

Below the root node, is the active topology version and subcomponents. The readers and other devices will convey their operational state with a similar color scheme as the M4SMS service root node. This will give the user a visual indicator if there is a problem with a specific device. The user can click on that device and filter for all the current errors.

In addition to display the state and data for a selected topology component, the Topology Viewer allows the users to inspect the configuration details and perform other tasks by right-clicking a component and selecting on of the commands below from a context sensitive menu:

MENU COMMAND	DESCRIPTION

Enable	A toggle menu command allows the user to enable or disable a particular device while the monitor is running. This is useful for sites that download data from multiple readers from a single serial port. Enabling a device will automatically disable another other device sharing the same serial port.
Configure	Same as dbl-clicking the item – it will display a separate window containing configuration settings for the selected item. If the monitor is running, all configuration settings will be read-only. If the monitor is stopped or paused, the user can change select configuration settings (minor changes only).
Reports (TBD)	Various operational reports can be run from this menu under the context of the selected component.

5.4.3 Other Topologies Folder

The Topology Viewer also displays an *Other Topologies* folder which will display all the past topology version used during data collection – or any new or pending topology versions that have yet to be used by the M4SMS service. This will give the user the same drill-down navigation for displaying historical data associated with past topologies and the ability to reopen a new topology for further editing.

5.5 *M4 Client Data Viewer*

The M4 Client console presents a *data viewer* that is synchronized with the *topology viewer*. As the user selects a component in the topology viewer the data viewer displays data for the specific component. This is call drilled-down reporting and allows users to quickly find the information they need in a complex topology configuration.

5.5.1 Message Viewer

The data viewer displays messages captured by or created by the monitor over time. Each message is displayed as a single row within the data viewer. Users can dbl-click a message row to view a pop-up window displaying the entire text and additional detail about the message.

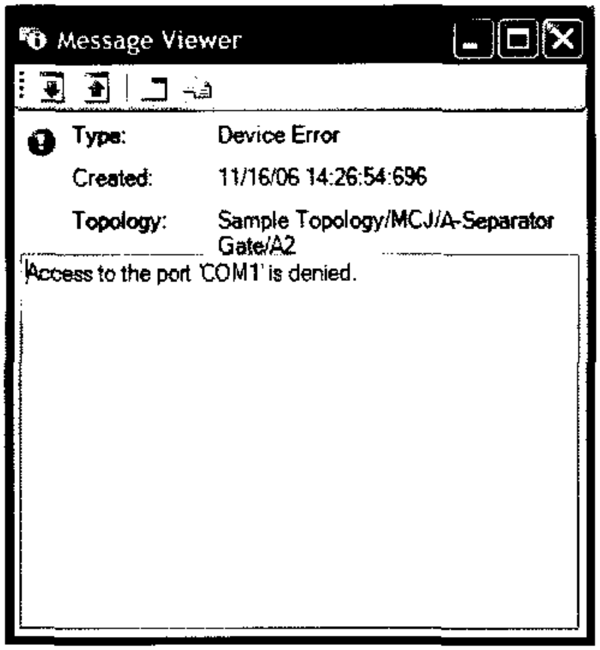

Figure 4 Message Viewer

The user can scroll and display other data messages using the navigation buttons on the Message Viewer window. Also, the user can lock the current message viewer and launch additional message viewers to perform comparisons. Only one non-locked viewer will be displayed at once.

When the context of the data viewer changes (user selects another component in the topology viewer) or the data viewer is refreshed, any non-locked message viewer will display the first record listed in the refreshed data viewer.

Message viewer feature is disabled when the data viewer is in auto-refresh mode.

5.5.2 Data Context

The context of the data viewer depends upon the type of component selected in the *Topology Viewer. The M4SMS service root component will display a summary of state* changes (start, stop, paused) starting with the most recent.

All other topology-related components display messages specific to the component starting with the most recent information.

It is important to remember that message data is partitioned by topology version. When users navigates to a particular topology (active or one of the expired topologies), only data for that topology is displayed.

5.5.3 Data Viewer Auto-Refresh Mode

The data viewer is static – meaning the user must refresh the viewer to get new messages since it was last display. Pressing a *Refresh* button will refresh the data viewer based upon the current context.

The user can also select *auto-refresh* mode to automatically refresh the viewer on a specified interval (every 5 to 10 seconds). The ability to scroll the data is disabled whenever the auto-refresh mode is on as well as sorting. Also, only the most recent records that fill the data viewer are displayed (computed dynamically).

5.5.4 Pages of Data

Because the amount of data increases over time, the data viewer displays a page of data at a time when not in *auto-refresh* mode. The amount of data within a page is user-configurable with a default value of the last 200 messages. The user can scroll pages up or down to view additional data for the current component.

5.5.5 Filtering the Data Viewer

Users can filter the data viewer by common message types:

- Messages: default message type
- Errors: all message types that are considered errors
- Alarms: all device alarm message types
- Tags: any tag data message
- SxC: any separation-by-code message.

These filters can be applied by pressing the appropriate tool menu button above the data viewer (figure 6). Filters can be combined together to provide a custom viewer for the user and remain active as the user navigates the topology.

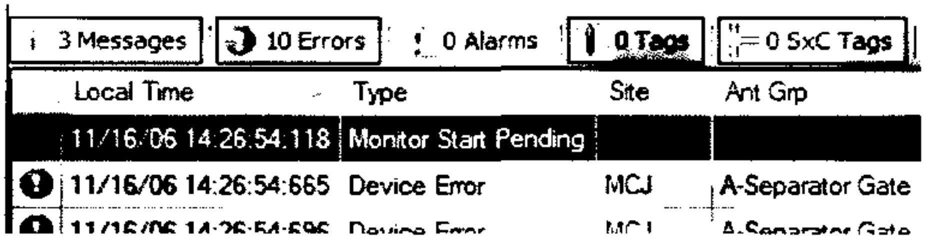

Figure 5 Filter Buttons

The filter buttons also provide a message count for each type.

5.5.6 Real-Time Data Viewer

The user will have access to a second type of viewer that presents data in real-time. Each time a new record is captured, it is displayed on the screen. This real-time viewer will not allow scrolling or freezing of the data (as the Data Viewer counterpart in the main window). The user will be able to provide a custom filter (selecting two or more antenna-groups etc.) to restrict the real-time viewer window to a particular set of components.

5.6 *M4 Topology Management Features*

As mentioned in a previous topic, changes to the active topology are limited to settings that will not change the context of the data collected. To make significant changes to the existing topology, users will need to create a new topology instead. This topic discusses the features available in the M4 client to support this.

5.6.1 Creating New Topology Versions

Users can create new topology version by selecting a command from the **File** menu, selecting **New** and then selecting one the following options:

- **Empty Topology:** this will create an empty topology.
- **Discover Topology:** a wizard will scan designated ports to determine any type of reader or other device connected on the other end. If a connection is established and type can be ascertained, a device configuration will be automatically created under a default site configuration and associated with a new topology version.
- **Existing Topology** will make a copy of the existing topology version that can be modified.
- **Import Topology** will prompt the user for an XML file from disk to import as a new version.

These commands are available regardless if the monitor is running. This allows users to configure a new topology while the monitor is running. When any of these menu commands are selected, the New Topology Manager window is opened to allow the user to create a new topology version.

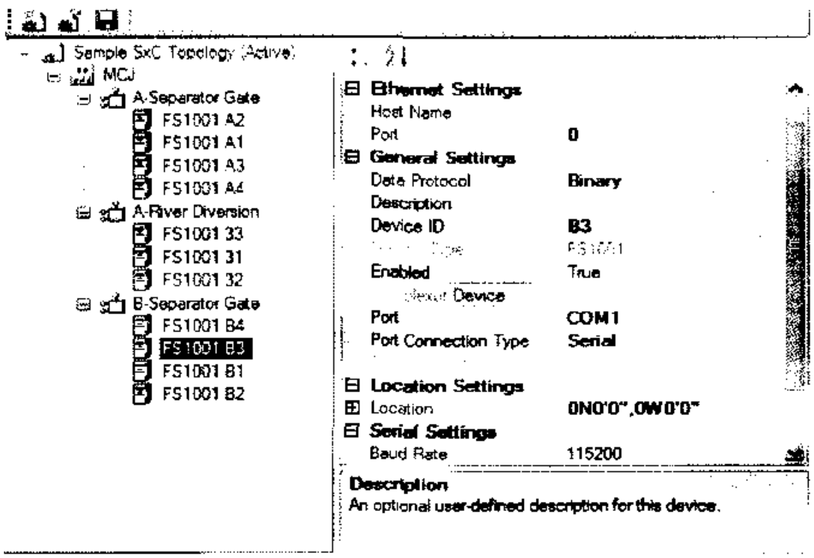

Figure 6 New Topology Manager

The New Topology Manager has a similar layout as the M4 Client. The left pane represents the new topology and the right pane presents context-sensitive configuration settings for the selected topology component in the left pane.

5.6.2 Adding a New Topology Component

Users can add new components to the topology by right-clicking a component and selecting the appropriate New menu command. A dialog window will appear to allow the user to specify configuration settings for this component as shown in Figure 7.

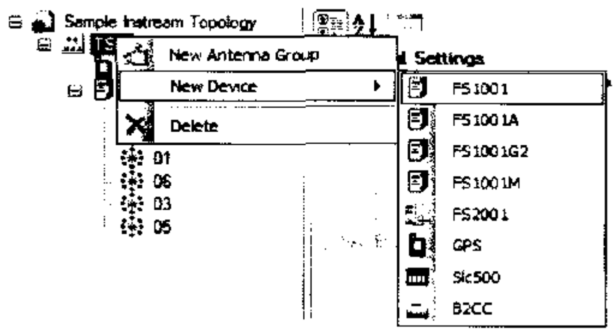

Figure 7 Adding a New Topology Component

All of the New commands are context-sensitive, meaning they only display features that make sense for the selected component or context. For example, right-clicking on a site will allow users to add antenna-groups or any device type; however, clicking on a device component will allow users to add a trigger device or mux-antenna if the device is a multiplexer.

5.6.3 Deleting a Component

Any topology component can be deleted by either selecting the component and pressing *Delete* key, or by right-clicking the component and selecting the *Delete* menu command. Any subcomponents will also be deleted.

5.6.4 Moving a Component

Device components can be moved between antenna-groups or site components by dragging-and-dropping the selected device. Similarly, antenna-groups can be moved between site configurations and trigger-devices can be associated with any component within the hierarchy. Hierarchy rules are applied so that users cannot drop a component onto a parent that does not make sense (i.e. antenna-group dropped onto a device).

5.6.5 Changing Component Configuration Settings

The New Topology Manager window will display the configuration settings in the left-pane based upon the selected component in the right pane. This should be a familiar functionality as many Windows applications support this type of layout. All of the configuration settings can be changed and the right-pane will update accordingly.

5.6.6 Ordering Components

Antenna-groups are displayed in ascending order based upon the *Sort Order* configuration setting. Similarly, sites and devices are displayed in ascending order based upon the *Reader Id* and *Site Code* settings respectively.

Users can arrange the hierarchy using these sorting fields to reflect the actual physical layout of a site where the top of the hierarchy display is upstream and bottom is downstream, left-to-right facing upstream per PTAGIS specifications.

5.6.7 Activating a New Topology Version

Before a new topology will replace an existing one, the user must *activate* the new topology by selecting the appropriate Activate command from the New Topology Manager. This will mark this topology such that the next time the M4SMS service is started, this new topology will replace the existing topology.

5.6.8 Saving Changes

Once the topology is complete the user can select the appropriate Save command and close the New Topology Manager. The user can also choose the Cancel command that will close the window without saving the new version. A warning will be displayed if the user saves the new topology without activating it.

The new topology can be reopened and changed if it has not been used with the M4SMS service, (or it was not activated). A new topology that was not activated yet will be listed when the user selects New | Existing Topology. This allows the user to work on the same new topology over a period of time.

Any new topology will be displayed in the Other Topologies folder along with any expired topologies. The user can reopen the topology for further editing. Once the new topology version is activated, it will be removed from this folder and displayed as the prominent "Active" topology.

A *New* topology command will overwrite any existing new topology – only one new topology can exist at one time.

5.7 *Validating Topology Version*

While the monitor is stopped or paused, a user can execute the Validation Wizard under the Tools menu that will attempt to connect to all devices configured within the current topology and verify their existence, device type and reader identification.

A report will be issued showing all reader firmware versions and listing any invalid configuration settings specific to the devices. The user can correct the topology configuration settings based upon the report's recommendations.

5.8 *Exporting a Topology Version*

Users can export the current or any expired topology by selecting the topology and selecting the *Export* command listed under the *File* menu. The user will be prompted for a file name and location to store the XML file. The XML file can be imported into another M4 installation as a new topology version.

Exporting a topology can be performed at any time.

5.9 *Importing a Topology Version*

Users can import a topology version from an XML file by selecting the *Import* command located under the *File* menu. Once the XML file is selected, the imported topology version will be displayed in the *New Topology Viewer* as a new version, allowing the user to make any modifications before saving and activating it.

5.10 *Controlling Monitoring from the M4 Client*

In addition to managing configuration and viewing data, the M4 Client also allows a user to start, stop and pause monitoring. The user can select Start Monitor, Stop Monitor and Pause Monitor commands from the File menu within the M4 Client console, or they can right-click the M4 Icon in the System Tray and select the same set of control commands. System administrators can control monitoring using the Service Control Monitor -- this is not recommended for general users.

The M4 Client provides real-time feedback on the state of the monitor and device topology components. Similar to stop-lights, green means the monitor is running, yellow means the monitor is paused and red means the monitor is stopped. Monitor errors are indicated with a standard error exclamation.

5.10.1 Starting M4 Monitor

The following processing steps occur when the monitor is started under normal operating conditions:

1. A Windows Service host instantiates the M4SMS
2. M4SMS opens the configuration file and reads the settings
3. M4SMS service makes a connection to the local database
4. M4SMS loads monitoring controllers into memory based upon the active topology version configuration provided by M4TM.
5. The monitoring controllers connect to the physical devices and begin monitoring for message data; all message data is written immediately to the database.
6. If SxC is enabled, M4SMS loads the M4SXC.dll library components into memory, passing configuration information from the database or configuration file.
7. Once the SxC controller signals it is ready, M4SMS begins to route all tag messages to the controller for further processing.
8. State is signaled to any M4 Client that may be running.

5.10.2 Stopping M4 Monitor

The following processing steps occur when the monitor is stopped under normal operating conditions:

1. SxC controller is signaled to stop and unload itself from memory
2. All monitor controllers disconnect from physical devices and unload from memory
3. The database connection is closed
4. M4SMS service is stopped and unloaded from memory.
5. State is signaled to the M4 Client.

5.10.3 Pausing M4 Monitor

The following processing steps occur when the monitor is paused under normal operating conditions:

1. SxC controller is signaled to stop and unload from memory
2. All monitor controllers disconnect from physical devices and unload from memory
3. State is signaled to the M4 Client.

5.10.4 Refresh M4 Monitor (TBD)

This allows users to refresh any configuration changes to the monitor – simply put, the system performs a restart of the service.

5.10.5 Download Wizard

Wizard will guide users in downloading buffered data from remote readers. It operates independent of the M4SMS and allows users to use a single serial port for several devices by mapping to an existing topology version. It also provides user with generate real-time tag codes from stored information. Initiated from Topology Viewer (provides *explicit mapping*).

5.11 *M4 Client SxC Features*

The M4 Client provides integrated configuration and control features for SxC processing. The majority of M4 installations do not perform SxC operations, therefore the visibility of the SxC features are only displayed when SxC is supported.

SxC features become visible whenever a gate component is added to an antenna-gate within the current topology and the *Support SxC* setting is set to *true* for a site component. A separate SxC component will be added within the target site component (Figure 7) to allow the user to monitor and control SxC operations:

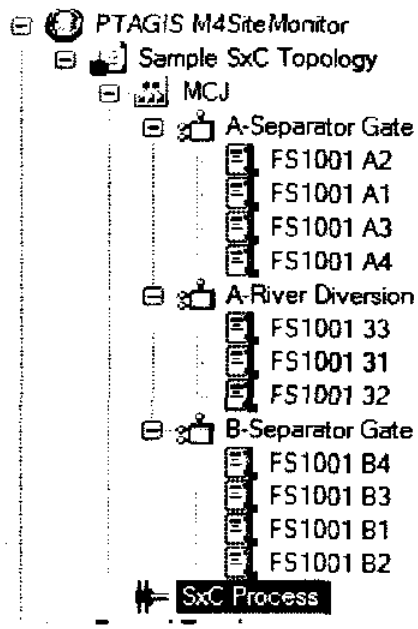

Figure 8 SxC Topology Component

5.11.1 SxC Control

M4 Client allows the user to stop SxC processing without effecting monitoring operations. Users can right-click the SxC component displayed in the topology viewer and control commands will be displayed in a pop-up menu to stop or start SxC operations. Stopping and starting the SxC is necessary to allow the user to specify configuration changes. The state of the SxC component is indicated similarly as the monitor process (green = on; red = stopped). This control may also have a **Refresh** option to reset any configuration changes.

5.11.2 SxC Configuration

M4 Client has an integrated SxC management console (SxC Manager) which is launched when the user right-clicks the SxC component and selects *Configure* menu command. The SxC Manager will allow the user to manage all aspects of the SxC operations, details of which are out of scope for this document.

The SxC configuration will also make use of revision notes that will be migrated to the PTAGIS Event Log.

5.11.3 SxC Messages

The data viewer supports filtering for SxC related messages in conjunction with drill-down navigation of each topology component. If the user selects an SxC component, all SxC messages (within the limits of paging) will be displayed for all system components.

5.11.4 SxC Reporting

M4 Client will support additional SxC reporting, the details of which are out of scope for this document.

5.12 *M4 Client Reporting*

The M4 Client can provide robust reporting features. This topic presents some of the basic reports, however detail is omitted. Additional reporting may be added to M4 at as needed.

All reports are listed under the Report menu. Users can also access reports that are within the context of a particular topology component by right-clicking a component within the topology viewer (Figure 3).

5.12.1 Tag Report

This report will allow the user to enter a list of one or more tags and then display matching tag message records (hits) for each tag listed in chronological order. The user can restrict the report by site, date/time and/or device. Tag hit lists can be imported from a file.

5.12.2 Device Status Report

This report will compile detail of all device status report messages for a selected device and date range.

5.12.3 Device Diagnostic Report

This report will display diagnostic summary of a selected device, antenna-group or site based upon information output in the device status report. The detail of the report will graph the following trends over a specified period of time:

- Exciter Current
- Exciter Phase
- Signal Level
- Tune Phase
- Temperature

5.12.4 Device Noise Report

This report will display a summary of noise information for a selected device, antenna-group or site based upon noise message records output from FS1001A or FS1001M devices. The detail of the report will graph the following trends over a specified period of time:

- Average Noise
- FDXB Peak Noise
- Peak Noise

5.12.5 *Site Operations Report*

This report provides a short summary of when monitoring operations started and ended at one or more interrogation sites. It will also include other system activity such as:

- Failover
- Uploads to PTAGIS
- Imports and Export operations
- Topology edits
- Errors

5.12.6 Antenna-Group Efficiency Report (TBD)

Antenna-group efficiency reporting may be computed and reported from the M4 client.

5.12.7 *SxC Gate Efficiency Report (TBD)*

Separation-By-Code efficiency reporting may be computed and reported from the M4 Client.

5.12.8 Tag Trends Report

This report will show tag activity over a specified time and system component (site, reader, or mux-antenna). This report can be extended to use geographic location of tagging activity over time.

5.13 *M4 Client Additional Features*

The M4 Client supports the following additional features:

5.13.1 Exporting Data

Besides exporting topology configuration, users can also export message data using the Export Data Wizard. This wizard, accessed from the File menu, provides the user with a simple mechanism for exporting all or a subset of message data in various formats (XML, CSV, Text) to be imported into other systems, such as Excel or Access.

When XML data is exported, the topology version associated with the data is always included within the file. Users can choose to exclude this additional topology information -- however, the file can no longer be imported into any M4 instance.

5.13.2 Importing Data

Message data can be imported from other M4 or MobileMonitor 2.0 installations using the M4 Client. This feature will be most often used for data managers collecting data from various remote sites that do not have a network connection to submit data to PTAGIS directly.

Only XML data exported from M4 or MobileMonitor 2.0 will be supported for importing. Because data has a one-to-one relationship with topology, the XML file must contain both topology and message data before it can be imported. Imported data can be accessed from the topology version listed under *Expired Topologies* folder in the topology viewer.

Any existing topology in the M4 target database will be updated if the exported topology has a greater version number; otherwise it will be ignored and only message data will be imported.

Users can select the import feature from the under the *File* menu and then navigate and select one or more files to import; or they can simply drag-and-drop the files onto the M4 Client to initiate importing. A prompt indicating the number of rows imported will be displayed upon successful completion. Any duplicate data will be silently ignored.

5.13.3 Device Commands

Users can communicate directly with physical devices by sending remote device commands from the M4 Client. Device commands can only be sent while the monitor is running. A user can access the Device Commands window by selecting it from the Tools menu or by right-clicking a specific device in the topology viewer and selecting *Send Command* menu command. The following window will display:

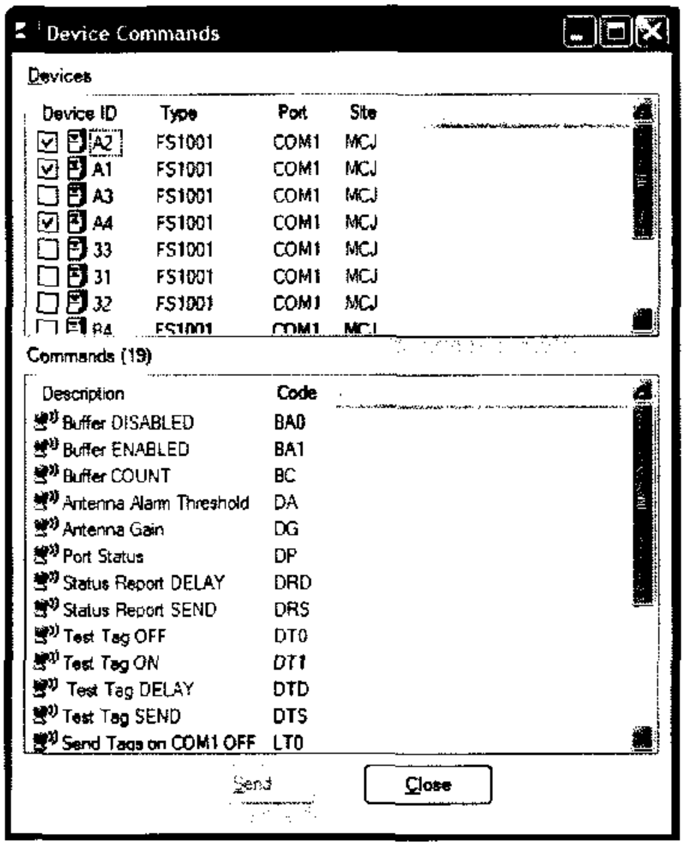

Figure 9 Device Command

The user selects one or more devices in the upper list and then a command to send from the lower list and then presses the *Send* button. Selecting dissimilar devices will list an intersection of common commands between two or more types of devices.

Users will use this feature to download data stored on a reader device.

5.13.4 Enabling and Disabling a Device

Users can enable or disable a device by right-clicking the device and toggling the *Enable* menu command. This feature is useful for devices that share a common serial port because only one device can access a port at one time. To use this command, the monitor must be running.

If a user disables a device and stops the monitor, the device will be reconnected the next time the monitor starts unless the topology configuration specifies otherwise.

5.13.5 Issuing Message Commands

Users can insert a *Data Marker* message at anytime by selecting the command from the Edit window. Users can also select *Trigger All Devices* that will insert messages from all trigger devices configured within the active topology. They can also issue a specific trigger device message by right-clicking on the device and select *Trigger* from the menu.

5.13.6 Database Maintenance Utility (TBD)

These utilities located under the Tools menu allow the user to manage the *Client Database* for optimum performance. This includes purging unnecessary data and performing compact-and-repair commands.

5.13.7 Terminal Viewer (TBD)

For troubleshooting device communications, M4 Client will provide a terminal window utility that can be accessed from the Tools menu or by right-clicking a specific device. If the monitor is running, the selected device will be disabled and taken out of data collection mode.

The terminal utility may support the following communication protocols:

- Serial/ ASCII
- Serial/ Binary
- UDP/ XML

Users can type device commands directly into the terminal viewer.

5.13.8 M4 Client Option Settings

The M4 Client contains optional settings that the user can change to adapt the M4 installation to suit their needs. These option settings are independent of any topology or SxC configuration.

SETTING	DESCRIPTION
PTAGIS Upload Interval	How frequently the M4 system will upload data to PTAGIS. Zero to disable
PTAGIS Account Name	Name of the PTAGIS account used for authentication during upload
PTAGIS Account Password	Password associated with PTAGIS account for authentication during uploads. Encrypted.
Use VLAN Connection	Indicates whether to use a TCP connection for uploading data if VLAN network is configured at the site.
Failover Support	Various settings described in the Failover Services Configuration section.
Pulse Interval	How frequently a pulse record will be generated indicating system health. Zero to disable.
Data Viewer Page Size	Number of records the data viewer will display per page.
Start Monitor on System Reboot	M4SMS monitor will be automatically started whenever the system is rebooted.

Alerts (TBD)	A list of email addresses that automated alerts will be sent based upon criteria.
Time Zone	Local or PST time for all data viewing and reporting

Table 8 M4 Option Settings

All of these setting are stored within the Config.XML file located in the M4 installation directory and are under the exclusive management of the M4 Client.

6. M4 DATA SUBMISSION

This topic describes how data collected at various M4 installations is transferred in a timely manner to a central repository within PTAGIS. Data can be transferred automatically on a user-defined schedule or it can be manually initiated by the user.

To handle the data transfer, the client communicates with a web service (WS-PDS) hosted at PTAGIS. This web service will provide procedures to safely upload all outstanding data from the client into a staging database that will eventually be transformed to the legacy PTAGIS database, which is explained further in the next section.

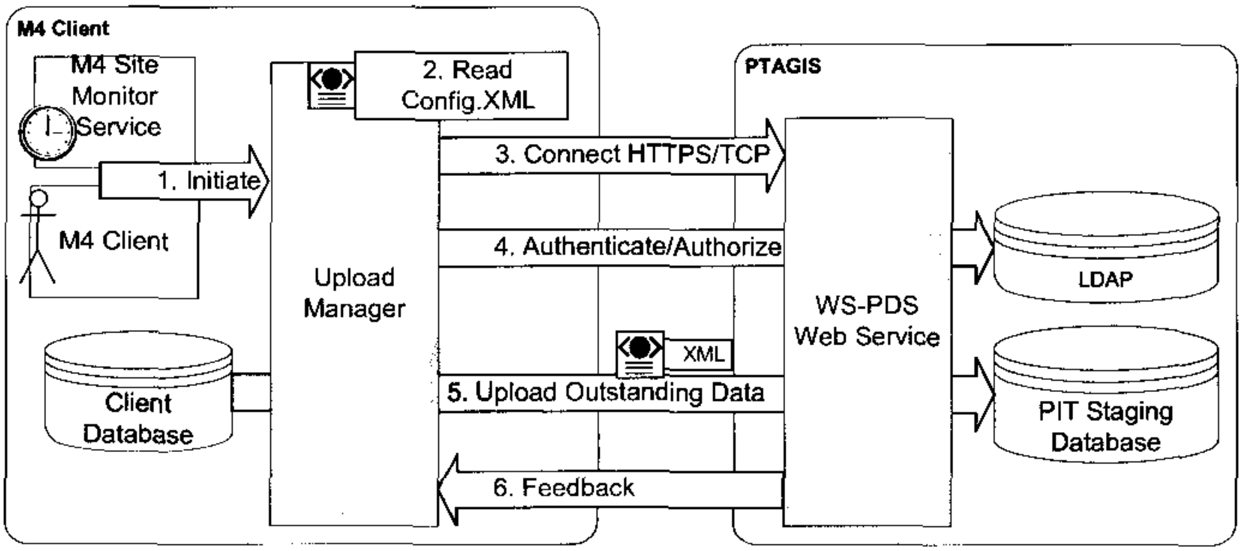

Figure 10 Data Submission

The basic steps for transferring data from the M4 client to the PTAGIS server are:

1. Initiate Upload Process
2. Read configuration
3. Upload Manager connects to the WS-PDS service based upon configuration
4. Authenticate and Authorize with the WS-PDS based upon evidence supplied by client
5. Upload outstanding Topology Versions and Message data

6. Upload Manager handles/reports feedback of transfer session.

Each of the steps above is detailed in the following subsections.

6.1 *Initiating the Upload Process*

All data uploads are initiated from M4 client in a *push* orientation. A *pull* data transfer initiated from the PTAGIS Staging server may be implemented if needed. This initiation is invoked by one of two scenarios:

6.1.1 Manual Upload

This type of upload is initiated manually by the user selecting the *Upload Data* command from the M4 Client interface. This type of upload can be initiated independent of the state of the M4SMS service. A separate window will be opened provided visual feedback to the user with the ability to cancel the upload operation.

6.1.2 Automated Upload

This type of upload is initiated automatically from the M4SMS service on a specified schedule. This requires the M4SMS service to be monitoring and should not impact the performance of the system. No data will be uploaded when the service is stopped or paused and data will be uploaded on the next occurring interval once the service is restarted.

Note: the upload schedule should allow a user to configure explicit times during the day that data should be uploaded to PTAGIS. This will optimize the existing batch loading process to PTAGIS infrastructure.

6.2 *Upload Configuration*

Before an M4 installation can upload any data, it must be configured with the information stored in the Config.XML and managed by the M4 Client. This information includes:

SETTING	DESCRIPTION
PTAGIS Upload Interval	How frequently the M4 system will upload data to PTAGIS. Zero to disable
PTAGIS Account Name	Name of the PTAGIS account used for authentication during upload
PTAGIS Account Password	Password associated with PTAGIS account for authentication during uploads. Encrypted.
Use VLAN Connection	Indicates whether to use a TCP connection if VLAN network is configured at the site.

The M4 Client configuration manager will include a *Test* command to test the account settings for authorization and authentication with the WS-PDS service.

6.3 *Connecting to the WS-PDS Service*

Regardless of how it was initiated, a connection to the WS-PDS Service residing on a PTAGIS server is made from the Upload Manager on the client. The Upload Manager attempts to make a network connection to query a PTAGIS host server for the existence of the WS-PDS service. The type of connection made is based upon the *Use VLAN Connection* setting. TCP connections are preferred for better performance; however, HTTPS will be used for all clients outside of the Commission network. If the service is disabled or the connection fails, the session is terminated and the condition is logged.

6.4 *Authentication and Authorization*

Once a connection is made, the Upload Manager requests authentication/authorization using credentials in the form of a user name and password sent to the WS-PDS service. The WS-PDS service queries a PTAGIS LDAP server with the credentials for an authorization role (Data Coordinator role). The service returns the result of the request to the client. If authorized and authenticated, the upload process continues, otherwise the session is terminated and the condition is logged. PTAGIS can also be alerted to any failed attempts.

6.5 *Upload Outstanding Data to Server*

The Upload Manager decides what client data needs to be sent to the server. Topology Configurations that are new or have been updated and any new messages must be bundled into one or more packages and submitted to the server. Once this data is transported to the server, the WS-PDS service verifies the package integrity using a file hash and then loads the data into *PIT Staging Database*.

The package representing the batch of data to load will be in XML format. This file will be retained on the server for future use.

6.6 *Handle Feedback from Service*

The WS-PDS service provides asynchronous feedback to the Upload Manager on the client indicating any exceptions or the success of loaded data. The M4 Client will provide robust reporting of this feedback in the case of manual uploads; however, automated uploads will indicate an upload in progress within the status bar of the M4 Client.

6.6.1 Data Replication Flags

M4 marks each data record with a special value to indicate whether it has been uploaded to PTAGIS or not. This enumerated field then is used to indicate at the staging database if it has been transferred to the legacy storage. Once a successful feedback is received from the service, the Update Manager will mark each record in the batch as submitted so only new records will be transferred on the next upload.

7. LEGACY DATA MIGRATION

This topic explains how M4 data is migrated into the legacy PTAGIS3 database. M4 clients periodically submit topology and message data to the PIT Staging Database using the WS-PDS service, as described in the previous topic. On a user-defined schedule, this new data is migrated from the staging database to the PTAGIS3 database using a workflow process described in Figure 10.

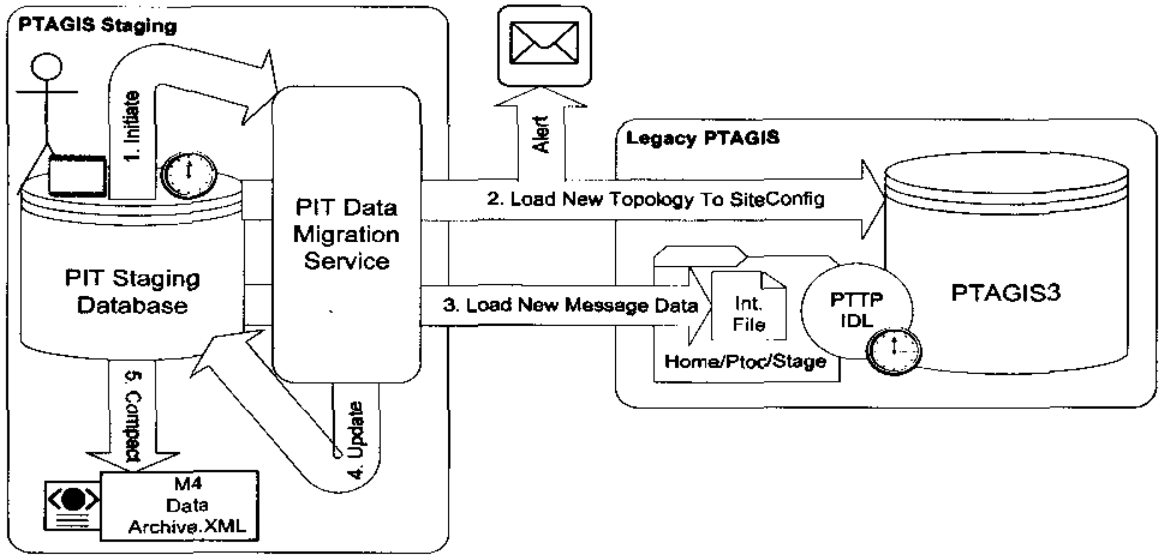

Figure 11 Legacy Data Migration

The following basic steps illustrate the process of legacy data migration:

1. Initiate
2. Load New Topology Data
3. Load New Message Data
4. Update Staging Data
5. Compress Staging Data

These steps are described in detail in the following subsections.

7.1 *Initiate*

This process has two ways of initiating. One is the user can initiate the upload from a custom application interface. The second way of initiating an upload is from an automated schedule.

7.1.1 Initiation Rule

If a new topology version is identified (one that has a major version that has not been migrated to PTAGIS3) this topology version and related data must be loaded manually. Any subsequent data submitted will wait until the prior data is loaded. PTAGIS personnel will be alerted to the new topology version via email and will initiate the load manually (see next section).

7.1.2 Manual Initiation

A custom application will present a simple summary of rows that represent all outstanding sets of data that need to be migrated from the staging to PTAGIS3 database. The data sets can be identified by the following columns:

- Topology Description

- Topology Version
- List of Site Codes
- Date range of message data (To, From)
- Record count of data.

A scenario where a user holds onto all data throughout the year and then submits data in a single upload will require PTAGIS personnel use this feature to submit topology versions and related data one at a time. This is to accommodate legacy PTAGIS infrastructure that does not support versioning of SiteConfig data tables with related data.

7.1.3 Integration Schedule

The PIT Staging Database hosts a custom SQL Server Integration Service (SSIS) called PITData Migration Service (PDMS). The PDMS Service can be set to fire on a daily schedule to correspond with the schedule of the legacy Interrogation Data Loader (IDL) service for optimum processing of data.

7.2 Load New Topology Data

The PDMS Service generates a query to determine if any new or updated topology records need to be loaded in to the PTAGIS3 database. For each new topology, an email alert is sent to list of subscribers. PDMS then transforms the M4 topology data and loads it directly into the SiteConfig schema in the PTAGIS3 database.

NOTE: new topology data will be loaded manually. An alert will be submitted to PTAGIS personnel and this data and all subsequent data will be held in the staging database until manually loaded.

7.3 Load New Message Data

The PDMS Service generates a query to get an in-memory set of new message records that have a common type in the legacy database. The PDMS Service then generates standard interrogation files, packages them into XML PTTP requests and deposits them into a known data directory for PTTP/IDL to load. Making use of existing PTTP and IDL infrastructure will ease deployment of M4 with existing legacy clients.

PDMS service can have the following configuration options:

- ~~Generate real-time tag records only (this could be set for a site-by-site basis)~~
- ~~Sites to exclude (can be set for period of time)~~
- ~~Limit number of real-time tags per second (Unique Off)~~
- Allow interrogation data files to span multiple days (generates less files to load)
- Suppress interrogation files that do not contain interrogation records
- Generates XML header for PTTP loading and puts them into staging directory

- ~~Submits them directly to IDL~~

7.4 *Update Staging Data*

Once the loading into the legacy database is complete, the PIT Staging Database must be updated to mark the data so it won't be loaded again. The same field that was used to mark the data as uploaded on in the client database will be reused here to be marked as loaded in the staging database.

Each data record will go through the following states:

1. New: generated and stored the client database
2. Uploaded: transferred from the client database to the staging database.
3. Migrated: migrated into the legacy PTAGIS3 database
4. Compressed: compressed into essential fields to optimize staging database

7.4.1 Log Integration

Each integration session is logged for success or failure to be used for administrative reporting.

7.5 *Compression*

For optimal performance, the PIT Staging Database can be compressed periodically. This compression will preserve the minimum field requirements (key and state) to prevent the accidental upload of duplicate data; all other ancillary data will be purged from each record.

7.5.1 M4 Production Data Storage

The PIT Staging Database is only a temporary data store to facilitate loading from M4 clients to the PTAGIS3 database. A second database was intended to store copies of all M4 and P4 data for current and future use; however, per the direction of the PTAGIS Program Manager, this data instead will be copied to XML data files (M4 Data Archive) that can be migrated to another type of database TBD.

8. FAILOVER SERVICES

To meet the continuous operational requirements, M4 can provide automatic failover service with a redundant (clustered) server in the event of a system/application failure or a planned-shutdown of one of the two servers.

Failover service is designed for specific sites:

- Sites that perform Separation-By-Code operations.
- Sites collecting a large segment of PTAGIS data and require operational redundancy.

To reduce the overall complexity from the user's perspective, by default, the M4 application assumes the failover services are disabled.

8.1 *M4 Failover Cluster System Architecture*

A failover cluster is a set of servers that are configured so that if one server becomes unavailable, another server automatically takes over for the failed server and continues processing. Figure 11 describes the basic failover cluster architecture for the M4 high-availability platform.

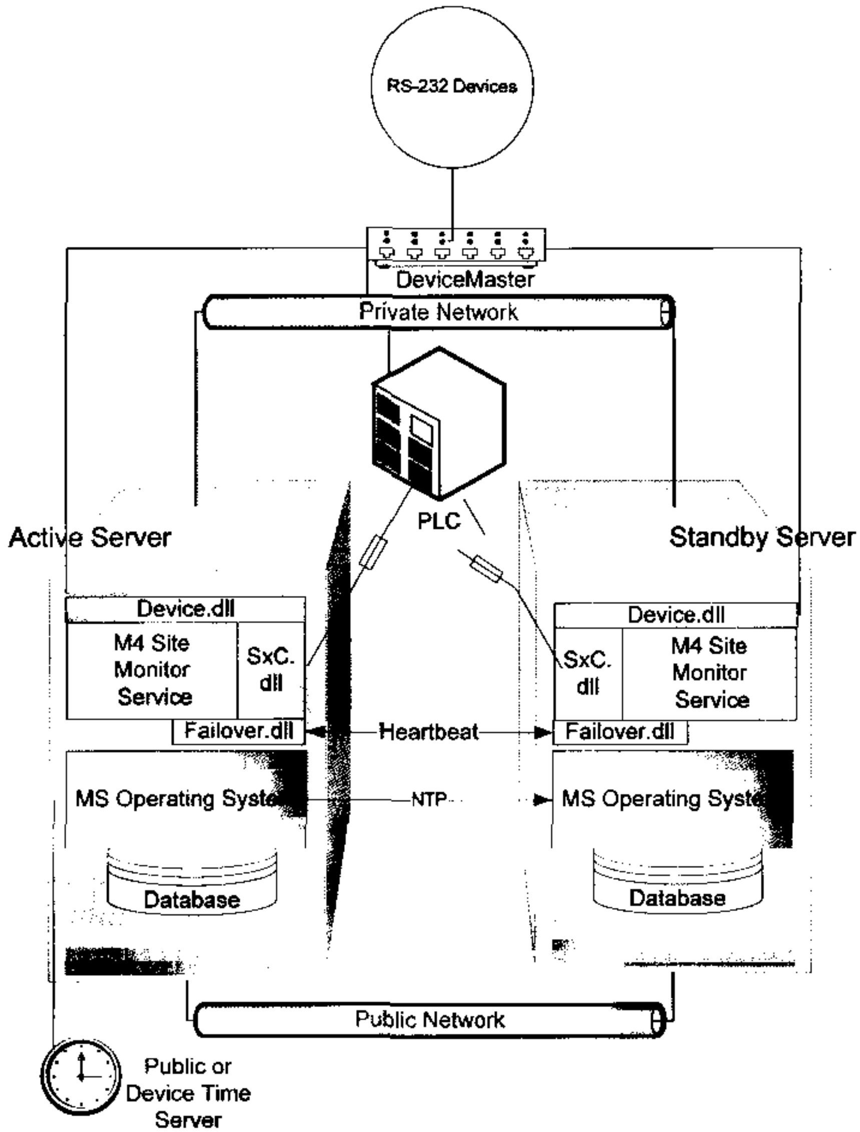

Figure 12 - M4 Failover Architecture

Some basic points about this architecture:

- Two redundant systems host independent M4 monitoring services collecting data in their local database and, if enabled, both process separation-by-code requests.

- The DeviceMaster transforms RS-232 data to Ethernet ports, allowing the monitoring services hosted on two servers to receive the same device data.
- Only the *active* monitoring service communicates directly with the PLC device to provide separation-by-code gate control. When a failover event occurs, the *standby* service becomes *active* and takes over communication with the PLC.
- The two monitoring services communicate their health with each other using a heartbeat communication channel. If the service on the Active Server fails to send a heartbeat over a specified period of time, a failover event occurs and the "standby" monitoring service becomes "active" and takes control of the PLC.
- A private network is used for device and heartbeat communication. A public network is used for end-user management and data uploads.
- The M4 Client application provides end-user configuration to manage the failover services supplied by the failover.dll library.
- Temporal data collected on the two systems is redundant and has millisecond precision. These two sets of data can be coarsely synchronized for recovery by periodically overloading the heartbeat messages as database checkpoints. It can be further synchronized using a NTP server (local or public) to maintain the system clocks for two Windows 2003 servers.

8.2 *Assumptions*

The primary design objective of this architecture is to provide high-availability features without affecting system performance or adding complexity to the application for general use where failover is not needed. The following system requirements facilitate these design goals:

- System platforms must be configured for high performance.
    - Dual or Quad Core, 2GB RAM, RAID
    - Install transaction log of M4 Client Database on separate partition
- System platforms should be identical for ease of administration.
- Data is not mirrored between the two systems; instead it is collected in separate databases with scheduled checkpoints to provide course alignment in recovery operations.
- Data recovery operations require manual user intervention
- Data events are not synchronized between the two servers and may not be recorded in the same order.
- Separation-by-Code counters are computed independently on the two systems.
- The single-point of failure is the heartbeat connection between the two servers; if this fails, the servers will be in "split-brain" mode operating as two independent systems. There is no guarantee of gate control in this mode.

8.3 *Failover Strategy*

Separation-by-code operations will be compromised if both monitoring services try to control the gates simultaneously – or none at all; therefore it is extremely important that both services maintain their respective states by communicating with each other.

8.3.1 Failover Service States

The Failover architecture has two basic states:

- **Active**: which means the service is controlling the separation-by-code gates
- **Standby**: which means the service is computing separation-by-code operations, but not controlling the gates.

8.3.2 Cluster Roles

The two redundant services will be configured to initially start as one of two types:

- **Primary** service attempts to start in the "Active State" performing data collection and processing separation-by-code operations.
- **Secondary** the redundant service starts in the "Standby" state and will take over operations if the Primary service fails.

8.3.3 Determining the Active Service

The basic assumption here is that only one monitoring service is "active" (controlling the gates) at one time. The other service is running as "standby": processing data but not controlling the gates. This allows simplicity in fail-over. The failover services on the two systems use a heartbeat communication channel to detect each other's existence and state. Collision detection (two active servers) is implemented via a combination of detection and promotion/demotion mechanisms before separation-by-code operations are enabled:

When the ***primary* service starts**, it performs the following sequence:

1. Sends heartbeat message as a notification of its existence as the *active* service.
2. Monitors the network for heartbeat messages from the redundant service.
3. If it does not receive a heartbeat message indicating another service is *active* within a specified period of time (Startup Period), it will promote itself as the *active* service and take control of the PLC.
4. If it receives a heartbeat message indicating that the other service is already *active*, it will demote itself as *standby* and continue operations in this role.
5. If no heartbeat message is received from the other service at all, it will report the failure and send an alert.

When the ***secondary* service starts**, it performs the following sequence:

1. Sends a heartbeat message as a notification of its existence as the *standby* service.
2. Monitors the network for heartbeat messages from the other service.

3. If it receives a heartbeat message from the other service indicating that it is *active*, it resumes operations in *standby* mode.
4. If it does not receive a heartbeat message from the other service within a designated period of time (Startup Period), it promotes itself as *active* and resumes operations in this role.

When an ***active* service fails**, the following occurs:

1. The failed *active* service stops sending heartbeat messages
2. The *standby* service notices the *active* service is down and promotes itself as *active* and takes control of the PLC.
3. The new *active* service reports the error and sends any alerts indicating the condition.

When a ***standby* service fails**, the following occurs:

1. The *standby* service stops sending heartbeat messages
2. The *active* service notices the *standby* service is down and reports the error and sends any alerts indicating the condition.

8.4 *Heartbeat Communication Channel*

This lightweight channel is used to communicate state, synchronization and control information between to failover services. It is comprised of two endpoints which represent the Failover.DLL libraries located on both servers connected by a transport-level protocol (TCP or UDP). The specialized heartbeat messages are passed between the two endpoints, primarily to indicate the health of the sender. Additionally, the message can be overloaded to provide database checkpoints for synchronizing redundant data.

8.4.1 Network

The failover service requires a dedicated network channel to communicate on. This channel can exist on the same private network as the device ports and PLC – however, this will take testing to determine this will introduce a latency issue.

The heartbeat channel presents a single-point-of-failure in this failover architecture. It is therefore recommended to configure a virtual network (two networks) that supports hardware failover.

8.5 *Configuration*

Failover library has a separate configuration section-group stored in the Config.XML namespace. The user can access and manage these configuration settings from the M4 client:

SETTING	DESCRIPTION
Cluster Role	Active/Standby – this determines which role a server will play in the Failover scheme.

Channel Configuration	TBD: this present transport and application level configuration for a network communication channel.
Heartbeat Interval	How often heartbeat messages are sent to the standby server in seconds.
Discovery Period	This period, defined in seconds, determines the active server using a promotion/demotion scheme.
Failover Alerts	A list of email address to send alert message on failover. Empty setting disables failover alerts.
Failover Interval	Period of time to wait to determine if a failover event has occurred.
Checkpoint Interval	Determines how often a checkpoint is sent between the two services

Table 9: Failover Configuration Settings

8.6 *Operational Control*

Failover requires both machines to have failover enabled and have the monitor running. Whenever the monitor is stopped or paused, the failover service is disabled until the monitor is running again.

The M4 Client will allow the user to control monitoring of both systems as if they were one system or two. Additionally, it will provide a mechanism to control failover service to perform manual failover for controlled shutdowns. These details are discussed further in *the following subsections.*

8.6.1 Simultaneous Control of Monitoring

Once the Active and Standby servers have been properly configured, the user can control both servers from a single M4 client. This includes the stopping, starting or pausing of the monitoring service simultaneously on both servers.

8.6.2 Independent Control of Monitoring

In addition to simultaneous control, each server can have their monitoring service independently controlled by the user by right-clicking the service component listed in the Topology Viewer of the M4 Client. This allows users to perform a controlled shutdown of one of the two redundant systems, forcing a heartbeat operation to occur to provide data synchronization.

8.6.3 Failover Service Control

The user also has the ability to shutoff the Failover services on one or both machines. This might be necessary to resolve network issues without interrupting data collection.

8.7 *State and Data Synchronization*

This failover architecture doesn't explicitly synchronize data or state (separation-by-code counters). This topic discusses synchronization issues in more depth.

8.7.1 State Synchronization

The state of the separation-by-code process (also known as counters) is computed independently on both servers, as data is processed on both machines. It is possible that the state could be computed differently between the two servers. For example, server one could process a tag code that server two did not receive due to network packet loss.

MultiMon software does not synchronize SxC state. Performance analysis may be determined that state synchronization is necessary. If so, the heartbeat communication channel could be used to perform this additional feature.

8.7.2 Data Synchronization

Data is collected in separate databases on the two redundant servers. The heartbeat channel will issue periodic checkpoint messages that will be written in both originating and destination databases. In addition, the system clocks on both servers should be synchronized using NTP. Checkpoints and timestamps will provide course synchronization between the two independent databases.

8.7.3 Data Recovery Manager (Patch Manager)

A tool called the Data Recover Manager will be provided from the M4 Client that will allow the end-user to view data from both redundant databases. The user can select a portion of data to submit to PTAGIS as a patch for recovering from a failover.

8.7.4 Use of Staging Database

This manager could triangulate data submission between the two client databases and the staging database located on the PTAGIS server (data already loaded). This will give the user the most accurate representation of which data is missing and needs to be patched.

8.7.5 Filtering Feature

This manager should allow the user to filter by one or more topology components (similar to the real-time viewer) so that users can select particular data from a series of devices. For example, if a DeviceMaster serial interface failed on one system, the user could select the mirrored devices on the redundant database to fill in the data gap.

APPENDIX 3: PIT Tag Detection and Separation-By-Code Activities at Interrogation Sites Operated by or for the Columbia Basin PIT Tag Information System 2006 Annual Summary Report

PIT Tag Detection and Separation-by-Code Activities at Interrogation Sites Operated by or for the Columbia Basin PIT Tag Information System

2006 Annual Summary Report

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June 29, 2007

PTAGIS

PIT Tag Information System
Columbia Basin | ptagis.org

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1. Introduction

The Columbia Basin PIT Tag Information System (PTAGIS) collects, houses, and distributes the data for essentially all migratory fish marked with passive integrated transponder (PIT) tags in the Columbia Basin of the U.S. Pacific Northwest. Data contributions into the PTAGIS database are a collaborative effort, with the tagging, release, and physical recovery data provided by over two dozen federal, state, tribal, industry, and not-for-profit entities. A key component of the PTAGIS Program is the operation of automated detection (interrogation) equipment deployed at fish passage facilities in the Columbia and lower Snake rivers. The detections of tagged fish at these interrogation sites provide the "recapture" component for most of the "mark - recapture" PIT tag research and monitoring (R&M) activities in the Columbia Basin. Consistent, reliable, and comprehensive detection effort at these sites is necessary in order to maximize the effectiveness of the Basin's PIT tag R&M programs.

The PIT Tag Operations Center (PTOC) manages and maintains the PTAGIS database and associated systems. PTOC is also responsible for all operations and maintenance (O&M) at the permanent interrogation sites at federally-operated fish facilities, and other sites, in the Columbia Basin.

In 2006, PTOC provided O&M support for eight interrogation sites located at all seven juvenile fish bypass facilities at federal hydroelectric dams in the lower Columbia and Snake rivers (see **Table 1**), including the new "Hi-Q" detection system installed in the Corner Collector transport flume at Bonneville Dam. There were improvements at three other juvenile fish facilities, with new antennas installed on the adult fish return routes at Lower Granite, Little Goose, and Lower Monumental dams. PTOC continued its O&M support for the PIT tag detection equipment in the juvenile fish sampling facility of the Chandler Canal bypass, located at Prosser Diversion Dam on the lower Yakima River. Summaries of PIT tag interrogation operations at each of these juvenile fish bypass facilities are presented in **Section 2A** of this report.

PTOC also provided O&M support for eight interrogation sites located in the adult fish ladders at four federal dams in the lower Columbia and Snake rivers. New antennas installed in the ladders at both Bonneville and McNary dams provided additional and redundant detection capabilities, ensuring that essentially 100% of adult fish ascending the ladders at any of these four dams in 2006 passed through at least four PIT tag antennas. PTOC also continued its O&M support for the PIT tag detection equipment deployed in the adult fish ladders at Prosser Dam. Biomark, Inc. (Biomark) contracted with Chelan County PUD, Douglas County PUD, and Grant County PUD to provide O&M services for detection equipment in the fish ladders at four dams in the mid-Columbia River, including a new deployment in 2006 at Rocky Reach Dam. Summaries of PIT tag interrogation operations at each of the adult fish passage facilities are presented in **Section 2B** of this report.

In 2006, PTOC provided O&M support for interrogation sites at three hatchery acclimation and release facilities in the upper Yakima Basin. As in previous years, PTOC contracted with Biomark to provide O&M support for the detection equipment deployed in the raceway outfall at

Rapid River Hatchery, near Riggins, Idaho. Summaries of PIT tag interrogation operations at all four of these juvenile fish facilities are presented in **Section 2C** of this report.

PTOC provided assistance with the O&M of two additional interrogation sites in 2006. This activity is summarized in **Section 2D** of this report.

In addition to providing O&M support at PIT tag detection facilities, PTOC manages the Separation-by-Code (SxC) activities at two adult fish traps and six juvenile bypass facilities. The SxC systems identify specific PIT-tagged fish immediately as they are detected, and can then route those fish to different destinations within a fish facility. Researchers generally request SxC operations to: 1) direct some or all of a fish stock to transportation vessels at the four collection and transportation sites; or to 2) direct individual fish to a dedicated sample tank where the fish can be physically recaptured and inspected. PTOC staff monitor and maintain the SxC systems to optimize the accurate segregation of target SxC fish while also minimizing the diversion of non-target fish. PTOC also maintains the look-up databases and site-specific instruction maps needed to identify and divert specific PIT-tagged fish. All SxC activities during 2006 are summarized in **Section 3** of this report.

Table 1. Dates of interrogation activities at adult and juvenile fish facilities and hatchery release facilities in the Columbia Basin, and the effort associated with those activities in 2006.

Site	Start Date	End Date	DownTime (HH:MM)	Percent Down Time	Percent Up Time
Juvenile Bypass Systems (JBS)					
B2J	03/01/06	12/20/06	1:26	0.02%	99.98%
BCC[1]	04/12/06	09/01/06	14:11	0.42%	99.58%
GOJ	04/01/06	10/31/06	2:50	0.06%	99.94%
GRJ	03/25/06	12/16/06	2:03	0.03%	99.97%
JDJ	04/03/06	09/14/06	0:08	<0.01%	>99.99%
LMJ	04/01/06	09/30/06	0:11	<0.01%	>99.99%
MCJ	03/30/06	11/27/06	0:17	<0.01%	>99.99%
Combined JBS and Adult Ladders					
ICH	01/01/06	12/31/06	0:03	<0.01%	>99.99%
PRO	01/01/06	12/31/06	8:48	0.10%	99.90%
TMF	11/08/06	12/31/06	2:26	0.19%	99.81%
Adult Ladders					
BO1	02/25/06	12/31/06	0:07	<0.01%	>99.99%
BO2	01/01/06	12/13/06	21:39	0.55%	99.45%
BO3	01/01/06	12/11/06	0:18	<0.01%	>99.99%
BO4	01/01/06	12/11/06	3:52	0.05%	99.95%
GRA	01/01/06	12/31/06	1:33	0.02%	99.98%
MC1	01/01/06	12/31/06	0:00	0.00%	100.00%
MC2[2]	01/01/06	12/31/06	0:13	<0.01%	>99.99%
PRA[a]	01/01/06	12/31/06	9:06	0.10%	99.90%
RIA[a3]	01/01/06	12/31/06	21:12	2.98%	97.02%
RRF[a]	03/03/06	12/31/06	16:19	0.55%	99.45%
WEA[a]	01/01/06	12/31/06	0:04	<0.01%	>99.99%
Monitored Hatchery Releases					
CFJ	01/20/06	05/23/06	0:02	<0.01%	>99.99%
ESJ	01/18/06	05/31/06	0:00	0.00%	100.00%
JCJ	02/13/06	05/09/06	0:03	<0.01%	>99.99%
RPJ[a]	02/13/06	04/25/06	2:57	0.17%	99.83%
Other					
RCX[4]	01/01/06	12/31/06	19:29	0.22%	99.78%

[a]Biomark provided O&M support at PRA, RIA, RRF, WEA, and RPJ.

[1]The BCC Activity Interval does not include Nov. or Dec. operations.

[2]MC2 was dewatered between Feb. 12 and Mar. 31, 2006. The data gap summary excludes this interval.

[3]The RIA data gaps are primarily from extended outages, due to a PC virus infection, between Feb. 9-18, 2006.

[4]RCX was out of service between Jan. 10 and Apr. 6, 2006. The data gap summary excludes this interval.

2. Interrogation Activity

A. *Juvenile Fish Bypass Facilities*

Bonneville Dam 2nd Powerhouse Juvenile Fish Monitoring Facility (B2J)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the Bonneville Dam 2nd Powerhouse (PH2) Juvenile Fish Monitoring Facility (JMF) since before the current JMF was constructed in 1999. In 2006, as in previous years, PIT tag detection activities began when the facility first switched into secondary bypass mode and water from the PH2 fish transport pipe was routed through the JMF.

Table 2. Dates of PIT tag detection activity at B2J during 2006.

Interrogation Start Date	03/01/06
Interrogation End Date	12/20/06
First Detection Date	03/05/06
10% Detection Date	05/06/06
50% Detection Date	05/17/06
90% Detection Date	06/23/06
Last Detection Date	12/20/06
Peak Detection Date	05/18/06
Tags Detected on Peak Date	2,937
Total Tags Detected in 2006	42,960

During the spring and early summer, four new PIT tag antennas were installed in the full-flow section of the transport pipe upstream of the primary switch gate (see b2j_150.pdf for a map of the site topology during 2006). The new antenna group was first activated on July 12, and subsequently provided detection capabilities at B2J even when the facility operated in primary bypass mode and fish were diverted away from the JMF. The full-flow antenna group also provided detection capabilities for steelhead kelts and other adult salmon fallbacks in the bypass that were routed away from the JMF. The JMF was dewatered for the season on October 31, but PIT tags continued to be detected at the full-flow antenna group until the transport pipe was dewatered on December 20.

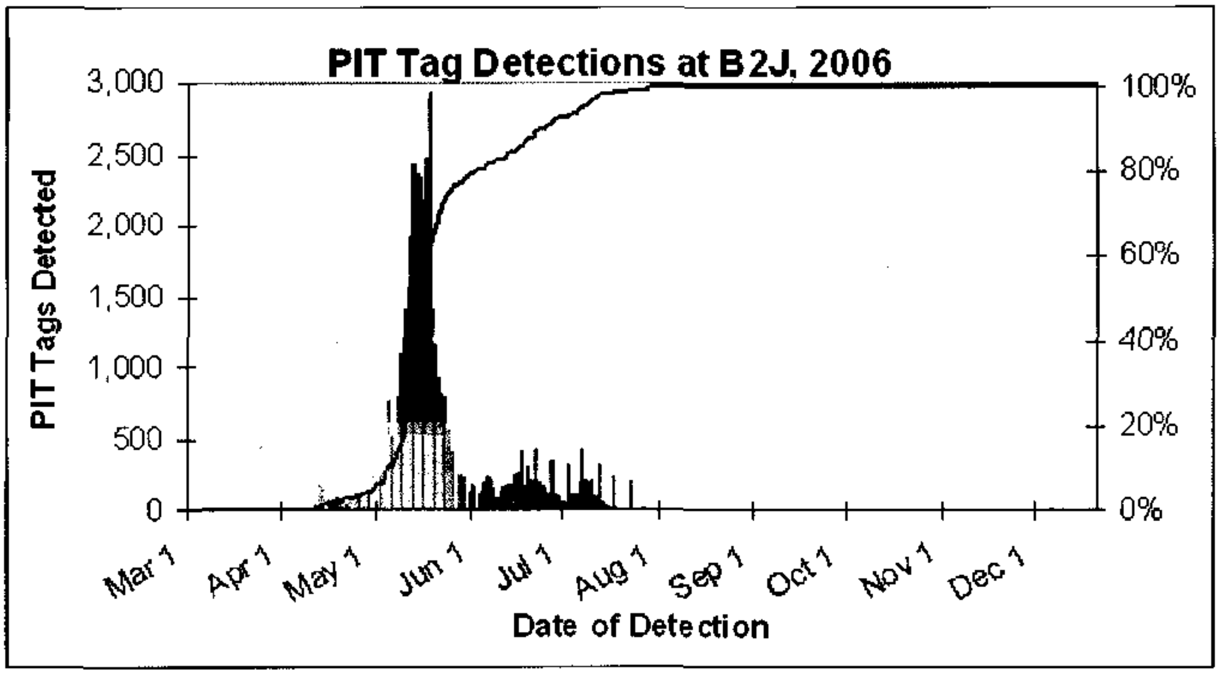


Figure 1. Daily PIT tag detections and the cumulative distribution at B2J in 2006.

Bonneville Dam 2nd Powerhouse Corner Collector (BCC)

During the fall and winter of 2005-2006, the U.S. Army Corps of Engineers installed a highly-customized new large-scale PIT tag detection system in the discharge and transport flume of the Bonneville Dam PH2 Corner Collector. The new antenna is 17' wide by 17' high. At a forebay elevation of 74.5' msl, approximately 5150 cfs of water is discharged through the Corner Collector flume at a velocity of about 35 ft/s (Stephen Schlenker, Corps of Engineers, pers comm).

Table 3. Dates of PIT tag detection activity at BCC during 2006.

Interrogation Start Date	04/12/06
Interrogation End Date	09/01/06
First Detection Date	04/13/06
10% Detection Date	05/09/06
50% Detection Date	05/20/06
90% Detection Date	07/05/06
Last Detection Date	09/01/06
Peak Detection Date	05/18/06
Tags Detected on Peak Date	1,862
Total Tags Detected in 2006	30,876

The BCC detector was activated on April 20, and PTOC assumed primary responsibility for site operations and maintenance. The unique design of the BCC PIT tag transceiver and antenna presented unique challenges to both the vendor and PTOC. Detection efficiency tests indicated that 40% of the ST model PIT tags (commonly used prior to and during 2006), and 70% of the new model SST model tags were detected as they passed through the single BCC antenna (Sandra Downing, NOAA Fisheries, pers comm). This exceeded the minimum 60% detection rate for SST tags established by the Corps of Engineers as the threshold measure of successful operation for this new detection system.

The BCC transceiver was deactivated when the Corner Collector was dewatered on August 31. The flume was watered up again on Nov.15 to pass trash from the forebay, and the BCC detector was reactivated from Nov. 16 until Nov. 21. No PIT tags were detected during this interval.

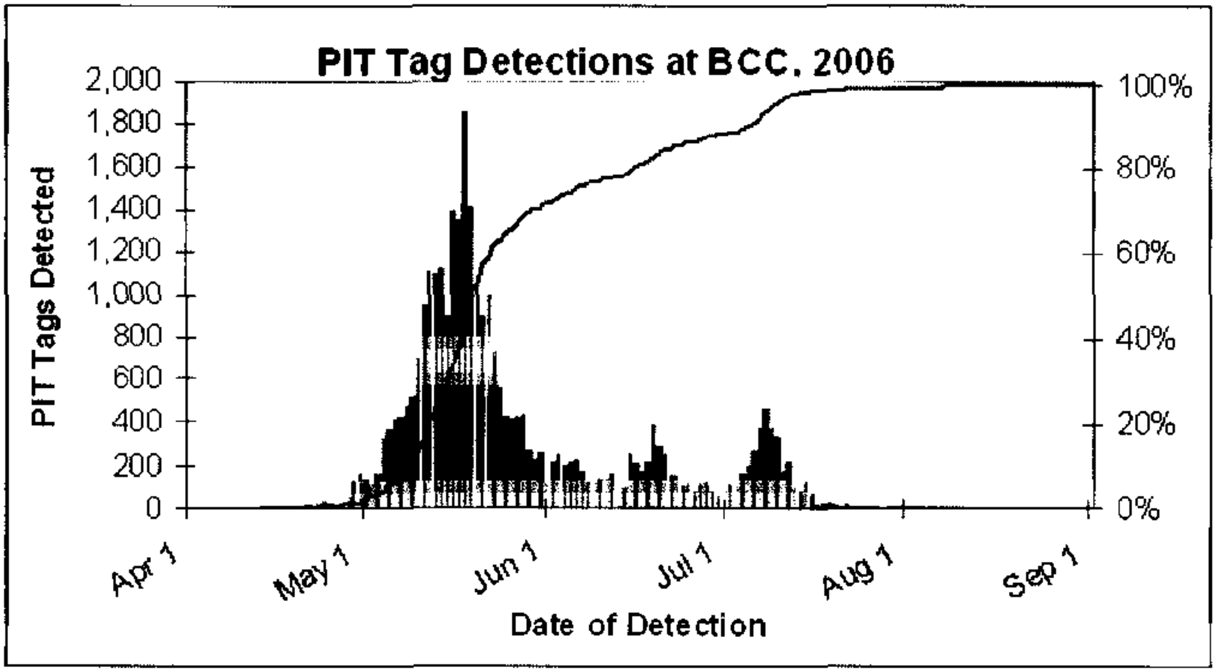


Figure 2. Daily PIT tag detections and the cumulative distribution at BCC in 2006.

John Day Dam Juvenile Fish Monitoring Facility (JDJ)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the John Day Dam Juvenile Fish Monitoring Facility (JMF) since the JMF became operational in 1998. There were no changes made to the site in 2006 (see jdj_150.pdf for a map of the site topology during 2006). As in previous years, PIT tag detection activities began when the facility first switched into secondary bypass mode and water from the main bypass flume was routed through the JMF. In 2006, PIT tag detection activities concluded on September 14, when the JMF was dewatered.

Table 4. Dates of PIT tag detection activity at JDJ during 2006.

Interrogation Start Date	04/03/06
Interrogation End Date	09/14/06
First Detection Date	04/03/06
10% Detection Date	05/04/06
50% Detection Date	05/18/06
90% Detection Date	06/19/06
Last Detection Date	09/12/06
Peak Detection Date	05/21/06
Tags Detected on Peak Date	4,835
Total Tags Detected in 2006	111,487

A new group of PIT tag antennas was installed during the winter of 2006-2007 in the full-flow section of the juvenile fish bypass above the primary switch gate. These four detectors will provide additional detection capabilities in the juvenile fish bypass system at John Day Dam during periods of primary bypass when the JMF is not operating.

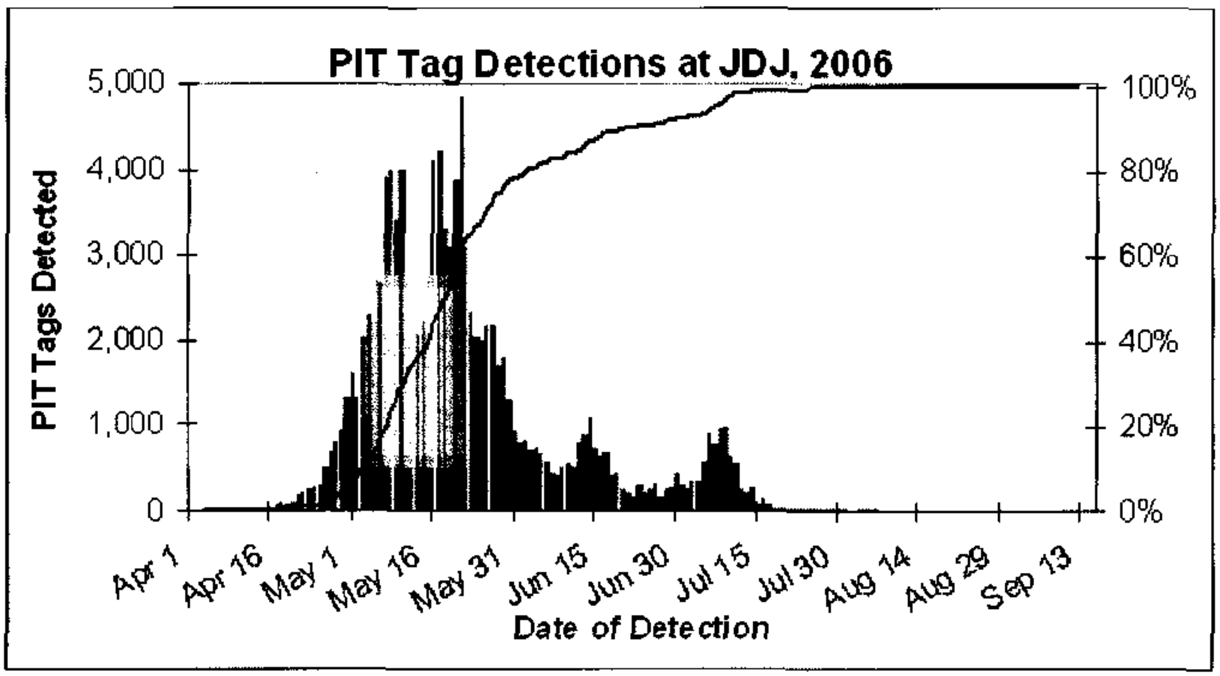


Figure 3. Daily PIT tag detections and the cumulative distribution at JDJ in 2006.

McNary Dam Juvenile Fish Facility (MCJ)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the McNary Dam Juvenile Fish Facility (JFF) since before the current system was constructed in 1994. The PIT tag detection system was last modified during 2003 (see mcj_160.pdf for a map of the site topology during 2006). In 2006, as in recent years, PIT tag detection activities began when the water (and fish) from the powerhouse was routed through the four PIT tag antennas in the full-flow section of the primary bypass pipe.

Table 5. Dates of PIT tag detection activity at MCJ during 2006.

Interrogation Start Date	03/30/06
Interrogation End Date	11/27/06
First Detection Date	03/30/06
10% Detection Date	05/01/06
50% Detection Date	05/14/06
90% Detection Date	06/28/06
Last Detection Date	11/28/06
Peak Detection Date	05/09/06
Tags Detected on Peak Date	7,248
Total Tags Detected in 2006	155,835

Between April 1 and July 5, the JFF alternated between primary and secondary bypass. On days of primary bypass, all fish were routed directly to the bypass outfall in the tailrace. On days of secondary bypass, all fish were routed across the separator into the JFF, where certain PIT-tagged fish, as part of an ongoing multi-year evaluation, were transported; all other fish were bypassed.

Between July 6 and September 13, the facility routed all fish across the separator, and all non-tagged, and some target PIT-tagged fish, were transported. On August 2, all fish for that day's collection and the previous day's collection were bypassed, due to a barge breakdown.

The facility returned to primary bypass on September 14, and remained in that mode until the primary bypass pipe was dewatered on November 28.

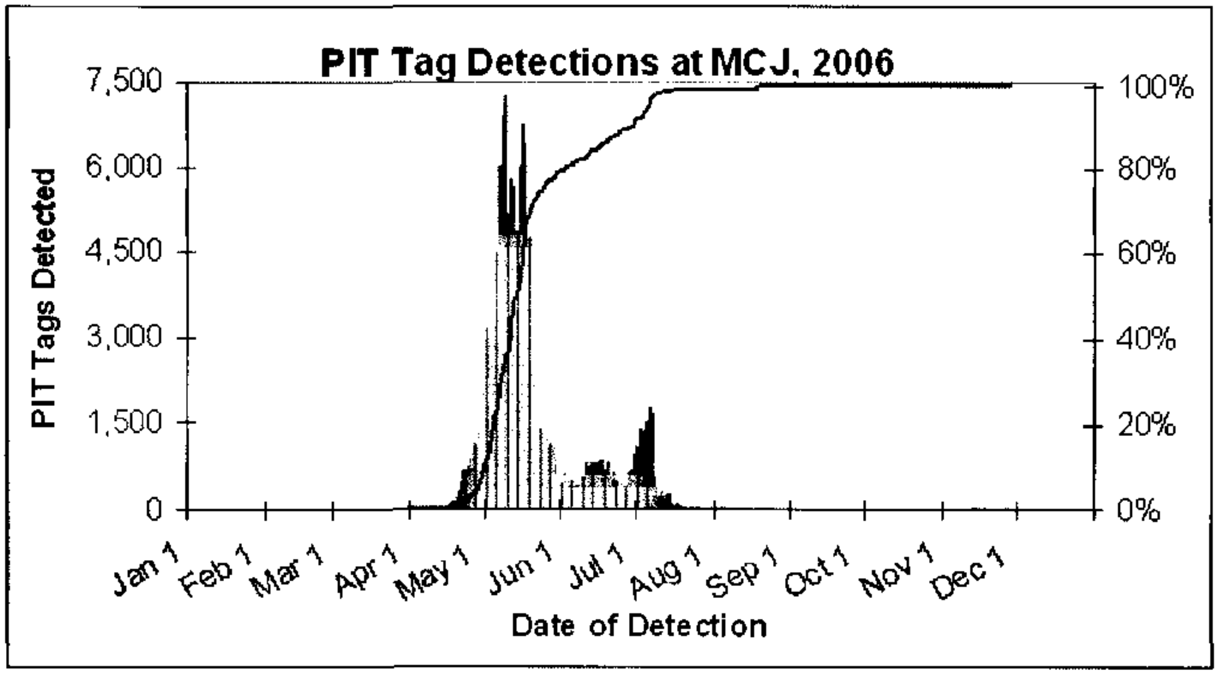


Figure 4. Daily PIT tag detections and the cumulative distribution at MCJ in 2006.

Ice Harbor Dam Full-Flow Fish Bypass (ICH-Bypass)

PTOC has maintained the PIT tag detection equipment in the Ice Harbor Dam full-flow fish bypass system since the antennas were installed in 2005. (See ich_100.pdf for a map of the entire ICH site topology during 2006.) In 2006, the bypass watered-up on March 2, and operated without interruption until it was dewatered on December 20.

Table 6. Dates of PIT tag detection activity at the ICH full-flow fish bypass during 2006.

Interrogation Start Date	*03/02/06*
Interrogation End Date	12/20/06
First Detection Date	03/02/06
10% Detection Date	04/25/06
50% Detection Date	05/07/06
90% Detection Date	05/31/06
Last Detection Date	12/20/06
Peak Detection Date	05/06/06
Tags Detected on Peak Date	4,008
Total Tags Detected in 2006	68,619

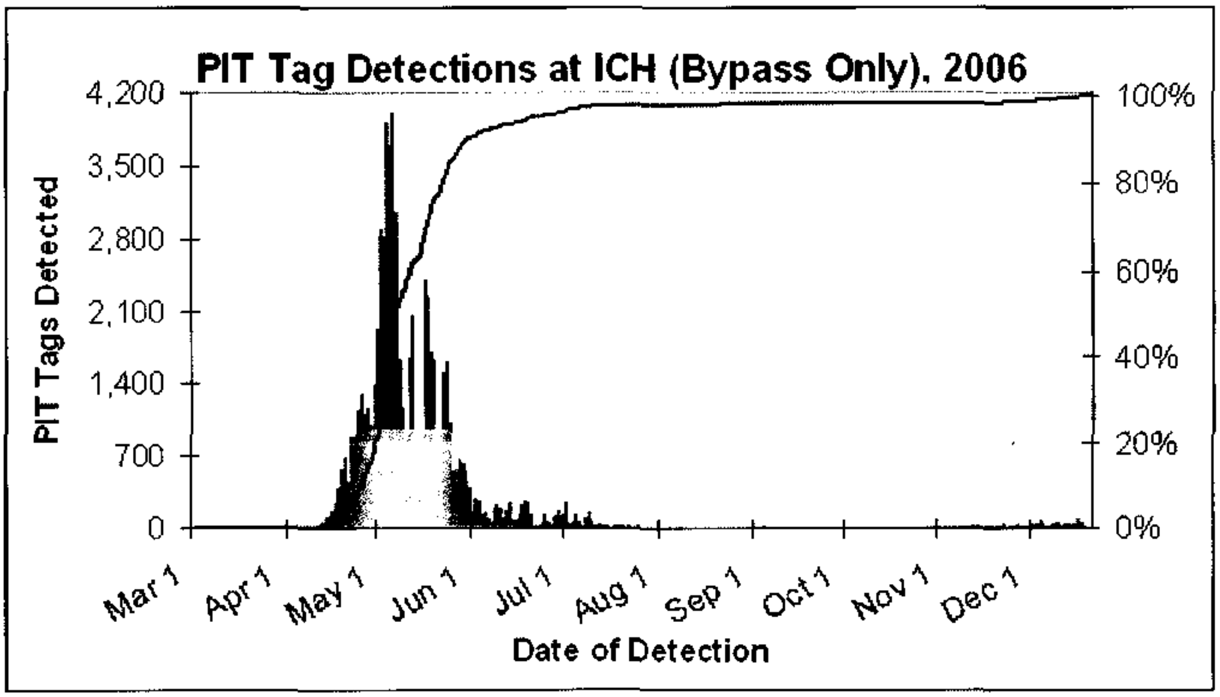


Figure 5. Daily PIT tag detections and the cumulative distribution at the ICH full-flow fish bypass in 2006.

Lower Monumental Dam Juvenile Fish Facility (LMJ)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the Lower Monumental Dam Juvenile Fish Facility (JFF) since the JFF was constructed in 1994. Unlike previous years, fish were not transported from Lower Monumental Dam in 2006 until April 28. Prior to April 28, all fish passing over the separator were "direct-bypassed" to the tailrace. Collection and transportation activities continued from April 28 until September 30, when the JFF was dewatered. The bypass pipe above the primary switch gate was not equipped with PIT tag detectors in 2006, so the PIT tag detection season also ended on September 30. (PIT tag detectors were installed in the full-flow section of the bypass system in the spring of 2007.) As at Little Goose and Lower Granite dams, the LMJ PIT tag detection system was modified prior to the 2006 field season to include two new antennas on the adult fish return pipe between the wet separator and the primary bypass return (see lmj_140.pdf for a map of the site topology during 2006). The antennas at the adult fish return detected 3,629 tagged fish in 2006 – about 2.0% of the total PIT tag detections at LMJ. Of those fish detected at the adult fish return, only 52 (1.4%) were considered to be "mature" fish (*i.e.*, juvenile fish tagged prior to the 2006 migration season, or adult fish tagged during 2006). The remaining 98.6% of tagged fish detected at the adult return were most likely entrained as part of the normal operations to remove adult fish and/or debris from the separator.

Table 7. Dates of PIT tag detection activity at LMJ during 2006.

Interrogation Start Date	04/01/06
Interrogation End Date	09/30/06
First Detection Date	04/01/06
10% Detection Date	04/26/06
50% Detection Date	05/09/06
90% Detection Date	06/03/06
Last Detection Date	09/29/06
Peak Detection Date	05/08/06
Tags Detected on Peak Date	9,196
Total Tags Detected in 2006	185,963

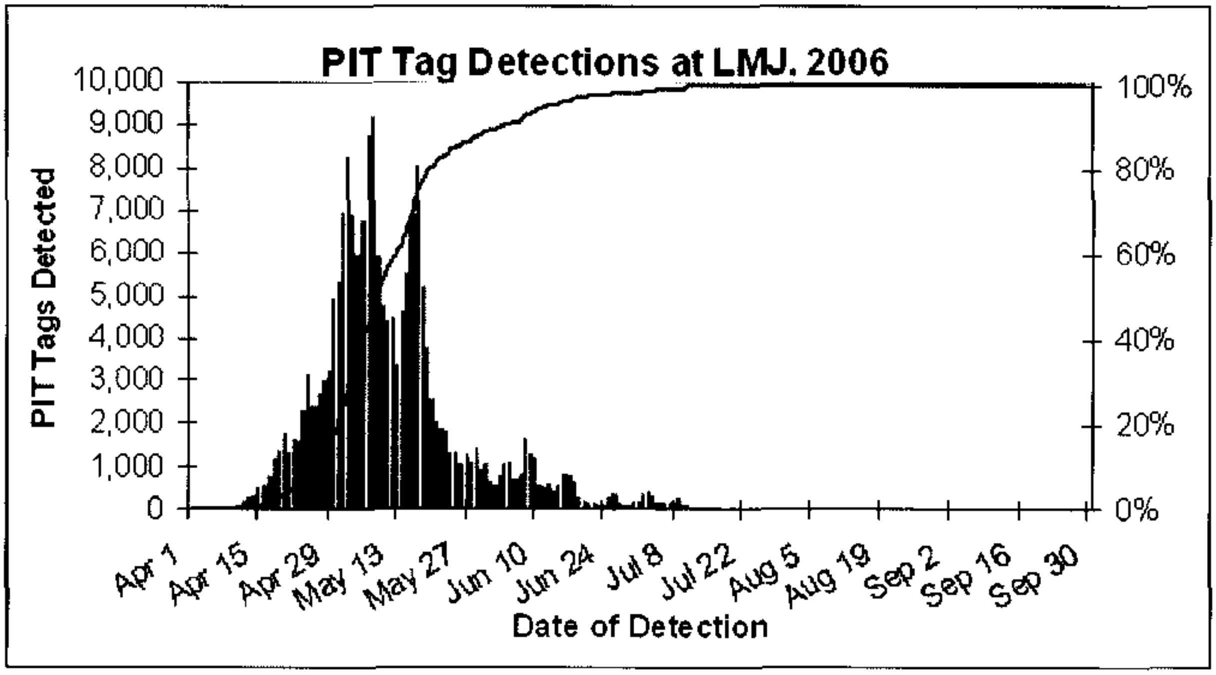


Figure 6. Daily PIT tag detections and the cumulative distribution at LMJ in 2006.

Little Goose Dam Juvenile Fish Facility (GOJ)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the Little Goose Dam Juvenile Fish Facility (JFF) since being tasked with that responsibility in 1993. Unlike previous years, fish were not transported from Little Goose Dam in 2006 until April 25. Prior to that, all fish passing over the separator were "direct-bypassed" to the tailrace. Collection and transportation activities continued from April 24 until October 31, when the JFF was dewatered. The bypass pipe above the primary switch gate was not equipped with PIT tag detectors in 2006, so the PIT tag detection season at Little Goose Dam also ended on October 31.

Table 8. Dates of PIT tag detection activity at GOJ during 2006.

Interrogation Start Date	*04/01/06*
Interrogation End Date	10/31/06
First Detection Date	04/01/06
10% Detection Date	04/26/06
50% Detection Date	05/09/06
90% Detection Date	06/18/06
Last Detection Date	10/31/06
Peak Detection Date	05/02/06
Tags Detected on Peak Date	14,377
Total Tags Detected in 2006	286,938

As at LMJ and Lower Granite Dam, the GOJ PIT tag detection system was modified prior to the 2006 field season to include two new antennas on the adult fish return pipe between the wet separator and the primary bypass return (see goj_140.pdf for a map of the site topology during 2006). The antennas at the adult fish return detected 2,942 tagged fish in 2006 – about 1.1% of the total PIT tag detections at GOJ. Of those fish detected at the adult fish return, only 55 (1.9%) were considered to be "mature" fish (*i.e.*, juvenile fish tagged prior to the 2006 migration season, or adult fish tagged during 2006). The remaining 98.1% of tagged fish detected at the adult return were most likely entrained in the adult return as part of the normal operations to remove adult fish and/or debris from the separator.

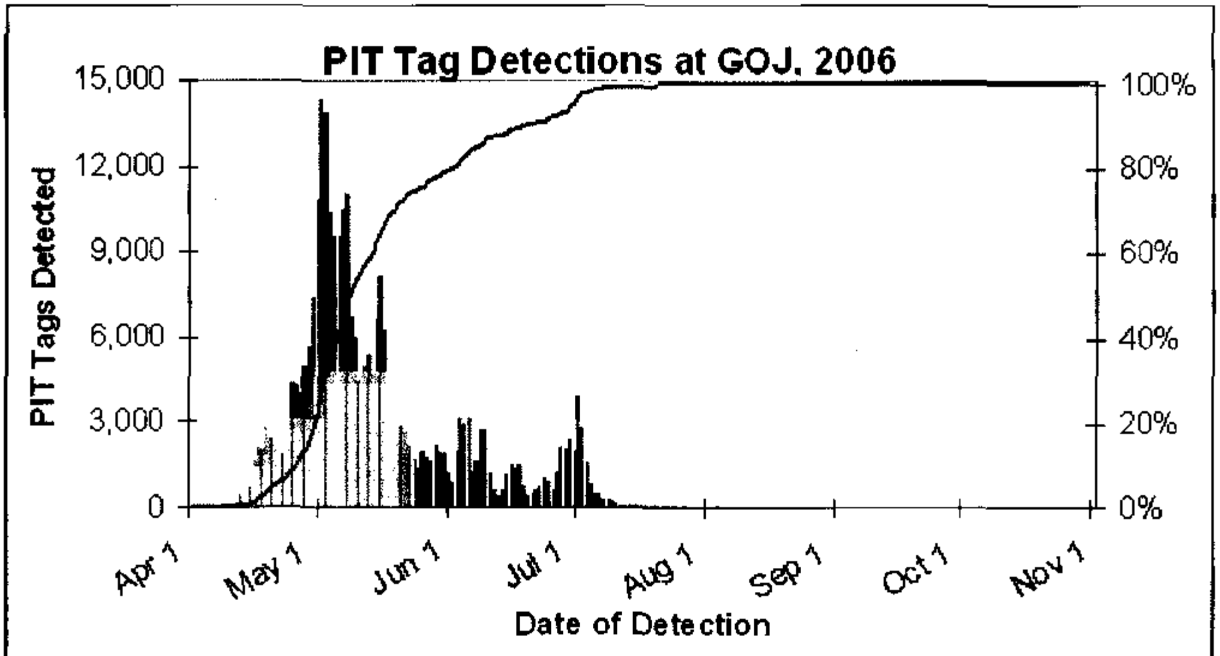


Figure 7. Daily PIT tag detections and the cumulative distribution at GOJ in 2006.

Lower Granite Dam Juvenile Fish Facility (GRJ)

PTOC has maintained the PIT tag detection and Separation-by-Code system at the Lower Granite Dam Juvenile Fish Facility (JFF) since being tasked with that responsibility in 1993. Unlike previous years, fish were not transported from Lower Granite Dam in 2006 until April 21. Prior to that, all fish passing over the separator were "direct-bypassed" to the tailrace. Collection and transportation activities continued from April 20 until November 1; after that, all fish were "direct-bypassed" until the facility was dewatered on December 16 (except that on Nov. 28 and 29, the facility was placed in primary bypass mode and no fish were passed over the separator) .

Table 9. Dates of PIT tag detection activity at GRJ during 2006.

Interrogation Start Date	03/25/06
Interrogation End Date	12/16/06
First Detection Date	03/25/06
10% Detection Date	04/23/06
50% Detection Date	05/09/06
90% Detection Date	06/25/06
Last Detection Date	12/16/06
Peak Detection Date	05/08/06
Tags Detected on Peak Date	6,319
Total Tags Detected in 2006	149,636

As at GOJ and LMJ, the GRJ PIT tag detection system was modified prior to the 2006 field season to include two new antennas on the adult fish return pipe between the wet separator and the primary bypass return (see grj_130.pdf for a map of the site topology during 2006). The antennas at the adult fish return detected 3,547 tagged fish in 2006 – about 2.4% of the total PIT tag detections at GRJ. Of those fish detected at the adult return, only 30 (0.9%) were considered to be "mature" fish (*i.e.*, juvenile fish tagged prior to the 2006 migration season, or adult fish tagged during 2006). The remaining 99.1% of tagged fish detected at the adult return were most likely entrained as part of the normal operations to remove adult fish and/or debris from the separator.

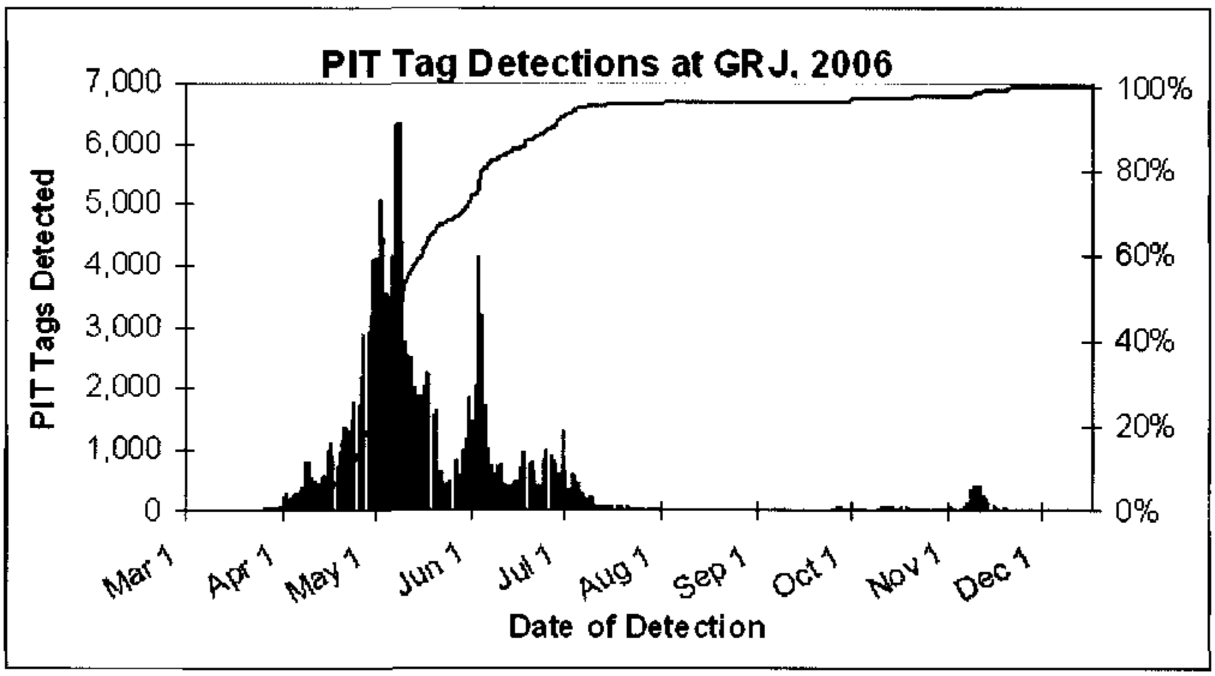


Figure 8. Daily PIT tag detections and the cumulative distribution at GRJ in 2006.

Chandler Canal Fish Bypass Facility at Prosser Dam (PRO-Bypass)

PTOC has maintained the PIT tag detection system in the Chandler Canal Fish Bypass Facility at Prosser Dam since being tasked with that responsibility in 1993. In 2004, the original "PRJ" site code was replaced with "PRO" when PIT tag detec-tors were first installed the dam's three adult fish ladders. There were no modifications to the configuration or location of the PRO PIT tag detectors in 2006 (see pro_110.pdf for a map of the entire PRO site topology during 2006).

Table 10. Dates of PIT tag detection activity at the PRO fish bypass facility during 2006.

Interrogation Start Date	01/08/06
Interrogation End Date	07/09/06
First Detection Date	01/22/06
10% Detection Date	04/15/06
50% Detection Date	04/28/06
90% Detection Date	06/04/06
Last Detection Date	07/09/06
Peak Detection Date	04/28/06
Tags Detected on Peak Date	577
Total Tags Detected in 2006	8,177

The juvenile fish sampling facility in the Chandler Canal bypass watered-up on January 8. PIT-tagged fish must be diverted into the sampling facility, but not necessarily sampled, in order to be detected. The facility flooded out on April 30 and, according to facility personnel, did not return to operation until May 31. However, as shown below in **Figure 9**, it appears the actual outages were limited to the period between April 30 and May 4, and another period between May 18 and May 31.

The juvenile fish sampling facility was dewatered on July 9 for the remainder of the calendar year. The Chandler Canal Fish Bypass likely continued to operate during this period, but the actual dates of operation are unknown.

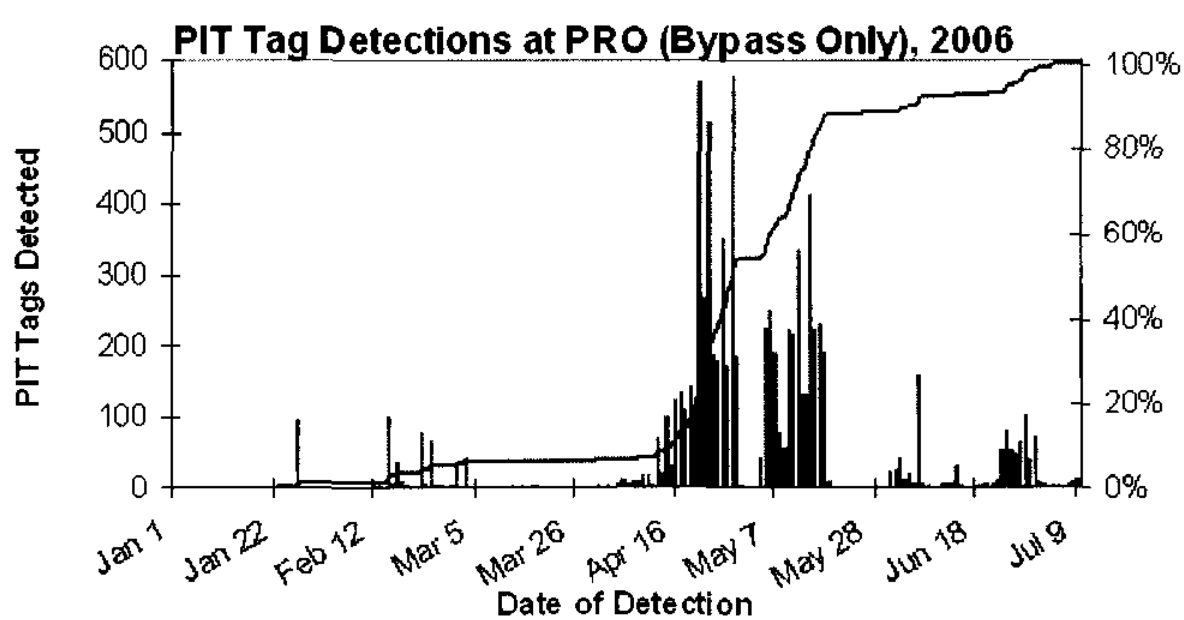


Figure 9. Daily PIT tag detections and the cumulative distribution at the PRO fish bypass facility in 2006.

B. Adult Fish Passage Facilities

Bonneville Dam Bradford Island Adult Fish Ladder (BO1)

PTOC has maintained the PIT tag detection system at the Bonneville Dam Bradford Island fish ladder since the antennas were first installed in the weir orifices of the A-Branch and B-Branch in 2002. While the ladder was dewatered during the winter of 2005-2006, four new antennas were installed in the vertical slots of the flow-control section of the fish ladder immediately upstream of the Bradford Island Visitors Center (see bo1_110.pdf for a map of the site topology during 2006). All fish successfully ascending the Bradford Island ladder must pass through these antennas. This includes PIT-tagged fish that might have passed over the tops of the weirs in the A- or B-Branch, and thus avoided being detected on those weirs' orifice antennas.

Table 11. Dates of PIT tag detection activity at BO1 during 2006.

Interrogation Start Date	02/25/06
Interrogation End Date	12/31/06
First Detection Date	02/25/06
10% Detection Date	05/12/06
50% Detection Date	07/15/06
90% Detection Date	08/28/06
Last Detection Date	12/29/06
Peak Detection Date	08/13/06
Tags Detected on Peak Date	98
Total Tags Detected in 2006	4,987

The new vertical-slot antennas were activated, along with the existing orifice antennas in the A- and B-Branch weirs, when the Bradford Island ladder watered-up on February 25. The ladder, and all of the BO1 PIT tag antenna groups, operated without interruption throughout the rest of 2006.

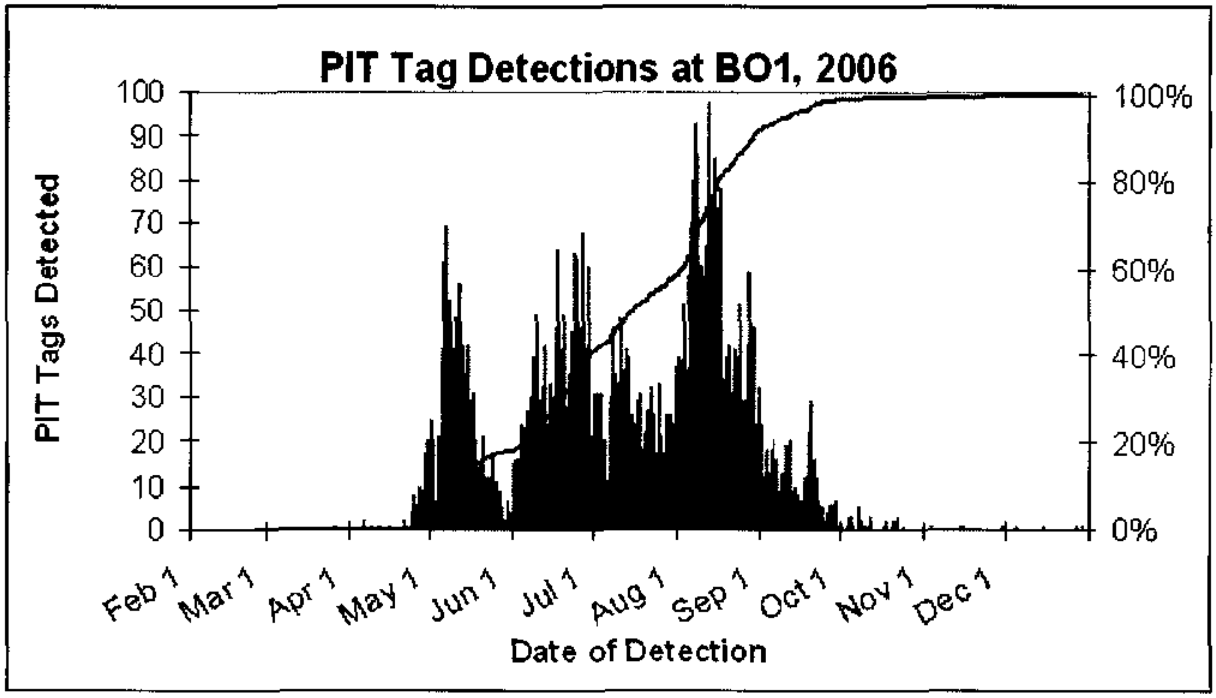


Figure 10. Daily PIT tag detections and the cumulative distribution at BO1 in 2006.

Bonneville Dam Cascades Island Adult Fish Ladder (BO2)

PTOC has maintained the PIT tag detection system at the Bonneville Dam Cascades Island fish ladder since 2002, when antennas were first installed in the weir orifices. There have been no modifications since then (see bo2_100.pdf for a map of the site topology during 2006).

Table 12. Dates of PIT tag detection activity at BO2 during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/13/06
First Detection Date	02/04/06
10% Detection Date	05/08/06
50% Detection Date	08/02/06
90% Detection Date	09/04/06
Last Detection Date	12/02/06
Peak Detection Date	08/08/06
Tags Detected on Peak Date	46
Total Tags Detected in 2006	1,946

The Cascades Island ladder operated continuously through the winter of 2005-2006, while the Bradford Island ladder was dewatered for the installation of the new vertical-slot PIT tag antennas. Thus, the BO2 detection system was in operation on January 1, 2006.

The Cascades Island ladder is usually connected to the Washington Shore fishway via the Upstream Migrant (fish) Tunnel (UMT) running through Powerhouse #2. PIT-tagged fish first detected at BO2 are generally detected again as they pass through the vertical-slot antennas in the upper Washington Shore ladder (BO4). On October 5, the Cascades Island ladder's forebay exit was opened and the UMT entrance was blocked in preparation for the dewatering of the Washington Shore ladder. Between October 5 and December 9, all fish ascending the Cascades Island ladder, including those with PIT tags, were routed directly to the forebay at the spillway, bypassing the (dewatered) detectors at BO4.

The Cascades Island fish ladder was taken to orifice flow on December 9, and completely dewatered on December 13, in preparation for its scheduled annual maintenance.

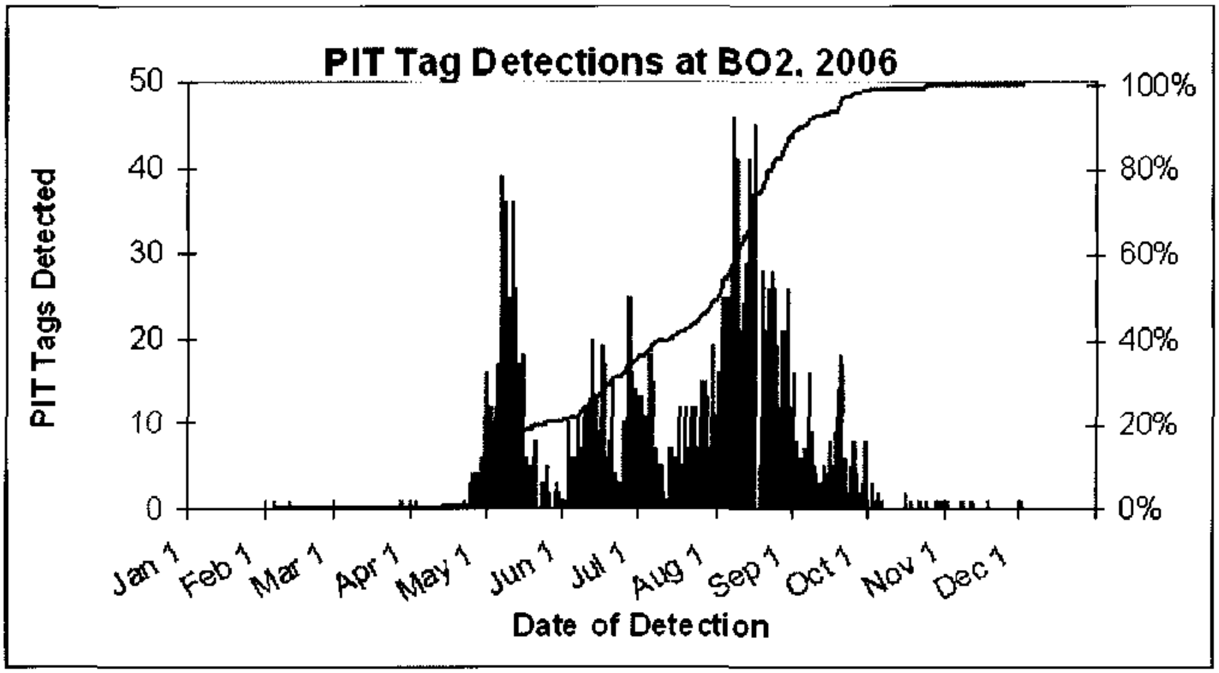


Figure 11. Daily PIT tag detections and the cumulative distribution at BO2 in 2006.

Bonneville Dam Lower Washington Shore Adult Fish Ladder (BO3)

PTOC has maintained the PIT tag detection and Separation-by-Code system in the lower section of the Bonneville Dam Washington Shore fish ladder since antennas were first installed in the Adult Fish Facility (AFF) in 1998. This initial topology was assigned a site ID of **B2A**. In 2001, 24 antennas were installed in the orifices of 12 weirs in the main ladder, and assigned a site ID of **BWL**. In 2003, the B2A and BWL sites were combined to form **BO3**. There have been no changes to the antenna group locations or configurations since then (see bo3_110.pdf for a map of the site topology during 2006).

Table 13. Dates of PIT tag detection activity at BO3 during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/11/06
First Detection Date	01/02/06
10% Detection Date	06/10/06
50% Detection Date	08/03/06
90% Detection Date	09/08/06
Last Detection Date	12/04/06
Peak Detection Date	06/28/06
Tags Detected on Peak Date	171
Total Tags Detected in 2006	8,608

The Washington Shore ladder operated continuously through the winter of 2005-2006, while the Bradford Island ladder was dewatered for the installation of the new vertical-slot PIT tag antennas. Thus, the BO3 detection system was in operation on January 1, 2006.

As in previous years, the AFF was operated on demand in 2006 by various researchers. PTAGIS was not necessarily apprised when these research operations occurred, so the antenna groups in the AFF remained active throughout the year, maintaining detection and Separation-by-Code capabilities at all times.

The entire Washington Shore fish ladder was taken to orifice flow on December 9, and completely dewatered on December 11, in preparation for its scheduled annual maintenance.

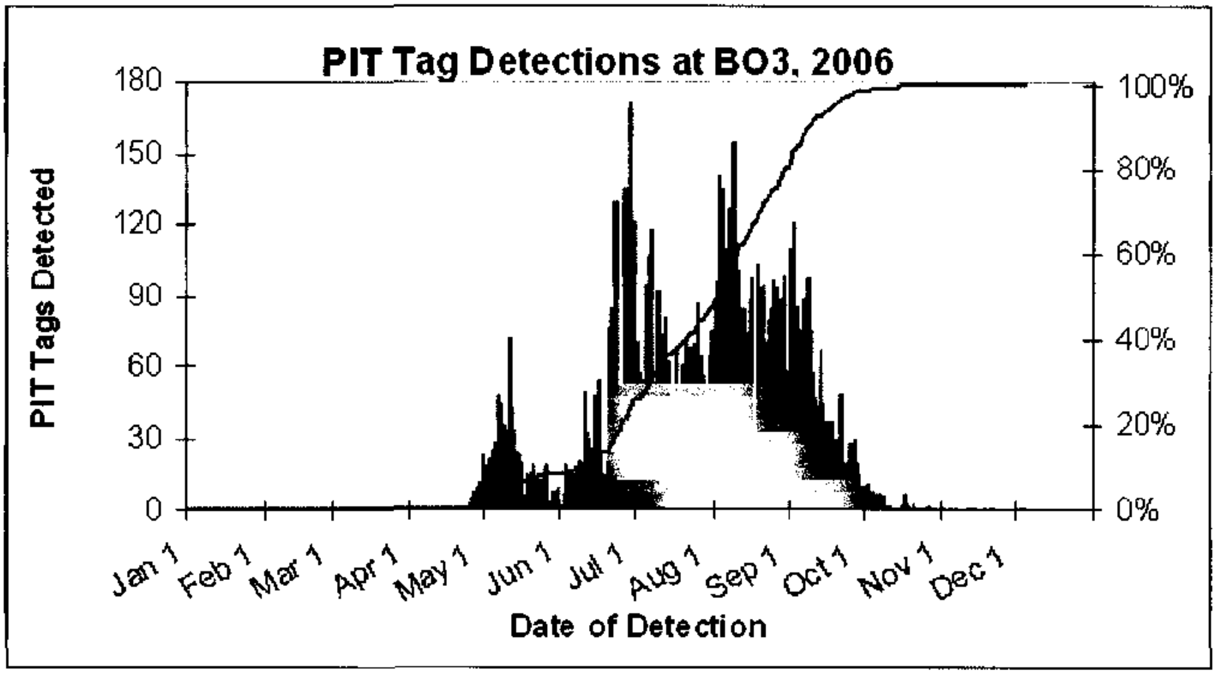


Figure 12. Daily PIT tag detections and the cumulative distribution at BO3 in 2006.

Bonneville Dam Upper Washington Shore Adult Fish Ladder (BO4)

PTOC has maintained the PIT tag detection system at the flow control section of the Bonneville Dam Washington Shore fish ladder since the four vertical-slot antennas were installed upstream of the counting window in 2005. There have been no modifications to the site since the initial deployment (see bo4_100.pdf for a map of the site topology during 2006).

Table 14. Dates of PIT tag detection activity at BO4 during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/11/06
First Detection Date	01/02/06
10% Detection Date	05/26/06
50% Detection Date	07/31/06
90% Detection Date	09/07/06
Last Detection Date	12/04/06
Peak Detection Date	08/09/06
Tags Detected on Peak Date	211
Total Tags Detected in 2006	11,479

The Washington Shore ladder operated continuously through the winter of 2005-2006, while the Bradford Island ladder was dewatered for the installation of new vertical-slot PIT tag antennas. Thus, the BO4 detection system was in operation on January 1, 2006.

The BO4 antenna group in the upper section of the Washington Shore ladder generally detects PIT-tagged fish that have ascended through the antennas groups in the lower section of the Washington Shore ladder (BO3) as well as tagged fish that have passed through the antenna groups in the Cascades Island ladder (BO2). See the discussion of 2006 BO2 operations on page 13 for an explanation of why this detection redundancy did not occur at BO4 for fish detected at BO2 after October 5, 2006.

The entire Washington Shore ladder was taken to orifice flow on December 9, and completely dewatered on December 11, in preparation for its scheduled annual maintenance.

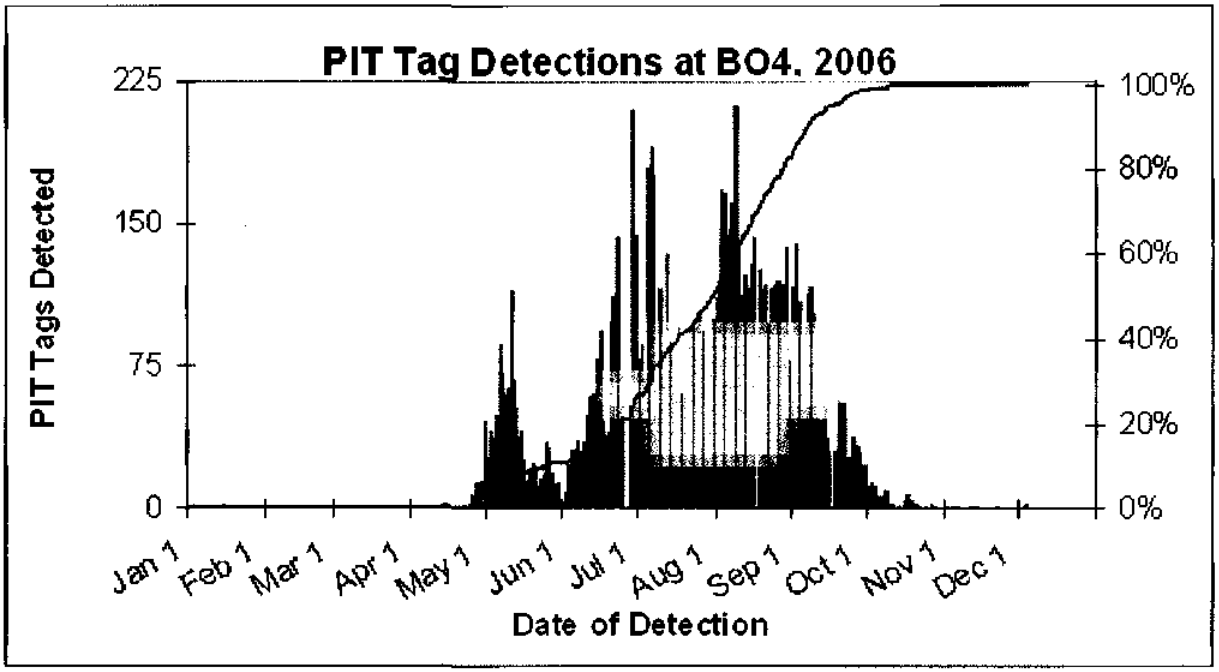


Figure 13. Daily PIT tag detections and the cumulative distribution at BO4 in 2006.

McNary Dam Oregon Shore Adult Fish Ladder (MC1)

PTOC has maintained the PIT tag detection system at the McNary Dam Oregon Shore fish ladder since the antenna groups were installed in 2002. No modifications have been made to the configuration or location of the antenna arrays since the initial installation (see mc1_120.pdf for a map of the site topology during 2006). The configuration includes two antennas located on either side of the counting window. All fish successfully ascending the Oregon Shore ladder must pass through these antennas, including PIT-tagged fish that might have passed over the tops of the weirs in the lower section of the ladder, and thus avoided being detected on those weirs' orifice antennas.

Table 15. Dates of PIT tag detection activity at MC1 during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	01/01/06
10% Detection Date	05/30/06
50% Detection Date	08/28/06
90% Detection Date	09/26/06
Last Detection Date	12/19/06
Peak Detection Date	09/10/06
Tags Detected on Peak Date	186
Total Tags Detected in 2006	7,110

The Oregon Shore ladder was operational on January 1, 2006. It was dewatered between January 12 - 20 for scheduled maintenance. The ladder then operated without interruption until it was dewatered on December 21 for scheduled maintenance; the ladder remained out of service for the remainder of the year.

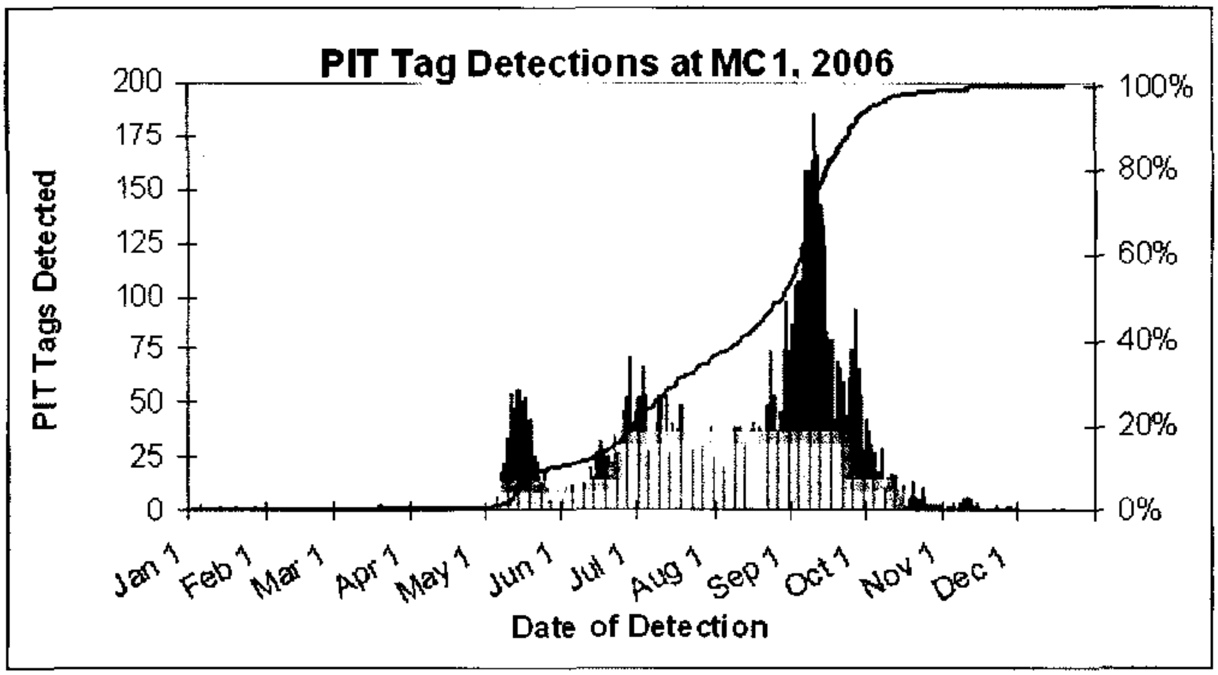


Figure 14. Daily PIT tag detections and the cumulative distribution at MC1 in 2006.

McNary Dam Washington Shore Adult Fish Ladder (MC2)

PTOC has maintained the PIT tag detection system at the McNary Dam Washington Shore fish ladder since antennas were initially installed in its weir orifices in 2002. The ladder was operational on January 1, 2006, but was dewatered between January 12 and March 31 for scheduled maintenance, and to installed three new antennas at the Washington Shore counting window. These antennas were activated when the ladder was returned to service. All fish successfully ascending the Washington Shore ladder must pass through these antennas, including PIT-tagged fish that might have passed over the tops of the weirs in the lower section of the ladder, and thus avoided being detected on those weirs' orifice antennas. (See mc2_120.pdf for a map of the site topology after March 31, 2006.) After watering-up on March 31, the Washington Shore ladder continued to operate without interruption for the remainder of the 2006 calendar year.

Table 16. Dates of PIT tag detection activity at MC2 during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	01/09/06
10% Detection Date	05/18/06
50% Detection Date	07/12/06
90% Detection Date	09/18/06
Last Detection Date	12/31/06
Peak Detection Date	06/30/06
Tags Detected on Peak Date	99
Total Tags Detected in 2006	4,654

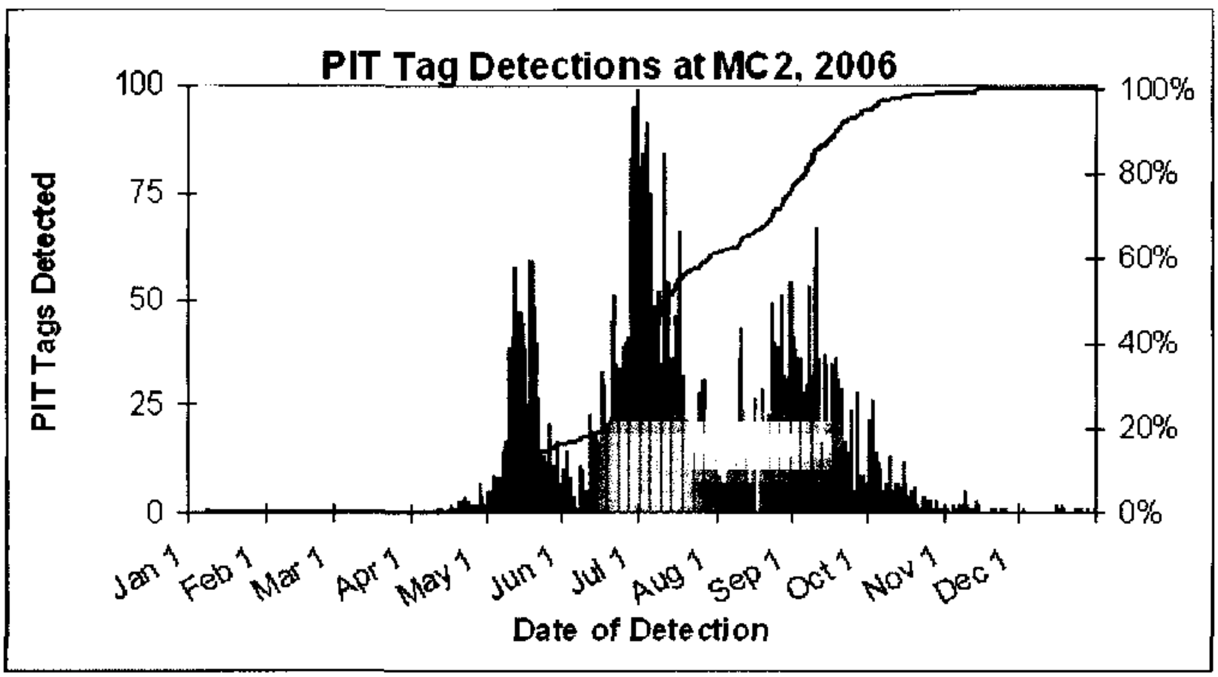


Figure 15. Daily PIT tag detections and the cumulative distribution at MC2 in 2006.

Ice Harbor Dam Adult Fish Ladders (ICH-Ladders)

PTOC has maintained the PIT tag detection equipment in both of the Ice Harbor Dam fish ladders since antennas were installed in the Left Bank (South) and Right Bank (North) ladders in 2003. In 2005, the original **IHA** site code was replaced with **ICH** when four antennas were installed in the full-flow juvenile fish bypass system at the powerhouse. There has been no modification to the configuration of the antennas in the two ladders since the initial installation (see ich_100.pdf for a map of the entire ICH site topology during 2006).

Table 17. Dates of PIT tag detection activity at the ICH adult fish ladders during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	01/06/06
10% Detection Date	05/15/06
50% Detection Date	07/27/06
90% Detection Date	10/07/06
Last Detection Date	12/20/06
1st Peak Detection Date	05/17/06
2nd Peak Detection Date	09/28/06
Tags Detected on Peak Dates	35
Total Tags Detected in 2006	2,022

The Left Bank ladder was dewatered for annual maintenance between January 3-18; it then operated without interruption for the rest of the 2006 calendar year. The Right Bank ladder was not dewatered during 2006.

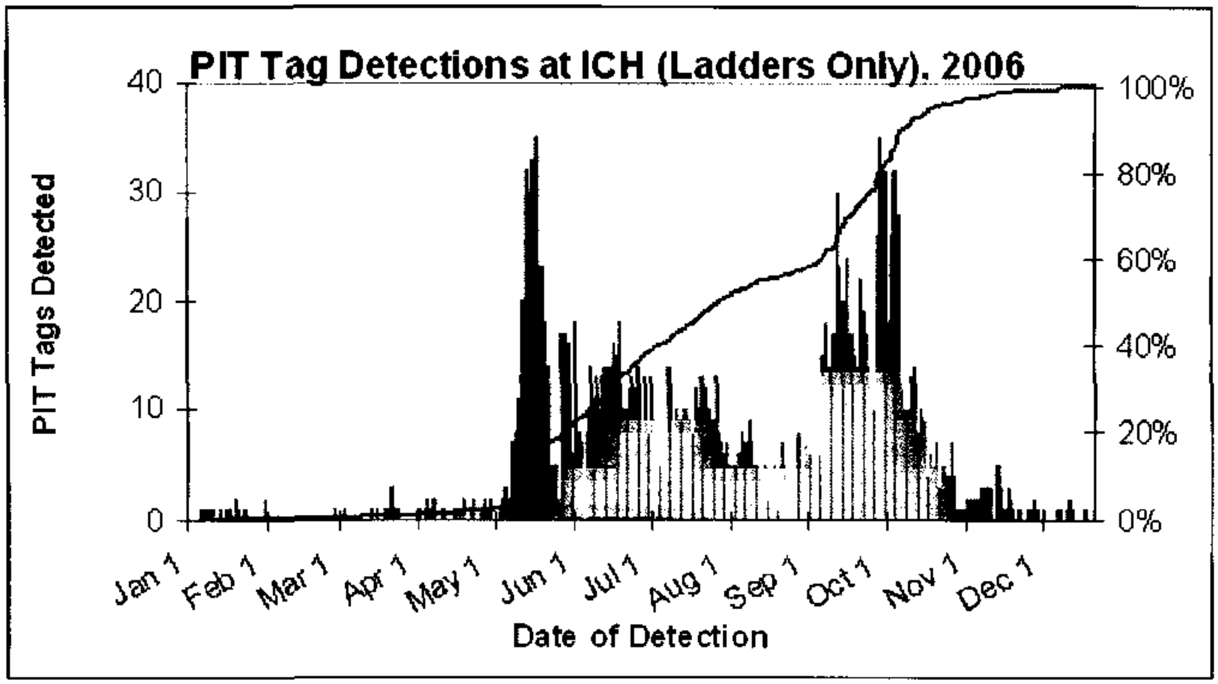


Figure 16. Daily PIT tag detections and the cumulative distribution at the ICH adult fish ladders in 2006.

Lower Granite Dam Adult Fish Ladder and Trap (GRA)

PTOC has maintained the PIT tag detection (and Separation-by-Code) system in the fish ladder at Lower Granite Dam since assuming that responsibility in 1993. The PIT tag antenna configuration at GRA was last modified in late 2003, with the removal of the remaining the 400 kHz detectors (see gra_140.pdf for a map of the site topology during 2006).

Table 18. Dates of PIT tag detection activity at GRA during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	01/02/06
10% Detection Date	05/20/06
50% Detection Date	09/11/06
90% Detection Date	10/19/06
Last Detection Date	12/15/06
Peak Detection Date	09/16/06
Tags Detected on Peak Date	41
Total Tags Detected in 2006	2,295

The Lower Granite ladder was operational on January 1. It was dewatered between January 3 and February 17 for annual maintenance, and then remained in operation for the rest of the 2006 calendar year.

Adult fish were diverted from the main ladder into the facility trap channel beginning March 1. The LGR adult trap is not dedicated solely to Separation-by-Code (SxC) operations, but only those PIT-tagged fish diverted into the trap channel are detected on the antennas that initiate SxC diversion actions. Trapping was suspended from April 20 until May 5 due to low numbers of fish. Trapping was suspended again from July 24 until September 1 due to high water temperatures. PTAGIS was not necessarily apprised when trap activities were interrupted, so the antenna groups in the LGR adult trap remained active throughout the year, maintaining detection and Separation-by-Code capabilities at all times. The trap was dewatered on November 21, and was out of service for the rest of the year.

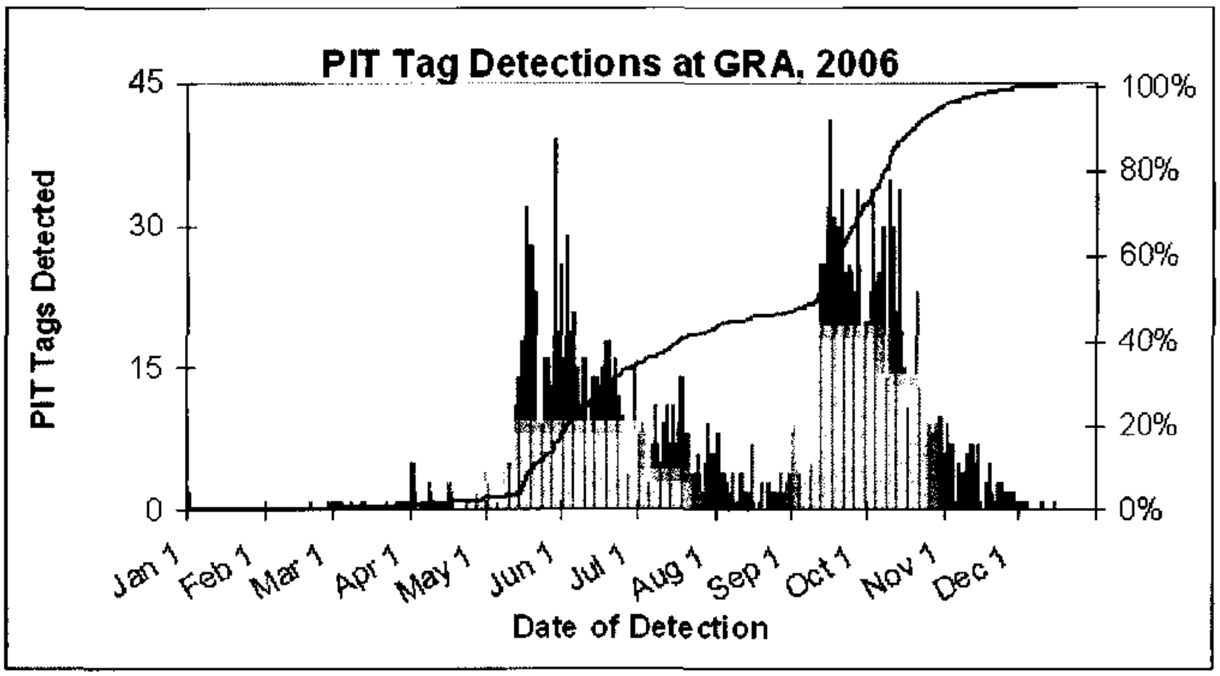


Figure 17. Daily PIT tag detections and the cumulative distribution at GRA in 2006.

Prosser Dam Adult Fish Ladders (PRO-Ladders)

PTOC has maintained the PIT tag detection systems in the three fish ladders at Prosser Dam since the first antenna arrays were installed in the Left Bank Ladder in 2004. At this time, the original "PRJ" site code (encompassing only the juvenile fish sampling system at the Chandler Canal bypass) was replaced with "PRO", to reflect the incorporation of the detection systems in the dam's fish ladders. Antennas were installed in the Right Bank and Middle ladders in 2005. There were no modifications to any of the PRO PIT tag antenna configurations in 2006 (see pro_110.pdf for a map of the entire PRO site topology during 2006).

Table 19. Dates of PIT tag detection activity at the PRO adult fish ladders during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	01/09/06
10% Detection Date	04/27/06
50% Detection Date	05/30/06
90% Detection Date	10/18/06
Last Detection Date	12/29/06
Peak Detection Date	05/08/06
Tags Detected on Peak Date	24
Total Tags Detected in 2006	461

The Left Bank and Middle ladder detectors were taken out of service on May 19 due to high river flows, with leaks or the threat of flooding in the PIT tag equipment vaults. The Middle Ladder detectors were returned to service on May 23, and the Left Bank Ladder returned to service on May 25. The Middle Ladder was dewatered on July 6, and rewatered sometime between November 6 - 13. The Denil steep pass trap in the Right Bank Ladder operated between September 25 - November 8, November 13 - 21, and November 27 - December 5. The Denil bypasses the counting window in the Right Bank Ladder, and so fish were effectively diverted around the Right Bank Ladder antennas during these intervals.

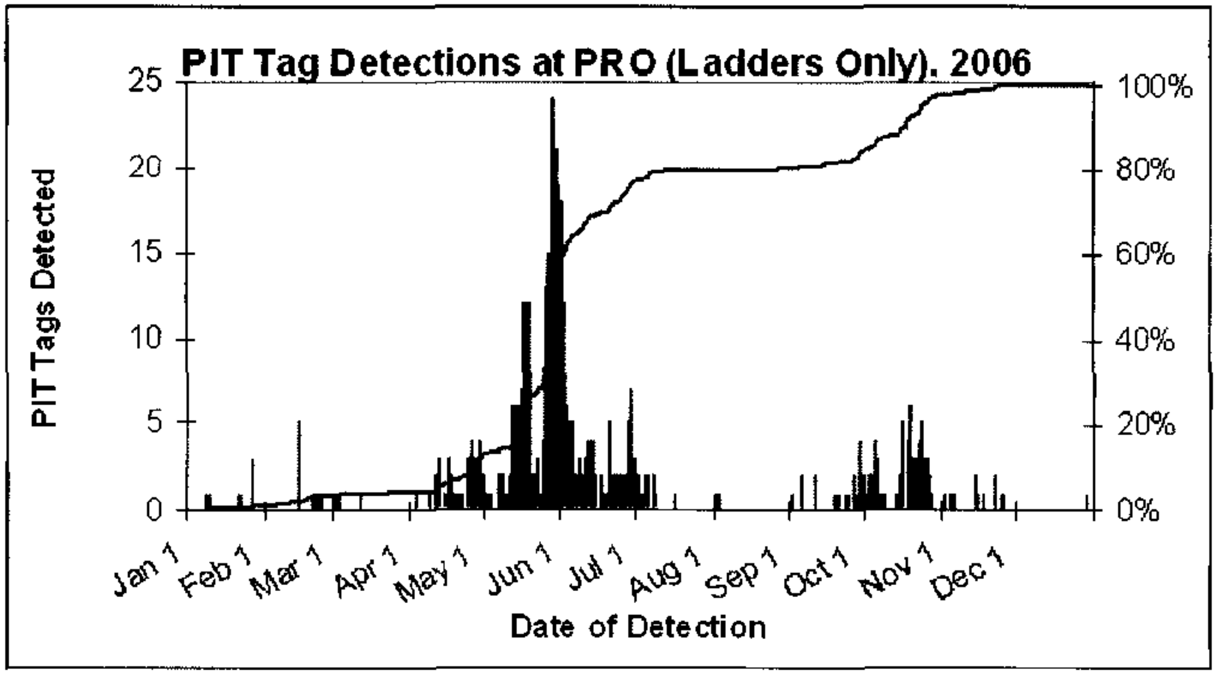


Figure 18. Daily PIT tag detections and the cumulative distribution at the PRO adult fish ladders in 2006.

Priest Rapids Dam Adult Fish Ladders (PRA)

Biomark has maintained the PIT tag detection equipment in the two fish ladders at Priest Rapids Dam since antennas were installed in the Left Bank (East Shore) and Right Bank (West Shore) ladders in 2003. There have been no modifications to the site since the initial deployment (see pra_100.pdf for a map of the site topology during 2006).

Table 20. Dates of PIT tag detection activity at PRA during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	02/22/06
10% Detection Date	06/24/06
50% Detection Date	08/13/06
90% Detection Date	09/22/06
Last Detection Date	12/16/06
Peak Detection Date	07/04/06
Tags Detected on Peak Date	144
Total Tags Detected in 2006	6,931

Sampling activity in the East Shore ladder can intercept fish that would otherwise pass through the weirs fitted with PIT tag antennas. While there was some sampling activity reported at Priest Rapids Dam in 2006, the actual dates of sampling are not known, nor are the impacts (if any) on PIT tag detection activity in the East Shore ladder.

The East Shore ladder was dewatered for annual maintenance in early November, 2006. The West Shore ladder apparently remained watered-up for the entire 2006 calendar year.

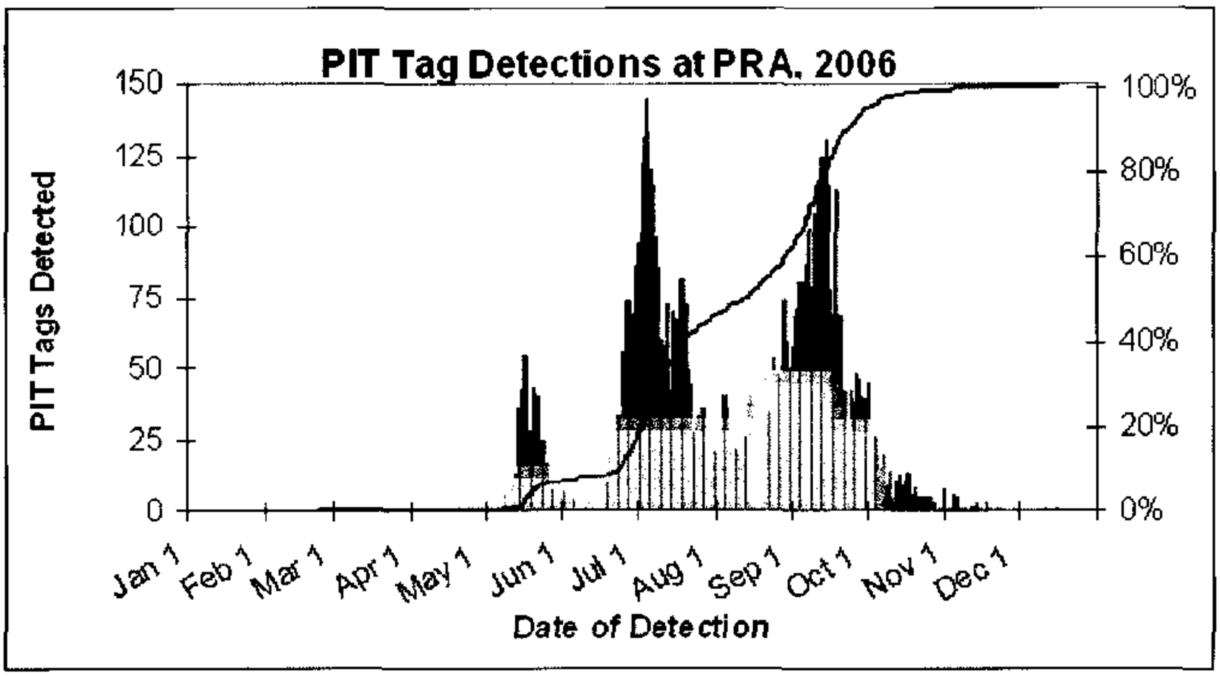


Figure 19. Daily PIT tag detections and the cumulative distribution at PRA in 2006.

Rock Island Dam Adult Fish Ladders (RIA)

Biomark has maintained the PIT tag detection equipment in the three fish ladders at Rock Island Dam since antennas were installed in the Left, Middle, and Right ladders in 2003. There have been no modifications to the site since the initial deployment (see ria_100.pdf for a map of the site topology during 2006).

Table 21. Dates of PIT tag detection activity at RIA during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	03/05/06
10% Detection Date	06/26/06
50% Detection Date	08/09/06
90% Detection Date	09/27/06
Last Detection Date	12/29/06
Peak Detection Date	07/05/06
Tags Detected on Peak Date	131
Total Tags Detected in 2006	6,312

There was a gap in data collection for nine days during February, 2006, when both of the data collection computers went down due to virus and spyware attacks, most likely because someone had been surfing the Internet. Biomark inspected all of the transceiver buffers and found no PIT tag detections during this nine-day interval.

The antennas in the Right Ladder (09, 0A, 0B, and 0C) have suffered from extreme noise problems since they were installed. In 2006, the noise level on these four antennas averaged between 70% and 80%, with peak noise levels often exceeding 90%. Recent tests suggest that nearby cooling pumps and attraction water pumps may be the source of the interference. Biomark is working with the Rock Island Dam plant engineer to try to fix this problem in 2007.

The Right Ladder was dewatered for annual maintenance on December 4, 2006. The Middle and Left ladders apparently remained watered-up for the entire 2006 calendar year.

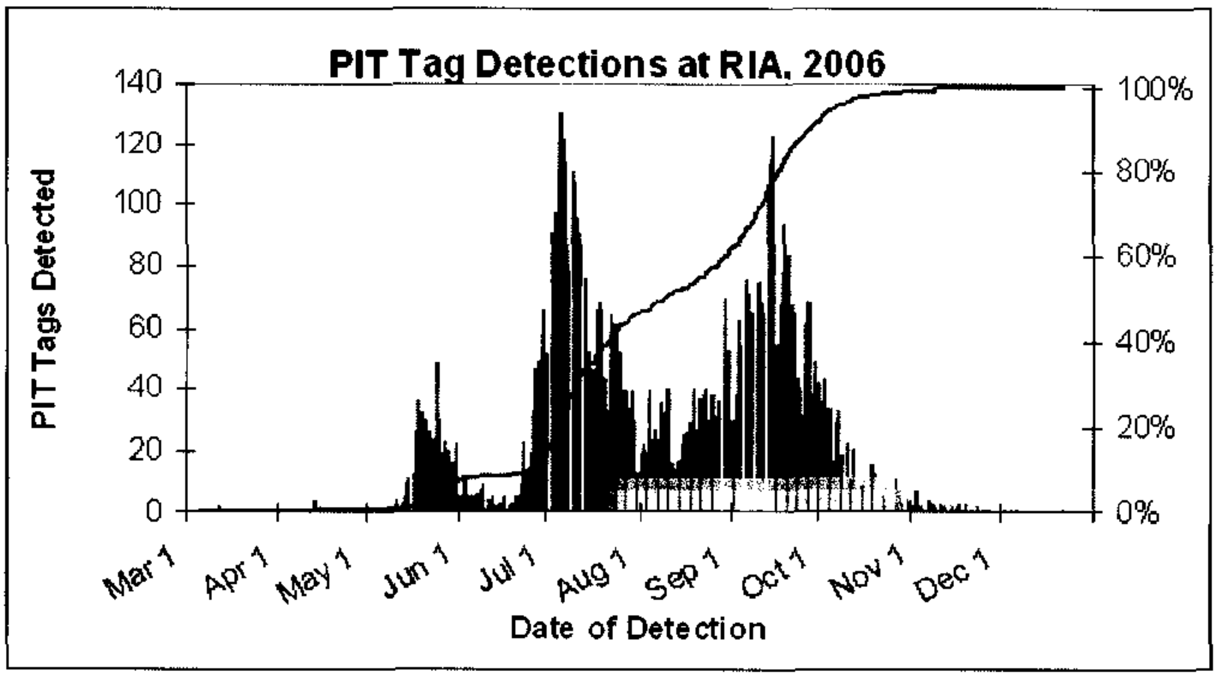


Figure 20. Daily PIT tag detections and the cumulative distribution at RIA in 2006.

Rocky Reach Dam Adult Fish Ladder (RRF)

Early in 2006, PIT tag antennas were installed in weirs #4 and #6 near the top of the single fish ladder at Rocky Reach Dam. The site was watered up on March 3, 2006. Biomark maintained the PIT tag detection equipment during the 2006 calendar year.

Table 22. Dates of PIT tag detection activity at RRF during 2006.

Interrogation Start Date	03/03/06
Interrogation End Date	12/04/06
First Detection Date	03/05/06
10% Detection Date	07/03/06
50% Detection Date	08/29/06
90% Detection Date	09/30/06
Last Detection Date	11/30/06
1st Peak Detection Date	09/15/06
2nd Peak Detection Date	09/17/06
Tags Detected on Peak Dates	121
Total Tags Detected in 2006	5,807

Biomark reports that they had significant problems at RRF for at least two months during the summer of 2006. All four transceivers (from Digital Angel) had bad analog boards, which worked intermittently and then stopped working altogether . The transceivers also occasionally switched back to their default factory settings, causing the antennas to de-tune. Digital Angel provided replacement boards that were installed in late August. The new boards resolved the problems.

Biomark also reported many reader overruns that caused the readers to lock up for short periods of time. They believe the overruns were caused by power spikes or noisy power. These overruns may have resulted in the loss of some detection data. High temperatures were also an issue at Rocky Reach in 2006, but are not thought to have affected PIT tag detections.

The Rocky Reach fish ladder was dewatered for annual maintenance on December 4, 2006.

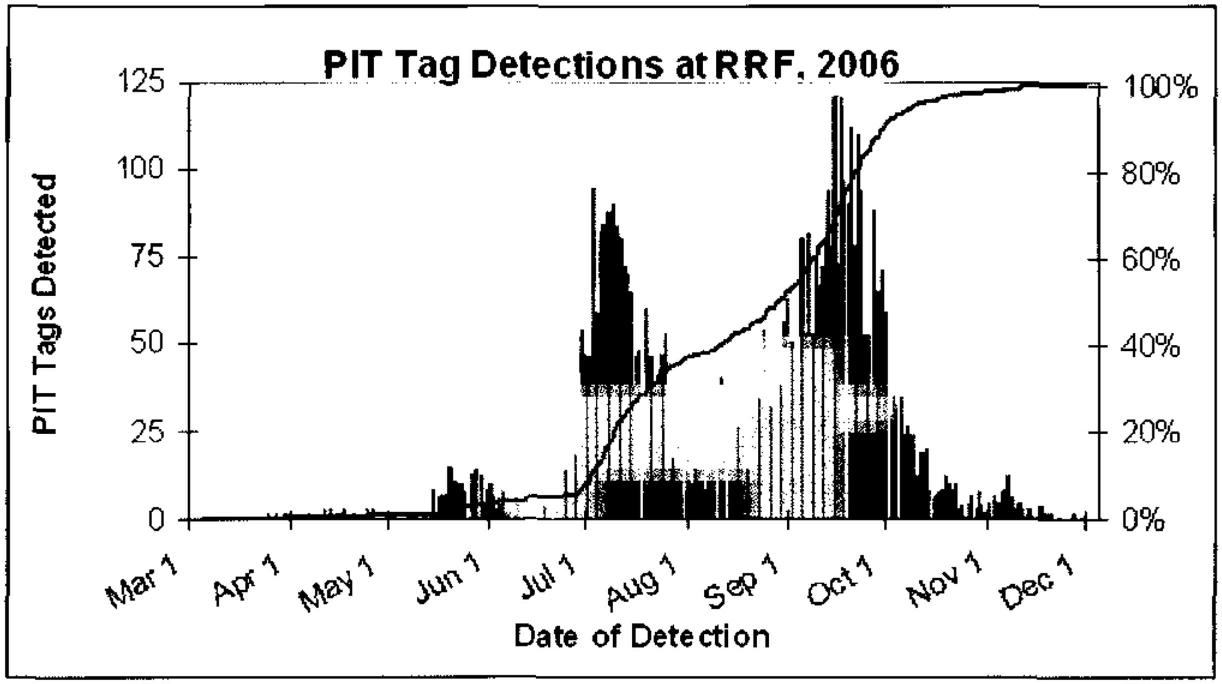


Figure 21. Daily PIT tag detections and the cumulative distribution at RRF in 2006.

Wells Dam Adult Fish Ladders (WEA)

Biomark has maintained the PIT tag detection equipment in the two fish ladders at Wells Dam since antennas were initially installed in the Left (East) and Right (West) ladders in 2002. Additional antennas were installed in the East and West ladder traps in 2004. There have been no further modifications to the site since 2004 (see wea_110.pdf for a map of the site topology during 2006).

Table 23. Dates of PIT tag detection activity at WEA during 2006.

Interrogation Start Date	01/01/06
Interrogation End Date	12/31/06
First Detection Date	03/30/06
10% Detection Date	07/11/06
50% Detection Date	09/10/06
90% Detection Date	10/07/06
Last Detection Date	12/04/06
1st Peak Detection Date	09/17/06
2nd Peak Detection Date	09/29/06
Tags Detected on Peak Dates	111
Total Tags Detected in 2006	4,639

Biomark reported no significant anomalies or issues affecting PIT tag detection at Wells Dam in 2006. Both ladders were apparently watered-up for the entire 2006 calendar year.

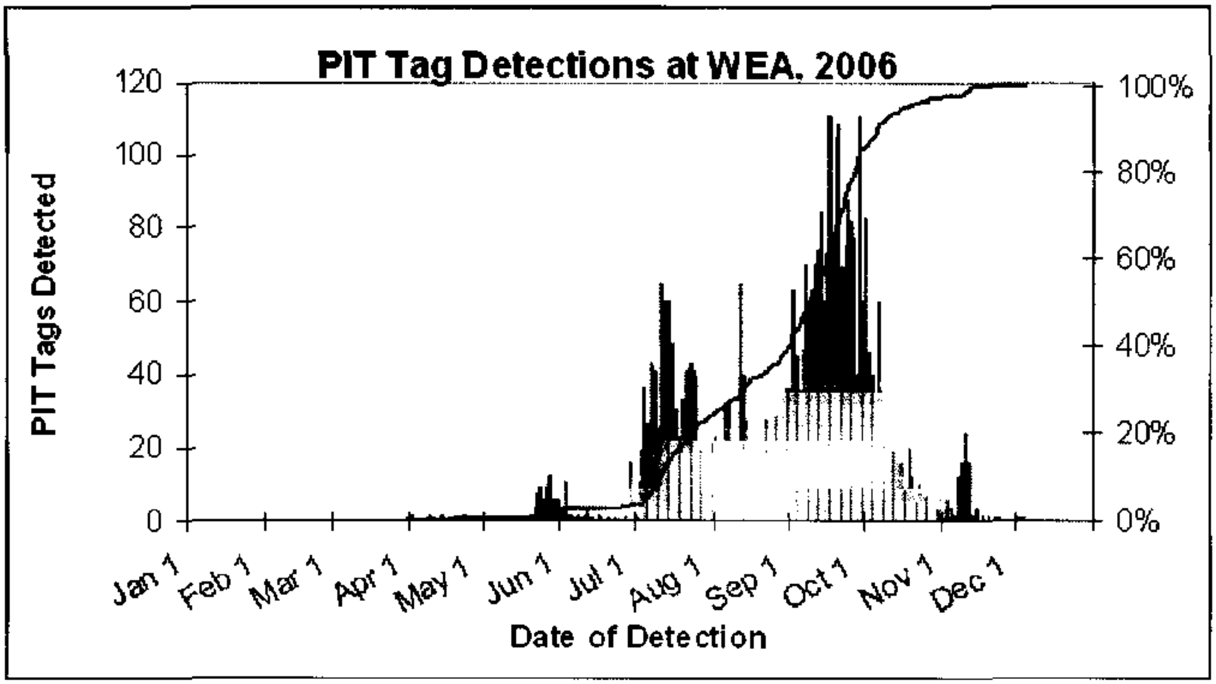


Figure 22. Daily PIT tag detections and the cumulative distribution at WEA in 2006.

C. Hatchery Release Facilities

Clark Flat Acclimation Facility (CFJ)

PTOC has maintained the PIT tag detection system at the outfall of the Clark Flat Acclimation Facility since the antennas were initially deployed in 1999. The site topology consists to two antenna groups, each configured with two antennas oriented in tandem; each of the two antenna groups are located in parallel flumes. All fish volitionally leaving the ponds at the Clark Flat facility must therefore pass through both antennas in either of the two antenna groups.

Table 24. Dates of PIT tag detection activity at CFJ during 2006.

Interrogation Start Date	01/20/06
Interrogation End Date	05/23/06
First Detection Date	03/15/06
10% Detection Date	03/28/06
50% Detection Date	04/16/06
90% Detection Date	04/29/06
Last Detection Date	05/19/06
Peak Detection Date	03/29/06
Tags Detected on Peak Date	1,523
Total Tags Detected in 2006	12,980

Fish were trucked to the Clark Flat Acclimation Facility from Cle Elum Hatchery on January 20, 2006. Fish were allowed to volitionally exit the ponds beginning on March 15. The fish screens were removed on May 15, and all remaining fish were flushed out of the ponds. The Clark Flat facility was dewatered on May 23, 2006.

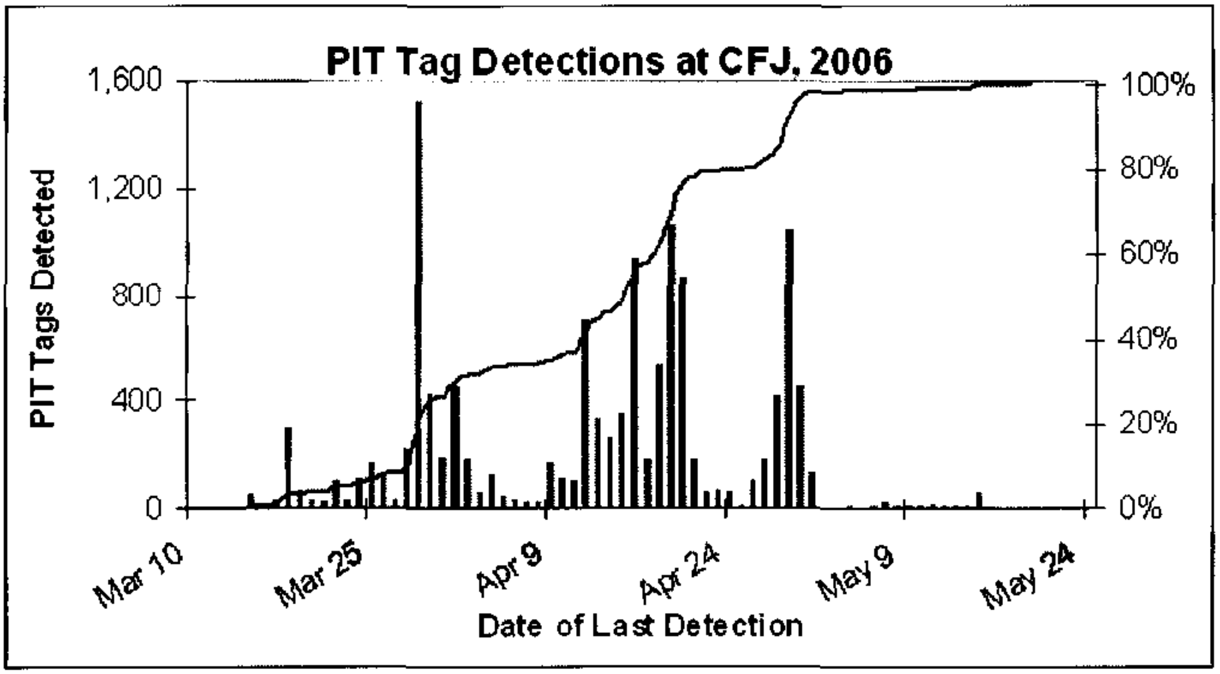


Figure 23. Daily PIT tag detections and the cumulative distribution at CFJ in 2006.

Easton Acclimation Facility (ESJ)

PTOC has maintained the PIT tag detection system at the outfall of the Easton Acclimation Facility since the antennas were initially deployed in 1999. The site topology consists to two antenna groups, each equipped with two antennas oriented in tandem; each of the two antenna groups are located in parallel flumes. All fish volitionally leaving the ponds at the Easton facility must therefore pass through both antennas in either of the two antenna groups.

Table 25. Dates of PIT tag detection activity at ESJ during 2006.

Interrogation Start Date	01/18/06
Interrogation End Date	05/31/06
First Detection Date	03/15/06
10% Detection Date	03/24/06
50% Detection Date	04/09/06
90% Detection Date	04/26/06
Last Detection Date	05/17/06
Peak Detection Date	04/09/06
Tags Detected on Peak Date	2,543
Total Tags Detected in 2006	12,766

Fish were trucked to the Easton Acclimation Facility from Cle Elum Hatchery on January 18-19, 2006. Fish were allowed to volitionally exit the ponds beginning on March 15. The fish screens were removed on May 15, and all remaining fish were flushed out of the ponds. The Easton facility was dewatered on May 31, 2006.

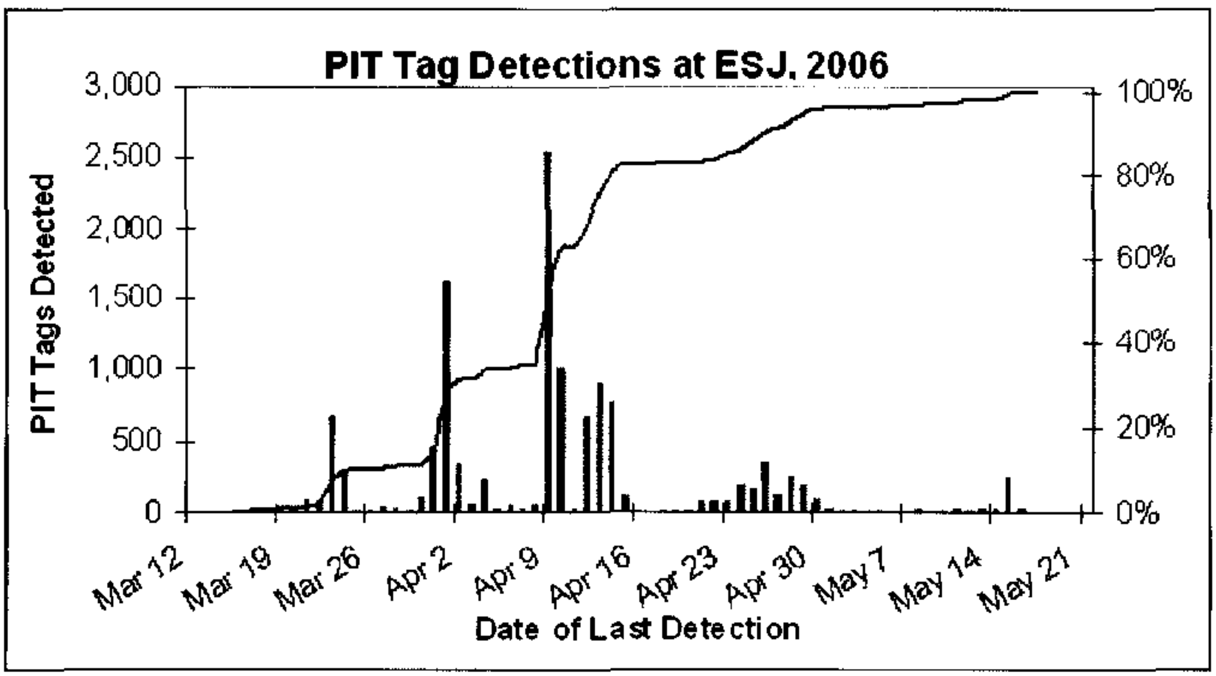


Figure 24. Daily PIT tag detections and the cumulative distribution at ESJ in 2006.

Jack Creek Acclimation Facility (JCJ)

PTOC has maintained the PIT tag detection system at the outfall of the Jack Creek Acclimation Facility since the antennas were initially deployed in 2000. The site topology consists to two antenna groups, each equipped with two antennas oriented in tandem; each of the two antenna groups are located in parallel flumes. All fish volitionally leaving the ponds at Jack Creek must therefore pass through both antennas in either of the two antenna groups..

Table 26. Dates of PIT tag detection activity at JCJ during 2006.

Interrogation Start Date	02/13/06
Interrogation End Date	03/22/06
First Detection Date	03/15/06
10% Detection Date	03/28/06
50% Detection Date	04/05/06
90% Detection Date	04/28/06
Last Detection Date	05/10/06
Peak Detection Date	04/06/06
Tags Detected on Peak Date	1,509
Total Tags Detected in 2006	10,691

Fish from Cle Elum Hatchery were delivered to four of the ponds at the Jack Creek Acclimation Facility on February 13, 2006, and fish were delivered into two additional ponds on March 6. Fish were allowed to volitionally exit the ponds beginning on March 15. All fish were forced out of the ponds on April 28, after the intakes became plugged. The Jack Creek facility was dewatered on May 10, 2006.

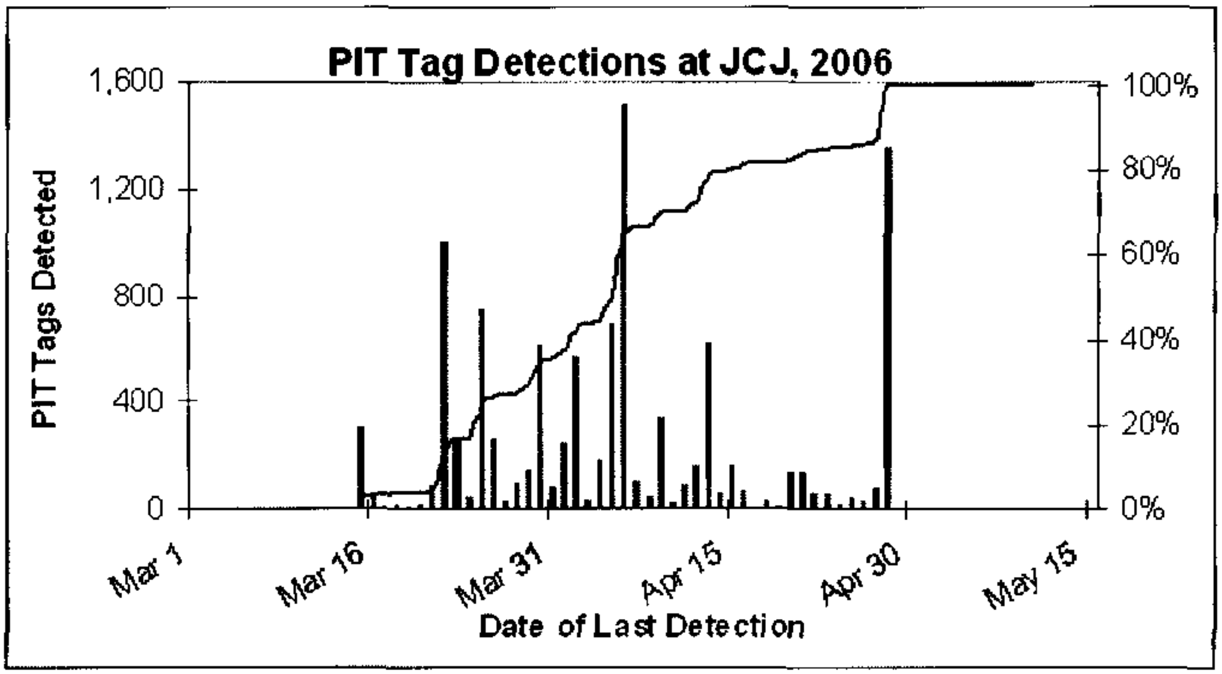


Figure 25. Daily PIT tag detections and the cumulative distribution at JCJ in 2006.

Rapid River Hatchery (RPJ)

As in previous years, PTOC contracted Biomark to maintain the PIT tag detection system in the main raceway out-fall at Rapid River Hatchery in 2006. The facility was initially fitted with PIT tag antennas in 1999. The current configuration, first deployed in 2002, consists to two molded antenna arrays, each with four "U"-shaped antennas; each array is located in the mouth of the out-fall, perpendicular to flow, and oriented in tandem. Fish volitionally leaving the raceway must pass through at least one PIT tag antenna in each of the two arrays.

Table 27. Dates of PIT tag detection activity at RPJ during 2006.

Interrogation Start Date	02/13/06
Interrogation End Date	04/25/06
First Detection Date	02/18/06
10% Detection Date	03/25/06
50% Detection Date	04/06/06
90% Detection Date	04/20/06
Last Detection Date	04/25/06
Peak Detection Date	04/04/06
Tags Detected on Peak Date	7,590
Total Tags Detected in 2006	95,515

In 2006, PIT-tagged fish were first introduced into the raceway on February 6. The RPJ antennas were enabled on February 13. On March 17, fish were allowed to volitionally exit from the pond. All remaining fish were forced out on April 25.

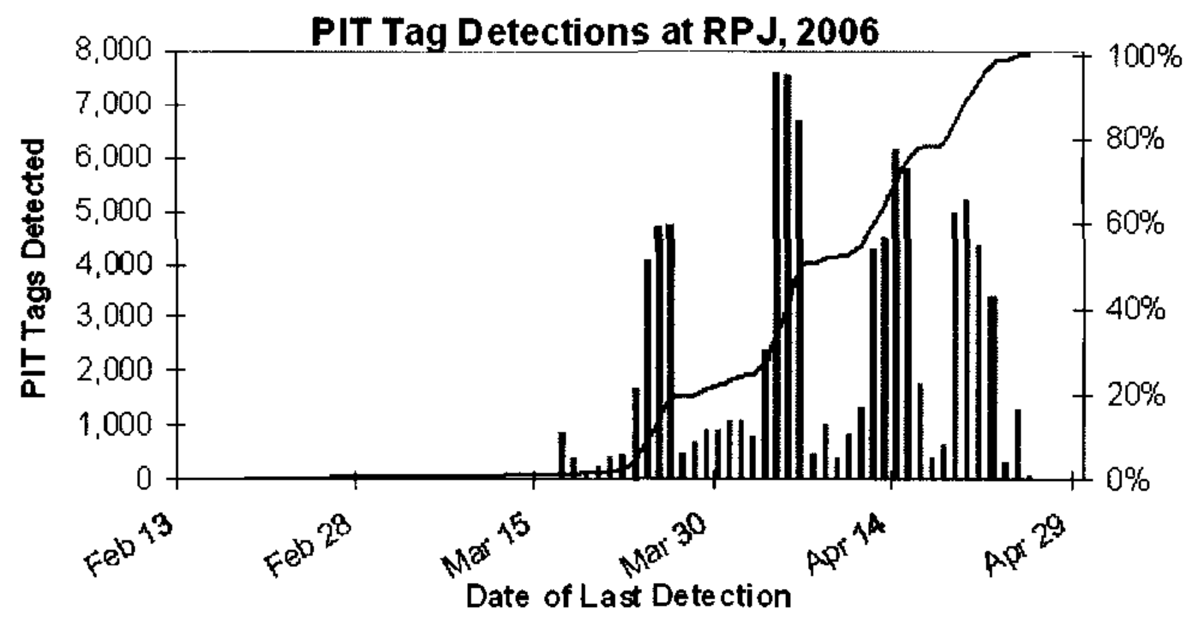


Figure 26. Daily PIT tag detections and cumulative distribution at RPJ in 2006.

D. Other Detection Sites

PTOC provided assistance with the O&M at two interrogation sites in 2006. The US Geological Survey (USGS) conducts research on fish stocks in Rattlesnake Creek, in the Wind River (WA) water-shed. PTOC helped the USGS staff maintain the **RCX** interrogation site. A total of 150 unique PIT tags were detected at RCX during 2006.

With some help from PTOC, researchers at the Oregon Department of Fish & Wildlife (ODFW) office in Hermiston have monitored the passage of both adult and juvenile PIT-tagged fish at Three Mile Falls Dam, located on the Umatilla River. In November, 2006, detections from the adult fish ladder (previously reported as **TMA**) and the juvenile fish bypass (previously reported as **TMJ**) were combined and reported through a common **TMF** interrogation site. While PTOC assumed a larger role in the O&M of the combined site, ODFW continued to provide primary responsibility for operations at TMF through the end of 2006. Six PIT-tagged fish, all adults, were detected in the TMF fish ladder after November 1, 2006.

3. Separation by Code Activities

In addition to providing O&M support in 2006 for most of the PIT tag interrogation sites in the mainstem Snake and Columbia rivers, PTOC also coordinated, implemented, and supported all of the Separation-by-Code (SxC) activity conducted at the eight sites with SxC capabilities in the Columbia River Basin. The Separation-by-Code protocol is used to divert specific tagged fish, based on their individual tag codes, away from the general population of tagged or untagged fish. Separation-by-Code was originally developed to allow researchers to identify, divert, and trap specific tagged fish as they were detected in the juvenile bypass systems and adult fish passage facilities at the federal hydroelectric dams. In 2006, researchers used the SxC systems to recapture individual PIT-tagged smolts in the juvenile bypass systems at Lower Granite, Little Goose, McNary, and Bonneville dams. Researchers also used the SxC systems to re-capture tagged adult salmon and steelhead at the Bonneville Dam Adult Fish Facility and in the trap in the Lower Granite Dam fish ladder.

Table 28. 2006 SxC Action Code definitions.

AC	Title	Description
11	CSS-RR	CSS: Rapid River Hatchery Chinook
12	CSS-MC	CSS: McCall Hatchery Chinook
13	CSS-DW	CSS: Dworshak NFH Chinook
14	CSS-IM	CSS: Imnaha River hatchery Chinook
15	CSS-CC	CSS: Catherine Creek hatchery Chinook
16	CSS-WF	CSS: Wild/unmarked steelhead and Chinook
31	DSS-D	Disease Susceptibility Study - Dworshak NFH
32	DSS-RR	Disease Susceptibility Study - Rapid River Hat.
41	NPT-NA	Johnson Creek Evaluation (NPT) - Take no action.
46	CLWH	Clearwater Hatchery Spring/Summer Chinook
47	TTSTHD	Touchet and Tucannon river steelhead
48	ASOTIN	Asotin Creek Steelhead - No Action
49	GRSTHD	Grande Ronde Subbasin Steelhead - No Action
51	BEARVC	Bear Valley Creek 2005 tagging
52	SULFUC	Sulfur Creek 2005 tagging
53	CHAMWF	Chamberlain Creek West Fork 2005 tagging
54	ELKC	Elk Creek 2005 tagging
55	HERDC	Herd Creek 2005 tagging
56	LAKEC	Lake Creek 2005 tagging
57	MARSHC	Marsh Creek 2005 tagging
58	UBIG2C	Upper Big Creek 2005 tagging
59	LBIG2C	Lower Big Creek 2005 tagging
60	SALRSF	SF Salmon River 2005 tagging
61	SECESH	Secesh River 2005 tagging
62	VALLEY	Valley Creek 2005 tagging
63	LOONC	Loon Creek 2005 tagging
64	CAMASC	Camas Creek 2005 tagging
65	CAPEHC	Cape Horn Creek 2005 tagging
66	SA05MY	All Steve Achord 2004 Salmon Basin tagging
71	B2EVAL	Eval Age 1 Chinook in transport pipe at BON PH2
76	XPTEVL	Chinook tagged at LGR for Extra Mortality Study
81	FC1DVT	Age 1+ fall Chinook to be left inriver
82	FC1XPT	Age 1+ fall Chinook to be transported
83	FC0GRJ	Age 0 fall Chinook to be collected at GRJ
84	FC0XPT	Age 0 fall Chinook to be transported
85	FC0B2J	Age 0 fall Chinook to be collected at B2J
89	FCRTRN	Returning fall Chinook to be collected at LGR
91	NPTSFS	SF Salmon Chinook tagged by the Nez Perce Tribe
92	JLCSFS	SF Salmon Chinook tagged for the Univ of Idaho
93	SMMCCA	McCall hatchery Chinook tagged for the SMP
94	UIMCCA	McCall hatchery Chinook tagged for the U of I
96	SHAD04	Shad tagged in 2004
97	SHAD05	Shad tagged in 2005
101	RPERRY	USGS Target tags at LGS
254	PTOC-2	PTAGIS Stick Tags - Alternate Gate Action
255	PTOC-1	PTAGIS Stick Tags - Default Gate Action

In addition to two groups of "stick tags" used by PTOC to test and tune the SxC systems, 44 separate groups of tagged fish were flagged in 2006 for SxC recognition at one or more sites. Each group was assigned its own SxC Action Code, as shown **in Table 28**. PTOC supported SxC requests from the 13 research and monitoring projects listed in **Table 29**. Over 1.5M individual fish were flagged for SxC action at one or more sites in 2006 (see **Table 30**).

By default, PIT-tagged fish detected at the four transportation sites in the Columbia and Snake rivers are normally routed back to the river. Since 1996, a substantial number of PIT-tagged fish have been "diverted" to the raceways at those sites, and then transported along with the general untagged population, using SxC to override the default routing action. This was the case again in 2006. However, because of the "Spread the Risk" policy implemented at the Snake River transportation sites during the first few weeks of the 2006 collection season, all fish, including those with PIT tags, were returned to the river at Lower Granite, Little Goose, and Lower Monumental prior to the week of April 21.

Table 29. Research and monitoring projects requesting SxC actions in 2006.

SxC ID	Project ID	Project Title	Project Description
2006001	FWP:1996-043-00	Johnson Creek Artificial Propagation Enhancement Project/LSRCP agreement#14110-3-j010 - NPT	Treat PIT-tagged groups as non-tagged fish at juvenile transportation sites.
2006002	FWP:1996-200-00	CSS - Comparative Survival Study	Proportional transportation of hatchery Chinook groups and wild fish at LGR, LGS, LMN and (possibly) MCN dams.
2006003	COE: See Title	Evaluate timing/condition of Age-1 Chinook passing through the BON PH2 fish bypass transport pipe.	PIT-tagged fish will be released at the upstream entrance to the transport pipe, and collected via SbyC.
2006004	COE: See Title	Disease Susceptibility Study - COE/NMFS	Chinook tagged at Dworshak NFH and Rapid River Hatchery will be collected at LGR and BON dams, and removed to a research facility.
2006005	FWP:1991-028-00	Monitor wild Snake River Chinook salmon migrations - NMFS	Sample fish at Little Goose that were marked in various Salmon River drainages in 2004 and 2005.
2006006	BPA:00-GS-75064	Estimate SARs for endemic stock hatchery steelhead released to the Touchet and Tucannon rivers.	PIT-tagged fish will be treated similar to the untagged population when detected at LMN or MCN.
2006007	LSRCP:See Title	LSRCP M&E #14110-6-J009: Clearwater Hatchery Spring/Summer Chinook	PIT-tagged fish will be treated similar to the untagged population when detected at LGR, LGS, LMN, or MCN.
2006008	COE: See Title	Subyearling Chinook salmon transportation and life history studies.	Transport wild and hatchery subyearling Chinook. Collect some age-1+ subyearling Chinook at LGR and BON. Collect scale samples at BON (for juvenile fish) and LGR (for adult fish). Transport CH-0 group. Collect 100% of CH-0 Growth group at GRJ.
2006009	FWP:2002-053-00	Monitor Passage of Asotin Creek Steelhead at federal transportation facilities	PIT-tagged fish will be treated similar to the untagged population when detected at LGR, LGS, LMN, or MCN.
2006010	COE: See Title	U of I radio tagging of adult salmon and steelhead at the BON AFF. Contract #DACW68-01-D-0006-0005	Selective trapping of PIT-tagged salmonids and shad at the BON AFF.
2006011	Batelle: See Title	Evaluate the molecular effects of *transported versus in-river migration* of juvenile Chinook salmon.	Collect 20 fish over a twelve-hour *period at MCJ from a population of 12k* fish released at LGR on May 3 for the NOAA-Fisheries Extra Mortality study.
2006012	COE: See Title	Fish Telemetry Studies at Lower Granite and Little Goose dams. MIPR #W66QKZ50145826.	Evaluate the condition of fish that have been surgically implanted with a radio-transmitter.
2006013	BPA:00-GS-75064	Smolt outmigration timing and survival, for LSRCP steelhead emigrating from the Grande Ronde River.	PIT-tagged fish will be treated similar to the untagged population when detected at LGR, LGS, LMN, or MCN. ODFW Project #40800-732002.

Table 30. Totals of PIT tag codes, by Action Code, in the 2006 SxC lookup database.

Action Code #	Title	B2J	JDJ	MCJ	LMJ	GOJ	GRJ	BO3	GRA
11	CSS-RR			34,540	34,540	34,540	34,540		
12	CSS-MC			34,517	34,517	34,517	34,517		
13	CSS-DW			34,620	34,620	34,620	34,620		
14	CSS-IM			13,920	13,920	13,920	13,920		
15	CSS-CC			13,967	13,967	13,967	13,967		
16	CSS-WF			60,869	60,869	60,869	60,869		
31	DSS-D	62,870					62,870		
32	DSS-RR	62,243					62,243		
41	NPT-NA			30,344	30,344	30,344	30,344		
46	CLWH			40,426	40,426	40,426	40,426		
47	TTSTHD			30,000	30,000				
48	ASOTIN			3,113	3,113	3,113	3,113		
49	GRSTHD			7,154	7,154	7,154	7,154		
51	BEARVC					1,000			
52	SULFUC					274			
53	CHAMWF					798			
54	ELKC					1,002			
55	HERDC					509			
56	LAKEC					415			
57	MARSHC					777			
58	UBIG2C					1,688			
59	LBIG2C					817			
60	SALRSF					1,009			
61	SECESH					1,092			
62	VALLEY					2,218			
63	LOONC					489			
64	CAMASC					500			
65	CAPEHC					238			
66	SA05MY					19,886			
71	B2EVAL	1,022							
76	XPTEVL			12,132					
81	FC1DVT	83,272					83,272		83,272
82	FC1XPT	84,844		84,844	84,844	84,844	84,844		84,844
83	FC0GRJ						5,499		
84	FC0XPT			275,955	275,955	275,955	275,955		
85	FC0B2J	124,397							
89	FCRTRN								312,330
91	NPTSFS							13,814	
92	JLCSFS							3,000	
93	SMMCCA							103,099	
94	UIMCCA							39,578	
96	SHAD04							44	
97	SHAD05							605	
101	RPERRY					5,800			
254	PTOC-2	497	497	497	497	497	497	497	497
255	PTOC-1	1,689	1,689	1,689	1,689	1,689	1,689	1,689	1,689
DB Totals:		**420,834**	**2,186**	**678,587**	**666,455**	**674,967**	**850,339**	**162,326**	**482,632**

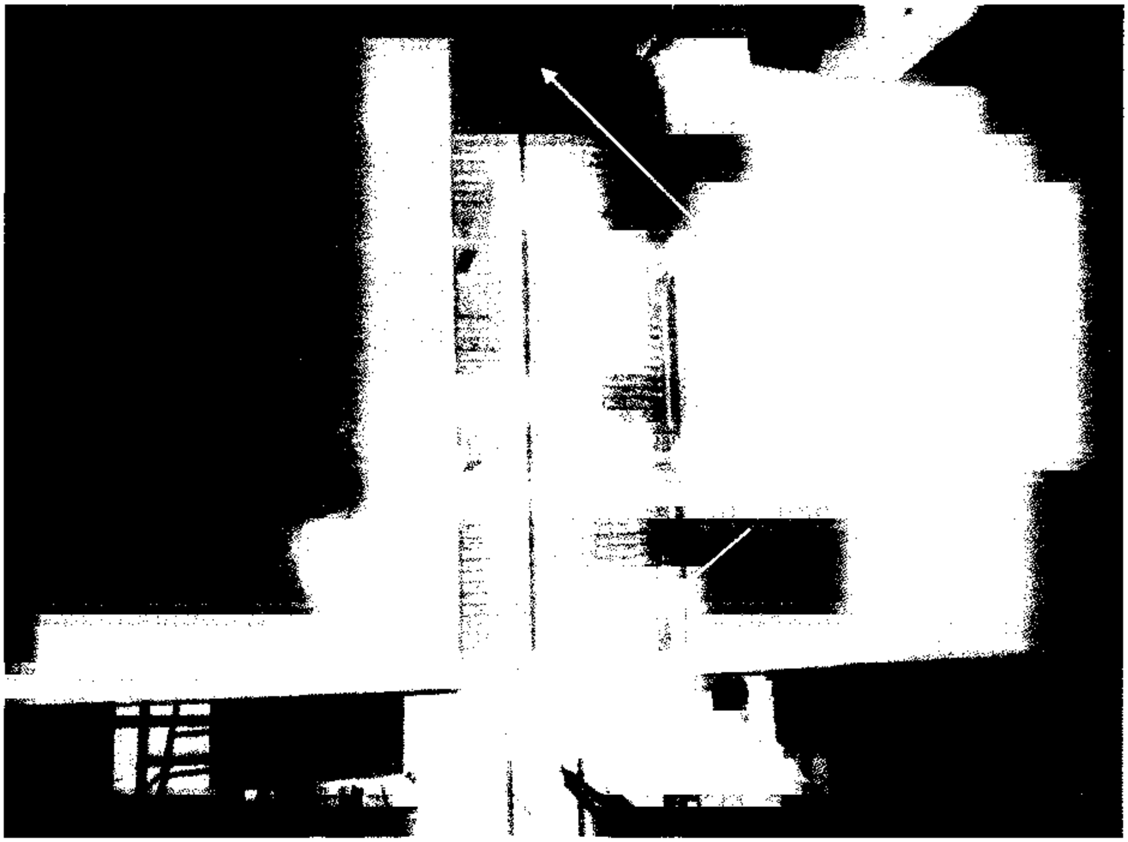
APPENDIX 4: Bonneville Corner Collector PIT Tag Detector Support

B2CC Antenna Testing and Results
February - March 2006
Bonneville Dam Powerhouse 2

Initial Alignment and Fitting of the Two Antenna Halves

The two antenna halves arrived at Bonneville Dam PH2 on February 13th, 06 and assembly commenced on February 14th. PolyCycle Inc. found that the antenna halves were somewhat warped due to the long trek by truck from Pittsburgh Pa. Some of this distortion was due to some of the internal bracing and support structure had wiggled loose therefore not providing the stability to the structure that was desired.

The arrow below shows an example of the mis-alignment.



Several methods were used to bring the two pieces back into alignment. Clamping and tugging with mechanical pullers were used again to help with realignment. The thought was that in the 70 degree environment that the powerhouse provided would allow the poly-propylene copolymer material to relax and become more flexible to facilitate the realignment process.