Columbia Basin PIT Tag Information System (1990-080-00)

2021 Annual Report

BPA Project # 1990-080-00

Report covers work performed under BPA contract #(s) 78040 REL 35

Report completed under BPA contract #(s) 78040 REL 46

1/1/2021 - 12/31/2021

John Tenney, Don Warf, Nicole Tancreto, Scott Livingston, Darren Chase

Pacific States Marine Fisheries Commission, Portland, OR, 97202

Report Created June 2022

This report was funded by the Bonneville Power Administration (BPA), U.S. Department of Energy, as part of BPA's program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The views in this report are the author's and do not necessarily represent the views of BPA.

This report should be cited as follows: Tenney, Warf, Tancreto, et al., Columbia Basin PIT Tag Information System, 1/1/2021 - 12/31/2021 Annual Report, 1990-080-00

Table of Contents

Table of Contents 2
Executive Summary 4
2021 Highlights 4
Background 9
Data Management 9
D: 160. Operate, Maintain and Enhance the PTAGIS System 13
Field Data Collection Systems Background 13
Server Data Management Systems 19
Web Data Management Systems 21
E: 160. Operate and Maintain the Separation by Code Database 25
2021 Accomplishments 26
2022 Plans 27
Interrogation Site System O&M and Installation 27
F: 70. Support Separation by Code Systems 28
2021 Accomplishments 29
2022 Plans 31
G: 70. Install Interrogation Systems in Field Locations 32
2021 Accomplishments 32
2022 Plans 36
H: 160. Operate and Maintain Interrogation Systems in Field Locations 36
2021 Accomplishments 37
2022 Plans 40
J: 122. Additional Support Actions 41
2021 Accomplishments 41
2022 Plans 43
Administration, Management and Coordination 44
C: 119 Routine Administration of the Contract 44
2021 Accomplishments 44
2022 Plans 45
I: 122 Technical Support and Training Assistance to Field Users 45
2021 Accomplishments 45
2022 Plans 45
K: 189 Coordination- Columbia Basinwide 45

Data Contributor Coordination 46
PIT Tag Distribution and Quality Assurance 46
2021 Accomplishments 46
2022 Plans 48

Executive Summary

The **Columbia Basin PIT Tag Information System (PTAGIS)** is a coordination and data management project of Pacific States Marine Fisheries Commission (PSMFC). PTAGIS develops software used to collect and contribute Passive Integrated Transponder (PIT) tag data; manages and provides those data for download and for reporting through the PTAGIS website; and operates and maintains large scale PIT tag detection sites throughout the Columbia Basin. This project is an important prerequisite component of all PIT tag research conducted for the Bonneville Power Administration (BPA) Columbia Basin Fish & Wildlife Program.

Researchers from twenty-eight organizations contributed data for 1.95 million fish marked with a PIT tag in 2021, with an accumulated total of nearly 53 million fish PIT-tagged since 1987.

Observation data collection occurs when PIT-tagged fish pass through automated detection systems, called interrogation sites, installed in facilities or streams. In 2021, the 283 interrogation sites contributing data to PTAGIS detected 842,171 unique fish, yielding a cumulative, detected fish total exceeding 19 million. One fish can generate many observation records as it passes through multiple PIT tag antennas at an interrogation site; 10.8 million observations were reported to PTAGIS in 2021, increasing the total number of observations recorded since 1987 to 267 million.

PTAGIS Operations and Maintenance (O&M) staff, headquartered in Kennewick, WA, are responsible for direct management and maintenance of thirty, large scale interrogation sites throughout the Columbia Basin, primarily at mainstem dam locations. This involves daily monitoring and regular onsite visits to maintain the detection equipment that provides the majority of the 267 million observation events available in the database. PTAGIS also supports the Separation by Code (SbyC) systems at nine locations, which enables researchers to selectively segregate individual PIT-tagged fish from other tagged and non-tagged fish. O&M staff also participate in the design, planning, and installation of new interrogation sites and detection technology.

2021 Highlights

Data Management: PTAGIS processed 820 thousand data files with 26 million records inserted into or updated in the database. All data is accessible to anyone through the PTAGIS website; this year, 566 users executed 694 thousand queries resulting in 13.3 billion rows of returned data.

New Website: a multi-year effort culminated in the launch of a brand-new PTAGIS website (*Figure 1*). The website was developed in-house using leading edge technology to present a clean and responsive design that looks good on all devices (desktops, tablets and phones). In addition to new features and numerous enhancements, existing users accounts and personalized reports were migrated to the new website ensuring a seamless transition. Since the launch in June 2021, the site averaged 17 hundred unique visitors viewing 17 thousand pages per month. A user survey conducted at the end of the year confirmed high levels of satisfaction and provided constructive feedback for further refinement.

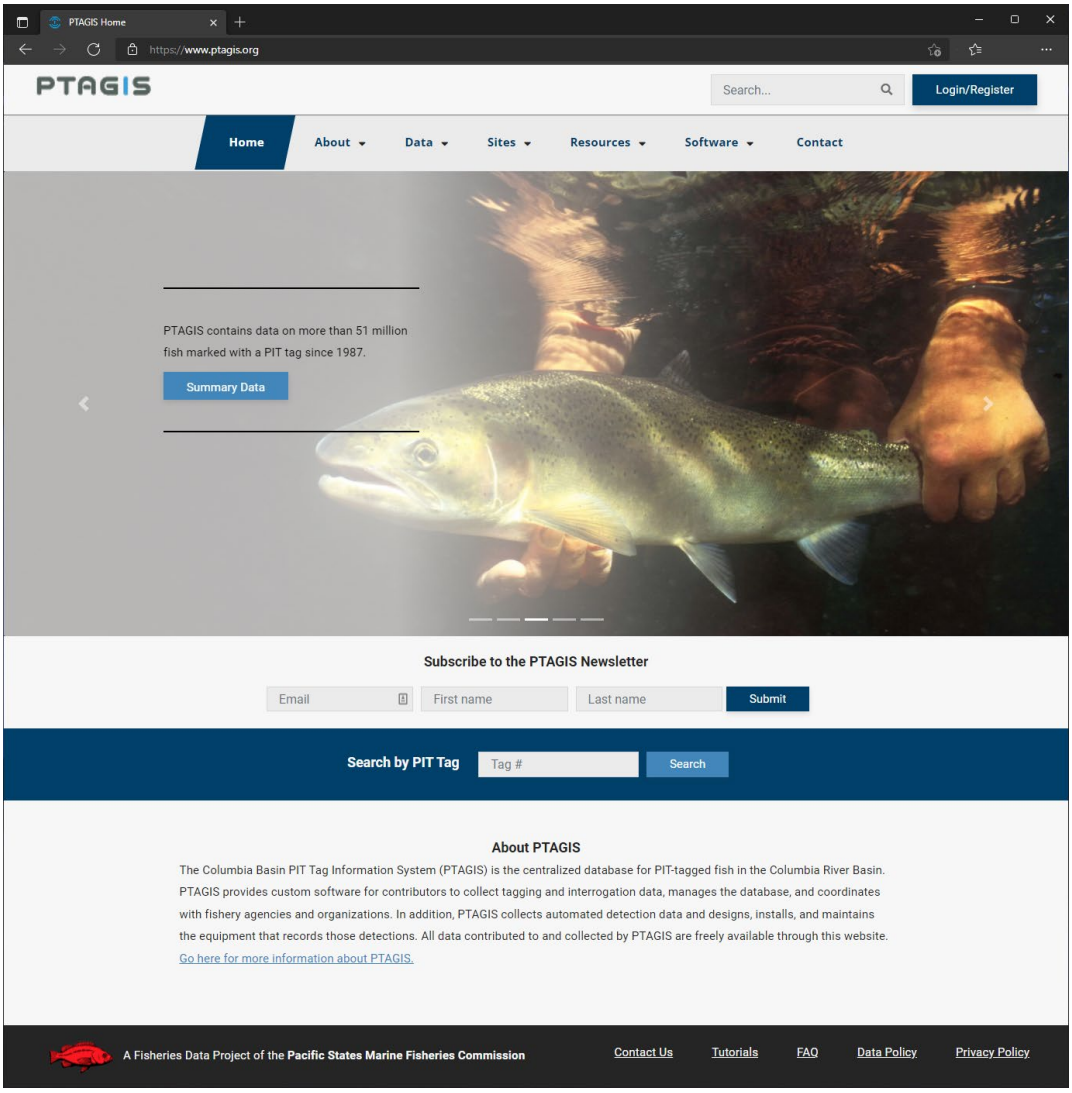

Figure 1. *Home page of the new PTAGIS website*

System-Wide Data Collection Platform Upgrade: automated data collection systems at 25 remote interrogation sites operated by PTAGIS were upgraded with new hardware and software. Obsolete computers and networking equipment were replaced with industrial-grade counterparts to ensure the program's goals for security, availability and performance for the foreseeable future. New M5 interrogation software developed by staff is now operating at these sites, uploading 35 thousand files of continuous observation data to the database. Staff also replaced poorly performing DSL internet service with cheaper and more reliable microwave and cellular data services.

Staff have completed the platform upgrades for the first SbyC interrogation site at Lower Monumental Dam juvenile fish passage facility (LMJ). Sites operating SbyC require additional upgrades to the facility control systems used to divert fish and allow site personnel to operate sample and diversion gates via touch-screen control panels (HMI). The experimental electronic slide diversion gates installed last year at LMJ demonstrated their overall effectiveness in diverting fish while reducing maintenance efforts compared to the pneumatically-controlled systems they replaced. U.S. Army Corps of Engineer site biologists have requested PTAGIS upgrade slide diversion gates at other sites with this technology as soon as possible. LMJ will be the first site to operate and evaluate the complex SbyC features of the new M5 interrogation software during the 2022 juvenile out-migration.

The upgraded data collection platform and other related systems were integrated into the supervisory control and data acquisition (SCADA) system in support of real-time monitoring of interrogation sites operated by PTAGIS. The SCADA system has significantly enhanced O&M efforts and reduced travel to sites.

Installation of Interrogation Systems: replaced obsolete and unrepairable solid body antennas in the serpentine weirs of the Washington Shore ladder at Bonneville Dam (BO4) with newly designed, lower cost slot antennas (*Figure 2*) fitted with underwater cable technology recently developed by NOAA. The new antennas operated flawlessly this year with detection efficiencies above 99.5 percent. Staff completed the installation of four antennas at the Bonneville Dam Cascade Island Fish Ladder (BO2). Work on a relocated electronics room near the counting window is nearly complete and the enhanced BO2 site will be fully operational for the 2022 season. With additional funding from BPA, new detection systems were installed at Lower Granite, Little Goose, and Lower Monumental juvenile fish passage facilities to monitor PIT-tagged fish loaded onto transportation barges.

Figure 2. *Installation of a slot antenna at Washington Shore serpentine weir (BO4)*

PTAGIS Software and Systems: researchers uploaded 19 thousand data files this year using P4 tagging software developed and released by PTAGIS over 5 years ago. As of June, all uploads were submitted through the new Web API component of the recently released PTAGIS website. Staff completed a series of online video tutorials to help new users configure, customize, and operate this fully-featured software for their specific research needs. A user survey conducted at the end of the year confirmed this mature software continues to meet the needs of the community.

For remote interrogation sites lacking power or communication to operate a dedicated data collection computer, PTAGIS released new I5 interrogation software letting stewards directly connect to one or more PIT tag readers at the site (in-person or over satellite/cell communication), download stored observation data, review and edit the data, and then submit it to PTAGIS with a push of a button. The software provides convenient profiles to store configuration for each site and tracks previously submitted data to prevent duplication.

A community release of the M5 interrogation software is planned for next year to support interrogation sites operated by agencies other than PTAGIS which can support a dedicated data collection computer. At the request of researchers, the software can be built to optionally run on Linux-based computers such as the Raspberry PI to leverage low-power requirements and reduce costs.

Additional internal software systems used by staff in support of program objectives were developed and further refined this year:

- *SbyC Configuration Manager* used to implement SbyC projects and push updated configuration to M5 operating at remote interrogation sites.
- *Tag Inventory Manager* used to inventory and distribute over a million PIT tags to various research projects each year.
- *Patch Manager* utility software used to patch gaps in observation data typically due to power failures at remote interrogation sites.
- *Transceiver Emulator* utility software emulates fish detection traffic at a large-scale interrogation site in support of M5 regression testing at the Kennewick lab.

Major updates to the database and extensive data migration were necessary in support of the new website. The database system was enhanced to process the new interrogation file format created by M5 and I5 interrogation software. The reporting server providing data to the research community was upgraded to the latest release and installed on new virtual server provided by the PSMFC IT department.

Impacts from Spill Program: the 2019-2021 Flexible Spill Operation Agreement is producing record-high spills in the last two years resulting in fewer fish passing via juvenile fish bypass facilities and reducing the number of PIT-tag detections at hydro facilities (*Figure 3*, shown in light green). The new spillway detection system that began operating two years ago at Lower Granite Dam has significantly boosted detections (*Figure 3*, shown in orange) as the amount of water spilled has increased at that site. However, researchers have noted the decreasing number of detections in juvenile bypass systems is lowering the precision to estimate fish passage elsewhere.[1] PTAGIS staff are working with NOAA and other research agencies to develop additional systems to increase juvenile detections, such as instrumenting the ice and trash sluiceway at the first powerhouse of Bonneville Dam as well as other potential projects at McNary Dam.

[1] Columbia Basin Bulletin, April 15, 2022, WITHOUT NEW SPILLWAY DETECTORS HARD TO KNOW IF HIGHER SPILL AT COLUMBIA/SNAKE DAMS IS BENEFITTING SALMON https://www.cbbulletin.com/without-new-spillway-detectors-hard-to-know-if-higher-spill-at-columbia-snake-dams-is-benefitting-salmon/

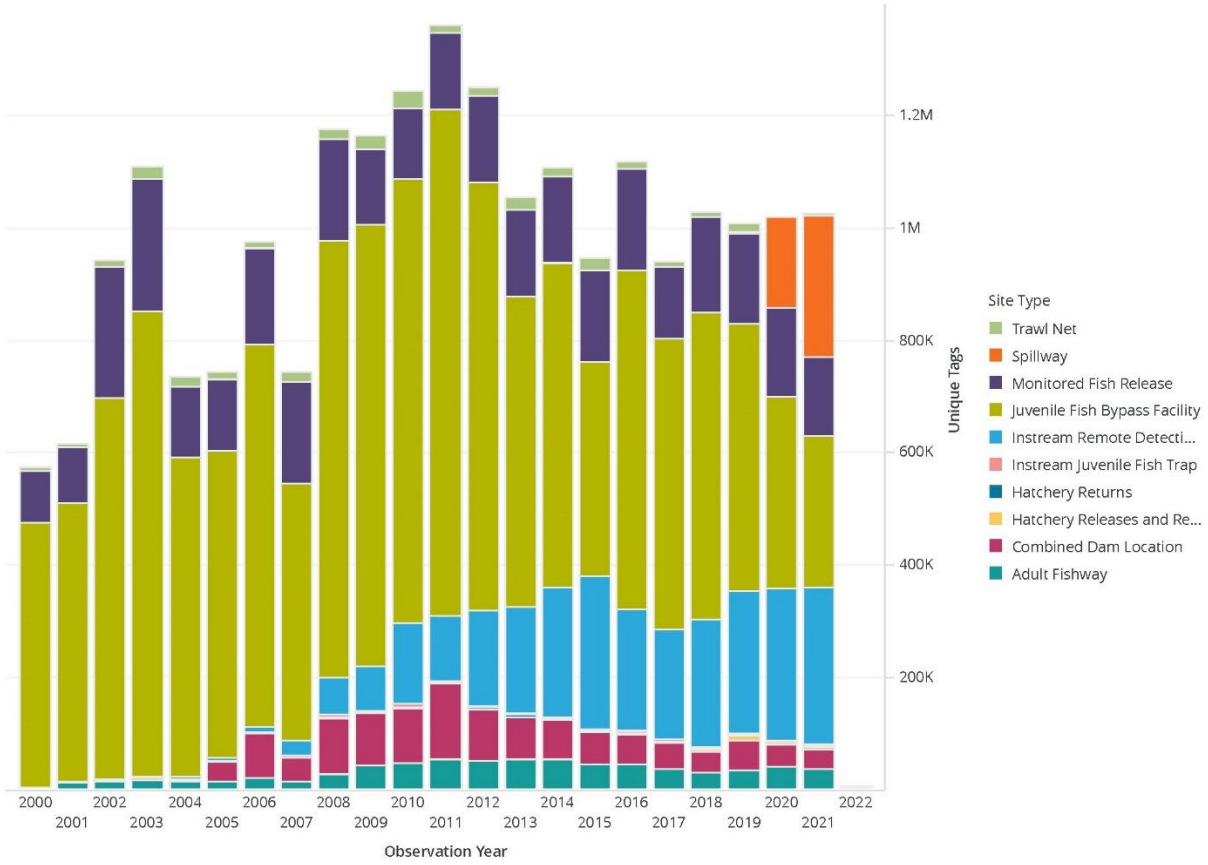

Figure 3. *Annual trend of unique tags detected at various types of interrogation sites*

Ongoing data management, coordination and O&M activities:

- Meeting coordination for the PIT Tag Steering Committee and Instream PIT Tag Data System (IPTDS) Subcommittee.
- Maintenance of validation codes used in data entry and reporting systems in addition to metadata and contact information for interrogation sites.
- Technical support to PTAGIS users.
- Publication of newsletters and news items.
- Provide computer-aided design (CAD) and other expertise in support of new interrogation site projects.
- Year-round daily monitoring of interrogation systems at large-scale mainstem dam fish passage facilities.
- Repair of detection system components.
- PIT tag distribution and quality assurance.

This year, the program's dedicated staff continued to work efficiently from their home offices, utilizing online collaboration tools for video conferencing, knowledge-sharing, and progress tracking. Multi-year objectives were completed and all contract work elements were delivered on-schedule and under-budget. The PTAGIS program continues to be a vital research tool to the region and provides an excellent return on investment to the BPA Fish and Wildlife Program.

Background

The Passive Integrated Transponder (PIT) tag is an electronic tag typically measuring 9 to 12 mm long and can be coded with one of 35 billion unique codes. The tag can be automatically detected and decoded in situ – eliminating the need to sacrifice, anesthetize, handle, or restrain fish during data retrieval. The PIT tag was developed in 1987 as a research and management tool for monitoring the movement of juvenile and adult salmonids in the Columbia River Basin. Detecting/recording devices strategically located within collection facilities at hydroelectric dams can automatically recognize fish injected with this tag.

When a fish is tagged, all related information about the tagging event and the individual fish is captured and entered into field software and uploaded to a central database by the organization responsible for the tagging. This information includes the unique PIT tag ID, tagging location, organization responsible for the tagging, species, run, rear type, weight, length, and condition. Once tagged, the fish is then released into the river system and can be identified and monitored indefinitely.

As the tagged fish migrates, it has the opportunity to pass through electronic interrogation antennas located in juvenile bypass facilities at many of the dams on the Columbia and Snake rivers as well as smaller instream detection sites in tributary locations. This electronic equipment automatically detects the PIT tag code, and records the time and location of detection. This information is automatically submitted to the central database where it is joined with the previously submitted tagging information.

