Electronic collection and transfer of salmon escapement biological data – Final Report for Northern Fund, Cooperative Agreement COOP-05-114

by

John A. Wilcock

December, 2007

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
mega bytes	MB
megahertz	MHz
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
integrated development environment	IDE
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

ELECTRONIC COLLECTION OF SALMON ESCAPEMENT BIOLOGICAL DATA – FINAL REPORT FOR NORTHERN FUND COOPERATIVE AGREEMENT COOP-05-114

by
John A. Wilcock,
Alaska Department of Fish and Game,
Division of Commercial Fisheries, Douglas

December 2007

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

John A. Wilcock,
Alaska Department of Fish and Game, Division of Sport Fish,
Anchorage, AK, USA

This document should be cited as:
Wilcock, J.A. 2007. Electronic collection of salmon escapement biological data – final report for northern Fund cooperative agreement coop-05-114. Alaska Department of Fish and Game, Anchorage.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination based on race, color, national origin, age, sex, religion, marital status, pregnancy, parenthood, or disability. The department administers all programs and activities in compliance with Title VI of the Civil Rights Act of 1964, Section 504 of the Rehabilitation Act of 1973, Title II of the Americans with Disabilities Act of 1990, the Age Discrimination Act of 1975, and Title IX of the Education Amendments of 1972.

If you believe you have been discriminated against in any program, activity, or facility, or if you desire further information please write to ADF&G, P.O. Box 25526, Juneau, AK 99802-5526; U.S. Fish and Wildlife Service, 4040 N. Fairfax Drive, Suite 300 Webb, Arlington, VA 22203 or O.E.O., U.S. Department of the Interior, Washington DC 20240.

For information on alternative formats for this and other department publications, please contact the department ADA Coordinator at (voice) 907-465-4120, (TDD) 907-465-3646, or (FAX) 907-465-2440.

TABLE OF CONTENTS

Page

LIST OF TABLES

Table **Page**

LIST OF FIGURES

Figure **Page**

LIST OF APPENDICES

Appendix **Page**

ABSTRACT

Mobile electronic data collection methods for recording data during biological sampling of salmon spawning escapements were investigated. Development of a software application for recording data on fully rugged handheld computers suitable for use under extreme environmental conditions was initiated. Successful system development depended upon completed implementation of software programs initiated under a separate project for recording similar biological information during fishery sampling. Although large-scale deployment of mobile data collection techniques under the fishery sampling project proved feasible, some project objectives critical for this project were not successfully met, and development of software for salmon escapement sampling was halted.

Key words: salmon biological sampling, coded wire tag, bar code, handheld computer, Southeast Alaska, electronic data capture, data collection automation

INTRODUCTION

Mobile electronic data collection techniques were investigated to improve collection and processing efficiency, as well as availability and reliability, of biological data gathered during salmon spawning escapement sampling. Methods implemented were to be based on software and database techniques developed under a separate project to automate data collection for commercial salmon fishery biological sampling. Of primary interest was collection of data required for stock assessment analyses used to evaluate abundance-based harvest sharing provisions of the Pacific Salmon Treaty.

Accurate estimates of the stock composition of harvests of sockeye, Chinook, and coho salmon in Southeast Alaska and Northern British Columbia fisheries are required for successful implementation of abundance-based harvest sharing agreements outlined in the Treaty. Results from stock assessment studies based on scale patterns analysis, genetic analysis, or mark recoveries are critical to evaluate compliance with treaty provisions that define these harvest sharing agreements in the Northern Boundary and Transboundary River Areas. ADFG, Commercial Fisheries Division, Southeast Region, personnel currently collect and analyze samples and data required for these studies, routinely handling more than 1 million salmon annually during fishery catch sampling. Personnel also routinely collect baseline samples from representative spawning escapements to calibrate stock assessment studies that estimate national contributions in sampled fisheries. Tissues collected from the same individual fish are frequently sent to different processing labs for use in an increasing variety of stock assessment methods, necessitating rigorous tracking of individual samples throughout the process to correctly match results afterward from separate analyses.

Associated data for these studies are typically recorded in the field using water resistant mark-sense paper data forms. However, these paper forms are inherently inefficient, unusually prone to human errors during data collection, and although water resistant, can prove be quite difficult to use under adverse weather conditions common during escapement sampling. As for all other paper data forms, they dictate additional expense during data collection, and for optical conversion to electronic format for analysis.

The current project was initiated to build upon the development of mobile electronic data collection systems to reduce problems inherent with using paper data forms during fishery sampling, and extend the use of electronic data collection to salmon escapement sampling. Although the information and tissue samples collected during salmon catch and escapement sampling are similar, environmental conditions and fish handling procedures for the two sampling situations are quite different. Extreme environmental conditions, protracted sampling in remote locations, and handling of live fish during escapement sampling require substantially more rugged hardware with extended power sources, and modification of data collection programs developed for catch sampling.

MATERIALS AND METHODS

Specific project objectives to meet the overall goal of automating salmon escapement sampling data collection were as follows:

Objective # 1 :	Modify an existing data collection application that runs on rugged handheld computers for collecting commercial salmon fishery biological data to collect salmon escapement biological data.
Objective # 2 :	Modify existing standard procedures for synchronizing field-collected data with the regional fishery database (IFDB), applying database constraints, validation rules, and programmatic error checking at each process level. Maintain concurrent capabilities for transmitting data through the existing paper data stream.
Objective # 3 :	Modify an existing database entry/edit application, if needed, to facilitate final validation and correction of data by field and laboratory personnel.
Objective # 4 :	Modify an existing database application to report summarized data and study results for all department personnel, and modify reporting procedures as needed to provide results as appropriate to the general public and other fishery managers via the internet.

Completion of project objectives depends on prior completion of a vertically integrated system consisting of interconnecting hardware and software components to collect, transmit, and report salmon biological sampling data. In particular, a functional software program running on handheld computers for recording associated field data for age, sex, and size information during commercial fishery catch sampling is required. Deployment requires selection of appropriate standard hardware products appropriate to the environmental conditions typically encountered during escapement sampling.

A. SALMON ESCAPEMENT SAMPLING DATA COLLECTION

ADFG samplers throughout Southeast Alaska annually collect biological samples and data from salmon spawning escapements, either on the spawning grounds, or at various points along migration corridors where stock specificity can be assumed. Results from data collections are used in studies to monitor population age structures, estimate stock or national contributions to mixed stock fisheries, and evaluate run timing and abundance. Number of fish sampled, tissues collected, and associated information recorded, vary by species examined and may change annually as information needs change.

Specifically, the type of sampling most commonly associated with stock assessment studies to evaluate Pacific Salmon Treaty harvest sharing agreement compliance is age, sex, and length

(ASL) sampling. Scales from sockeye, chum, and Chinook salmon escapements may be collected seasonally to determine age of individual fish, information used to estimate population age structure. Researchers may use scales collected from sockeye salmon in studies that estimate contributions of specific populations to mixed stock fisheries. These studies are based on consistent spatial differences in growth history information inherent in visually identifiable annular patterns on the scale surface. For some of these stock identification studies, other tissues collected from the same fish can include whole heads for recovery of marked otoliths to estimate contributions from hatchery releases, and for determination of prevalence of parasites (a stock-specific characteristic of some contributing populations). Other tissues collected from fish sampled for scales may include fin tissues for genetic stock identification analyses. Information gathered for individual fish during sampling includes species, length, sex, and specimen identification numbers for simultaneously collected scales and other tissues. Information about the sample collection can include species, date, location, and gear type. Data are recorded on standardized mark-sense forms issued by the regional scale reading laboratory in Douglas. Completed forms are sent to the lab for optical scanning, along with completed scales, from days to many months later.

Procedures and protocols for sampling data collection are updated and distributed annually to field personnel (Iris Frank, ADFG, Douglas, personal communication). Electronic versions of the collection of distributed memos and printed documents were previously replicated on field office servers, but were often out of synchrony with official documents due to network issues. To address existing problems, and accommodate frequent changes anticipated from development of electronic data collection, project leaders developed an intranet website to distribute updated port sampling instructions and project documentation to sampling personnel.

Priority and timing for development of sampling data collection applications for each sampling type were established based on application importance, scope and complexity of the application, and availability of participating staff. Locations for deployment were selected based on existence of adequate wide area network bandwidth, and potential for cost effective implementation of any needed network upgrades.

B. MOBILE HARDWARE AND OPERATING SYSTEM

A wide variety of rugged handheld computer devices were reviewed and examined to determine the most appropriate hardware configuration and platform. Selected equipment had to be suitable for use in environmentally demanding situations inside fish processing plants, where most sampling occurs. Selected devices also had to meet recently imposed statewide standards. Specific criteria considered for selection included the following:

- Ruggedness. Concrete floors and wooden decking are common at most fish processing plants. Although many sampling areas are enclosed from the weather, exposure to rain and water spray is frequent. Minimum requirements included surviving multiple drops from 1 m to concrete, and environmental sealing equivalent to International Electrotechnical Commission document 60529 (©IEC 2001) standard of at least IP54, highly resistant to dust ingress and resistant to water spray.
- Battery Capacity. Samplers often work long days to collect assigned samples. Devices must be able to operate for extended periods with a minimum of battery changes, and retain all data stored in memory during battery changes in the field. A minimum of 8-10 h battery life claimed in manufacturer specifications was required.

- Cost. Devices would be in constant use around open water, rain, spray, and concrete floors; often carried loosely in backpacks; and frequently set aside to do other tasks. Occasional lost, stolen, or damaged units are a virtual certainty. Replacement cost had to be as low as possible while meeting all other requirements for ruggedness and performance.

- Size. Data recording devices must be highly portable, and because they are often held in the hand for long periods, low weight was required. Rugged tablet computers were rejected due to weight, high cost, and short battery life to power the large display screen. Although its smaller display presented more challenge for designing functional user input screens, the rugged Personal Digital Assistant (PDA) form of handheld computers were deemed the most appropriate size and weight for general port sampling situations.

- Performance. Ability to run multiple programs at the same time (e.g. open a file documenting fishing place names while a data collection program is running) was considered highly desirable. Data collection applications had to be able to perform data recording tasks at least as fast as recording on paper. Wait times for user input and program actions had to be minimal to reduce sampler frustration and chances for erroneous data entry. A minimum central processor capability similar to that of an Intel® XScale™ 400 MHz processor, and 64MB of flash memory were considered required.

- Features. A backlit color display screen visible in bright daylight was required to function over a wide range of sampling conditions. Bar codes were expected to become the preferred method for entering specimen identification numbers, and bar code scanning capability was required. Although data collection would generally occur while not connected to a network, standard 802.11b/g wireless network capability to offload collected data was required.

- Statewide IT Standards. All selected handheld computers, operating systems, development software, and database software had to meet published statewide standards (ADOA 2007) for purchase, or receive official waiver approval for variance. Statewide IT standards specified approved PDA operating systems to be PalmOS® or any of the various operating systems built around Microsoft® Windows® CE™.

C. INTEGRATED DEVELOPMENT ENVIRONMENT SOFTWARE

Project collaborators evaluated a number of standard integrated development environment (IDE) software packages to determine the most appropriate choice for building and deploying data collection applications for handheld computers. Appropriate IDE software was also selected for developing applications for editing data stored in central databases. Criteria for IDE selection were:

- Compliance with statewide and departmental IT standards.

- Compatibility with long-range development plans for regional databases and database software.

- Compatibility with selected mobile data collection hardware and operating system.

- Time required for developers to gain proficiency, and speed of application development.

D. Compact Database Software and Data Synchronization

Compact database software for storing port sampling data on handheld devices, and data synchronization software for automating data transfers between handheld devices and central databases were investigated. Because these integral system components must interact seamlessly, options were considered and described here jointly. Solutions for both components involving small third party companies at risk of disappearing from the volatile high technology scene were excluded from consideration. Solutions involving transitional data file formats easily accessible to users were also rejected. These were felt to present unacceptable risk of introduction of errors by well meaning, but inexpert, samplers trying to edit data in the field. We considered only solutions that provided a true relational database on handheld devices with inherent data validation features that could be adequately secured from user access.

System design called for database synchronization to occur using standard TCP/IP communication protocols over 802.11b/g wireless local area networks located at ADFG field offices connected to the state of Alaska wide area network. Wireless access points meeting statewide IT standards were purchased and installed at ADFG offices in Douglas, Sitka, Petersburg, and Ketchikan, Alaska. Wireless access points and handheld computers were all configured to allow communication from any handheld at any enabled location. Network managers did not consider the small ADFG office in Craig adequately secure or large enough to justify installation of a wireless local area network. Although it did not meet the project design criteria, the level of sampling at that location justified an alternative approach to enable the office for electronic data collection. The single port sampler stationed in Craig was enabled for synchronization through a cabled connection between a handheld computer and a desktop computer.

Backup and restore procedures were investigated for compact databases to prevent data loss in the event of handheld computer hard reset (e.g. following full battery depletion). The data collection applications were configured to periodically write all data to a replica of the compact database on non-volatile flash memory storage. In the event of system reset, previously saved data could be retrieved from this replica and synchronized.

E. Central Databases and Data Editing Applications

Electronically recorded sampling data were transmitted from the field into Oracle® 10g databases during the data synchronization process. These preexisting central databases, hosted at ADFG facilities within the state's existing wide area network, met statewide IT standards and did not require evaluation of alternatives. Project database administrators developed or modified database tables to store incoming data from the field, and developed data insertion routines triggered during the database synchronization process. Insertion routines performed any required reformatting or lookups and assigned unique sequential sample identification numbers.

By design, no data validation occurred during central database insertion. This approach allowed offloading any samples containing null values for required fields when that information was not known at the time of sampling, but requiring that samplers edit data to correct these critical errors prior to final data validation and insertion into a production database. To meet this requirement, project developers modified existing data editing programs to accommodate changes for electronic data collection, or developed custom data editing programs as needed.

RESULTS

One of five planned electronic data collection applications proposed under project Objective #1 (recording of CWT sampling data) was successfully completed and fully deployed at five Southeast Alaska salmon port sampling locations. Three additional data collection applications that utilized components of the same data transmission system were developed to varying levels, but were not completed before project end. No development occurred on a fifth application considered to be of low priority.

Development through deployment of a CWT sampling application required successful assemblage of a vertically integrated data transmission system to collect data in the field, transfer data to and from central databases, and report results to various data users, while applying appropriate data validation rules at each step (Figure 1). This development of underlying database and network infrastructure to enable remote data synchronization resulted in nearly complete fulfillment of project Objective #2. At project outset, it was anticipated that specimen information for tissues collected for genetic analysis during ASL sampling would be synchronized with a central database hosted at the ADFG Gene Conservation Laboratory in Anchorage. During the course of development, it was determined that simply establishing consistent standards for specimen labels would solve most data consistency issues, and that portion of project Objective #2 was dropped.

Project Objective #3 to develop database editing programs was largely met for the CWT sampling application. Currently existing data editing programs for ASL and FPD sampling are largely complete, although both would require additional modifications to fully accommodate electronic data collection. An existing data editing program for ASL sampling would require moderate modification. Electronic data collection for this sample type would also require substantial revision to basic sample processing procedures.

Project Objective #4 was also largely met with regards to CWT sampling. Web-based applications were developed that allowed samplers to view collected data immediately after synchronization, report specimen identification numbers of heads collected and shipped to the lab, and view samples rejected during nightly synchronization between backend databases. Data reporting applications for other sampling types were not addressed before project end.

A. Sampling Type Development Priority

Relative importance of suitable locations for application deployment was based on number of samples collected at each location, a rough indication of relative costs to collect and process the samples and data. Although commercial catch sampling occurs throughout the region, wide area network bandwidth was judged to be adequate for transmitting data from field offices at only 5 Southeast Alaska locations where sampling occurs (Ketchikan, Sitka, Petersburg, Juneau, and Craig). Average number of samples collected annually at each location, and relative magnitude of region total at each location are presented in Table 1.

ASL and CWT sampling applications were judged to be highest priority due to high volume of sampling and recurring problems related to complex data forms and collection procedures for both types. Issues with these sampling types were prime motivating factors in initiating this project. FPD sampling was felt to be of second priority, although automating data collection would likely provide immediate benefits to fishery managers who rely heavily on the information being quickly available for decision making. PSR was judged to be slightly lower priority, due to low overall sample size, and an existing adequately responsive paper-based data collection process. Infrequent sampling of Atlantic salmon (50-300 fish/yr) and lack of direct importance to fishery management, ranked this application low priority.

Scope and complexity of system development for each application were largely determined by the extent of existing database structures and pre-existence of data entry/edit programs. Database tables, data editing programs, and data reports for PSR and FPD sampling existed prior to project initiation, and required minimal modification for implementing electronic data collection. Data collection applications for these sampling types were expected to be relatively straightforward to build. PSR sampling was judged least complex, followed by FPD sampling. Automation for ASL sampling was relatively more complex, requiring development of a richly featured data recording application, moderately difficult modification of an existing database editing program, and major revision of procedures used to collect and process scales and other tissue samples. Data for Atlantic salmon sampling were stored in a Microsoft Excel spreadsheet, and required moderate effort to automate and migrate to a central database. A data collection application would be relatively simple to develop, but data standards would need to be established from scratch. It was judged approximately equally difficult to ASL sampling automation. Mobile data collection for CWT sampling was the most complex, requiring extensive intra-agency collaboration. Development required construction of transitional database structures, a new data editing software program, numerous modifications to sampling processing procedures, and development of a separate synchronization program to automate exchange of data between transitional and production central databases.

The high complexity of the CWT sampling application logically indicated later development of this component, after developers had improved skills and system infrastructure during prior development of simpler applications. However, high priority need for a CWT sampling application, impending retirement of the lead CWT data management clerk, and a window of opportunity for availability of programming staff from the two involved facilities (the Southeast Region Scale Lab and the Mark, Tag, and Age Lab) resulted in its selection as the first application to build. Based on selection of an initial data collection application, project collaborators evaluated and selected appropriate hardware and software solutions for each of the required system components.

Development of the CWT sampling application was monitored and controlled through a collaborative process involving staff from the Mark, Tag, and Age Lab facility in Juneau, and the Southeast Region Scale Lab in Douglas. Periodic meetings of all involved staff occurred as often as weekly over a two-year period to review progress, evaluate results, set new priorities, and assign tasks. Mark, Tag, and Age Lab staff established a thorough set of certification criteria to evaluate release candidate versions of the application. Each new version underwent many hours of testing to ensure compliance with all established rules, team review of testing results, and assignment of tasks for any corrections identified. Periodically, release candidate versions were field tested in processing plants in Juneau or Sitka to ensure that changes to functionality or data entry procedures worked properly under a range of typical sampling conditions.

Project programmers conducted exploratory development of data collection applications for ASL, PSR, and FPD sampling concurrently with focused development of the CWT sampling application. Following production release of the CWT sampling application, they attempted to sequentially complete remaining applications in order of increasing complexity and need: PSR, FPD, ASL, and Atlantic salmon. Following early departure of the lead mobile application programmer, project leaders attempted to complete this task through a series of service contracts with private consultants, but could not complete this work before project end dates.

B. MOBILE HARDWARE AND OPERATING SYSTEM

ADFG biologists in Ketchikan investigated the use of obsolete off-the-shelf handheld bar code scanners built for the warehouse industry, for capturing CWT recovery specimen numbers beginning in 2002 (Glenn Hollowell, Assistant Area Research Biologist, ADFG, Ketchikan, personal communication). These units, made by Symbol Systems®, became widely available used through the internet at very low cost when companies in the warehouse industry began rapidly replacing them with newer equipment. The units proved to be generally reliable and functional, but their usefulness was constrained by an obsolete proprietary operating system, a discontinued software development environment, and very limited hardware capabilities.

More current rugged devices from Symbol Systems® based on the PalmOS® operating system (model SPT-1800 series) were tested, and again demonstrated the potential benefits of electronic data collection for biological sampling. These units proved to be as reliable as the older units, but offered much greater flexibility for designing and building new data collection applications. These units were also widely available at low cost used, and at moderate cost new. A proof-of-concept application was built using a non-standard development environment (PenWrite® MobileBuilder™ 5.0) by a project biologist, and further demonstrated the potential benefits from data collection automation for salmon port sampling.

These inexpensive units were provisionally adopted as an informal standard platform for all salmon port sampling data collection development for Southeast Alaska. A Northern Fund proposal was submitted in 2005 to obtain dedicated funding for more extensive development and testing, and wider scale system deployment if successful. The original intent was to develop applications primarily for these and other PalmOS® devices, but it was recognized early on that some data collection situations might be better suited to the features and capabilities available from devices running Microsoft® WindowsCE® operating systems. Opportunity for development for use on multiple platforms was a consideration in all early product evaluations.

We eventually rejected all devices running older PalmOS® operating systems. The operating system was not capable of running multiple programs at once, a feature deemed very desirable for salmon port sampling applications. It also severely limited the available options for a development environment used to build the applications, and it complicated selection of other system components, specifically the synchronization processes and compact database. Very few vendors manufacture rugged devices running the PalmOS® operating system. Because there were no rugged devices running the latest versions of PalmOS® available at that time, and because most industry experts predict the PalmOS® operating system may become obsolete in the near future, we rejected that platform for all future development.

Several devices were examined that met the statewide rugged PDA operating system standard running Microsoft® WindowsCE® 3.11 (Symbol model PPT-2700), PocketPC_2002 (Symbol model PDT-8146), and Windows Mobile 2003™ (Symbol model PPT-8800). These all showed clear advantages over the older PalmOS® devices for performance and functionality, although purchase costs were generally higher. Late in 2005, Intermec® Technologies Corporation introduced the model CN2A, a moderately rugged PDA handheld computer running Microsoft® Windows® CE.NET™ 4.2 operating system. This model included options for a built-in bar code scanner and 802.11b/g wireless networking, and was priced well below all other current model devices available with similar features, including the PalmOS® devices. Four CN2A units were purchased for software development and rigorous field testing of the prototype CWT sampling data collection application.

Field tests clearly demonstrated the hardware was well suited to the sampling environment, but a number of issues arose around slow operating system performance and compatibility with the chosen software development environment. Intermec® introduced a new product, the model CN2B, in early 2006. This model was built around a similar hardware configuration as the CN2A, but running the Windows Mobile® 2003 operating system. After revising the prototype application, and rigorous field testing of the hardware, operating system, and application, this unit was selected to be the standard model and configuration for all subsequent salmon port sampling development and deployment. State procurement officers granted trade-in approval for all previous equipment used for initial testing and development, and a total of 20 CN2B units were eventually purchased for system deployment on a region-wide scale.

C. Integrated Development Environment Software

Development of the CWT sampling application began for a standard hardware and operating system configuration consisting of the Symbol® SPT-1800 series running PalmOS® 4.2. Several rapid application development solutions that included a combined compact database and rapid application development environment for quickly creating simple user input screens were briefly considered. The available solutions were rejected because they were 1) unlikely to meet state standards, 2) did not provide sufficient power and flexibility for creating robust applications that connect directly to backend central databases, and 3) increased the risk of a vendor dropping support for older products. Project managers proceeded to increase internal expertise with in-house development, and to identify the most suitable development environment to build data entry programs for handheld devices.

Software development platforms meeting the statewide IT standard of Java™ development for PalmOS® operating systems were considered and evaluated, although the ability to develop programs for multiple platforms was considered to be a desirable feature. Evaluations included JDesignerPro™ 5.0 from BulletProof® Software, and Oracle® JDeveloper. Concerted efforts were made to obtain outside expertise to mentor the existing staff in developing programs written in Java™ that write data to compact databases, and synchronize directly with enterprise databases. Although this was apparently technically feasible, few contractors had actual experience with specific solutions, and no available contractor could be located for mentoring.

JDesignerPro™ was tested, but lacked some highly desirable capabilities. Mobile development products from Oracle® were investigated in depth, but were also eventually rejected. At the time, the available products were under intense development by a small group within the Oracle development community. Although the approach appeared capable of eventually becoming a viable solution, the current versions suffered from incorrect documentation, inadequate support, and software bugs. This solution was provisionally rejected until the product matured.

Identifying a suitable Java™ Virtual Machine (JVM) runtime also quickly emerged as a problematic element in selecting Java™ as a development platform. A JVM is client software that runs on the handheld computer enabling an application written in Java™ to run under a specific operating system. Because it is specific to the device and operating system, it greatly limits the portability of any developed applications, and suitable JVM versions may not be available for some devices. A JVM can also involve additional cost to purchase licensing from third party vendors, greatly increasing the risk of a vendor later dropping support for their product in this volatile industry.

In contrast to Java™ programming for Windows® CE-based operating systems, development under Microsoft® .NET™ Compact Framework has been widely implemented (Maine Department of Transportation, 2004). Although this development environment did not meet the chosen department IT standard, statewide IT managers approved a temporary waiver from the standard. Project programmers investigated application development through Microsoft® .NET Compact Framework™. Applications were built using Microsoft® Visual Studio® 2003 and AppForge® Crossfire™, a Visual Studio® plug-in that provided pre-built controls for rapid development of applications to run on either PalmOS® or Windows® CE-based platforms. Although, Crossfire™, required purchase of a separate client runtime for each device, it was hoped the ability to rapidly develop applications would increase the chances for meeting project timelines. Development for multiple platforms was also seen as a potential advantage.

Investigation of devices running Windows® CE-based operating systems, quickly demonstrated faster program development, a larger community of experienced developers and support resources, and fewer problems with client software. Following introduction of the Intermec® CN2A running the Windows® CE.NET™ operating system at lower cost than similar PalmOS® devices, project managers examined development options for this platform, and eventually selected Visual Basic®.NET™ (VB.NET) programming language with the Crossfire™ plug-in to complete the CWT sampling application. A functional test version of the application was released for sampling troll fishery catches in Sitka in January 2006.

After the Intermec model CN2B running Windows Mobile® 2003 operating system was chosen as the deployment platform, the application was quickly revised to accommodate the platform change. A final production version of the CWT sampling application was released in April 2006, and fully deployed to five Southeast Alaska locations over the following summer and fall.

Restrictive licensing of the Crossfire™ client runtime proved to problematic, and developers later rejected this solution for building all succeeding port sampling applications. Development initiated for ASL, FPD, and PSR sampling applications used the .NET® Compact Framework and straight VB.NET™ programming language without the Crossfire™ client runtime.

The dangers of relying on third party software were demonstrated in spring 2007, when Oracle® purchased all AppForge® intellectual property rights with no plans to support those products going forward, including the Crossfire™ client license activation. Workarounds to client license activation were obtained from internet resources, and revision of the existing CWT application using programming alternatives was accelerated.

D. COMPACT DATABASE SOFTWARE AND DATA SYCHRONIZATION

OracleLite 10g compact database and Oracle® Mobile Data Server, a data synchronization component of Oracle® Application Server 10g, were evaluated for storing and transmitting the data on handheld computers. These solutions ostensibly offered seamless interaction with Oracle® 10g central databases, and met statewide IT standards for enterprise databases. These products included the attractive ability to automate distribution of applications and software updates through the synchronization service. In reality, mobile development products available from Oracle® at the time were undergoing major product development, and support resources were not widely available. No developers who had direct experience with the current products could be located for mentoring or training, and support and documentation were extremely limited. In addition, large memory requirements on handheld devices to install the OracleLite™ compact database restricted choices for hardware platforms. Oracle® mobile development products were provisionally rejected with an intention to investigate their suitability at a future time.

In contrast, compact database and synchronization server components of SQL Anywhere® Studio v9 from Sybase® iAnywhere Solutions™ proved to be functional, well documented, easy to learn and use, and relatively inexpensive. Components selected from their suite of available solutions included the UltraLite® compact database and development software, and MobiLink™ synchronization server and server console. Useful examples of program code for establishing database connections, writing data to the compact database, and scripts for synchronizing data were readily available directly from their documentation. Although the products did not meet statewide IT standards, department and state IT managers approved a temporary waiver of the standard, and all subsequent salmon port sampling application development was completed using UltraLite™ databases and MobiLink™ synchronization server.

Mobile devices and data collection applications were configured to perform database synchronization over standard 802.11b/g wireless local area networks through the state of Alaska wide area network. Network configuration on all handhelds was standardized so that devices could be used in any office without changing the configuration, and settings were stored in saved registry files so that all settings were automatically refreshed when devices were reset. The single sampler in Craig configured for cabled network connection through a desktop computer experienced substantially more problems than did samplers synchronizing wirelessly.

A data recovery system was developed for storing a replica of the compact database on persistent flash memory media during sampling. This data backup and restore system proved to be invaluable for recovering data following hard reset of the devices when samplers allowed batteries to discharge completely. Avoidance of battery discharge and hard reset was stressed during training of samplers, but could not always be prevented, and data recovery procedures were successfully used on numerous occasions following deployment of the CWT sampling application.

E. Central Databases and Data Editing

Salmon ASL, FPD, and PSR port sampling data were stored in an existing Oracle® 10g central database that meets a statewide IT standard. ADFG, Division of Commercial Fisheries, Southeast Region relies heavily on this comprehensive database containing information about all commercially caught species in Southeast Alaska fisheries. This database, termed the Integrated Fishery Database (IFDB), is accessible from all department desktop computers in the region through a user interface program called Alexander (abbreviated as ALEX), named after the Alexander Archipelago of Southeast Alaska. This legacy user interface application was written in Gupta Centura Team Developer®, a database programming development environment that does not meet current department or statewide IT standards for development software. Data editing routines for ASL, FPD, and PSR sampling data exist as data entry forms within the ALEX program. Regional IT staff is currently developing a web-based user interface program written in Java™ (termed Zander to reflect its status as the Alexander successor) that will meet statewide IT standards and eventually replace all existing ALEX data entry forms.

The production level central database for CWT data was also an Oracle® 10g database that meets statewide IT standards. This database is hosted at the ADFG statewide Mark, Tag, and Age Laboratory in Juneau. Data entry and editing programs, and data reporting applications, were written in programming languages under the Microsoft® .NET™ Framework, which does not meet the selected departmental IT standard for software development platform.

By design, data from the CWT sampling application were to be transitionally stored in IFDB at the time of synchronizing the handheld database with a central database. This transitional storage in IFDB enabled data editing to correct known errors, and to enter required information not known at the time of sampling, before inserting data into the CWT production database. Final validation and insertion of valid sample data from IFDB into the CWT production database occurred nightly during an automated stand-alone procedure (named ANNA3). Any sample not passing all validation checks, was rejected, and remained flagged as such in IFDB until corrected. This approach required a dedicated desktop editing application drawing on information stored in both IFDB and the CWT database to apply complex validation rules while editing data. This new data editing program (named NERKA3) was derived from the existing CWT data entry program written under the Microsoft® .NET™ Framework. Although it too did not meet the department IT standard for software development platform, it was consistent with legacy applications implemented prior to imposition of IT standards.

F. APPLICATION DEPLOYMENT

A functional prototype version of the electronic data collection application for recording CWT sampling data was released for extensive field testing in Sitka during the 2005-2006 winter troll fishery. Samplers recorded CWT sampling data concurrently using both paper forms and the prototype electronic data collection application. Attempts at objective evaluation of differences between paper and electronic recording were abandoned, because we could find no way to set up meaningful comparisons under live situations without compromising productive data collection. Subjective evaluations demonstrated recording accuracy for electronic recording to be at least as good as or better than paper, with only a slight reduction in sampling time. However, electronically recorded samples required less editing after synchronization, drastically reduced many CWT sampling errors common to paper forms, and completely obviated manual data entry.

Technical difficulties with keeping the handheld units functioning properly were frequent to start with, but gradually decreased as samplers, supervisors, and support staff became more familiar with the equipment. Experiences with occasional hardware malfunctions (most frequently battery depletion) prompted developers to create database backup and restore system components, and to implement usable data recovery procedures for samplers.

Following proven field functionality, and satisfactory final certification testing results, a production level version of the applications was released in April 2006 for deployment in Sitka and Juneau. The completed application was deployed in Ketchikan, Craig, and Petersburg over the 2006 fishing season, as time allowed for equipping and training field crews. Final deployment at the last location occurred in October 2006. Number of CWT samples recorded using electronic data collection at each location, and percent of region total CWT samples collected from April 2006 through June 2007 are presented in Table 2. CWT samples collected at these locations using electronic recording neared 100% of the region total during the first half of 2007. However, sampling occurs at very few other locations during that time of year, and the final proportion of electronically recorded samples for the year at these locations is expected to more closely resemble the 2003-2006 average annual percent of region total samples (approximately 70%) presented in Table 1.

DISCUSSION

Completion of virtually all technical development tasks for this project took longer than anticipated in proposed project schedules. Unanticipated delays at all stages, and frequent retracing of steps to explore alternatives resulted in major portions of some project objectives remaining unfulfilled at project end. The biggest hindrance to project completion was a recurring need for project developers to research, learn, and implement new methods to complete individual system components. Although electronic data collection techniques have been widely deployed in warehouse, medical, and other industries, the technology has advanced rapidly in recent years. Few programmers are available who have wide ranging experience with the specialized technical skills needed to build an entire system from scratch. Each system component, change in solution for a component, or change in programming personnel, required time to evaluate potential solutions, learn to use the associated development environment, and finally to develop and test the requisite system component.

Imposition of statewide IT standards early in the project started developers investigating hardware and software options that met required standards, but greatly protracted development time. Investigation of standard Java™ programming solutions and database synchronization solutions proved particularly unproductive before project developers concluded that those technologies were not sufficiently functional or adequately supported at the time. We eventually obtained approval for variance from the standards for some components, which greatly simplified and accelerated development. Although these alternatives allowed the project to proceed, we recognized that reliance on non-standard solutions would be a temporary and problematic situation requiring periodic reassessment, and probable future conversion to standard solutions.

Departures of key technical staff, listed as a serious potential risk in the project proposal, also contributed heavily to delays, as well as to substantial changes to project expenditure plans. A field project leader in Ketchikan departed shortly after the project began. Although his departure did not greatly alter the schedule, it did change plans for personnel expenditures. Departure of the lead mobile application programmer not long after completion of the production CWT sampling application was a more serious loss. Since available funding and project duration were inadequate to attract a suitably skilled replacement at that late date, in-house development of custom applications could not proceed. We attempted to complete the remaining planned applications through service contracts with outside technical consultants, again affecting both the project expenditure plan and completion schedule.

A small initial contract was established with a technical consulting firm to produce a second data collection application. Although costs were greater than in-house development, the approach initially showed considerable promise for providing development products on a timely schedule, and a possible long-term solution advantageous to the department for continuing mobile development and support in the future. A programmer working for the contractor quickly gained experience and skill with mobile application development technologies. However, the danger of heavy reliance on a single knowledgeable programmer was again realized when he was unable to work, and the task was reassigned to yet another programmer requiring time to build the requisite skills. Progress was delayed and the situation repeated yet again when the state suspended its primary procurement system for establishing service contracts with outside consultants, and eventually awarded the contract for mobile development to another firm.

Although delays eventually prevented satisfactory project completion, the development team did successfully finish and deploy one complex data collection application, very nearly completed a simpler second application, made substantial progress on developing a complex third application, and laid initial groundwork for a fourth application. The team implemented a reasonably robust data handling system that efficiently transmitted data collected in the field to central databases, and provided data managers with easy access to database editing programs and data reports. Some benefits were clearly realized. Important lessons were also learned regarding key elements of the system that will be critical in any future mobile development.

Although we made no attempt to quantify total reduction in personnel time resulting from electronic data collection, there were obvious benefits at several points in the CWT sampling process. Port samplers felt that electronic data collection was slightly faster than recording on paper, resulting in an ability to collect more samples during busy delivery periods. Electronic data collection completely eliminated a substantial amount of time spent each week for a crew member in each port to review paper forms for completeness and accuracy before submitting for data entry, and virtually eliminated manual data entry costs. Program functionality and features that enforce data integrity resulted in few electronic samples requiring later error corrections. Port sampling supervisors felt these to be substantially less than for data recorded on paper.

We found that negative aspects of using handheld computers for electronic data collection could usually be overcome with adequate training. Some samplers felt intimidated when faced with such a radical change in procedures, but nearly all accepted the benefits and quickly learned to use the system. Inherent quirks of handheld computers over desktop computers did present some training challenges for samplers new to the system, but written instructions and training regarding specific problem areas for port sampling supervisors to focus on greatly reduced the number of support calls.

Development of a robust and efficient database synchronization process between handheld computers and the central databases was recognized early on to be a critical element for project success. Project developers designed and implemented a very acceptable solution for this component. Synchronization server software proved to be stable and relatively easy for both developers and system support staff to learn. Nearly all issues encountered for the synchronization server resulted from network communication problems unrelated to the synchronization software.

The design choice of synchronization over wireless local area networks contributed greatly to the overall efficiency of this system component. Wireless data transmission vastly simplified the synchronization procedure from the viewpoint of samplers. They could simply collect data, walk into a field office, initiate synchronization from a menu selection, and complete the process within two minutes. However, wireless communication also presented the greatest number of challenges. Hardware and network configuration problems on handheld computers frequently resulted in inability of devices to connect properly to the network. Changes to network infrastructure, as well as security measures implemented by network administrators, occasionally prevented synchronization from functioning properly. Resolving the issues was not usually difficult, but required that users be able to differentiate and resolve issues related to network connectivity from issues related to database corruption, because both types of dysfunction manifest to the sampler as an inability to synchronize. Although the system was adequately robust to prevent data loss during most such events, learning to deal with problems did sometimes prove challenging to field supervisors and support staff.

Difficulties and support calls were frequent early in the deployment phase. Familiarity with the system through hands-on experience, development of simple troubleshooting protocols that could be taught to port sampling supervisors, and implementation of a functional data backup and recovery system, greatly reduced the frequency and severity of problems. Database backup and restore procedures particularly proved invaluable for preventing data loss. Over the first year of production deployment, data restore procedures were performed numerous times at all locations. Samplers were able to recover all but nine samples lost in two malfunction events out of well over 3,000 samples collected since deployment.

Although the completed CWT sampling application has shown the system to provide benefits stated in the project proposal, several modifications would improve the functionality of the existing system. Completion of an additional data collection application to inventory specimen identification numbers of specimens being prepared for shipment to the lab, and a web report to compare these specimen numbers with previously synchronized sample data is needed. This application would save samplers a great deal of time, assist laboratory personnel tracking sample processing progress, and fully satisfy Objective #4 for CWT sampling. Revision of the CWT sampling application to eliminate reliance on Crossfire™ client activation is currently underway, and should be completed in the near future.

Purchase of handheld computers and wireless network hardware to deploy the CWT sampling application to five ADFG field offices, enabled deployment of other data collection applications at little or no additional hardware cost. We believe that benefits realized from the existing production application demonstrate its value, and completion of the remaining salmon port sampling data collection applications proposed in this project are still worthwhile objectives. ADFG Southeast Region and Headquarters IT staff is currently pursuing development of electronic data collection technologies that better adhere to statewide IT standards. We hope this effort proves fruitful, and the remaining salmon applications can eventually be completed under these technologies.

REFERENCES CITED

ADOA (Alaska Department of Administration). Enterprise Technology Services: State of Alaska Information Technology Standards, version 57 dated June 28, 2007. http://state.ak.us/local/akpages/ADMIN/info/, accessed7/6/2007.

International Electrotechnical Commission. ©IEC 2001. Document 60529: Degrees of protection provided by enclosures (IP Code). http://www.iec.ch/, accessed 7/6/2007.

Maine Department of Transportation, Information Systems Division. 2004. PDA Applications Pilot Project Summary Report. http://www.maine.gov/mdot/cadd-support/tims/pda_pilot_findings.pdf, accessed 7/6/2007.

Sykes, Daryl. 2002. ERNIE: Electronic recording of nature, investigation of environment. Seafood New Zealand, Vol. 10-2. Mar. 2002.

Terry, Lisa. 2004. Handhelds deliver the need for speed. Supply Chain Systems, Vol. 24-7. Aug. 2004.

Terry, Lisa. 2005. Mobility road test. Supply Chain Systems, Vol. 25-7. Jul. 2005.

Van Tamelan, Peter. 2002. A comparison of the efficiency, cost, and data integrity of electronic data capture and traditional methods during the red king crab stock assessment survey in southeast Alaska. Unpublished report. ADFG, Juneau, Alaska.

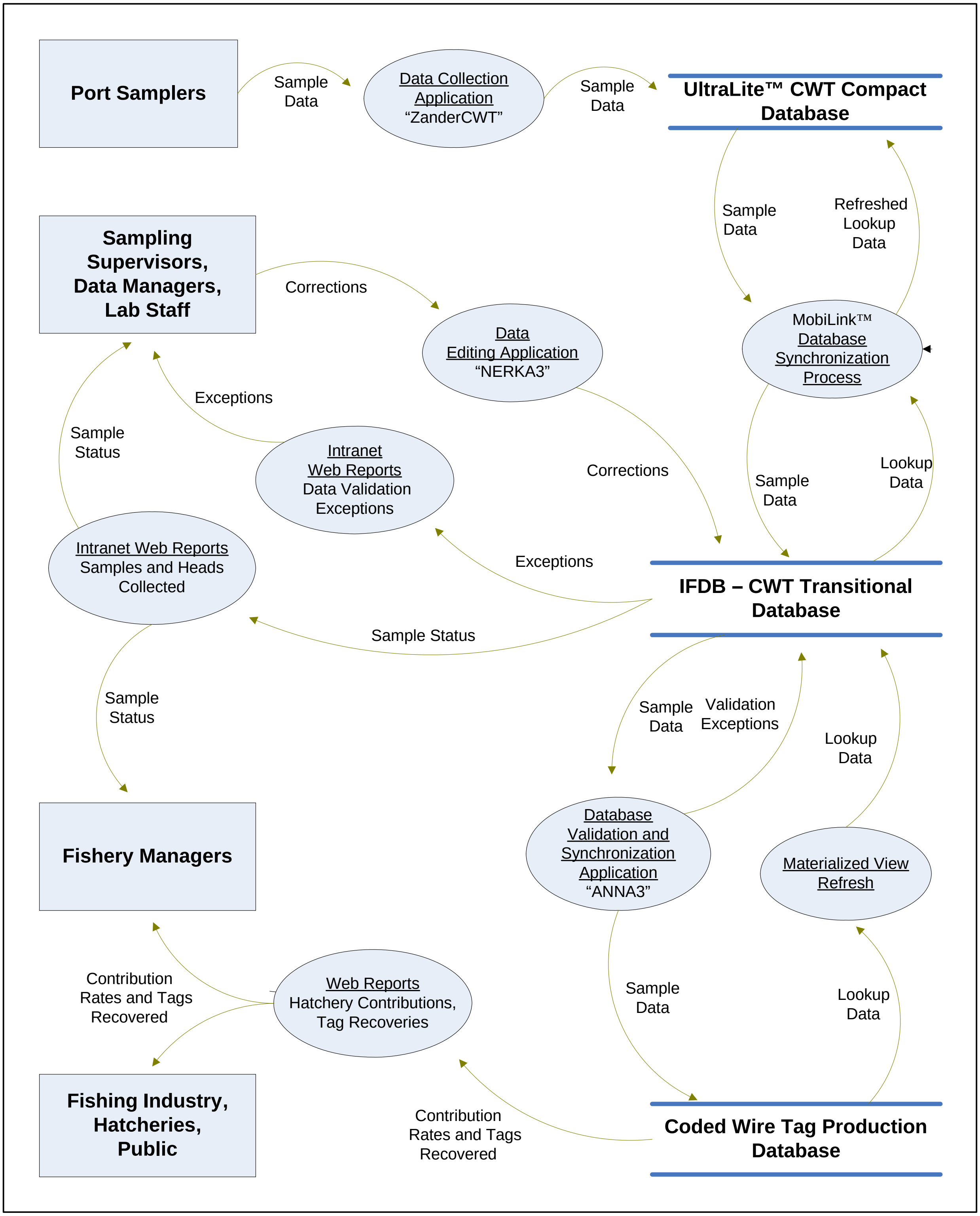

Figure 1. Data flow diagram for coded wire tag recovery sampling using an electronic data collection and processing system.

Table 1. Average number of samples collected during salmon commercial fishery sampling at five Southeast Alaska locations, and average percent of region total collected at those locations, 2003-2006.

	ASL		CWT		FPD	PSR
PORT	Scale Cards	Fish	Data Forms	Heads	Data Forms	Data Forms
Craig	107	951	375	1,854	415	
Juneau	52	715	186	1,066	9	
Ketchikan	424	14,702	636	2,600	121	29
Petersburg	291	10,417	1,170	2,093	120	69
Sitka	132	2,100	1,448	5,372	573	17
Grand Total	1,004	28,884	3,815	12,985	1,238	115
Percent of Region Total:						
Craig	5%	2%	7%	10%	19%	
Juneau	2%	1%	3%	6%	0%	
Ketchikan	18%	27%	11%	14%	6%	19%
Petersburg	13%	19%	20%	12%	5%	47%
Sitka	6%	4%	25%	30%	26%	11%
Grand Total	43%	52%	67%	72%	57%	77%

Table 2. Number of CWT samples and head specimens collected using electronic data collection techniques, and percent of region total collected between 11 April 2006 and 22 June 2007.

	2006		2007		Total	
PORT	Samples	Heads	Samples	Heads	Samples	Heads
CRAIG	243	801	107	107	350	908
JUNEAU	224	1,092	30	19	254	1,111
KETCHIKAN	577	1,473	167	297	744	1,770
PETERSBURG	86	41	338	310	424	351
SITKA	1,193	3,761	753	1,484	1,946	5,245
TOTAL	2,323	7,168	1,395	2,217	3,718	9,385
CRAIG	6%	8%	8%	5%	7%	7%
JUNEAU	6%	11%	2%	1%	5%	9%
KETCHIKAN	15%	15%	12%	13%	14%	15%
PETERSBURG	2%	0%	24%	14%	8%	3%
SITKA	32%	38%	54%	67%	38%	43%
TOTAL	61%	72%	100%	100%	72%	77%

APPENDIX A

Appendix A.–Financial Statement.

Actual expenditures for this project differed substantially from expected expenditures for several important cost categories: labor, subcontractors & consultants, travel, and training costs (Appendix A.1).

As originally conceived, existing department employees were to complete most project software development tasks following intensive training and mentoring to "jump start" their skills for the new techniques. Because many technical aspects of the project were to be based on very recently developed software and hardware solutions, training staff programmers and database administrators to use these emerging technologies would be of significant benefit to the department for this project and for anticipated future data collection automation projects.

However, securing knowledgeable vendors for training or mentoring proved to be quite problematic for these quickly evolving technologies. Early on, we were unable to locate any suitable contractor in a nation-wide search for mentored training on Java application development and mobile data processing technologies from Oracle. In addition, scheduling conflicts prevented database administrators from attending desired advanced Oracle training offered at several out-of-state locations. Project managers decided to pursue self-directed training options instead. This permitted project developers to build the needed skills, and essentially eliminated direct expenditures for training and contracts. However, this approach also drastically increased total personnel costs to cover the required time spent learning.

Travel for training and to attend symposia was expected to be a significant project cost. However, changes to training plans reduced these costs to half of the expected costs.

Personnel changes, which were noted as potential risks in the project proposal, occurred at several times during the project, and mandated additional change to spending plans. Original plans called for employing a junior fishery biologist to take on some tasks of a research biologist in Ketchikan to allow him to actively participate in the project as a developer. His departure for another position shortly after project approval eliminated the need for these personnel costs.

Late in the project, departure of the lead programmer of mobile data collection applications to another job again required major alteration of expenditure plans. Because we were unlikely to find a skilled programmer available for the short funding and time left to the project at that point, we decided to pursue project completion using private outside contractors. One application and most of the network infrastructure were complete by that time, and state procurement procedures existed that would allow us to contract services quickly and efficiently from a single vendor. However, pursuit of this option also would likely require that the prospective contractor would need to learn any unfamiliar underlying technologies. We intended to pursue a series of contracts with a single vendor that would permit them to learn needed skills incrementally, and for us to evaluate their performance, over a logical sequence of increasingly complex applications. Use of a single vendor would also us to build an ongoing relationship with them for mobile development projects in the future. Agency personnel expenditures were curtailed at that time, and all remaining funds were reserved for contracting costs.

Suspension of the state's procurement system for outside service contracts before our first contract was completed, and re-implementation of the system with a new set of service providers, again threw all plans into disarray. Attempts to establish contracts under the new procurement rules before the project ended proved futile.

Site cost expenditures for specific equipment items differed slightly from original plans. However, total cost for equipment deployed to the field was similar to anticipated costs. Although only a single data collection application was successfully completed, equipment sufficient to support that application and the applications not successfully completed, was successfully deployed at more field locations than were listed in original proposals.

Appendix A.1. Antcipated and actual cost category expenditures for 2005 Northern Fund project "Electronic Collection and Transfer of Salmon Fishery Biological Data."

Project Budget Form

Name of Project: Electronic Collection and Transfer of Salmon Fishery Biological Data

ELIGIBLE COSTS | BUDGET | OTHER FUNDING | CONTRIBUTION FUNDING

Labour
Wages & Salaries

Position		Location	# of crew	# of work days	hrs per day	rate per hour	Total (PSC + In-kind + cash)	In-Kind & Cash	PSC Amount (8-10-05 Revision)	ADFG Actual Expenditure - Final	Actual # of Work Days
AP-III	Damerval	Juneau	1	143	7.5				14,544	25,855	142
FWT-III	Dinneford	Juneau	1	110	7.5				5,709	9,045	80
FB-I	Vacant	Ketchikan	1	88	7.5				11,508		
FB-III	Wilcock	Juneau	1	55	7.5					2,954	13
	Holiday Leave Adjustment									4,804	
Person Days (# of crew x work days)				55		sub total			31,761	42,657	

Labour - Employer Costs (percent of wages subtotal amount)

	# of crew	rate		rate per hour	Total	In-Kind & Cash	PSC Amount	ADFG Actual
	rate	35%		sub total			18,196	22,114

Subcontractors & Consultants

Subcontractors & Consultants	# of crew	# of work days	hrs per day	rate per hour	Total	In-Kind & Cash	PSC Amount	ADFG Actual
State IT Task Order Contract								13,112
Insurance if applicable	rate	0%						
				sub total				13,112

Volunteer Labour

Volunteer Labour	# of crew	# of work days	hrs per day		Total	In-Kind & Cash	PSC Amount	ADFG Actual
Skilled								
Un-skilled								
Insurance if applicable	rate	0%						
				sub total				

	Total	In-Kind & Cash	PSC Amount	ADFG Actual
Total Labour Costs			49,957	77,883

Site / Project Costs

Site / