Development of Thermal Mark Data Sharing Methods

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Executive Summary

The objective of this project was to create a system to facilitate the exchange of thermal mark data between the Alaska Department of Fish and Game (ADFG) and the Department of Fisheries and Oceans Canada (DFO). For data sharing methods to become feasible, systems and methods were developed to assist in the organization, storage and retrieval of otolith thermal mark and recovery data.

Canada received a copy of an existing thermal mark database and software developed by the ADFG. Canada created an Oracle database and Windows application based closely on the designs and ideas of the Alaskan version.

In the development of the Canadian database and software, an iterative development life cycle methodology was followed. The iterative life cycle approach involved breaking the entire project into six milestones where feedback from end users was used to measure progress, efficiency and success. Once these milestones were decided, new deadlines were established and followed.

The system was installed and users were trained in both the Port Alberni and Whitehorse laboratories. Both laboratories successfully utilized the system and provided valuable feedback on necessary changes including, missing location codes, reporting requirements and modifications to add additional functionality to the program.

Through a series of correspondence between ADFG and DFO, methods and techniques were agreed upon to transfer and share the North Pacific Anadromous Fishery Council (NPAFC) Mark Identification and release data.

There are several benefits associated with this new system. They include 1) end users saving time by using automating tasks, 2) scalable storage and organization of data, 3) real time results, 4) improved accuracy of results and, 5) the enhanced collection of available information through data sharing methods.

There are a number of ongoing tasks. The completion of these tasks would greatly enhance the quantity of data. These tasks involve, 1) completion of the program to capture the reference data sent in by the hatcheries, 2) protocols to transfer the DFO laboratory resolved otolith specimen data to the ADFG, 3) importing of existing otolith data and, 4) creation of tools to assist in managing the laboratory's duties. Completion of these tasks is dependent on funding, available developer time and the coordinated efforts between ADFG and DFO.

Future recommendations include 1) relating the Age and Otolith databases together to mend deficiencies in current resolution processes, 2) continual monitoring of accurate results through cross-referencing of data until software is proven to be stable and 3) assigning a developer to deal with future technical issues.

Introduction

History

Otolith thermal marking is an effective method to determine the origin of hatchery-reared salmon. The ability to mark a mass amount of fish with a unique identifying code has popularized the usage of this technique in Canada, Japan, Korea, Russia and the United States.

There are practical limits on the number of mark patterns available for use. Therefore the North Pacific Anadromous Fish Commission (NPAFC) Working Group on Salmon Marking was established to coordinate the application of otolith thermal mark patterns, improve the accuracy of mark identification among nations and prevent the release of identical marks among countries (Working Group on Salmon Marking).

Issues dealing with the assignment and coordination of unique thermal mark patterns have largely been dealt with by the NPAFC. The NPAFC, with the assistance of the Alaska Department of Fish and Game (ADFG), have created a database to store, organize, manage and exchange this information. This database facilities the assigning and creation of the NPAFC Mark Identification code (referred to as the NPAFC Id). The NPAFC Id is an internationally unique code used to identify a hatchery's particular release group of salmon including the, brood year, release year, hatch code and species type.

Canada's participation in utilizing the NPAFC database has been minimal to this point. Canada did not have the infrastructure and procedures in place to facilitate an effective utilization of the NPAFC data. This lack of participation and appropriate infrastructure led to problems in using the hatch code to accurately identify the originating hatchery of the individual specimens as well as managing the associated data. For example, if a fish was recovered in a country outside of where it was originally marked, determining the correct NPAFC Id to assign the fish was difficult. The NPAFC Id and release data was not easily accessible outside of the country the fish originated in. This fish would often then be classified as "unknown". Yet, these fish could have been assigned the correct NPAFC Id if the infrastructure was in place to allow laboratory personnel easy access to the NPAFC Id and its release data.

For a comprehensive description of the NPAFC Working Group database and public website created by the Alaska Department of Fish and Game, see the link to the paper "Revised Web-based North Pacific Salmon Otolith Mark Directory" found in the *Reference Section*.

Need for a system

There was a need for a system to assist in the organization, storage and retrieval of the otolith thermal mark data. The volume of data generated in the process of recovering the samples, reading the specimens and assigning the correct NPAFC Id is substantial. Without such a system, the data quickly grows to a point where acquiring the desired data and drawing the correct results becomes time consuming and complicated to manage.

Otolith data can be used to assist in making decisions relating to research and stock management. Decision makers require accurate and complete information to effectively manage fisheries and fish populations. Thus it is important these data are accurate, complete and presented in an understood manner to allow fisheries managers to concentrate on making correct decisions instead of organizing and verifying data.

As a result of the substantial amount of otolith data and the need for accurate reporting tools, a relational database quickly becomes a necessity. A relational database provides a scalable storage medium where data with common characteristics are grouped together, data integrity constraints are programmed in and results are quickly calculated. An intuitive interface then needs to be created allowing users to access and manipulate this database. The created interface provides users with tools to store, navigate, filter and create reports based on the otolith data.

Objective

Our objective was to create a system to facilitate the utilization of the NPAFC international database and to assist in the organization, storage and retrieval of the necessary otolith thermal mark data. The completion of this objective will potentially allow the Canadian laboratories to correctly associate the NPAFC Id of any fish regardless of the country the fish was originally marked in. These results are then recorded and organized in a system allowing for accurate reports and easy access for future use.

Methods

The methods section describes how the project was carried out. This section lists the life cycle methodology used; milestones created; deadlines followed; and a timeline description.

Canada was fortunate to receive a copy of the Alaskan otolith database and software. Essentially, the design and implementation of the Canadian software and database were based on the ideas and designs of ADFG analyst and programmer, Tim Frawley. An analysis of the Alaskan software and database design was done to understand the methods and procedures used by the Alaskan's and how these procedures differed from the Canadian laboratory protocols.

Incremental/Iterative Life Cycle Methodology

The software life cycle used was an incremental or iterative development. This approach involves breaking the project into small sections and iterate over a series of steps to incrementally produce an end product. This method allowed us to receive user feedback after each section was completed, thereby providing us with an opportunity to make corrections to the final design and produce a more efficient and accurate program.

The entire project was broken into six sections or milestones based the on DFO requirements and the architecture of the Alaskan design. The sections were:

1. Recovery Samples
2. Printing Labels
3. Reading/Associating Marks to Specimens
4. Laboratory installation and training
5. Reports
6. NPAFC Mark Identification Data Sharing

For a detailed explanation of each milestone, please see the *Quality Assurance/Control – Methods* section.

Each of the above sections was then subject to a series of phases known as the *waterfall model*. The phases are as follows: system feasibility, requirement analysis, system design, coding/unit testing, integration and deployment.

System feasibility and requirement analysis

For each milestone, the system feasibility and requirement analysis depended on the existing Alaskan program as well as on feedback from end users. The existing database design and software was analyzed to identify features that needed to be incorporated into the Canadian design. Extensive correspondence with the Thermal Mark Coordinator Jeffery Till was also done to ensure the usefulness and accuracy of the purposed requirements.

System design and coding/unit testing

This phase involved modeling the Alaskan design and using sections of the Alaskan code to write software to meet the requirements identified during the previous phase. The code was tested by the developer to ensure functionality.

Integration and deployment

The software was sent to users for testing and review. The program was checked by the end users to ensure the needs and requirements of the Canadian users were met and to receive feedback on improving software functionality.

For a more detailed explanation of life cycle methodologies please see Microsoft's article on "Testing Methodologies" found in the *References* section.

After initial requirements

Once the first three milestones were reached, the program was distributed to the laboratories. As the laboratories utilized the software, periods of rapid iterative improvements were made based on the communication between the laboratories and the developers. Critical changes to the software were implemented and sent back to the laboratories minimizing processing delay due to software issues.

Quality Assurance/Control

Progress towards completion was measured by the delivery of milestones. The project was divided up into six sections; therefore six milestones had to be completed. The first four milestones were dependent on each other and needed to be finished in the order given.

Milestones

1. **Recovery Samples**
   Develop a system to store and retrieve recovery sample data including box and specimen identification numbers.
2. **Printing Labels**
   Automate the procedure of creating and printing the otolith box and specimen identification slide labels.
3. **Reading/Resolving Marks to Specimens**
   Assist laboratory personnel in identifying the correct hatchery associated with a hatch code and assign this identifier to the recovered otolith specimen. Store and retrieve the resulting information

4. **Laboratory installation and training**
   Install the developed software and train the staff at the Port Alberni and Whitehorse laboratories.
5. **Reports**
   Display data in a pre-defined printable form showing the breakdown of hatch codes, hatcheries and NPAFC Mark identifiers associated with the recovered specimens. To view example reports see *Figure 3 – Example Summary Report* and *Figure 4 – Example Breakdown Report* in the *Appendix* section. For more information on how these data fields are related to each other see *Figure 2 - Database Entity Relationship Diagram* found in the section.
6. **NPAFC Mark Identification Data Sharing**
   Develop methods to utilize the NPAFC Mark identifier data from the common NPAFC database and create procedures to encourage DFO's participation with the NPAFC.

Deadlines

1. **August 1, 2009**: Deliver the first three milestones, *Recovery Samples, Printing Labels,* and *Reading/Associating Marks to Specimens*
2. **August 15, 2009**: Deliver the forth milestone, *Laboratory installation and training*
3. **October, 2009**: Deliver the fifth milestone, *Reports*
4. **March 30, 2010**: Deliver the sixth milestone, *NPAFC Mark Identification Data Sharing*

Timeline

April 2009

- Assembled project team
- Reviewed existing database and sharing mechanisms and defined general software requirements
- Outlined general requirements to adapt current software to meet program needs
- Formulate project plan and identify milestones and deliverables
- Identify and arrange for equipment and programming services

May – July 2009

- Rewrote the software to accommodate Canadian needs
- Developed and delivered Recovery Sample milestone
- Developed and delivered Printing Labels milestone
- Developed and delivered Reading/Associating Marks to Specimens milestone

August 2009

- Tested new system – determine optimal methods for use in lab
- Configure Port Alberni Laboratory and trained staff to utilize the software
- Configure Whitehorse Laboratory and trained staff to utilize the software

September - October 2009

- Developed and delivered Reports milestone

November 2009

- Meet with Alaskan representatives Tim Frawley and Dion Oxman to make decisions regarding data sharing
- Alaska develops data sharing web service of NPAFC Mark Identification Release data

October 2009 – February 2010

- Series of incremental updates and revisions were made based on correspondence with Whitehorse laboratory personnel

March 2010

- Developed and delivered NPAFC Mark Identification Sharing milestone

Results

This section describes the resulting database, software, data sharing methods and current results produced by the end of this project. A high level overview is presented to describe each component.

For a visual representation of each component in the system and the relationships between them, see *Figure 1 - System Relationship Diagram* found in the *Appendix*.

Oracle Relational Database to Manage Data

An essential element of this project is the underlying structure used to store the data. An Oracle relational database was utilized to store, organize and retrieve the otolith data.

There are many advantages to the creation and utilization of the Oracle relational database. It allows for a single location where all the Canadian otolith related data can be entered and queried. All Canadian laboratories, whether in Whitehorse or Port Alberni, will be entering and accessing their data into this single database. Having the single database will help maintain data consistency and accuracy as well as provide nearly instantaneous access to data from any location where the software is installed.

The Oracle database is also designed to handle the storage and quick retrieval of high volumes of data. Common characteristics are grouped together in a single table consisting of rows and columns. A single row in the table corresponds to a single record. The columns in the table are the attributes of this record. Each column can have constraints programmed in to ensure the attributes follow the same structure and assist in data integrity.

The records can be linked together allowing a record in one table to be an attribute of another table. For example, a species table and a sample table were created and related to each other. The species table contains a grouping of the various species of salmon. Each species has the same characteristics including a name, an abbreviated name and a unique code. The sample table contains the groups of recovered samples. These samples have common characteristics including gear type used, location caught, and species. The species characteristic of the sample table can then be linked to the corresponding record in the species table. This method of relating data tables and attributes to each other forces the data to follow a defined set of requirements and assists in the data being scalable.

The database contains a wide variety of otolith related data and their relations including;

1. **Recovery Samples**
   The recovered samples are a group of recovered otolith specimens with common characteristics including species, gear used, and locations recovered.

2. **Recovery Readings**
   The recovery readings are the resulting records the laboratory technicians assign to a particular otolith specimen. These include, hatch mark, NPAFC Id, facility and brood year.
3. **NPAFC Mark Ids**
   The NPAFC Mark Id's contain a grouping of data downloaded from the international NPAFC database. The NPAFC Mark Id is grouped with the hatchery the mark was assigned to, actual hatch code used, species and brood year.
4. **Supporting Data**
   There are many more tables containing other supporting data. These tables include relational data on locations, gear types, agencies, species, users, facilities and hatch codes.

Consult *Figure 2 - Database Entity Relationship Diagram* located in the *Appendix* for a more detailed description of the data stored within the database.

Windows Application to Access the Database

As useful as the database is for storing and retrieving data, it is not designed for use by the general computer-using public. Thus a user interface was employed to give laboratory personnel and fisheries managers an easy way of entering and manipulating the necessary data. Microsoft Visual Studio 2008 was used to create a Windows desktop application for use as a user interface. This application allows the user to interact with the Oracle database by using a user friendly, intuitive graphical user interface that converts the data into forms easily understood by each party.

The application can assist with a diverse range of otolith related tasks as described below.

1. **Recording/Displaying Recovery Samples**
   Methods were developed to allow users to enter the recovery sample data and the associated data quickly into the database. Users can also filter and view the existing sample data entered.
2. **Recording/Displaying the Laboratory Readings**
   The program assists the laboratory staff in resolving a recovered otolith specimen to a particular NPAFC Mark Id, hatch code, brood year and hatchery. This is done by filtering the possibilities based on the information the user enters. Once the user has decided on the appropriate resolution of the specimen, the data is entered directly into the database. The user can view and edit their decisions as needed.
3. **Printing Specimen Labels**
   Once the recovery sample data has been entered into the database, a user can print labels to go on the otolith specimen slides.
4. **Generating Reports**
   Users can run both custom and user-defined reports to get requested results from the database. The user has the option to copy the data into an Excel spreadsheet for further manipulation or to print the data.

5. **Adding/Editing supporting data**
   There is a significant amount of extra data needed to support the otolith data. These data may need to be updated and modified as new information becomes available. Screens were developed to allow a user to add and modify supporting data to the database.
6. **Downloading the NPAFC Mark Identification**
   The NPAFC Mark Identification is entered in the international database. The NPAFC Id data is then downloaded onto the DFO's servers and integrated into the system to be displayed in Canadian laboratories.
7. **Viewing the NPAFC Id Images**
   Images showing the actual reference otoliths are retrieved from the international database to allow laboratory personnel to see the actual sample hatch code image produced from a given hatchery.

Sharing of the NPAFC Mark Identification Data

Alaska and Canada have established methods to ensure that the NPAFC Mark Identification and recovery data can be utilized by both countries. Alaska has set up a web-reference allowing Canada to query the NPAFC database to return a dataset of the recorded NPAFC Mark Identification and recovery data. This dataset is then processed and downloaded into the Canadian database giving the laboratory personnel the ability to view any mark entered within the international database.

Otolith mark images that have been entered into the NPAFC database will also be shared and transferred to the Canadian database.

An added benefit to this process is that it encourages the entry of Canadian NPAFC data into the NPAFC database. This is done by requiring the data be entered into the international database before the data will appear within the Canadian software.

Current Results

As of May 28, 2010, there have been 36 recovery samples entered in the deployment of this system. The 36 recovery samples have produced 7,294 specimens. There have been 5,905 laboratory readings done on these specimens. This data set only reflects the 2009 data entered after October 2009. As we can see, the amount of data to keep track of is significant.

Results, reports and specimen labels have all been produced based on the data entered.

Discussion

The purpose of this section is to discuss how the project is currently being monitored and some of the obvious benefits of the software so far. Future recommendations and ongoing work are also presented along with a reflection on the original project purposed schedule and objectives.

Monitoring and Evaluation

The software is undergoing continuous evaluation for improvements to the design and added functionality. While there has been much success with the use and accuracy of the software so far, the developers advocate continual monitoring of the software and the results to ensure the software release is in a stable condition.

In development, the software was continuously monitored and evaluated by the developers and laboratory personnel for accuracy and performance issues. Through the use of the software, the program will be continually monitored and evaluated indirectly by the end users. At this point in time, however, there are no plans for additional monitoring by the developers. It may be beneficial for developers to periodically monitor and evaluate the performance of the software as well as deal with issues brought up by the end users. See the *Recommendations* section of this document for more information.

Benefits

Saving workers time through automation

One of the key benefits of the implementation of this system is the automation of some of the more trivial tasks. For example, label printing and creating predefined reports have become an automated process leading to direct time savings by laboratory workers and fisheries managers. By minimizing the time spent on repetitive mundane tasks, the users can focus on their higher level responsibilities.

Computerized label printing

An obvious example of this time saving technique is demonstrated in the generating and printing of the specimen labels. In a given year, it is not unusual to have 10,000 specimens. Every specimen usually contains two otoliths. Each of the otoliths needs to be mounted and given a label. Consequently, this requires 20,000 labels (J. Till, Canadian DFO, pers. comm.). This is labour intensive and time consuming process when done by hand. With the Otolith software, we can now print out sticker labels containing all the required data within minutes of data entry. These labels can be mounted on the slides and saves the lab personnel a tremendous amount of time.

Predefined reports

Users can print out common predefined reports by quickly specifying a few parameters. The user can save time searching and formatting frequently needed reports by using these predefined templates. For a sample report, see *Figure 3 – Example Summary Report* and *Figure 4 – Example Breakdown Report* found in the *Appendix* section.

Real-time results

Another benefit of this system is that the results are entered in real time. Therefore, results can be accessed by users as they are entered. There is no need to wait for an entire sample to be processed. The data can be viewed as soon as the results from each specimen within a sample are entered into the system's database.

Scalable organization and storage of mass amounts of data

With the large volume of data produced, this system allows for an efficient and effective means of storing and organizing data. This system is very scalable and should allow for considerable growth with minimal maintenance.

Improved Accuracy of Reports

Access to the NPAFC Id data allows laboratory staff access to international marks and their corresponding images. Each country entering a NPAFC Id into the NPAFC database has the option to include an image of the actual mark. The laboratory staff can then view the images of potential marks to aid in resolving the mark. This increased availability of NPAFC Ids and the corresponding images potentially increases the correct associations of hatchery to recovered hatch codes. The end result is more accurate mark identifications and summary reports.

Data sharing techniques developed

Alaska and Canada have developed techniques for the transferring of the NPAFC Mark Identification and release data. There is a potential here for future collaboration and expansion of each country's collection of available data.

Recommendations

Relate the Age and Otolith databases to increase accuracy

Significant otolith mark resolution data are lost in the current laboratory specimen resolution system. The otolith laboratory technicians do not have access to the age of a particular specimen. Since a single hatch code may correspond to multiple NPAFC Ids spanning a narrow range of brood years, knowledge of the specimen's exact brood year is critical in distinguishing between NPAFC Ids. As the otolith laboratories do not have access to this brood year information, the resolution of a specific hatch code to the actual NPAFC Id is in many cases lost.

The otolith specimen's brood year information is already captured within the Age laboratories. Relating the Age and Otolith databases together would provide significant improvements in determining the actual NPAFC Id of a thermally marked specimen thus improving the quality and accuracy of the generated reports.

Monitoring and Cross-reference validity of yearly data

Although testing has shown that the database works efficiently and accurately, we recommend that the system continued to be monitored for accurate results before completely relying on the new system alone. This program recently had significant changes made to increase functionality. It is possible new uncaught issues preventing reliable operation have been created. A backup Excel file could be used to cross-reference the validity of yearly data. This cross-referencing and close monitoring should be done at least in the first year of operation to ensure correct behaviour. If the system undergoes any revisions affecting the storage or retrieval of the data then cross-referencing and monitoring should then be resumed. Even a small change can potentially cause the system to behave unpredictably leading to inaccurate results or loss of data.

Developer assigned to deal with future issues

The nature of software development requires that developers address issues such as changing requirements, additional features, and the discovery of unnoticed "bugs". Although much care went into the system to capture the scope of needed features and requirements and to avoid errors within the system itself, there is still the likelihood that changes to the software will be needed throughout the year.

There is also the issue of rare situations requiring the direct attention of a developer to help resolve. For example, when updating the NPAFC Id, a critical piece of data, like the hatchery name, could be changed. If there are existing readings associated with the old NPAFC Id, the correct action to take is uncertain. In this case, the decision of how to handle the associated readings may be needed to be decided on a per case basis. Manual changes may need to be done within the database itself.

Having a developer available to quickly address and resolve issues and modify the software to satisfy the needs of end users can minimize laboratory downtime due to technical issues and increase the value of the software. This can lead to improved productivity among the laboratory personnel.

Ongoing Work

This section describes ongoing and future work to improve the functionality and usefulness of the developed system. The completion of the following sections is dependent on funding, developer time and the coordinated efforts between the ADFG and DFO.

Sharing Laboratory Readings with ADFG

ADFG and DFO gain a more comprehensive understanding of the correct number of hatchery recovered specimens by sharing each laboratory's resolved otolith data. The ADFG has an online web service allowing outside access to querying their resolved otolith data (http://tagotoweb.adfg.state.ak.us/OTO/reports/MarkSummary.aspx). DFO does not have an equivalent system to allow other organizations the ability to view Canadian resolved otolith data. Originally, it was thought DFO would transfer a summary report of the laboratory resolved otolith data to the ADFG. However, it was recently determined it would be beneficial to allow ADFG the ability to run their own interpretations and results by sharing the DFO laboratory resolved data. Thus protocols to transfer the DFO laboratory resolved data to the ADFG are being developed to allow both countries access to a more complete understanding of the resolved otolith specimen's results. This procedure is dependent on the coordinated efforts of the ADFG and DFO.

Reference Sample Data

Hatcheries send in a small sample of the thermally marked salmon, known as reference samples. These reference samples are then checked by the laboratories for quality and correctness. Multiple reference samples from the hatcheries are combined to determine the official data to associate with the NPAFC Mark Identification. There is a substantial volume of data associated with this procedure. We are in the final process of completing the necessary tools to store, organize and manage this reference sample data.

Import of Existing Otolith Data

The Otolith data from previous years have been entered into Excel spreadsheets. Due to data integrity issues found within the spreadsheets, these data have not been imported into the database. These data are close to being converted to a corrected format. A program will need to be created to assist in this import as there are approximately 100,000 records to import.

Laboratory Management Tools

As the volume of otolith data grows, methods need to be created to assist in managing the samples. A program to assist in prioritizing the examinations of each sample and check what stage the samples are in needs to be created.

Original Project Schedule and Objectives

Finished close to expected end date despite slow start

The original start date of this project was January 2008. However, significant work did not start on this project until April 2009. This delay required modifications to the existing schedule. However, by having a developer dedicated to this project over the summer months who also provided maintenance throughout the year, the project was able to be completed within six months of the expected due date.

Deviations in expected approach

The original proposal called for the development of a web-based application. However, the time to transfer the potentially large datasets was too great to be effectively used in a laboratory setting. Consequently, the design was changed to accommodate a Windows desktop application.

Original project objectives met

As stated in the original project proposal, the objective of this project was to facilitate the joint Canada/U.S. use of a common database. This project met that objective through the utilization of the existing NPAFC database. By creating a system in which the data are downloaded from the single master NPAFC database, we meet this goal.

The measure of success of this project was stated as whether data can be easily shared, and whether labs and programs from each agency develop joint standards and joint quality control. Both the Canadian and Alaskan laboratories follow similar procedures when with dealing with otolith thermal marks. There is a need for the data to be converted from the Alaskan format to a Canadian format as was done in the sharing of the NPAFC Mark Identification. However, the overall paradigm of dealing with otolith thermal marks is similar enough between countries to allow for most of the data to be transferable. At this time, the data being transferred is the NPAFC Mark Identification and release data.

Conclusion

This project *Development of Thermal Mark Data Sharing Methods* was created to facilitate the development of a joint Canada/U.S. database. For data sharing techniques to become feasible, it required an elaborate infrastructure to be built to store, manage and retrieve large amounts of data. Consequently, an Oracle database was utilized to manage the generated data. A Windows application was then employed to provide users with an intuitive interface to store and retrieve otolith data, print specimen labels, create reports and assist in resolving the NPAFC Mark Identification of a particular otolith specimen.

Data sharing techniques and protocols were then organized and implemented through correspondence between Alaska and Canada. Alaska provided Canada access to the common international NPAFC database where Canada is required to enter their NPAFC Mark Ids. Using the newly built database and application, Canada was able to access the common database thereby increasing the available international mark data.

In conclusion, this project met the goals and objectives outlined in the Development of Thermal Mark Data Sharing Methods application form. We produced a system where the relevant records are available to assist laboratory personnel in correctly resolving the otolith specimens, thereby improving the quality and accuracy of the generated reports for the fisheries managers. Developing data sharing methods and techniques with Alaska has given both countries the ability to expand their collection of available information and has encouraged future collaboration.

Acknowledgements

We wish to thank the following people for their contributions to this project;

Department of Fisheries Data Group manager Carmen McConnell who provided clear direction and leadership in coordinating the efforts of the people and organizations involved in this project.

Department of Fisheries thermal mark coordinator Jeffery Till for providing his expert insight and advice on the needs and requirements of the Canadian laboratory personnel and fisheries managers.

Department of Fisheries technician Matt Waugh who extensively utilized and tested the system and supplied valuable feedback on software issues.

Alaska Department of Fish and Game analyst and programmer Tim Frawely for providing Canada with a copy Alaska's Otolith software and database as well as creating the web service used by Canada to download the NPAFC Mark Identification data.

Alaska Department of Fish and Game biologist Dion Oxman for reviewing and offering constructive feedback and revisions to this report.

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“Welcome to the Working Group on Salmon Marking.” North Pacific Anadromous Fish Commission. 2006, 28 May 2010 <http://npafc.taglab.org/>

Appendix

The following pages contain diagrams and figures meant to supplement the understanding of this project.

Figure 1 - System Relationship Diagram

This diagram gives an overview of the relationships between the different components within the entire system. Specifically, the diagram describes the relationships between the end users, the NPAFC database, the windows application and the Canadian database.

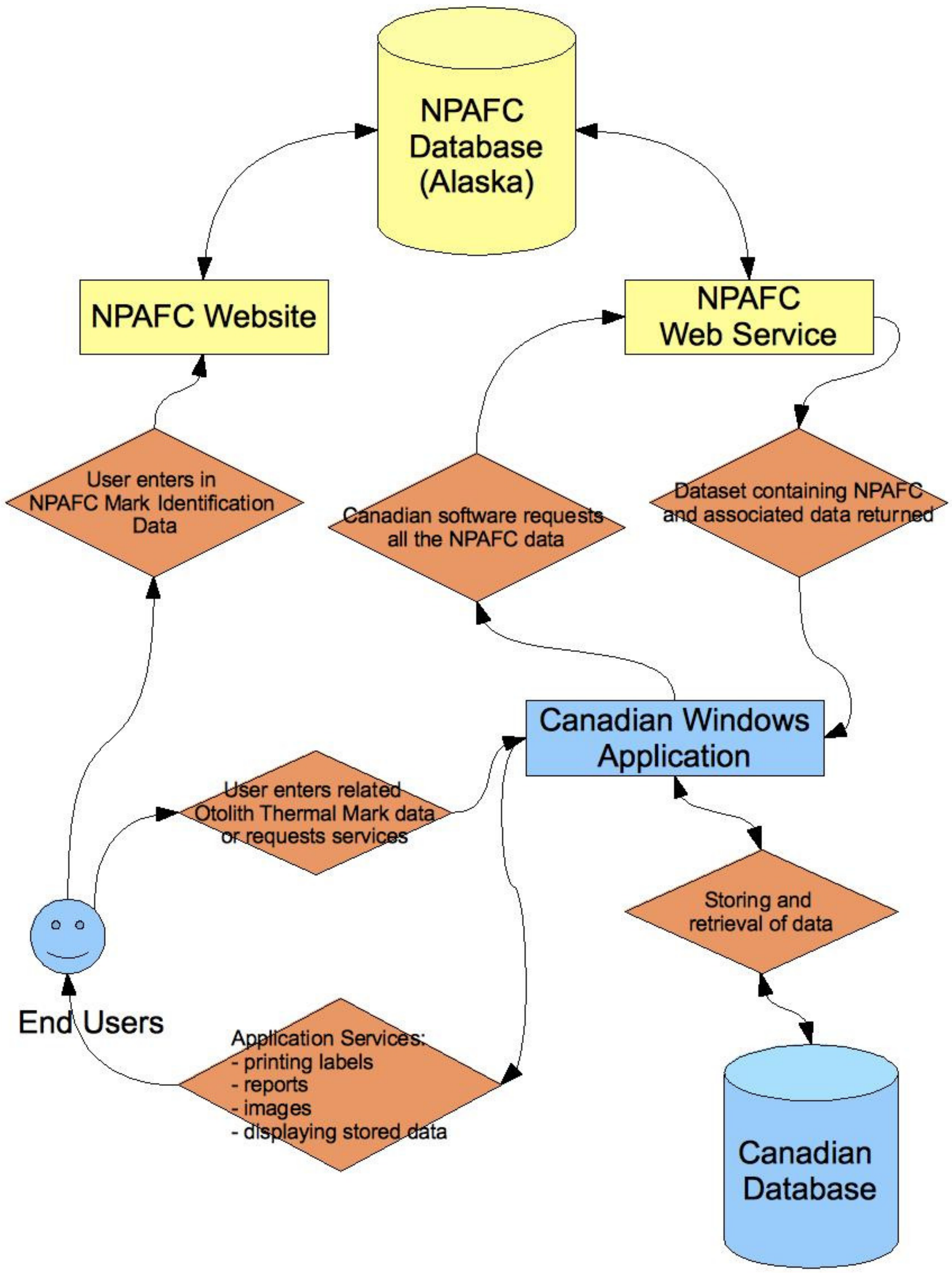

Figure 2 - Database Entity Relationship Diagram

This figure displays a subset of the tables stored within the Oracle database. The diagram is meant to show the relations between the recovery samples, marks and readings as well as give an appreciation of the amount of supporting tables needed.

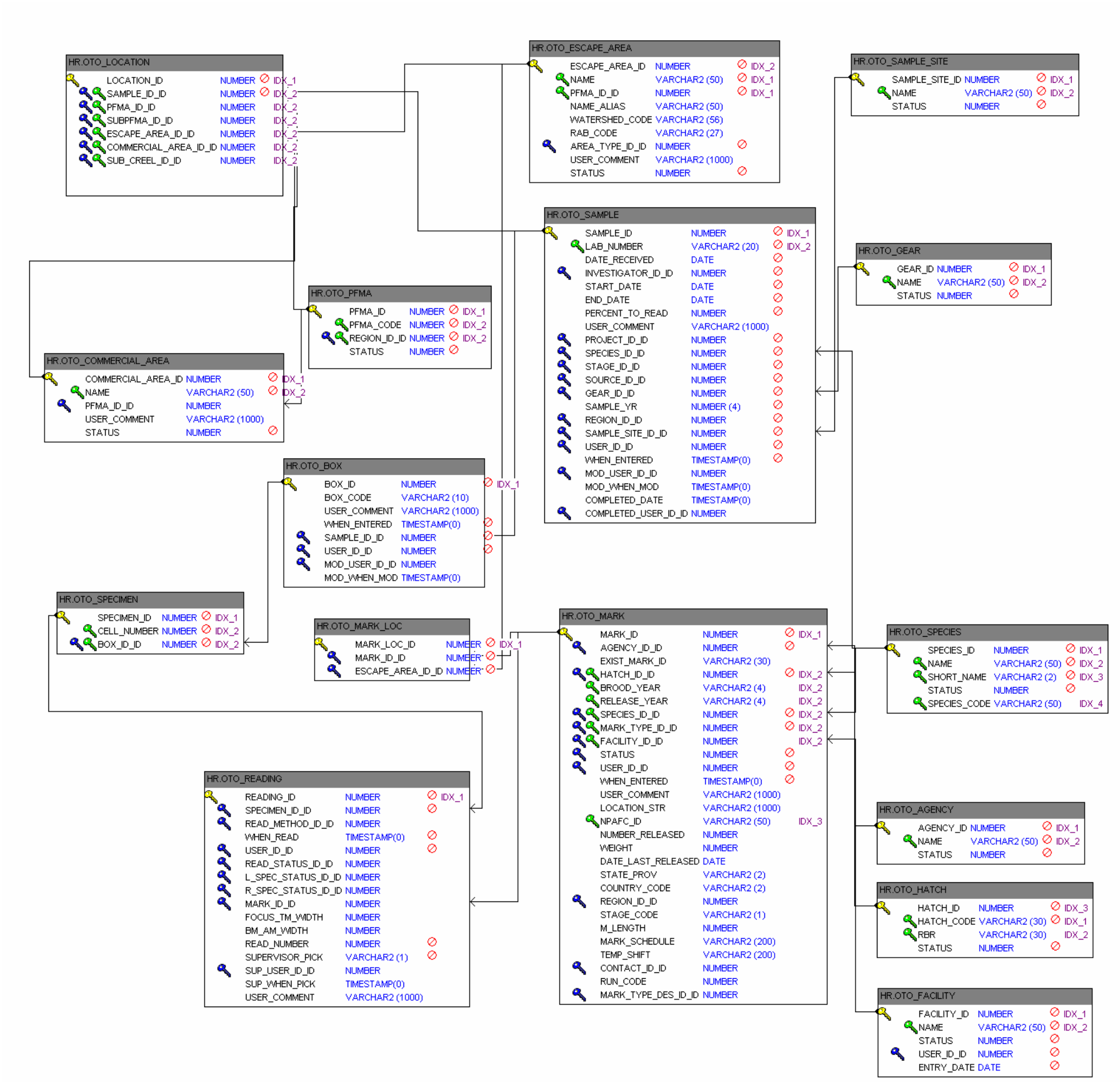

Figure 3 – Example Summary Report

Below is the first page of an example pre-defined summary recovery report. This report was generated by requesting a summary of all 2009 Sockeye recovery data

Otolith Thermal Mark Data Summary

Printed Date: 6/20/2010

2009 Sockeye

This report contains summary information on the recorded specimens. This is the current data as of the time it was printed.

All percentages are caluclated based on the number of Resolved Specimens

Total Specimens:	4434	Marked:	1809	43.18%	Mark Unknown:	1	0.02%
Total Reads Done:	4243	Not Marked:	2323	55.45%	Unreadable:	0	0%
Resolved:	4189	Destroyed:	9	0.21%	No Sample:	47	1.12%

Total Results Based on Facility

Facility	Count	Percentage
SNETTISHAM	1808	43.16%
TRAIL LAKES	1	0.02%
Facility not matched	2380	56.82%

Total Results Based on Facility, NPAFC ID and Hatch

Facility	NPAFC ID	Hatch Code	Count	%
SNETTISHAM	AK03-60	3,3H	1	0.02%
SNETTISHAM	AK03-65	4H	35	0.84%
SNETTISHAM	AK03-67	5H	2	0.05%
SNETTISHAM	AK03-68	5H3	3	0.07%
SNETTISHAM	AK03-70	6H	30	0.72%
SNETTISHAM	AK04-62	4H3,3	12	0.29%
SNETTISHAM	AK04-63	6H4	678	16.19%
SNETTISHAM	AK04-64	4H5n	25	0.60%
SNETTISHAM	AK04-67	6H6	251	5.99%
SNETTISHAM	AK05-65	4,2H	21	0.50%
SNETTISHAM	AK05-66	4H4	34	0.81%
SNETTISHAM	AK05-67	4H3	3	0.07%
SNETTISHAM	AK05-68	4H5	2	0.05%
SNETTISHAM	AK06-63	2,2,3H	2	0.05%
SNETTISHAM	AK06-65	2,1,2H	3	0.07%
SNETTISHAM	AK06-74	3,3H	4	0.10%
SNETTISHAM	AK06-76	3n,2H	8	0.19%
SNETTISHAM	AK06-86	2,2,1H	2	0.05%
SNETTISHAM	AK07-07	1,2n,3H	131	3.13%

Figure 4 – Example Breakdown Report

Below is the first page a pre-defined example report containing a detailed breakdown of the individual specimen results within two recovery samples.

Otolith Thermal Mark Data Breakdown

Printed Date: 6/21/2010

SK09-001, SK09-002

This report shows a detailed breakdown of the recorded specimens. This is the current data as of the time it was printed.

Lab Number	Box Code	Cell	Specimen Barcode	Read Status	NPAFC ID	Hatch Code	Facility
SK09-001	001	1	586	Not Marked	Unresolved		
SK09-001	001	2	587	Not Marked	Unresolved		
SK09-001	001	3	588	Not Marked	Unresolved		
SK09-001	001	4	589	Not Marked	Unresolved		
SK09-001	001	5	590	Not Marked	Unresolved		
SK09-001	001	6	591	Not Marked	Unresolved		
SK09-001	001	7	592	Not Marked	Unresolved		
SK09-001	001	8	593	Not Marked	Unresolved		
SK09-001	001	9	594	Marked	AK06-86	2,2,1H	SNETTISHAM
SK09-001	001	10	595	Marked	AK07-87	2,3n,1H	SNETTISHAM
SK09-001	001	11	596	Marked	AK07-85	2n,3H	SNETTISHAM
SK09-001	001	12	597	Marked	AK07-18	3,2n,1H	SNETTISHAM
SK09-001	001	13	598	Marked	AK07-87	2,3n,1H	SNETTISHAM
SK09-001	001	14	599	Destroyed	Unresolved		
SK09-001	001	15	600	Not Marked	Unresolved		
SK09-001	001	16	601	Not Marked	Unresolved		
SK09-001	001	17	602	Marked	AK07-18	3,2n,1H	SNETTISHAM
SK09-001	001	18	603	Marked	AK07-85	2n,3H	SNETTISHAM
SK09-001	001	19	604	Not Marked	Unresolved		
SK09-001	001	20	605	Marked	AK07-86	1,3n,2H	SNETTISHAM
SK09-001	001	21	606	Not Marked	Unresolved		
SK09-001	001	22	607	Not Marked	Unresolved		
SK09-001	001	23	608	Not Marked	Unresolved		
SK09-001	001	24	609	Not Marked	Unresolved		
SK09-001	001	25	610	Not Marked	Unresolved		
SK09-001	001	26	611	Not Marked	Unresolved		

Figure 5 – Financial Statement