When the tagged adult fish returns to the Columbia River system to spawn, the fish is again automatically detected at the permanent adult detection sites as it travels up-river. These data detections are associated with the previous information about that individual fish in the database and provides additional data on its history and migration.

The PIT tag Separation by Code (SbyC) process allows researchers to target individual tagged fish and separate them from the general population as they move through juvenile and adult fish passage facilities that are equipped with PIT tag actuated gates.

The Columbia Basin PIT Tag Information System (PTAGIS) was implemented in 1991 to manage the collection, correlation, and exchange of Columbia Basin PIT tag data. PTAGIS encompasses dedicated data collection software, a centralized relational database management system, and standardized data descriptions and reporting processes. In 2002, the scope of the Columbia Basin PTAGIS program expanded to include entries for resident and semi-anadromous stocks of rainbow and cutthroat trout, bull trout, and lamprey, sturgeon and other species.

Staff responsible for managing the data systems are located at the PSMFC headquarters in Portland, OR. A second field operations office is centrally located in Kennewick where staff designs, installs, and maintains the equipment and software needed for automated PIT tag detection and SbyC diversion. A PIT Tag Steering Committee (PTSC) provides program oversight, data standardization and technical coordination for the research community. Additional information about this program is available at www.ptagis.org.

Data Management

This section provides a summary of the program's overarching deliverable for 2021 and further describes work elements of the PTAGIS project related to collection, management and web delivery of all PTAGIS data.

PTAGIS received and processed 19,248 MRR (mark/recapture/recovery) data file submissions in 2021. Through these data file submissions, researchers contributed 1.95 million fish marked with a PIT tag to the PTAGIS database in 2021 with a cumulative 53 million records (*Figure 4*). These records were collected and submitted to PTAGIS by 28 organizations as they marked and released fish at 393 locations throughout the Columbia Basin. The composition of marked species was similar to previous years.

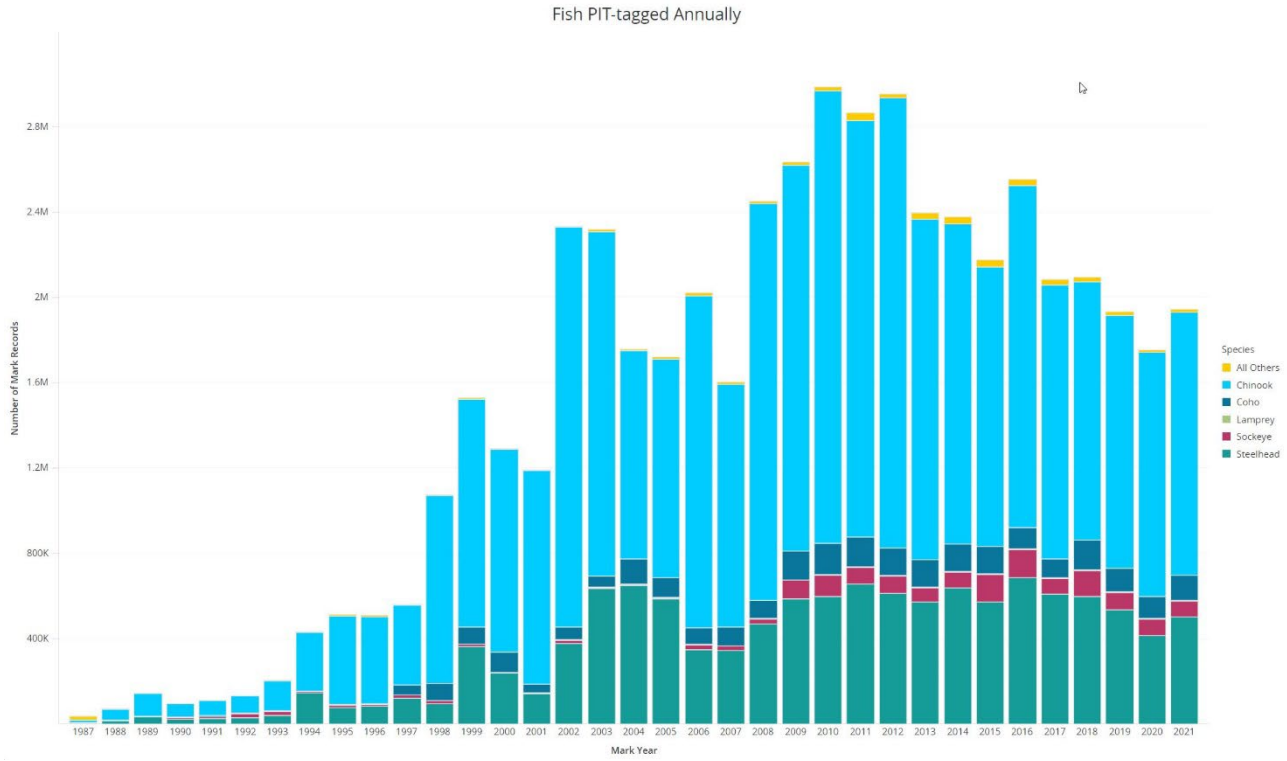

Figure 4. *Numbers of fish PIT-tagged annually by major species group.*

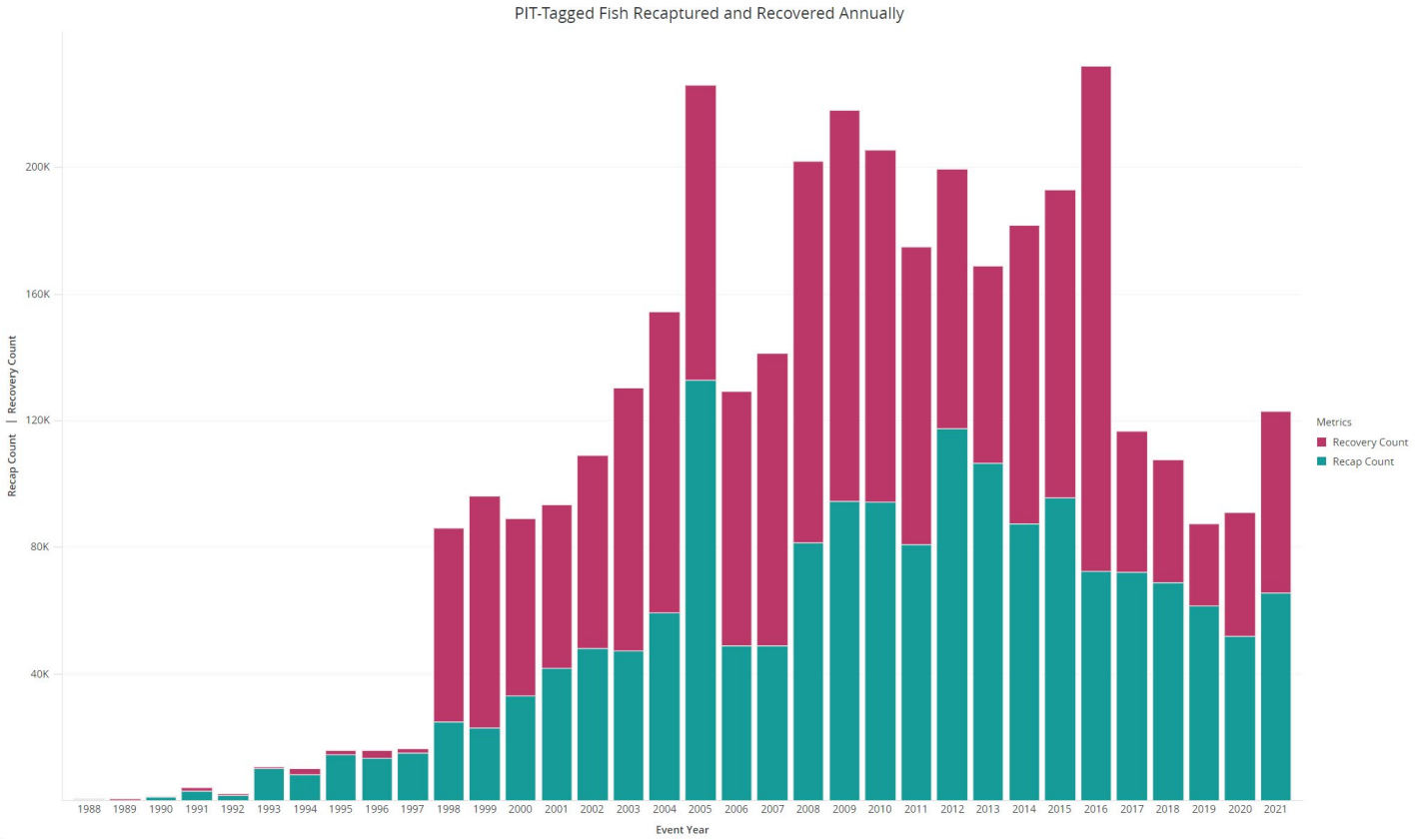

Figure 5. *Numbers of PIT-tagged fish recaptured or recovered annually.*

The number of marked fish reported as *recaptured and re-released* in 2021 was just over 65,000 and approximately 57,000 have been reported as recovered (*Figure 5*).

PTAGIS received and processed 809,176 interrogation data file submissions from 283 interrogation sites in 2021. These data file submissions contained detections of 842,171 distinct tagged fish (*Figure 6*). One fish can generate many interrogation records (observations) as it passes through multiple PIT tag antennas at one or more interrogation sites; 10.8 million observations were reported to PTAGIS in 2021 totaling 267 million observations since 1987.

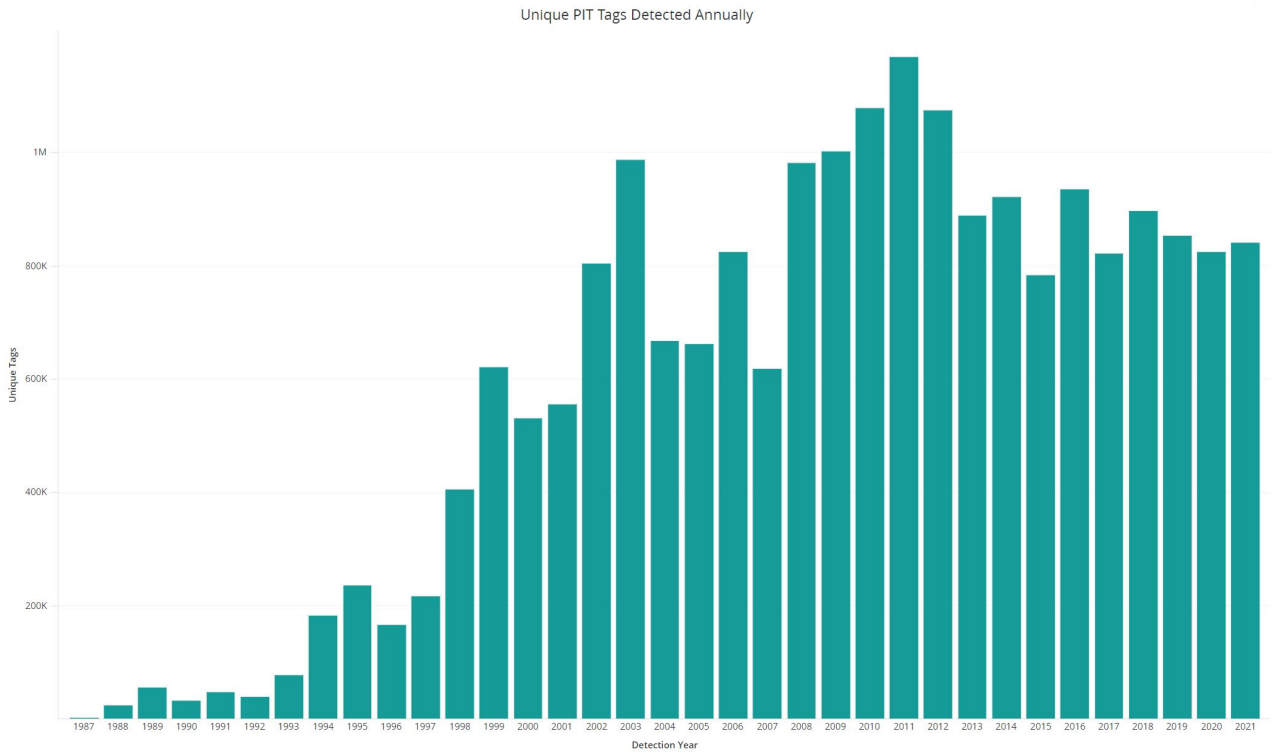

Figure 6. *Unique tags detected annually at interrogation sites registered with PTAGIS.*

To give additional scope to the overall data management efforts in 2021: 566 PTAGIS users executed 694,387 queries resulting in 13.3 billion rows of data returned. Those 566 users are grouped by their respective organizations in Table 1.

Organization	No. Users
All Others	164
Washington Dept. of Fish and Wildlife	60
Oregon Dept. of Fish and Wildlife	55
Idaho Dept. of Fish and Game	48
Nez Perce Tribe	35
U.S. Fish and Wildlife Service	34
Pacific States Marine Fisheries Commission	30
NOAA Fisheries	28
Yakama Nation	25
Colville Confederated Tribes	16
U.S. Army Corps of Engineers	14
Shoshone-Bannock Tribes	13
U.S. Geological Survey	12
University of Idaho	12
Columbia River Inter-Tribal Fish Comm.	10
Confed. Tribes of the Umatilla Indian Reser.	10
TOTAL	**566**

Table 1. *PTAGIS data access in 2021 summarized by organization*

D: 160. Operate, Maintain and Enhance the PTAGIS System

This objective delivers secure, high performance\availability systems for the collection and dissemination of near-real-time PIT tag data. Managed by PTAGIS staff in the Portland, OR office, the following three subsystems provide a logical grouping of this objective:

- Field Data Collection Systems
- Server Data Management Systems
- Web Data Management Systems

The following subsections provide background, efforts and plans related to each subsystem that comprise the whole of this objective.

Field Data Collection Systems Background

PTAGIS develops and maintains three basic types of field data collection systems described in Table 2. This software is freely available to the research community to download and install on any modern Windows-based PC.

System Type	Software	Description
Tagging Software	P4	Tagging software captures MRR data by interfacing with tag readers and other devices to provide an ergonomic and highly customizable data entry system to support various usages. Users can identify and correct issues with fish in-hand using robust validation and alerting. Authorized users can easily submit their datasets to PTAGIS using the software.
Interrogation Software	MiniMon, M4, M5	Interrogation software combined with communication networks provide unattended operation and continuous recording of observation data in real-time. The central database processes hourly uploads of observation data from hundreds of sites operating this software. Interrogation software provides automatic diversion of target fish to examination tanks or for transportation – called separation by code (SbyC).
Utility Software	I5, SbyC Configuration Manager Tag Inventory Manager, Tag Sorter Utility, Data File Repository Browser, Patch Manager, Peripheral Emulator	PTAGIS provides utility software to import, standardize and submit raw observation data collected from the internal storage of a tag reader operating at a small-scale interrogation site. PTAGIS also develops and supports internal software systems to perform data/configuration/file management, QA/QC, and performance regression testing of software systems.

Table 2. *Types of PTAGIS field data collection systems*

2021 Accomplishments

M5 Software Internal Release

Fifth-generation interrogation software, called M5 (*Figure 7*), was deployed into production at all monitoring-only PTAGIS sites (those not operating SbyC). This was the result of successful field evaluation conducted last year. The production deployment of this software coincided with the system-wide data collection platform upgrade (computers, networking, UPS systems) discussed in H: 160. Operate and Maintain Interrogation Systems in Field Locations. Since deployed into production in the third quarter of this year, M5 has operated without issue at 22 interrogation sites and uploaded 34-thousand data files into the database.

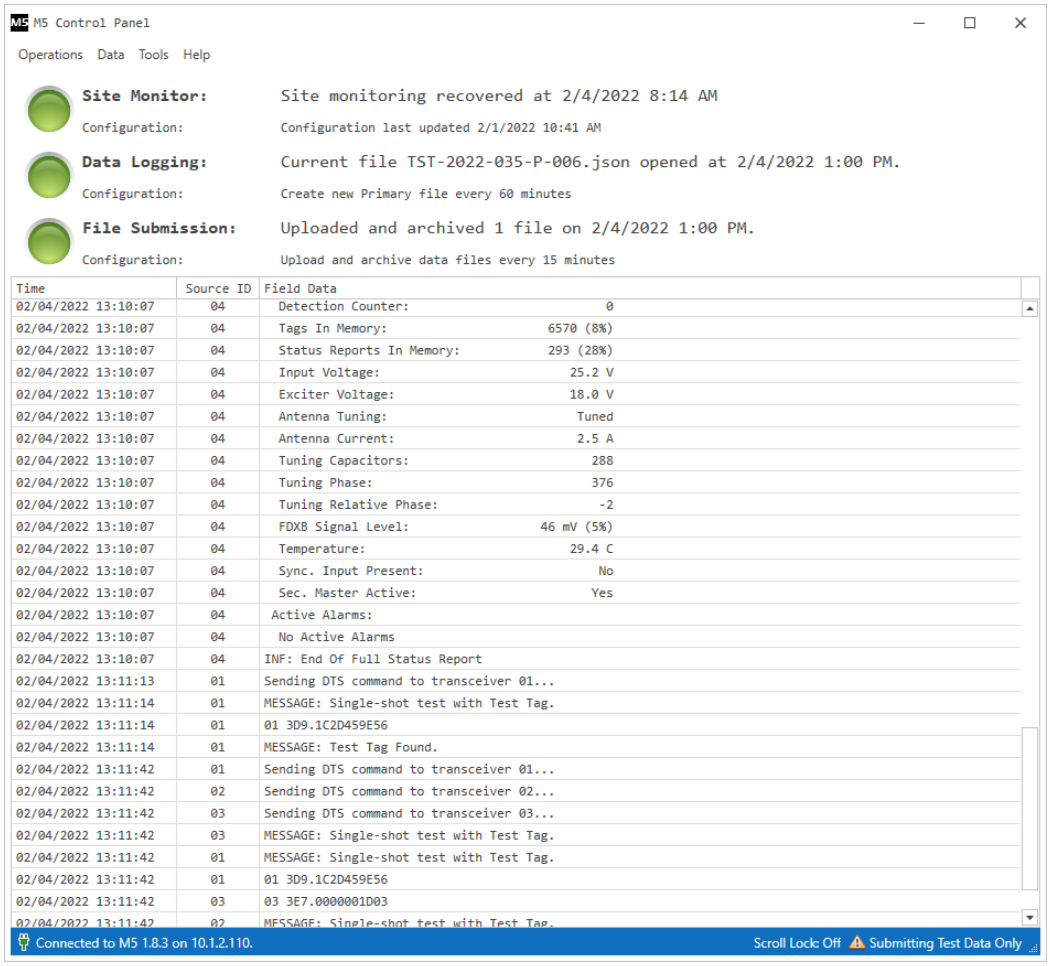

Figure 7. *Control Panel of new M5 interrogation software system*

Continued development of complex M5 SbyC features having real-time and high-availability requirements. This included further development of an internal application called *SbyC Configuration Manager* (*Figure 8*) to implement features such as deploying configuration updates with a push of a button to both M5 instances running as a high-availability cluster at a remote interrogation site. The M5 SbyC features were meticulously evaluated using a simulated interrogation site created in the Kennewick Lab (see F: 70. Support Separation by Code Systems). The simulation required redevelopment of utility software to emulate the rapid fish detection output from groupings of transceivers typical of a large interrogation site. Based upon lab evaluation added with successful production deployments at non-SbyC interrogation sites, staff determined the updated SbyC features of M5 were ready to operate in production at a target interrogation site as an in-situ evaluation for the 2022 juvenile out-migration. Based upon the evaluation, the software will be deployed to additional SbyC interrogation sites in conjunction with scheduled platform upgrades.

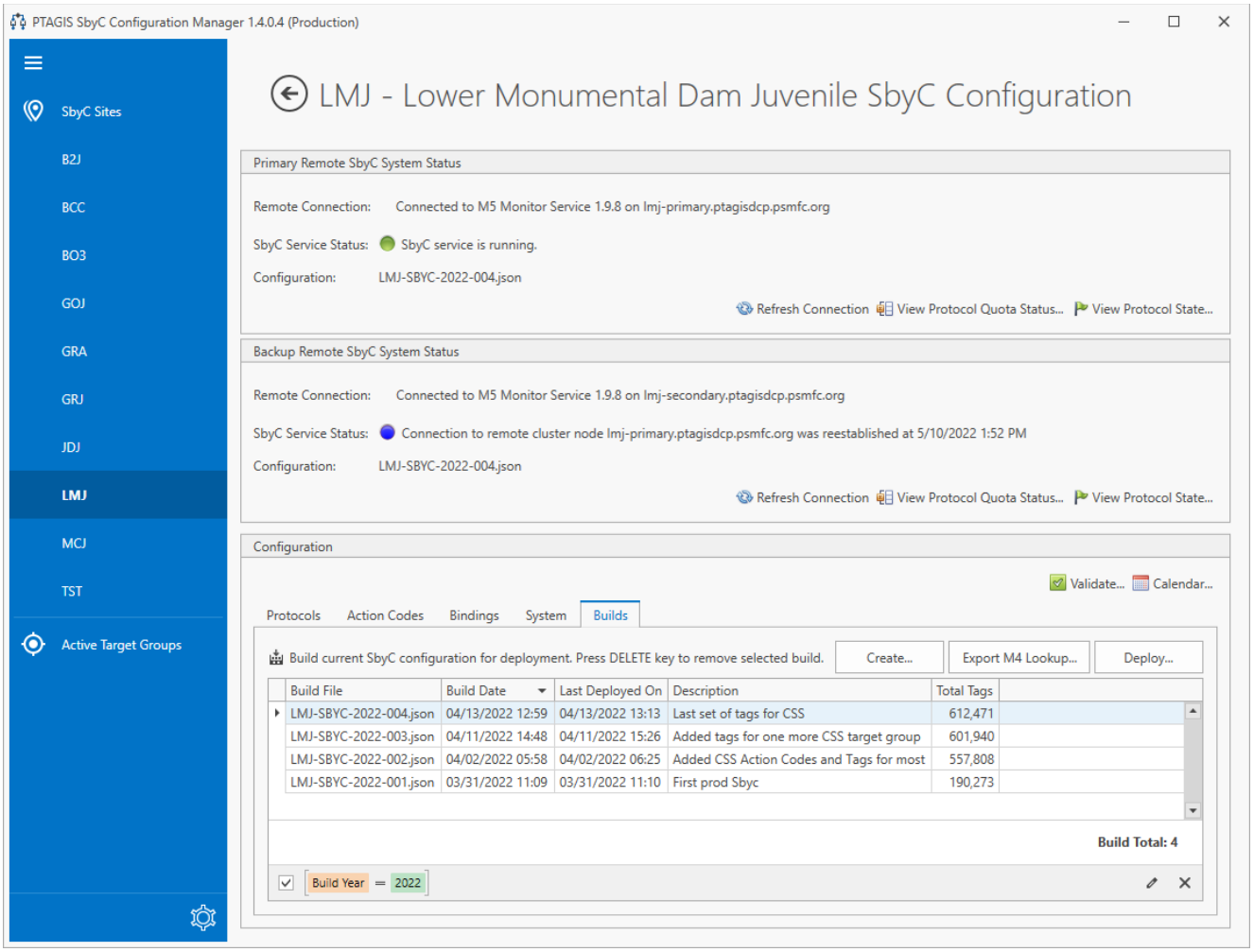

Figure 8. *SbyC Configuration Manager*

P4 Tagging Software Upgrades

P4 tagging software required only one minor update this year. Users uploaded 19-thousand data files to PTAGIS from this mature software released 5 years ago. As of June, all uploads were submitted through the new Web API (discussed in a subsequent section) and this transition was transparent to the users of P4. The software continues to perform well for a variety of use-case scenarios *e.g.* mass marking at hatcheries and capture-and-release studies at screw traps. It also scales up to handle a large number of data records in support of a common QA/QC workflow conducted by some agencies before data is uploaded to PTAGIS.

Towards the end of 2021 (and partially into early 2022) a user survey was conducted and received 79 responses (*Figures 9 and 10*). The overall high satisfaction of the software shown in Figure 10 trends with general feedback received over the years.

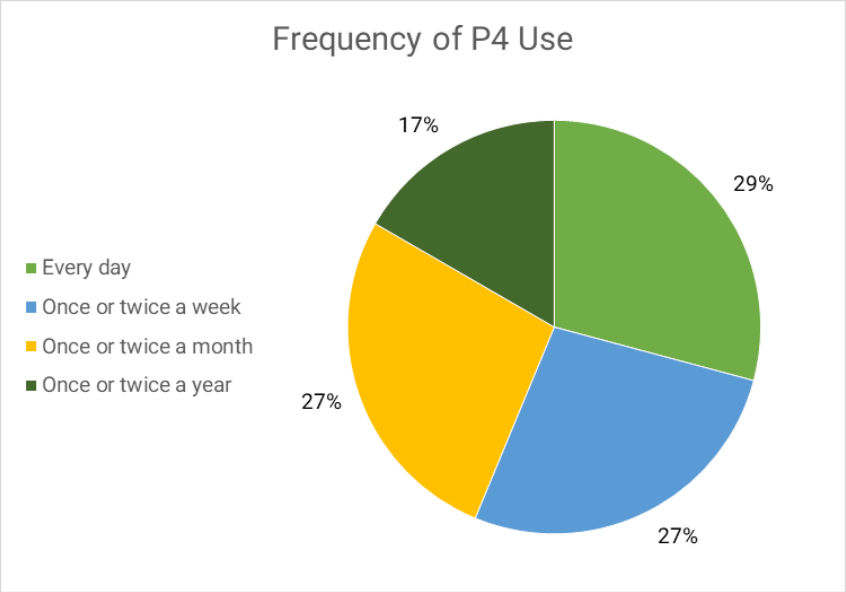

Figure 9. *P4 usage based upon user survey*

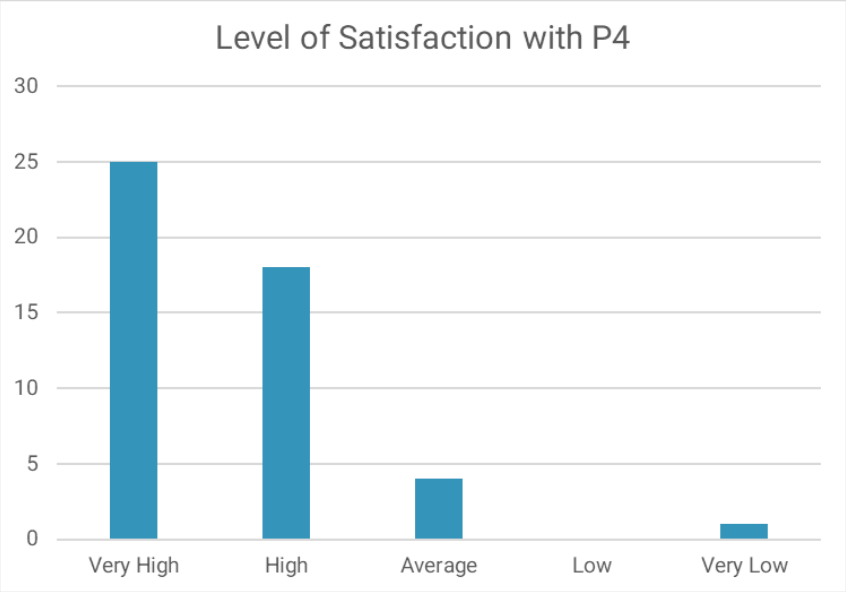

Figure 10. *P4 satisfaction based upon user survey.*

One issue with P4, however, is that it can be difficult to deploy on agency computers with restrictive security policies (the one survey response with a "*very low*" level of satisfaction in Figure 10 was because of this issue). The issue is a result of P4 installing an older version of SQL Server database server to support large workloads running on older 32-bit computers and newer 64-bit (x64) machines. This year staff evaluated other database options that could run the database 'in-process' with P4 and have fewer installation requirements. It was determined a few of the popular features, such as free-form queries on all records in a P4 database, would not perform well with the alternative databases. Upgrading the deployed SQL Server database to a newer version would solve the security/installation issue, but the P4 software could no longer operate on older 32-bit computers which are still prevalent in the research community.

Additional Utility Software Upgrades and Development

Continued development of I5 interrogation software in support of manual data collection and submission for remote instream interrogation sites. Refined data capture workflow for a better user experience. The data submission features were completed using the new Web API. The underlying application framework was upgraded to Microsoft NET6 for long-term support. Documentation and installer were also completed this year. A feature-complete beta release was provided to IPTDS Subcommittee for evaluation towards the last quarter of 2021.

The Tag Inventory and Management (TIM) software (*Figure 11*) was redeveloped using latest NET6 technology and a streamlined database schema aligned with related system upgrades. New features include UPS shipment integration with label printing support and a redesigned user interface/reports to improve overall usability. This software is used to inventory and distribute PIT tags to various FWPs (see PIT Tag Distribution and Quality Assurance). This software integrates with the new PTAGIS website that has updated workflow to allow users to request PIT tags for their projects and for BPA administrators to approve those requests.

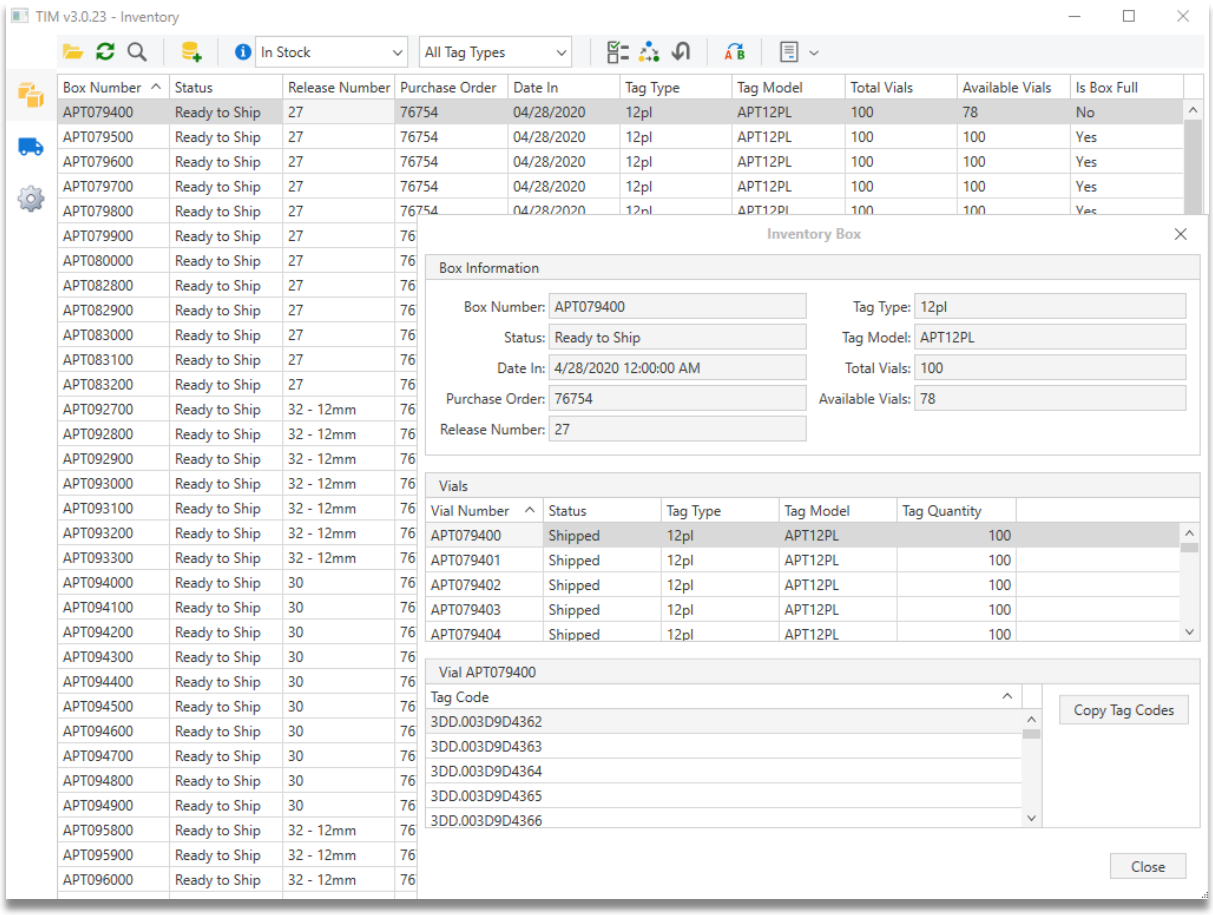

Figure 11. *Tag Inventory and Management 3.0 (TIM)*

Last year, staff developed utility software (*Figure 12*) to browse, view and audit the PTAGIS data file archive, called the Data File Repository Browser. This software allows staff to search for specific file submissions and manage millions of data files loaded into the database. This year, staff added new features to tag certain data files requiring 'follow-up actions' by the interrogation site steward or project coordinator to correct data files that do not meet validation. Staff can also select an interrogation data file and quickly view all observation records loaded into the database associated with that file.

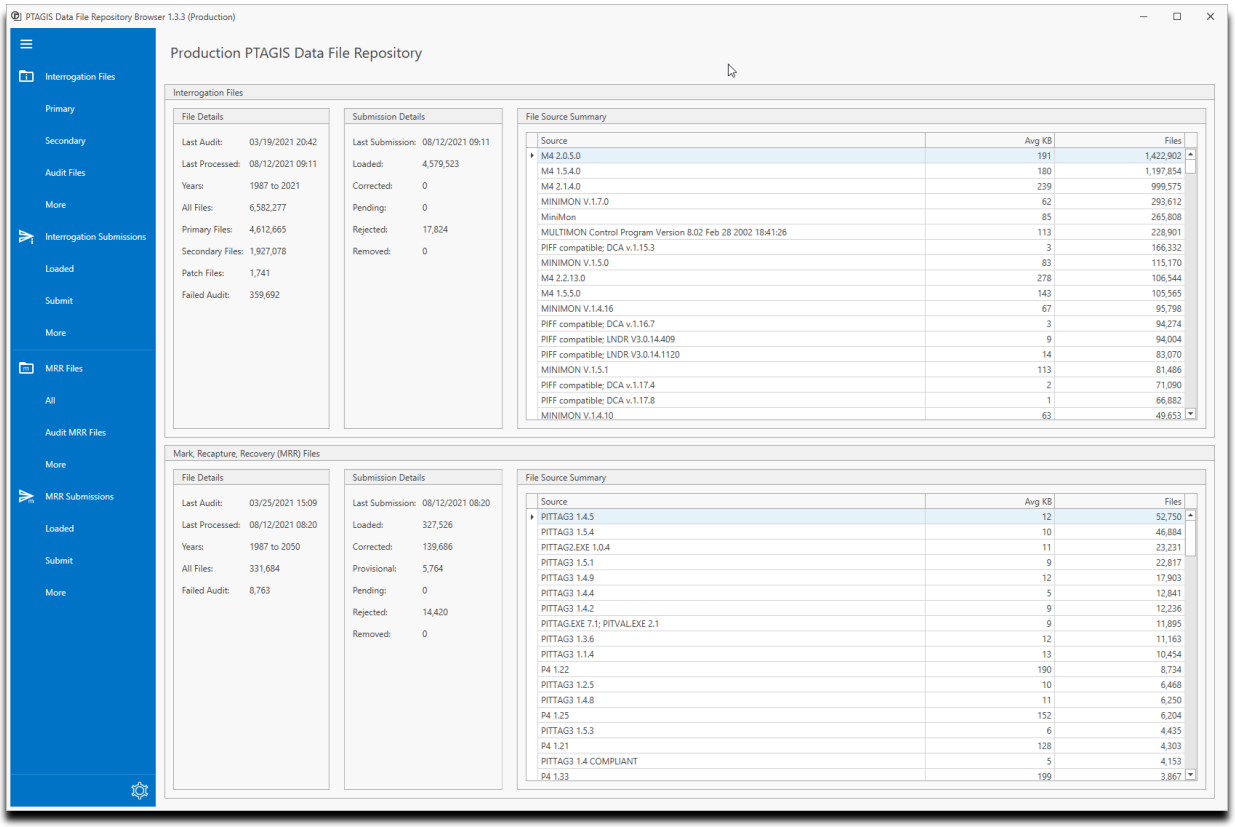

Figure 12. *PTAGIS Data File Repository Browser*

In support of high-availability goals of the program, staff must sometimes patch data from a multiple backup data sources when an interrogation site managed by PTAGIS encounters a power outage or other types of interruptions to primary data collection. This year, staff created a new version of the Patch Manager V2 (*Figure 13*) software to make this process much more efficient, supporting features of the new interrogation file format, and the ability to directly download transceiver memory buffers operating in the field via M5 software without the need to take them offline.

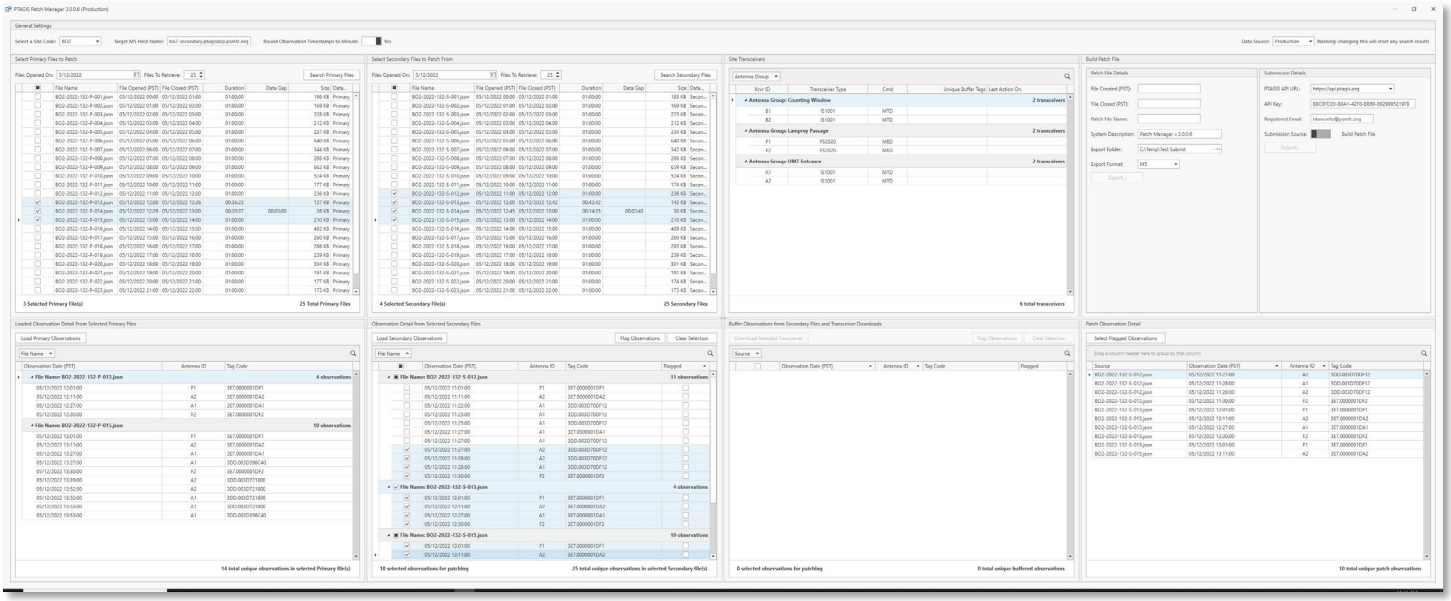

Figure 13. *Patch Manager V2 Utility Software*

Dev Ops Upgrade

Upgraded the technology stack used by staff to develop field and web software systems to the latest release of Microsoft .NET. This also included a challenging migration to the industry standard Git Repos system hosted in the cloud via Azure DevOps and provides source code control and work-item tracking. The P4 project was not migrated to the Git Repos system since it is nearing end-of-life and new development will start in 2022.

2022 Plans

Maintain all field data collection systems and enhance as needed. Continue refinement of all utility software utilized by PTAGIS staff in support of program objectives.

Evaluate SbyC features of M5 in-situ with M4 at the LMJ interrogation site. This will be coordinated after the data collection platform upgraded at that site. It will also require enhancements to the Diversion Gate Efficiency (DGE) analysis software to measure precision and performance of the new M5 SbyC system compared with M4. Review SCADA system integration in support of DGE analysis. Consider deployments at other PTAGIS interrogation sites operating SbyC in coordination with the ongoing data collection platform upgrade process. Make a general release of M5 for use at agency interrogation sites. This will include robust documentation and the ability to run the software on low-cost, low-power Linux devices such as a Raspberry Pi per the request of IPTDS Subcommittee.

Release I5 interrogation software into production and promote adoption at instream sites with technical support and training videos to guide site stewards.

Initiate the redevelopment the next-generation version of P4 software as a project named P5. Assemble a focus group of users to evaluate proof-of-concept, ergonomic-based solutions such as using tablet platforms as a potential replacement of using digitizer tablets for data entry and length measurements. Ensure P5 will meet the installation requirements in support of trending agency security policies that will also scale to meet large QA/QC workflows performance needs.

Server Data Management Systems

This portion of the objective addresses the continuous administration and development of a central repository for all PTAGIS data and related metadata. The central repository consists of relational and dimensional database systems that extract, transform, load and collate MRR and observation (interrogation) data submitted via various field data collection software systems developed by PTAGIS and other agencies. The deliverable of this objective is a highly functioning/available, cost-effective, extensible, and secure data management system.

Ongoing tasks related to this portion of the objective include:

- Maintenance and enhancement of system components that support the automated extraction, transformation and loading (ETL) of field data into the central transactional and dimensional databases in near real-time with data validation and integrity verification
- Tuning automated alerting system notifying data stewards of anomalous events such as data validation failures or when remote interrogation sites fail to upload on schedule
- System administration, tuning, backup and capacity planning following industrial best practices
- Maintain processing of periodic data file extracts to support large scale data users (FPC, DART)
- Provide extended support (outside office hours) to maintain the high-availability goals of the program

2021 Accomplishments

While concurrently administrating the production database, substantial effort was needed to remodel database features in support of rolling out the new website and the processing of a new data file format output from M5 and I5 interrogation software.

Database schema was created to house content previously stored in an off-the-shelf content management system (CMS) replaced by a custom CMS incorporated into the new PTAGIS website. Enhancements to programmatic metadata required modeling and refinement using copies of the current production database system. Just before the website was deployed into production this year, many of these database copies used for feature development were consolidated into formal database server environments (production, testing, and development) to support on-going enhancements for years to come. The consolidation included the fine-tuning of table indexes and partitioning to ensure the overall performance of the database. The database continues to operate on dedicated hardware to support high-performance/capacity computing. Three obsolete servers were formally retired after the consolidation.

To support interrogation site O&M requirements, developed automated features to import SCADA dataset into the production database in near-real time. Refined the Interrogation Data Loading (IDL) to support M5 and I5 formatted data files which include JSON schema validation, field data parsing, and enhanced alerting.

Staff leveraged free consulting from Microsoft to guide a series of evaluations to learn advantages of migrating the database into the cloud and to estimate upfront and annual costs. Established the existing database licensing is flexible during the migration process. Determined the current database server could be migrated to the cloud as an Azure SQL Managed Instance to significantly enhance security, performance and availability with affordable annual costs in line with the current program budget. Estimated annual costs for a similarly managed MicroStrategy reporting server were not affordable and may require further negotiations -- or continue operating the reporting server on a virtual server in the cloud that is managed by program staff and PSMFC IT as it currently is on-premise. Another area of concern is costs related to supporting large data file extracts used by FPC and DART such as the downloading of the larger annual-build files from the cloud could result in significant egress charges.

Staff discovered a concerning issue when restoring a portion of the database from cloud-based backup repeatedly failed with an unspecified error. Working with PSMFC IT and the backup software vendor, the issue couldn't be resolved and the portion of the database was recovered using other methods that took much more effort and time to complete. Staff reviewed all backup media for the entire database and couldn't recreate the problem again.

2022 Plans

Continue support of database processing (ETL) for data loading, reporting, and system alerting. Perform daily system administration to ensure the overall integrity of the PTAGIS database and backups. Refine features of transactional and dimensional databases and continue support for data file extracts for large scale data users. Implement features to reduce dependencies on obsolete data file submission systems (FTP and email) and transition downloading of automated research reports via the Web API.

Initiate lift-and-shift of database and related systems to Azure cloud, ensuring annual costs will not impact overall program budget. This 30-year program is constructed around large number of data files *processed into* the system and reporting files containing raw data *processed out* of the system and *imported elsewhere* for analysis. Similar systems built with technology from today are message-based for ingress of field data and the resulting data analysis performed in-the-cloud instead of extracting raw data downloads. Migrating the system as-is to the cloud will require it to remain file-based; verify egress costs of downloading reporting and data extract files large in number and size will not impact annual costs. The promise of migrating to the cloud is enhanced security and availability; unlocking of modern features

that could provide additional insights into this historic dataset, and safeguard maintenance efforts and costs are aligned with flat-funding for years to come.

Web Data Management Systems

The PTAGIS website (www.ptagis.org) provides online access to PTAGIS data, metadata, content and services to the public. Users can browse most of the online resources anonymously, but others needing identification and authorization require the user to create an account and log in to the system. The deliverable for this portion of the objective is a high performance, high available, cost-effective, extensible, and secure web server and reporting systems providing public access to PTAGIS data and related resources.

Key tasks related to this portion of the objective include:

- Development and refinement of online functionality such as:
    - Online request/approval workflow services, such as PIT tag distribution for all FWP
    - Content management
    - Community outreach features to support technical coordination
    - Web API interface to allow automated systems to consume and submit PTAGIS data and metadata
- Development and refinement of reports, dashboards and other related infrastructure for public research and internal O&M activities
- System administration, tuning, and capacity planning following best practices in the industry
- Interoperation with server data management systems and field data collection systems
- Support high-availability and security goals of the program and Commission

2021 Accomplishments

The final features of the new website (*Figure 1*) were completed and the MicroStrategy reporting system was upgraded to the latest release. Both systems are running on new virtualized servers managed by PSMFC IT. Refined the single sign-on feature between website user accounts and the advanced reporting features of the MicroStrategy reporting server. Migrated user accounts and up-to-date content from the legacy website into the underlying database supporting the new website. Incorporated new dossier technology to host quick reports on the new site for enhanced visualization. Fine-tuned the responsive layout allowing pages of the new website to be viewed on a variety of platforms such as smartphones. Ensured the new website achieved GDRP compliance.

Enhanced the PTAGIS Web API (*Figure 14*) with redesigned endpoints to support versioning of the interrogation data file format in the future. Additional endpoints were added in support of new features of the PTAGIS data file repository. Consolidated endpoints from legacy web API to support P4 features (including data submission) without impacting users.

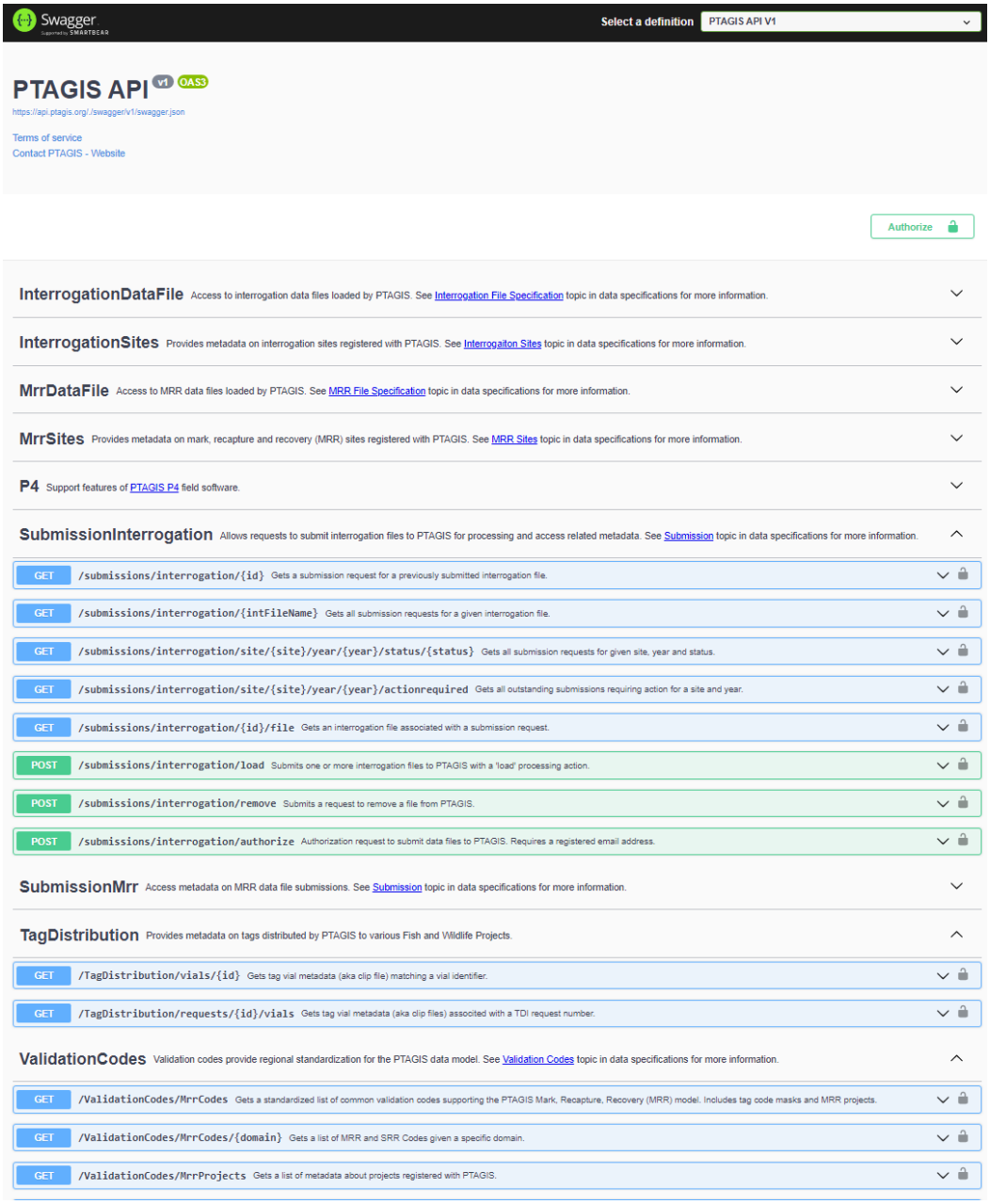

Figure 14. *Enhanced PTAGIS Web API*

After a pre-launch of the website for PTSC review, the new website (*Figure 1)* was launched into production in June. Users logging into the new site for the first time would use the same account name and then verify their email address via two-factor authentication while acknowledging updated data and privacy policies. All reports created by users in the legacy system were available in the new system. Eleven updates were deployed throughout the rest of the year to support features requested by the community and to fix bugs.

Some of the new features and enhancements included on the Public website (no login required):

- The popular *Complete Tag History* report can be quickly generated by entering a PIT tag code in the *Search by PIT Tag* field on the home page. Users can copy-and-paste up to 50 codes into the list box on the report page itself to view all data recorded in PTAGIS for fish marked with those tag codes.

- Enhanced *Quick Reports* are accessed from the *Data* menu on home page. The Observations report shows the tag detections at a single interrogation site over a period ranging from the last day to 5 years ago. By popular demand, the Adult Ladders report was added to query tag detections from combined ladder sites at a dam, so researchers can quickly see all the fish detected at Bonneville Dam overall (*Figure 15*) instead of site by site.

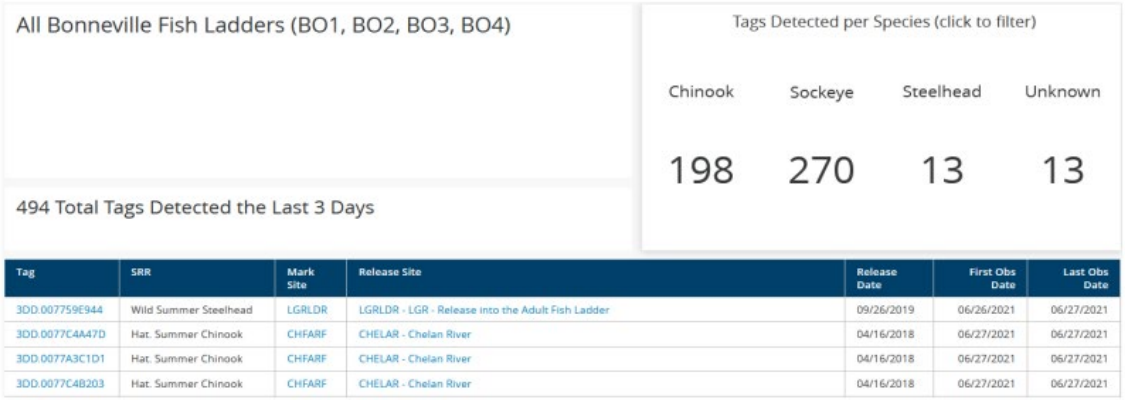

Figure 25. *New Adult Ladder Quick Report*

- An About section is available on the home page to introduce new users to PTAGIS, the PIT tag data, and the tools available through the website.
- The Video Library of tutorials for P4 and the reporting system have been updated and include closed captions.
- The PTAGIS Data Specification is available on the new site and referenced throughout.
- Search feature has been significantly improved on the new site, and will now find site codes and terms embedded into meeting notes or newsletter articles along with terms on any of the web pages.

Website features that require users to login are now located on the PTAGIS Dashboard (*Figure 16*) and include:

- Advanced reporting system used by researchers to build and run complex reports
- View and download loaded interrogation and loaded MRR data files, including any data files that require action (those rejected and not loaded)
- Request new validation codes, MRR projects, MRR sites, and tag masks
- Request new SbyC projects
- Request PIT tags for Fish & Wildlife Program projects
- View and submit event logs for interrogation sites
- View and manage MRR data submitters
- View a summary of the files and records submitted for a MRR project

New features were also added to the new site upon request of the PTSC and research community:

- The ability to record trap events allow those who run screw traps or weirs to record the operational status of a trap using a PTAGIS MRR site code as the trap identifier.
- New QA/QC reports are available under the **MRR Project Admin** section of the dashboard: Record Summary and Find Orphans. These reports have been available through the advanced reporting system, but having them available directly on the dashboard may be more useful to project coordinators.
- Researchers can now register test tags through the website instead of having to contact us via email. A test tag is one that intended for use only for testing PIT tag readers or interrogation site equipment operation. Once a tag is registered as a test tag, it will automatically be filtered out of the reporting system if received in MRR or interrogation data.

- Researchers can request to borrow a PIT tag reader for any Fish & Wildlife Program project.

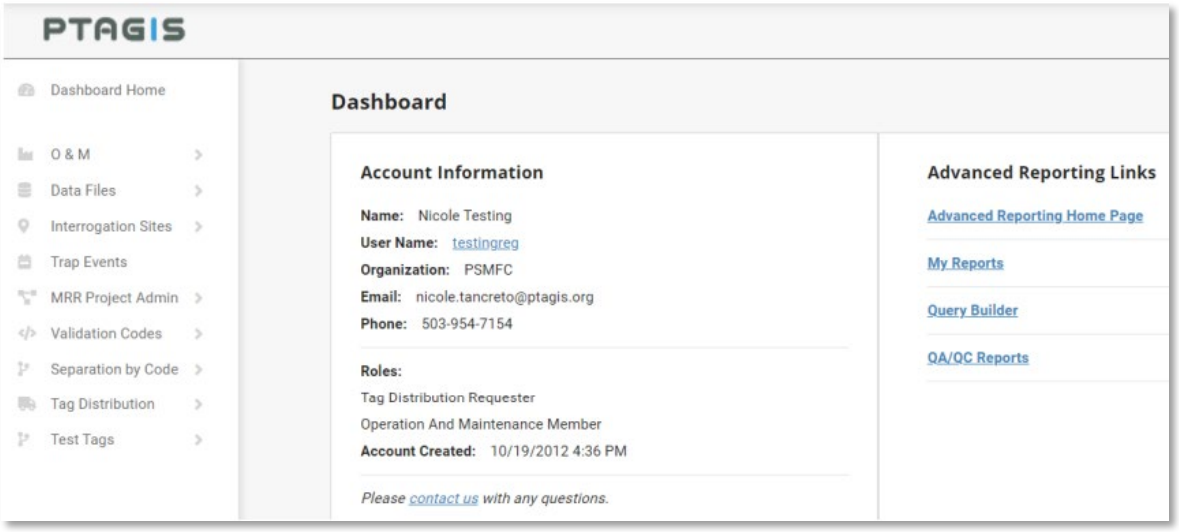

Figure 36. *User logged into the PTAGIS Dashboard portion of the website*

The new site averaged 1,700 unique visitors viewing 17,000 pages per month. Staff integrated a cloud-based, application performance monitoring solution called Application Insights *(Figure 17)* to ensure the site is continually operating at peak efficiency.

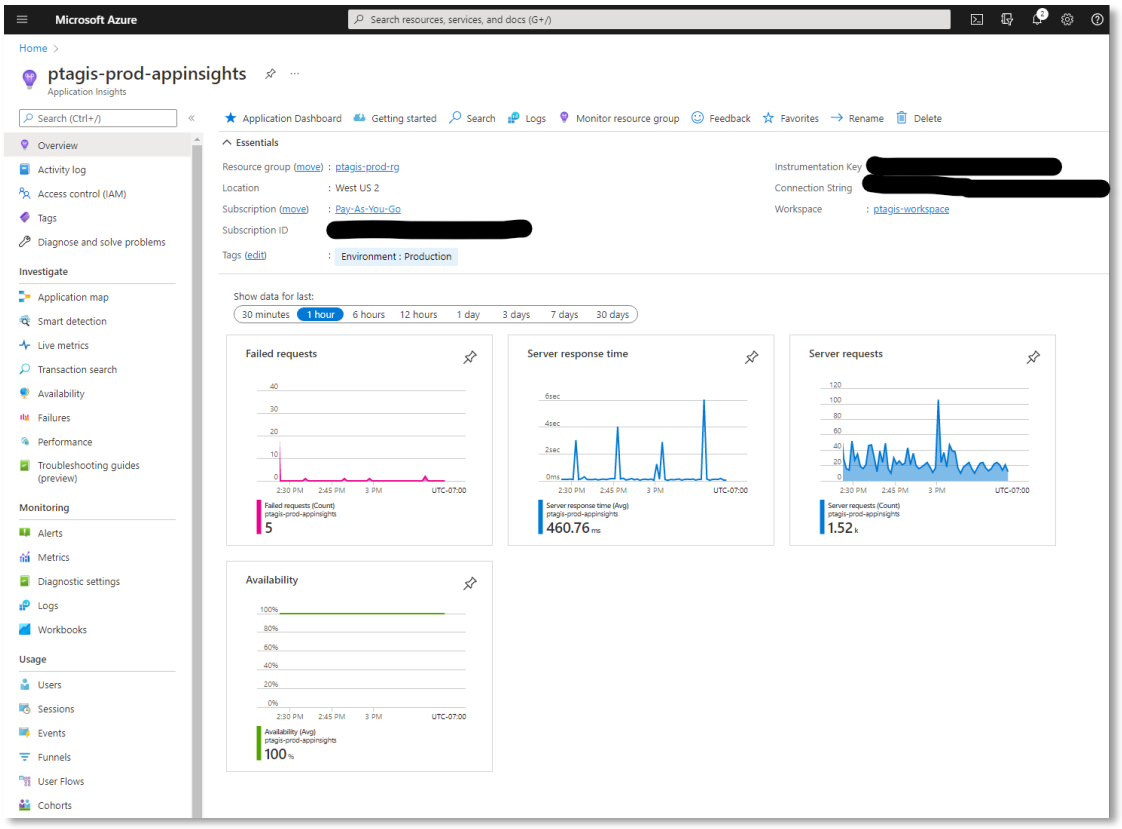

Figure 47. *Monitoring Health of PTAGIS Website via Application Insights*

A survey, conducted towards the end of the year, showed high levels of satisfaction with the website (*Figure 18*) and reporting system (*Figure 19*). The few "average-to-low satisfaction" results were from fishermen complaining the occasionally used observation reports were moved to a slightly different location on the new website, or that PTAGIS wasn't doing enough to satisfy their concerns regarding breaching of dams.

Figure 58. *Website User Satisfaction Survey Results*

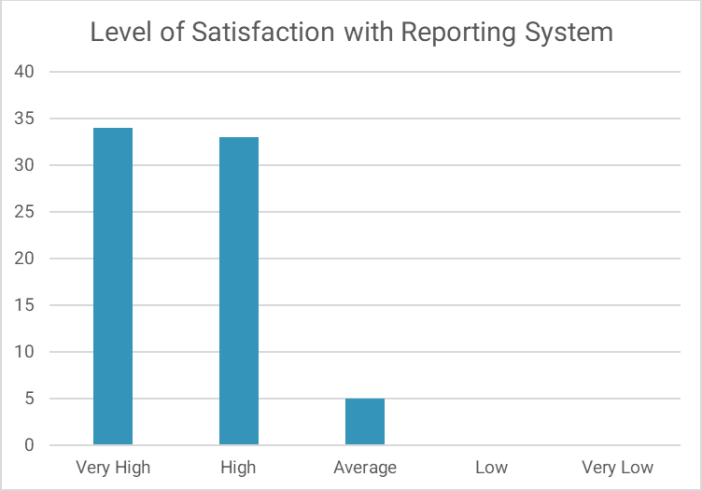

Figure 69*. Reporting System User Satisfactions Survey Results*

2022 Plans

Continue refinement of the website and reporting system features as requested. In coordination with IPTDS Subcommittee: implement interrogation site metadata management features, such as updating site diagrams per new specifications. Monitor website to ensure high-availability and peak performance. Review advantages of MicroStrategy cloud offerings. In coordination with a successful migration of database server to the cloud, also lift-and-shift website and reporting system and engage enhanced security, performance, and other cloud-based features.

E: 160. Operate and Maintain the Separation by Code Database

Before PTAGIS implements a Separation by Code (SbyC) project, the researcher must coordinate with all applicable agency contacts. The necessary coordination varies from project to project and facility to facility. If the project involves only routing PIT-tagged fish toward collection for transportation, minimal coordination is necessary. If the project involves diverting fish into holding tanks, much more coordination is necessary.

PTAGIS is responsible for the coordination and implementation of SbyC requests in the following nine fish passage structures at six mainstream FCRPS:

- Lower Granite Juvenile Bypass (GRJ)
- Lower Granite Adult Fish Trap (GRA)
- Little Goose Juvenile Bypass (GOJ)
- Lower Monumental Juvenile Bypass (LMJ)
- Ice Harbor Dam South Ladder (ICH)
- McNary Juvenile Bypass (MCJ)
- John Day Juvenile Bypass (JDJ)
- Bonneville PH2 Juvenile Bypass (B2J)
- Bonneville Adult Fish Facility (BO3)

The agencies and researchers whom request SbyC vary year-to-year. The focal species are typically salmonids.

The coordination portion of this objective requires various researchers to enter request metadata for each SbyC project into the database using an online service implemented on the PTAGIS website. The requester must notify appropriate contacts at the USACE, NOAA and Smolt Monitoring Program which are referenced on the PTAGIS website. If the planned SbyC projects targets another researcher's PIT-tagged fish, the requester must contact and obtain the permission of that researcher. The online request service provides a checklist for these coordination actions with automated workflow so that the Fish Passage Advisory Council (FPAC) can approve each request based upon the metadata provided.

Once approved, PTAGIS staff implements the SbyC request by updating the local database of the interrogation software operating at the target facility, often more than once for each request. This is a time-sensitive process and requests often overlap each other at the same passage structure of an interrogation site. In some cases, the database containing the target fish must be computed and updated by staff in near real-time. Internal O&M reports are used to verify implementation. Additional ad-hoc coordination with researchers and facility staff is necessary to resolve issues and to ensure a successful implementation.

Implemented requests are permanently stored as metadata in the PTAGIS database and are available on the website for public review. Researchers can use past requests to quickly populate new SbyC requests that are on-going.

2021 Accomplishments

In 2021, 10 projects targeted 37 groups of fish totaling 607,393 tags to be separated by tag code for additional sampling or for different transportation outcomes. *Table 3* provides a summary of the 2021 projects.

Agency	Project Title	Target Tags
FPC	Comparative Survival Study 2021	405,244
IDFG	Monitoring and evaluation of BY2019 Chinook Salmon smolts released from Idaho hatcheries in the Clearwater and Salmon River basins in migration year 2021.	100,317
IDFG	Monitoring Upper Salmon River A-run Steelhead Reared in Circular Tanks	2,100
IDFG	Snake River Sockeye Salmon Trap and Haul Emergency at Lower Granite Dam	53
NOAA	Investigating the origin and migration patterns of bull trout encountered at Lower Granite Dam	11
NPT	Nez Perce Tribe 2021 Separation by Code Request	15,896
ODFW	Wallowa and Imnaha Stock Steelhead Smolt Monitoring and Evaluation_2021 Releases	18,514
USGS	Estimate growth to Lower Granite Dam of subyearling fall Chinook salmon tagged in the Clearwater River during 2021	12,008
WDFW	BY19 yearling and BY20 subyearling Lyons Ferry Hatchery FCH On-station release and BY20 subyearling FCH released at Grande Ronde River 2021	29,800
WDFW	2021 Lyons Ferry Hatchery Complex -Snake River, Steelhead Tributary Releases	23,450
	Total Target Tags	607,393

Table 3. *Separation by Code request summary for 2021*

2022 Plans

Continue processing SbyC Requests in a similar manner as this year. Utilize SbyC Configuration Manager tool to manage the LMJ site operating M5 interrogation software. This tool can also manage and *manually* deploy configuration changes to all of the other interrogation sites still operating M4.

Interrogation Site System O&M and Installation

PTAGIS has a complete field operations office that designs, installs, and maintains the equipment and software needed for automated PIT tag detection, including systems for enabling individual fish segregation, examinations and relocation, known as Separation by Code (SbyC). This section provides additional background on these activities and further describes the work efforts as defined in the statement of work portion of the BPA contract.

An overwhelming majority of the 267 million observation records contributed to the PTAGIS system have come from large-scale interrogation sites located at Federal Columbia River Power Systems (FCRPS) projects on the Columbia and Snake rivers (*Figure 20*). PTAGIS staff operate and maintain the electronic detection systems that collect this information under a *Memorandum of Understanding (*MOU)[2] between BPA and USACE. Staff performing these tasks work out of a centrally located office in Kennewick, WA.

[2] MOU between BPA and USACE (COE) defining roles for installing and maintaining PIT tag infrastructure: https://www.ptagis.org/content/documents/coe-and-bpa-mou-regarding-pit-tag-infrastructure.pdf

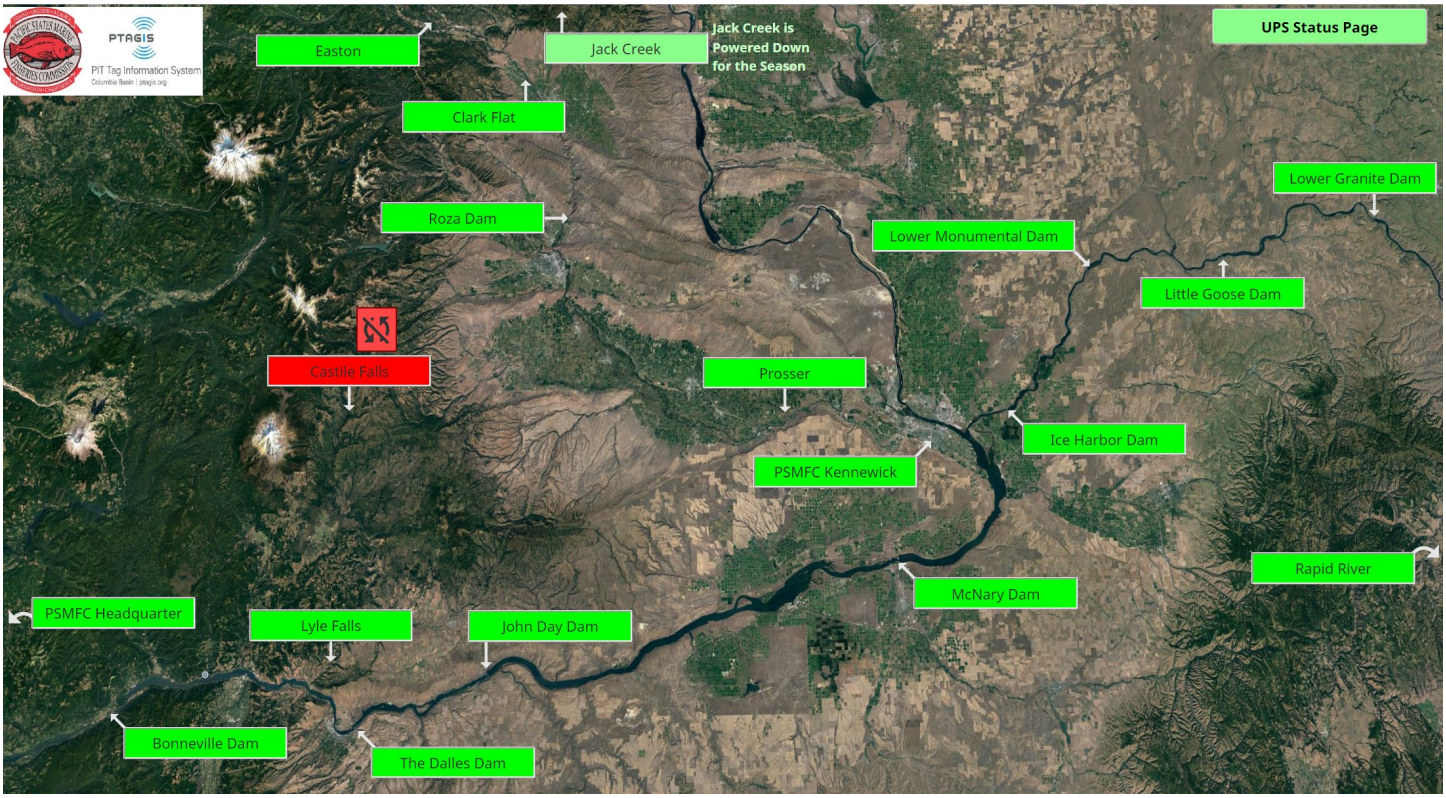

***Figure 20**. SCADA operational map of the mostly large-scale interrogation sites managed by PTAGIS*

F: 70. Support Separation by Code Systems

The SbyC system is composed of fish-ways or flumes, diversion gates of all types (slide gates, rotational gates, side to side gates), air cylinders, solenoids, Programmable Logic Controllers (PLC), serial and Ethernet interfaces to PTAGIS data collection software, server-side system diagnostics and more. This work element relates to mandatory efforts to operate and maintain the systems and controls necessary to actuate the gates based upon SbyC database lookup information.

During the migration season, PTAGIS field systems personnel inspect and test SbyC pneumatic, electrical, and mechanical components at each facility on a weekly basis. During these site visits, PTAGIS staff coordinate with USACE facility biologists and other researchers at the site. PTAGIS is fully responsible for the design, installation, operations and maintenance of the SbyC electrical control equipment and infrastructure to support this on-going process. The SbyC diversion gates are directly incorporated into complex passage fish structures and any malfunction or failure of the SbyC equipment can result in catastrophic consequences for smolts and adult fish routed through these facilities.

Detectors located downstream of the PIT tag diversion gates audit the path taken by tagged fish passing through those gates. The Diversion Gate Efficiency (DGE) system automatically computes the rate at which individual tagged fish are correctly routed through the diversion and facility sub-sample gates at those facilities. The instantaneous and cumulative year-to-date efficiencies are refreshed in near real-time as new detection data are received into the PTAGIS database. Staff review those efficiencies from a Web-accessible DGE report (*Figure 21)* to verify that, for each gate, the SbyC system issues the correct instructions to divert or ignore PIT-tagged fish, and that the gate operates properly to divert the targeted tags. A reported drop in the instantaneous efficiency is usually indicative of a mechanical problem at that gate. Having been alerted to the problem through the DGE report, PTAGIS staff can respond to and resolve the issue before the gate fails.

2021 Accomplishments

The diversion gate efficiencies at each SbyC site (*Figure 21*) remain high due to SCADA monitoring, upgraded electric slide gate at LMJ in 2020, and in-year and off-season maintenance programs by PTAGIS and USACE staff.

Diversion Gate Efficiency Summary

({Divert Time} (Value) Between 1/1/2021 12:00:00 AM and 1/1/2022 12:00:00 AM)

B2J - Bonneville PH2 Juvenile

Site Code	Diversion Gate Antenna Group	Total Fish	Success Count	Failure Count	Percent
B2J	SBYC SEPARATOR GATE	19,965	19,960	1	100.0%

Last Processed at 5/17/2022 12:15:01 PM

GOJ - Little Goose Dam Juvenile

Site Code	Diversion Gate Antenna Group	Total Fish	Success Count	Failure Count	Percent
GOJ	A-SEPARATOR GATE	3,387	3,365	15	99.6%
	B-SEPARATOR GATE	5,873	5,824	40	99.3%
	DIVERSION SBYC GATE	4,682	4,669	11	99.8%

Last Processed at 5/17/2022 12:15:04 PM

GRJ - Lower Granite Dam Juvenile

Site Code	Diversion Gate Antenna Group	Total Fish	Success Count	Failure Count	Percent
GRJ	A-SEPARATOR GATE	8,227	8,162	59	99.3%
	B-SEPARATOR GATE	6,171	6,089	72	98.8%
	DIVERSION / SBYC GATE	6,634	6,631	1	100.0%
	RCWY-10 GATE	6,989	6,805	183	97.4%
	SBYC GATE	19	0	0	

Last Processed at 5/17/2022 12:15:07 PM

JDJ - John Day Dam Juvenile

Site Code	Diversion Gate Antenna Group	Total Fish	Success Count	Failure Count	Percent
JDJ	SBYC GATE	0	0	0	0.0%
	SBYC SEPARATOR GATE	2,202	2,188	14	99.4%

Last Processed at 5/17/2022 12:15:09 PM

LMJ - Lower Monumental Dam Juvenile

Site Code	Diversion Gate Antenna Group	Total Fish	Success Count	Failure Count	Percent
LMJ	A-SEPARATOR GATE	1,512	1,503	7	99.5%
	B-SEPARATOR GATE	4,416	4,381	30	99.3%

Last Processed at 5/17/2022 12:15:14 PM

Figure 21. *Diversion gate efficiency (DGE) summary for 2021*

Note: the diversion efficiency of the gate labeled *SBYC GATE* at GRJ cannot be measured because it does not have a downstream detection point. No SbyC projects were operated at MCJ this year due to cessation of fish transportation.

LMJ is the first SbyC interrogation site to be completely upgraded and the remodeled electronics room is shown in Figure 22. This included new industrial PCs that will eventually run M5 in 2022 and an additional gateway PC to collect environmental data via SCADA. An upgraded Programmable Logic Controller (PLC), shown in Figure 23, controls SbyC diversion gates and captures environmental metadata, such as the disposition of facility sub-sample gates. All Human

Machine Interface (HMI) panels, shown in Figure 24, were also upgraded with updated programming. The HMI panels allow site personal to monitor and control sampling and diversion gates. The Uninterruptible Power Supply (UPS) systems that keep the data collection platform operating through semi-frequent power outages were also upgraded and have lithium batteries with increased lifespan compared to the lead-acid systems they replaced. The new UPS systems were integrated into the SCADA system for much improved status monitoring.

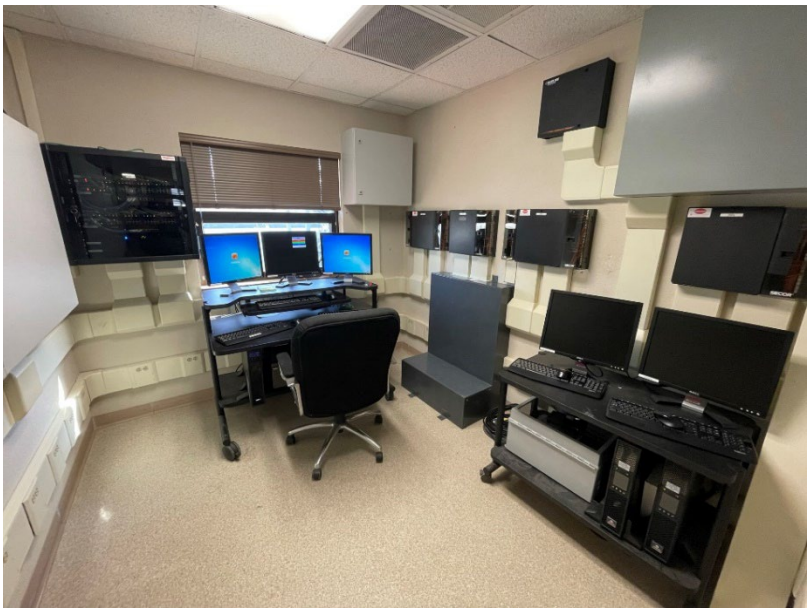

Figure 22. *Remodeled electronics room at LMJ*

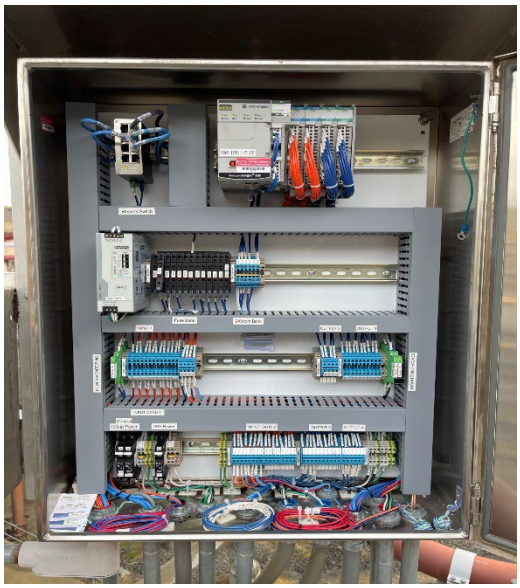

Figure 23. *PLC upgraded at LMJ*

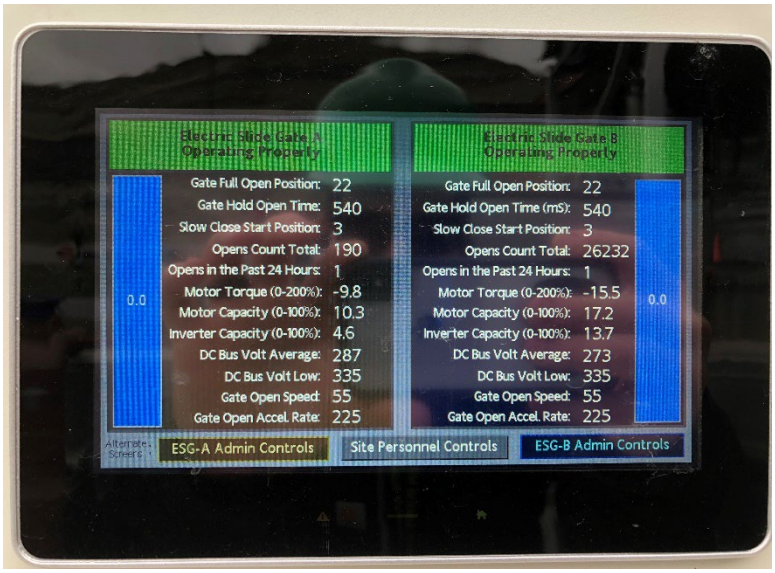

Figure 24. *Upgraded HMI panel at LMJ*

Field staff assisted with performance evaluation of SbyC features of M5 and new hardware platforms throughout the year with systems developed and deployed in the Kennewick lab to emulate real-world interrogation sites. Additional features were programmed into the SCADA system (*Figure 25*) to support regression testing over several days. The M5 system combined with new hardware and PLC programming out-performed M4 and legacy hardware by a significant margin over repeated testing. This increase in performance should allow for the eventual development (2 to 3 years out)

of more precise diversion control to increase overall efficiency, reduce bycatch, and allow the system to scale for future research applications.

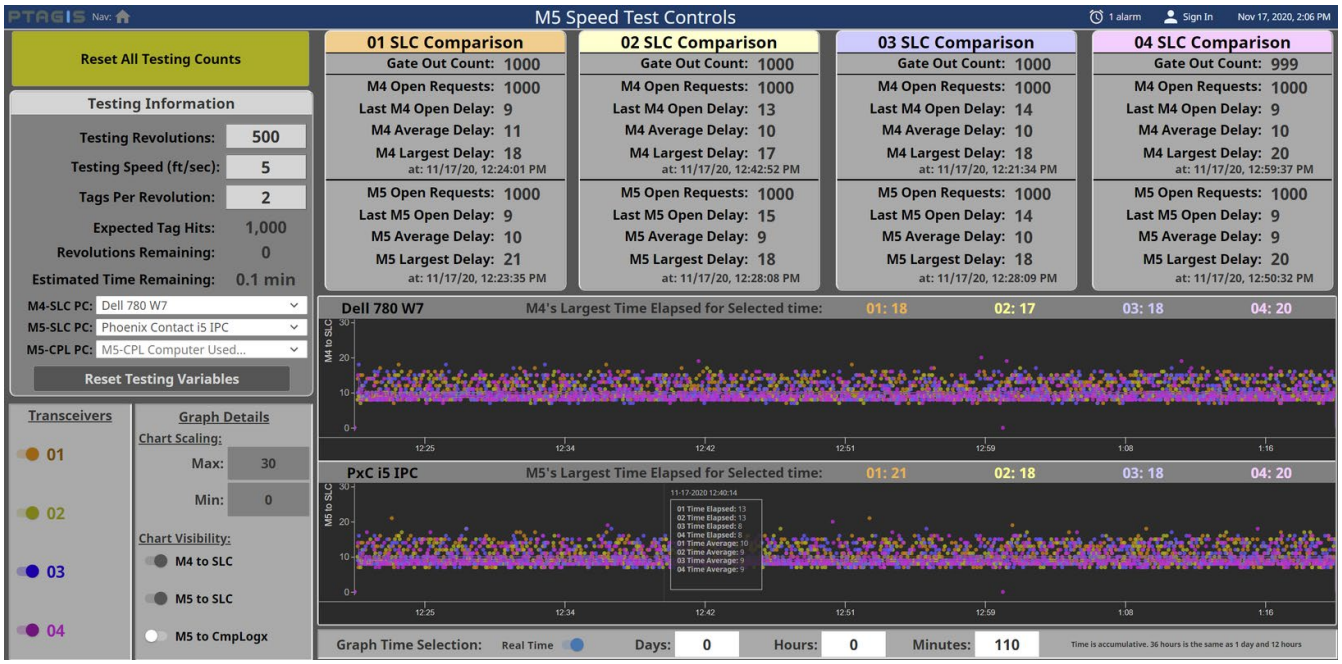

Figure 25. *Early Version of SCADA Dashboard used for M5 Regression Testing in KLAB*

PTAGIS captures and records environmental metadata about facility operations at an interrogation site, such as the opening or closing of a facility sample gate needed to accurately compute diversion gate efficiency analysis (*Figure 21*). This environmental metadata is captured via sensors and probes connected to the PLC (*Figure 23*). The SCADA system reports this information in real-time so that field staff can monitor conditions at a site. A decision was made last year to ingest the environmental metadata into the PTAGIS database through the SCADA system instead of adding features in M5 to do the same thing (this data has been traditionally recorded into the database via M4 data files). However, the system clocks between PCs running M5 and the PC recording SCADA data at an interrogation site would need to be synchronized to the second (or better) in order of accurately perform DGE analysis. The default clock synchronization strategy currently used could allow these systems to drift by more than a few seconds which would skew the DGE report. Staff worked with PSMFC IT to evaluate a third-party clock synchronization strategy that guaranteed clock synchronization to a second (or better) between all three field data collection platform computers.

2022 Plans

Staff will continue to operate and maintain the SbyC systems. Staff will coordinate with USACE to locate and fund additional opportunities in replacing current pneumatic gate mechanisms with electrically activated diversion gates to reduce maintenance costs and improve performance, specifically at GOJ and GRJ sites. Continue upgrading data collection platforms at other SbyC interrogation sites.

Evaluate the production deployment of M5 at LMJ and monitor performance against the legacy M4 system operating in standby. Monitor enhanced clock synchronization strategy to incorporate SCADA dataset for redeveloped DGE analysis. Continue evaluation and refinement of M5 high-availability features in the Kennewick lab by enhancing the SCADA system with the ability to trigger simulated hardware faults.

G: 70. Install Interrogation Systems in Field Locations

PTAGIS works with a wide range of researchers and agencies that are looking to incorporate PIT tag detection equipment into large-scale interrogation sites.

This process for installing a new interrogation system typically has the following stages:

- Field staff evaluate fish passage conditions at the proposed site
- Pre-qualification of the proposed site using radio frequency detection equipment
- Provide design requirements and feedback throughout the process to ensure the success of the project

Once a system is approved by BPA, PTAGIS coordinates with USACE or other agency to install the electrical components of this system that include the transceivers, network, PLC, and the data collection computers.

Since 1993, PTAGIS has had an integral role in the NOAA Fisheries project 1983-31-900 (New Marking and Monitoring Techniques for Fish) when PTAGIS assumed responsibility from NMFS for the operation and maintenance of the permanent interrogation systems installed in the juvenile fish bypass facilities at Lower Granite, Little Goose, and McNary dams. In recent years, PTAGIS has assumed a larger role in the research, development, and evaluation of new PIT tag technologies, such as a new generation of tags, antennas, diversion gates and transceivers that provides greater read range, and lower cost for installation.

2021 Accomplishments

Completed the installation of new antennas this year at two sites located at Bonneville Dam. At the request of BPA, three PIT tag detection systems were installed at GRJ, GOJ and LMJ to monitor the loading of fish into transportation barges. The following subsections provide detail about this work performed by Kennewick staff.

BO2 Cascades Island Relocation Project:

Staff installed PIT tag antennas at the entrance of the Upstream Migrant Tunnel (UMT) and at the Counting Window (CW) at Cascades Island (*Figure 26*). At the end of 2021, the USACE completed only 25% of the scheduled in-ladder electrical work as part of their commitment to this project. When they complete the remaining work rescheduled to Q1 2022, staff will complete the installation of the data collection platform equipment in the relocated PIT tag room and the system will be brought online to serve the fisheries research community with near 100% detection efficiency for decades. The new system completely covers fish passage routes whereas the ladder system provides orifice detection only (fish going over the top of weirs are not detected). The original system installed in the ladders below this area is in danger of failure due to soil subsidence around the electronics building causing it to list and is a safety hazard to operate. This year, staff instrumented a temporary M5 installation to monitor the two UMT antennas and daily comparisons confirmed the enhanced detection efficiency of the new site compared with the original ladder site that will be used to collect production data until the new system is online.

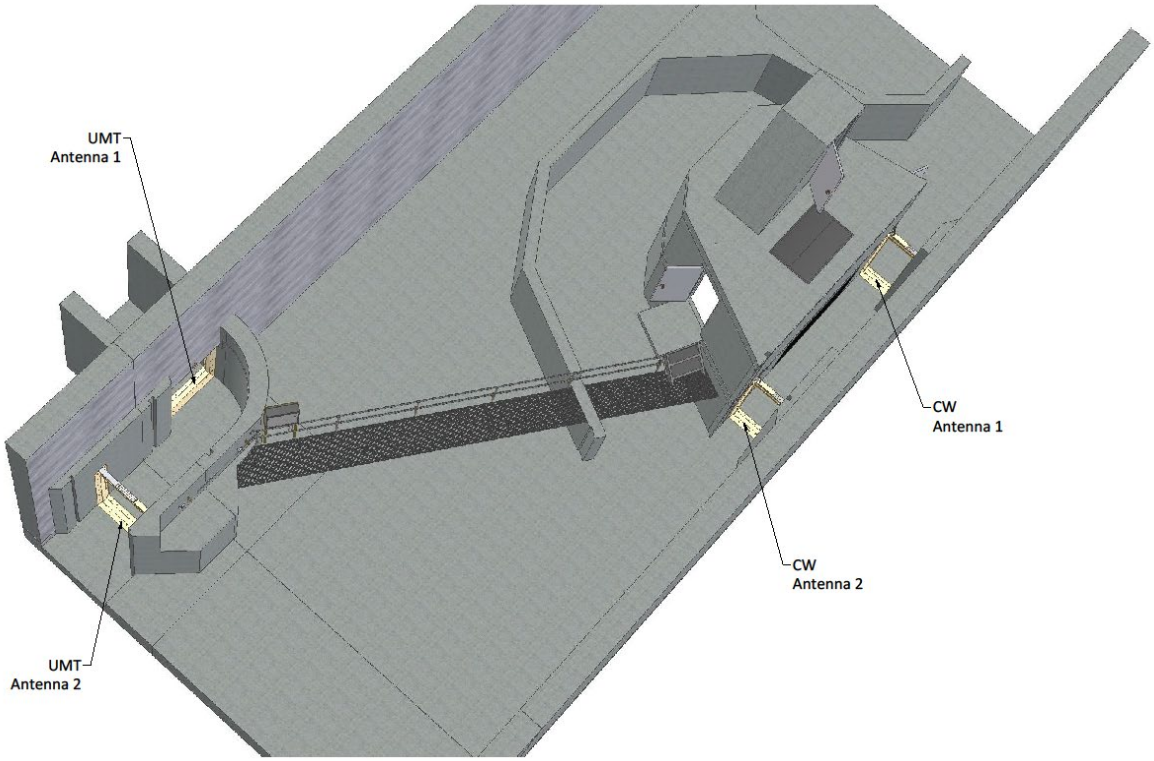

Figure 7. *Overview of the BO2 Cascades Island Relocation Project at Bonneville Dam*

Figure 27. *UMT Antenna #2*

Figure 88. *UMT Antenna #1*

Figure 99. *CW Antenna #2*

Figure 30. *CW Antenna #1*

BO4 Slot Antenna Replacement Project:

Staff coordinated with USACE personnel to install four replacement slot antennas using crane support (*Figure 2*) at the Washington Shore ladder with minimal modification to the existing infrastructure. The original antennas being replaced were near end-of-life and unrepairable. The project was completed prior to the start of the 2021 season and the antennas operated at peak detection efficiency throughout the year and required only routine site visits. The original antennas replaced were a potted design, making them heavy (3000+ pounds) and expensive to build. Staff designed the replacement antenna using underwater cable developed by NOAA's R&D project. This cable allowed the antennas to be built without a watertight housing. This reduced the weight by two-thirds and cost less than 25% of the original to manufacture.

PTAGIS would like to acknowledge the Bonneville project fisheries and maintenance personnel for their outstanding support during the BO2 and BO4 antenna installation projects.

New PIT Tag Antennas on Barge Load Lines at GRJ, GOJ and LMJ:

Last year, PTAGIS was asked by BPA to investigate the possibility of adding PIT tag detection on the barge load lines at Lower Granite (GRJ), Little Goose (GOJ) and Lower Monumental (LMJ) juvenile fish facilities. Installation of the antennas began in December 2020 and all three sites were completed in March of 2021. Staff installed all the infrastructure for electronics, communications and antennas while the USACE helped with infrastructure for new PVC piping that was required at each site. Staff leveraged an off-the-shelf wireless Ethernet antenna system (*Figure 31*) to minimize installation costs at GRJ and GOJ.

Figure 31. *PIT tag antenna infrastructure including wireless Ethernet antenna dish (upper left) at GRJ barge dock*

Daily barging began on April 23 and ended on May 17. Every other day barging began on May 19 and concluded on June 20. Early checks of the systems indicated that they were operating with overall efficiencies between 70-80%. The exception was the direct barge load line at GOJ, which required design and installation of new antenna shield to improve field strength. The new shielding improved the detection efficiency but may require additional efforts.

Once the barge load season was concluded, staff roughly estimated the overall detection efficiency of these systems using detections of upstream raceways and sample monitors. At GRJ, the estimates included fish tagged and released by Tiffani Marsh's research group (*Table 4*).

GRJ	Detections	Efficiency
Raceway East (71-72)	3,017	
East Raceway 10 (31-32)	1,660	
Tiffani Marsh Tags	10,918	
Total	15,595	
Barge Load Line (61-62)	12,662	81.20%
Antenna 61	10,618	68%
Antenna 62	10,395	66.70%

Table 4. *Estimated Barge load antenna detection at GRJ for 2021 season*

LMJ	Detections	Efficiency
A Raceway (11-13)	418	
B Raceway (21-23)	1472	
Sample	223	
Total	2113	
Barge Load Line (71-72)	1687	79.80%
Antenna 71	1272	75.40%
Antenna 72	1317	78.10%

Table 5. *Estimated Barge load antenna detection at LMJ for 2021 season*

GOJ efficiency is difficult to estimate for the entire season due to the multiple paths the fish can take from the separators to the barge (*Figure 32*). When a barge is getting loaded from the raceways, the fish travel from the raceways to the barge in a line that is monitored by antennas 61 and 62. When a barge is getting direct-loaded, the fish from the A-Separator travel to the barge in the line that is monitored by 31 and 32 and fish from the B-Separator travel to the barge in the line that is monitored by 61 and 62. Periodic monitoring of the detection efficiency during the season can be done when the exact times are known for loading from the raceways vs direct-loading. Several estimates were calculated during the season showing antennas 61 and 62 to be in the 80% efficiency range and antennas 31 and 32 in the 30% range. Factors such as tag collision, orientation and velocity are especially challenging for the barge load antenna system. Staff will continue optimization efforts during the offseason to reach the highest possible detection efficiencies for all of these systems.

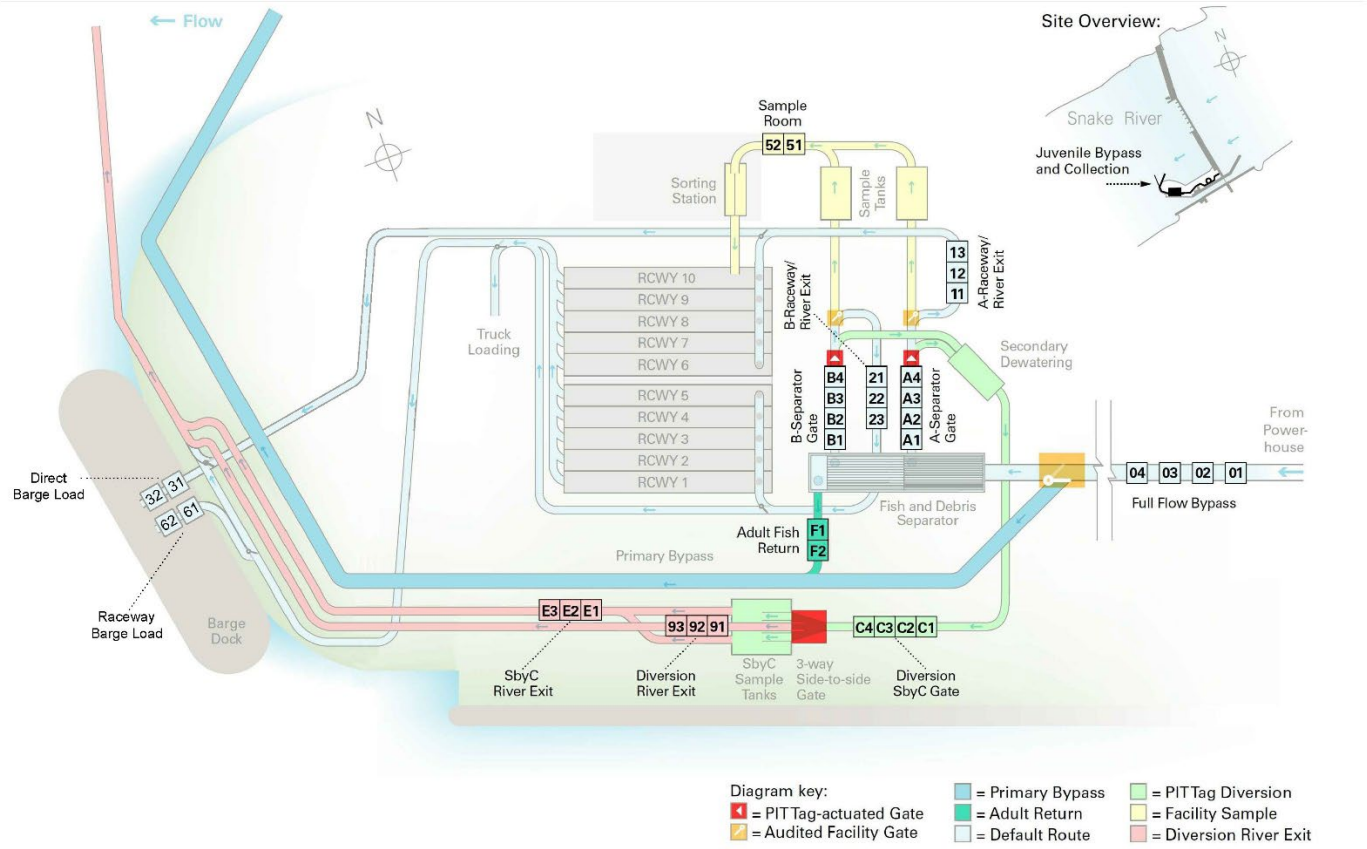

Figure 32. *Little Goose Dam Smolt Bypass and Collection site configuration diagram showing new barge load antennas*

2022 Plans

- If approved, install prototype antenna system at Bonneville B1 I&T Sluiceway.
- If approved, install antenna system for monitoring the weir wall at Castile Falls.
- If approved, proceed with antenna installation at Easton Dam Adult Ladder & Juvenile Bypass for the BOR. This will include 5 antennas on the ladder and 2 on the juvenile bypass and a PIT tag electronics room. Once complete PSMFC will take over O&M of the system.

H: 160. Operate and Maintain Interrogation Systems in Field Locations

The PTAGIS field staff monitor operational reports throughout the day, 365 days a year. These reports identify the following conditions and allow field staff to respond to situations quickly:

- Data collection gaps
- Low reading efficiency of a detection system
- Transceiver failures and alarms
- Computer, network or other system failures and alarms

- Changes in environmental conditions (such as power, temperature, relative humidity) that may impact a detection system

During the portions of the season with high fish migration, field staff performed weekly, on-site, standard maintenance checks at each facility. Perform maintenance checks every other week in periods with lower migration. Site visits include tuning all readers, inspecting and adjusting the timing of diversion gates, maintenance of the data collection computers, and coordination with site operators and biologists.

Juvenile fish bypass facilities on the Snake and Columbia rivers begin operating around April 1st. Prior to these operations, the field staff perform all the necessary preseason tuning and maintenance to ensure peak performance of the juvenile fish detection and diversion equipment.

Radio frequency (RF) noise data is tracked on a continual basis, 365 days per year for the 456 antennas PTAGIS currently operates. Sites that have been quiet for years may suddenly become noisy. Tracking and mitigation consumes 10% to 30% of labor resources per year. USACE and other agencies are cooperative in helping to control noise sources.

Field staff record general maintenance and anomalous events by submitting event logs to the PTAGIS system. The logs are publicly available on the PTAGIS website as metadata for each interrogation site.

As certified electricians and electronic technicians, field staff repair and extensively test PIT tag reading equipment in the Kennewick lab before returning devices to service. PTAGIS inventories a minimal number of spare readers to expedite the replacement of failures and as a cost savings, repairs the equipment in-house.

2021 Accomplishments

System-Wide Data Collection Platform Upgrade

Completed the data collection platform upgrades at all 25 interrogation sites operated by PTAGIS that are not performing SbyC. M5 interrogation software was also deployed and is operating at all of these sites (see M5 Software Internal Release).

The data collection platform upgrades include:

- Replacement of consumer-grade PCs with industrial PCs running Windows 10 Enterprise LTSC
- Replacement of serial communications equipment with Ethernet-based counterparts
- Replacement of lead-acid UPS systems with SCADA-ready lithium battery models
- SCADA real-time monitoring integration

Replaced DSL internet services at Lower Granite, Little Goose and Lower Monumental sites with Startouch Microwave Service. The microwave service is lower cost and more reliable than DSL. Upgraded the following sites with cell service (from DSL and satellite services): Clark Flat, Roza Dam, Jack Creek, and BO2.

The SCADA system was enhanced this year with additional monitoring of new equipment and systems. For example, the integration of the new UPS systems (*Figure 33*) will alert staff in advance of a failure so it can be replaced without losing data or requiring and emergency site visit.

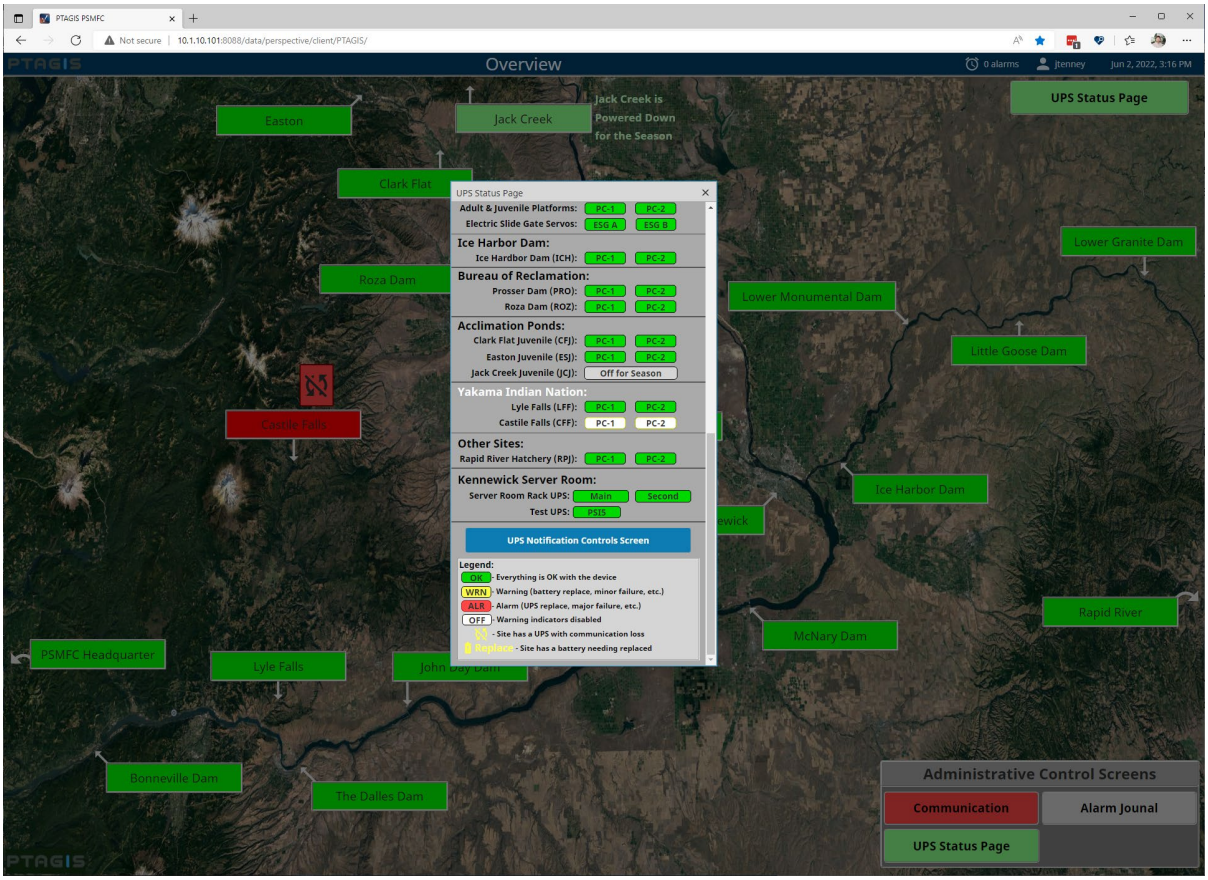

Figure 33. *SCADA system monitoring of upgraded UPS systems deployed at PTAGIS interrogation sites*

Juvenile Bypass O&M

Juvenile fish bypass facilities (JFF) on the Snake and Columbia Rivers began operating in March and April. Detection efficiency rates for 2021 were maintained at or above previous year's detection efficiency rates of greater than 99%. The single antenna in the Bonneville Corner Collector (BCC) is the exception to this with an estimated efficiency rate in the seventies based on NOAA live fish testing using 12mm tags. BCC detected 98,230 PIT tags during 2021.

Lower Granite Spillway O&M

On April 3, 2021, the spill gates were opened just after midnight, operating under the Flex Spill pattern schedule. The Lower Granite Spillway (GRS) PIT tag detection system continues to detect PIT tags at an exceptional rate. All 11 antennas exceeded detection rate expectations throughout the duration of the spill and operated without issue. The center row antennas had the greatest amount of detections (*Figure 34*). The spill season ended on September 1st, although the spillway is periodically opened and closed for various reasons. The GRS system detected 251,480 unique tags in 2021.

GRS - Lower Granite Dam Spillway

Subsite	Antenna Group	Antenna	Unique Tags Detected by Subsite	Unique Tags Detected by Antenna Group	Unique Tags Detected by Antenna	Tags Missed per Antenna	Percent Tags Detected by Antenna	Tags Missed per Antenna Group	Percent Tags Detected by Antenna Group
GRS	Upstream	01	251,480	158,111	10,028	148,083	6.34%	93,369	62.87%
		02	251,480	158,111	57,247	100,864	36.21%	93,369	62.87%
		03	251,480	158,111	54,215	103,896	34.29%	93,369	62.87%
		04	251,480	158,111	36,631	121,480	23.17%	93,369	62.87%
	Middle	05	251,480	169,956	45,508	124,448	26.78%	81,524	67.58%
		06	251,480	169,956	65,528	104,428	38.56%	81,524	67.58%
		07	251,480	169,956	58,925	111,031	34.67%	81,524	67.58%
	Downstream	08	251,480	152,754	21,472	131,282	14.06%	98,726	60.74%
		09	251,480	152,754	64,227	88,527	42.05%	98,726	60.74%
		0A	251,480	152,754	55,517	97,237	36.34%	98,726	60.74%
		0B	251,480	152,754	11,546	141,208	7.56%	98,726	60.74%

Figure 34. *GRS antenna detection efficiency for 2021*

After the annual spill concluded on November 15, 2021, the entire GRS transceiver system was upgraded with a new synchronization schema. In the event of transceiver failure, the new design will allow a transceiver to be replaced without disrupting the operation of other transceivers. This will allow for continuous operation and PIT tag detection if one of the transceivers fails and needs to be replaced.

A work barge access platform was designed by USACE to provide safe and secure access to the OGEE surface for inspection and maintenance of the GRS antennas embedded in the surface. All or most of the platform components have been procured and are awaiting assembly. The platform should be ready by the end of the 2022 spill season.

Kennewick staff continue to provide daily monitoring of the GRS PIT tag system performance and supporting infrastructure.

Adult Ladder O&M

Adult ladder detection efficiency remains high in dam-to-dam comparisons. All sites maintained an approximate 98 to 99% detection efficiency over a 12-month rolling report period (*Table 6*). Heavy shad traffic seems to have slightly reduced detection efficiency at JDA. A new noise source was detected and traced to the variable frequency drives (VFD) controlling the lock gates at Ice Harbor Dam (ICH). Staff will continue to work with site personnel to mitigate this noise.

Ladder Location	Bracket Tags	Ladder Tags	Missed Tags	Percent Detected
BON	4,756	4,754	2	100.0
GOA	4,074	4,060	14	99.7
GRA	1,103	1,103	0	100.0
ICH	4,302	4,266	36	99.2
JDA	10,588	10,464	124	98.8
LMA	4,115	4,092	23	99.4
MCN	4,332	4,296	36	99.2
TDA	10,506	10,467	39	99.6

Table 6. *2021 adult ladder efficiencies in dam-to-dam comparisons*

At the request of the USACE and with support of the PTSC, PTAGIS is providing O&M support for the entrance and exit antennas at GRA (*Figure 35*). This year, ownership of equipment was transferred to PTAGIS to allow staff to easily swap out transceivers for repair. The system, designed and installed by another agency, needs additional work as the exit antenna is failing.

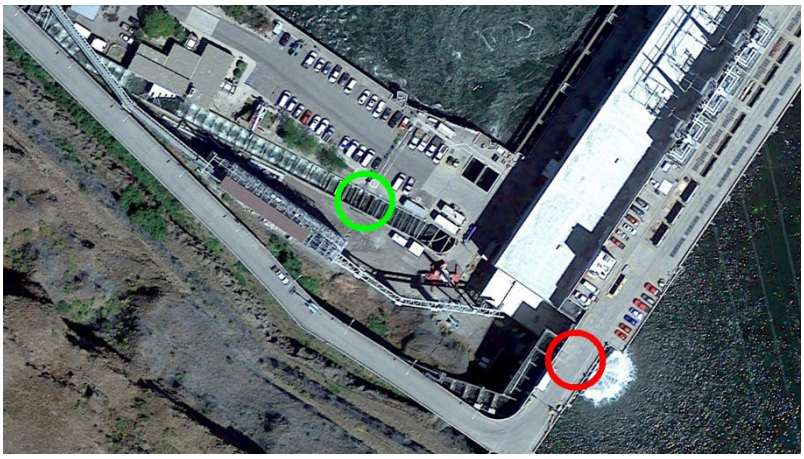

Figure 35. *Location of entrance and exit antennas at Lower Granite Dam now supported by PTAGIS in 2021*

2022 Plans

- Continue working with site personnel at ICH to mitigate noise from VFDs operating the lock gates.
- Coordinate with NOAA and USACE staff to complete construction of access barge before the 2023 season in support of GRS O&M.
- Install NOAA-funded remote controllable power supplies at GRS and integrate into SCADA system.
- Install a remote sensor on the GRS tainter gate to record spill operations in support of O&M.
- Support NOAA live fish test at GRS scheduled for March 2022.
- Continue upgrades of entrance and exit antennas at GRA to bring this system up to PTAGIS O&M standards.

- Investigate installing water probe sensors to provide better information about full-flow fish passage in support of O&M.
- Continue to enhance the SCADA monitoring system for all 31 remote interrogation sites and Kennewick lab.

J: 122. Additional Support Actions

The regional community often tasks PTAGIS staff to share their unique expertise in solving complex PIT tag detection and operational issues. This "catch-all" deliverable describes these types of ad-hoc requests that are within the program's scope of work and typically range from the following tasks:

- Regional coordination including FPOM and FFDRWG
- Transceiver, antenna and PIT tag conformance testing
- Electronics, process and control engineering
- Electrical design for PLC controls at sampling facilities
- Radio frequency identification (RFID) design
- Computer-aided design (CAD) detail
- Antenna design for the USACE and others
- Cost analysis for installing PIT tag systems for the USACE, NOAA and other various agencies

NOTE: tasks in this section overlap with deliverables already described in previous sections

- *F: 70. Support Separation by Code Systems*
- *G: 70. Install Interrogation Systems in Field Locations*
- *H: 160 Operate and Maintain Interrogation Systems in Field Locations*

2021 Accomplishments

Staff collaborated with NOAA's R&D project to develop a prototype detection system for the Ice and Trash Sluiceway at the first powerhouse of Bonneville Dam per request of the BPA. From this collaboration, conceptual drawings (*Figure 36*) were presented at FFDRWG for feedback and a prototype antenna system is being developed to fast-track this project for installation in 2022 if funded.

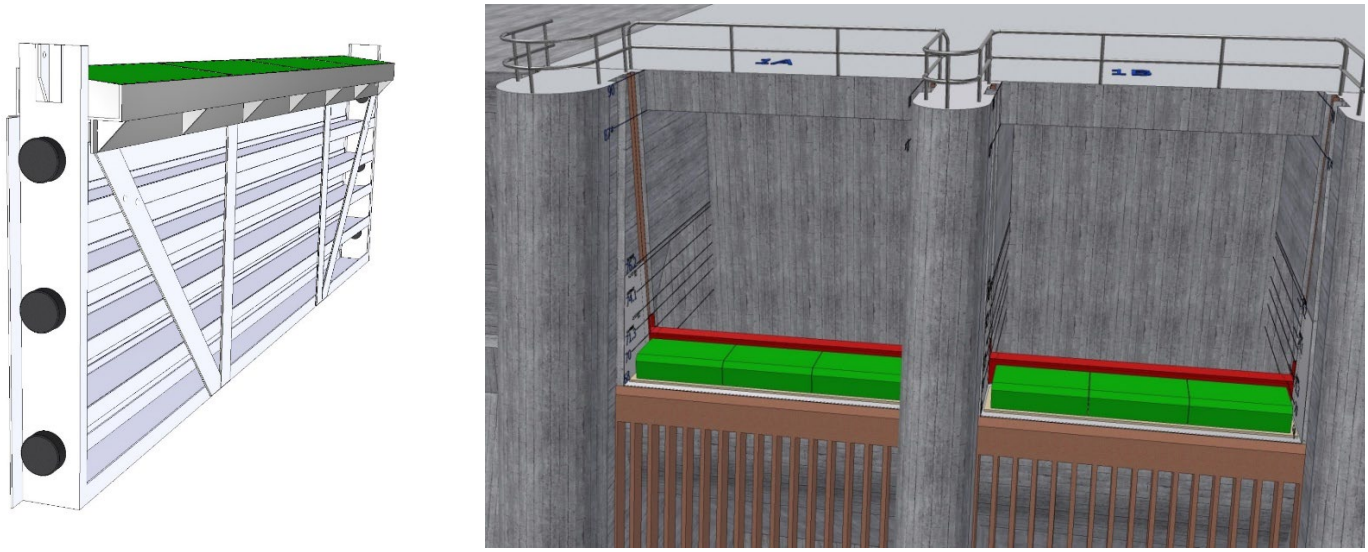

Figure 36. *Conceptual designs for antenna installation at Bonneville Ice & Trash Sluiceway, Power House 1*

A low-cost system (estimated at $30K) for antenna installation at the north entrance of Little Goose ladders was presented to the Walla Walla District FFDRWG. The design (*Figure 37*) is possible due to low water speeds and limited debris. The antenna was prototyped at the Kennewick lab and projected to read the entire cross-section of the water column. The antenna can be dropped flat to clear debris if necessary, and then raised back into position. The antenna frame would be constructed out of a fiberglass housing, wrapping a single NOAA antenna cable.

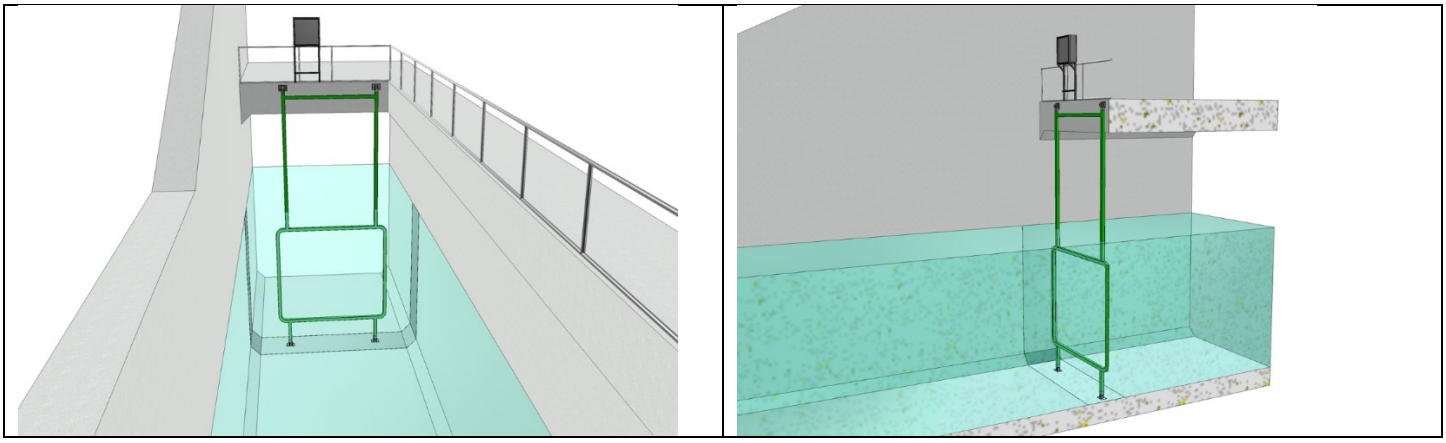

Figure 37. *Conceptual designs for antenna installation at north entrance of ladder at Little Goose Dam*

Staff presented designs to the Bureau of Reclamation for instrumenting the adult ladder and juvenile bypass system at Easton Dam (*Figure 38*). After a walkthrough of the site, staff delivered 90% design set comprised of 56 pages to BOR. The design set included antenna designs (*Figure 39*), electrical infrastructure, panel placements, fiber optic communications and a room to house PIT tag data collection platform and related electronics.

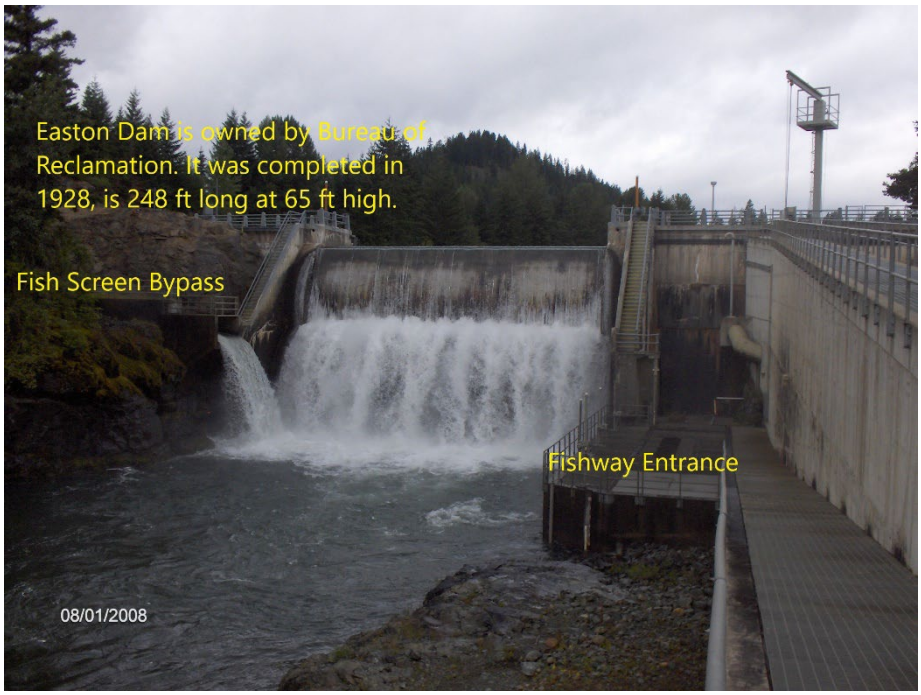

Figure 38. *Easton Dam on the Yakima River*

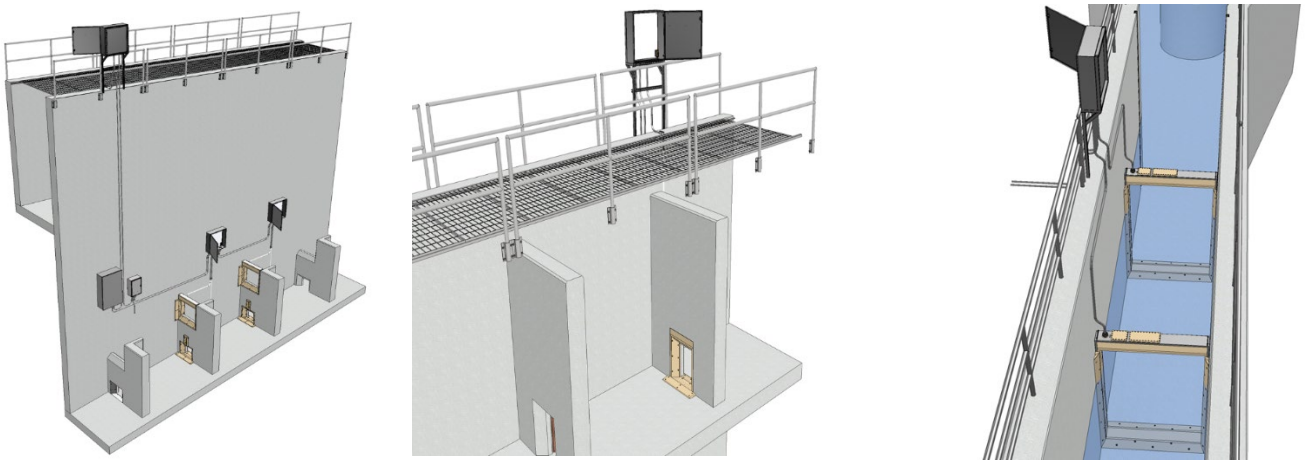

Figure 39. *Conceptual antenna designs for Easton Dam entrance, exit, and juvenile bypass system*

Staff coordinated with NOAA and Yakama Nation to extend the PIT tag detection already at place at the Castile Falls (*Figure 40*). The experimental antenna design would be installed on or near the weir wall and would become part of the existing interrogation site.

Figure 40. *Castile Falls Interrogation Site*

2022 Plans

Continue with design and development of new PIT tag infrastructure as requested by the fisheries managers. Focus will be on the Bonneville Ice & Trash Sluiceway project; if funding is secured this project will most likely be fast-tracked for installation of a prototype antenna in 2022. Partner with NOAA R&D to improve juvenile detections at McNary Dam.

Administration, Management and Coordination

This objective is comprised of the multiple contract work elements described in the following subsections. The work elements listed below are limited in scope and/or are well defined; therefore, no additional detail is needed:

- A: 185. Produce Pisces Status Reports – Periodic Status Reports for BPA
- B: 165. Produce Environmental Compliance Documentation
- L: 132. Submit Annual Progress Reports
- M: 202. Produce BiOp RPA Report

C: 119 Routine Administration of the Contract

This work element delivers general administration and on-going management of the BPA contract including:

- Funding package
- Hiring and supervising personnel
- Subcontracting
- Purchasing
- Budget and inventory tracking

PTAGIS is a fisheries data project of the Pacific States Marine Fisheries Commission. The Commission provides administrative support to the program, such as:

- Payroll
- Procurement
- Accounting
- Travel arrangements
- Contract review and monitoring
- Benefits, recruitment and other HR-related administration
- IT services

2021 Accomplishments

Completed all contract-related deliverables such as annual and periodic status reports on schedule. Submitted new funding package for FY22 in December 2021. Staff performed an annual inventory audit and the product was included with the FY22 funding package.

In May of 2021, a formal request was submitted to BPA requesting funding for additional Kennewick field staff in support of added work and succession planning. The request was not granted by BPA due to ongoing funding pressures.

Staff performance plans and reviews were completed and submitted on schedule per PSMFC guidelines.

Revised budget was submitted to BPA for the FY21 contract year using the *Line Item Transfer Budget Template*. The overall budget changes were less than 5% of the contract budget within existing top-level line items. The revisions were in support of the following changes that occurred during this contract year:

- Postponement of the 2022 PIT TAG Workshop due to COVID
    - Will be rescheduled in 2022 per PTSC
- Unable to obtain lease for new vehicle this year
    - Due to ongoing BPA/GSA negotiations this year, we didn't get approval for GSA lease
    - Private lease option doubtful this year anyway due to very low vehicle inventory

- Postponement of antenna replacement and installation at GRA due to COVID
- Postponement of electric slide gate installation at GOJ due to COVID
- PSMFC fiscal misapplied the purchase of server budgeted in FY20 to the FY21 contract
- Adjustment of Kennewick field supplies due to cost increases
    - Rescheduled purchasing of additional UPS units from FY22 to FY21

2022 Plans

Continue routine administration of the contract as described. Audit program inventory and submit request to dispose obsolete equipment well before contracting period.

I: 122 Technical Support and Training Assistance to Field Users

This work element delivers online, email, and phone technical support/training to entities engaged in PIT tag research activities in the Columbia Basin. The focus of this support pertains to the publicly accessible *PTAGIS Field Data Collection* and *Web Data Management* systems described in previous sections of this document.

2021 Accomplishments

Staff answer approximately 20 support and coordination-related requests a month for various field software and web/reporting systems. Staff recorded and published four additional P4 tutorial videos completing a comprehensive series describing features and functionality of this software. Provided guidance for PTAGIS users onboarding to the new PTAGIS website. A robust About section was added to the new PTAGIS website to introduce new users to PTAGIS, PIT tag data, and the tools available through the website. The PTAGIS web API follows OpenAPI specifications in support of machine-readable interface for consuming this RESTful web service. A user survey was conducted in 2021 and a few comments received initiated technical support requests.

2022 Plans

Complete video tutorials for release of I5 interrogation software. Complete online help documentation for the general release of M5 software to the community including guidance on how to install M5 on Linux platforms. Guide agencies on migrating from submitting interrogation data files via email to using the PTAGIS web API instead. Participate in a webinar in support of Klamath PIT Tagging efforts.

K: 189 Coordination- Columbia Basinwide

This objective covers standard regional coordination activities such as:

- Participating and the hosting of PIT Tag Steering Committee meetings[3]
- Participating and the hosting of Instream PIT Tag Detection System (IPTDS) Subcommittee meetings[4]
- Participating in and providing ad-hoc data requests to policy and technical forums
- Conducting email campaigns and surveys
- Publishing and distributing a semi-annual PTAGIS newsletter[5]

The following subsections describe additional coordination activities.

[3] PIT Tag Steering Committee Meeting Notes Archive: https://www.ptagis.org/Resources/DocumentLibrary?filterDocumentsBy=Meeting%20Notes
[4] IPTDS Subcommittee Meeting Notes Archive: https://www.ptagis.org/Resources/DocumentLibrary?filterDocumentsBy=Meeting%20Notes
[5] PTAGIS Newsletter Archive: https://www.ptagis.org/Resources/DocumentLibrary?filterDocumentsBy=Newsletter

Data Contributor Coordination

A diverse array of fisheries management and research organizations working in the Columbia Basin contribute MRR data and some observation data to PTAGIS. Basinwide coordination is necessary to ensure the contribution of these data are valid, timely and have adequate metadata. New *Tag Data Projects* and interrogation sites must be coordinated and approved through the PTSC before they can submit data into PTAGIS. Once approved, staff add the site metadata and implement automation features in the Server Data Management System.

Ongoing coordination among active data contributors involves the following activities:

- Manage Tag Data Project coordinator information
- Manage Interrogation Site steward information
- Manage validation codes, MRR sites and interrogation sites
- Provide start-up information for new data contributors
- Notifications about data anomalies
- Year-end reminders about data QA/QC and metadata requirements
- Special mailings as needed to disseminate information about process changes

PIT Tag Distribution and Quality Assurance

PTAGIS inventories and distributes all PIT tags to BPA Fish and Wildlife Projects (FWP). PTAGIS provides a web-enabled workflow to simplify the coordination effort and make it transparent. Aspects of this workflow process are:

- Forecasting annual PIT tag needs from FWP project leads
- Inventory management coordination between BPA and the PTAGIS Kennewick office
- BPA approval of tag requests for each project
- PTAGIS staff ship tags for each approved request
- Coordinate distribution with vendors for tags that are preloaded into needles
- Tag distribution information is archived and made available online

In addition to inventory and distribution, PTAGIS performs quality assurance (QA) on a sample of the PIT tags. This QA process uses advanced automation technology to verify the manufacturing of PIT tags meet specifications described in the contract between BPA and the vendor. This includes:

- Turn-on voltage
- Modulation percentage
- Resonant frequency
- Bandwidth/"Q"
- Size and weight

2021 Accomplishments

Participated in the PNAMP Fish Monitoring Workgroup and provided information in support of HCAX. Integrated a third-party email service into the new PTAGIS website to manage newsletter signups and distribution. Completed a security assessment of the PTAGIS program with Department of Interior in support of data contributions into our system from U.S. Fish & Wildlife Service.

Distributed 1.17 million tags to 64 FWP in 2021. The testing of 3% sample of those tags for quality assurance found no significant manufacturing defects.

General, on-going activities that include data contributor coordination are summarized in *Table 4.* This coordination had to be managed between two systems in support of the rollout of the new PTAGIS website. Staff provided year-end summaries to MRR and interrogation data contributors and coordinated resulting metadata and data corrections in the database. Staff corrected several Transceiver/Antenna ID combinations in interrogation site configuration metadata to support enhanced validation implemented on the database server. Many of the contacts associated with user accounts in the new PTAGIS website required updating and eventually stale accounts will be removed.

Coordination Type	Action	Count
MRR Projects	Added/Updated	95
MRR Sites	Added/Updated	20
Interrogation Sites	Added	11
	Decommissioned	37
	Updated	59
Newsletters	Published	2
News Items	Published	13
Support Requests	Fielded	~20/mo.

Table 4. Summary of on-going, general coordination activities performed in 2021

The subsequent sections describe other principal coordination activities completed in 2021.

PIT Tag Steering Committee Coordination

The annual PIT Tag Steering Committee (PTSC) Meeting was held via a virtual meeting on January 21, 2021. Meeting notes are available in the PTAGIS document library. Staff provided a review of program accomplishments in 2020 and plans for 2021. NOAA staff provided a similar update on the NOAA R&D contract. The chair and co-chair of the Instream PIT Tag Detection Subcommittee (IPTDS) reported back to the PTSC about their first annual meeting. Notable action items:

- PTSC agreed with PTAGIS on postponing the PIT Tag Workshop to 2023 due to COVID and uncertainties in agency travel budgets; will reconfirm the feasibility of this date at the end of the 2021.
    - Later in 2021, PTSC and PTAGIS decided postpone the workshop indefinitely until conditions improve
    - **NOTE:** the workshop requires a commitment at least 2 years out in order to:
        - Fund a down payment via PTAGIS annual budget (contract submitted 4 months before start of performance period)
        - Negotiate a suitable venue (300-person capacity)
        - Allow participants time to budget costs for travel and workshop fee
- PTSC agreed to preview an early release of the new PTAGIS website and provide feedback before a general release
- PTAGIS discussed the benefit of updating SbyC slide gates to electronic models
- PTAGIS discussed adding detection capabilities to barge load lines at transportation facilities
- PTAGIS and NOAA provided an update on the first year of GRS operation and continuing needs
- PTSC approved changing how River Kilometers (RKM) values will be updated when an interrogation site is moved and how observation data will link to those changes

Instream PIT Tag Data System Steering Subcommittee Coordination

PTAGIS coordinated and hosted an Instream PIT Tag Data System (IPTDS) Subcommittee virtual meeting in March 2021. The official meeting notes are available in the PTAGIS document library.

Members provided a summary of O&M for their instream interrogation sites during COVID. Members reviewed draft guidance for creating site diagrams for interrogation site metadata supported by PTAGIS. PTAGIS staff presented the new interrogation site metadata section of the PTAGIS website. Members agreed on how to associate observation data with interrogation sites that change locations. Staff presented a preview of the I5 interrogation software. Members discussed addition of environmental metadata into PTAGIS such as water depth, temperature, timer tags and other transceiver diagnostics; all agreed it would be difficult to standardize to make it useful, but virtual timer tags would be a good starting point to further this effort. Staff implemented a dedicated channel in Microsoft Teams for this group to share documents and provide feedback.

PTAGIS Data Specification

The PTAGIS Data Specification is a living web publication that replaced the *PIT Tag Specification Document* that has traditionally been published as a static document. The primary purpose of the Data Specification is to provide details about both MRR and interrogation data and file requirements, submission procedures, and lists of current validation codes. A change log provides links to past specification documents and will record any changes made to current specification. The PTAGIS Data Specification is available online at www.ptagis.org/Resources/Specifications.

In 2021, the data specification was updated:

- Added M5 file specifications pages
- Added submissions of M5 files through the API page
- Added page about timestamps associated with data
- Updated Interrogation Data Specification page
- Updated M4 File Specification page

2022 Plans

Coordinate annual meetings and related activities with the PTSC and IPTDS. Continue distribution, inventory and QA sampling of PIT tags to all FWP. Participate in other ad-hoc coordination efforts as requested. Continue refinement of metadata and *PTAGIS Data Specification*.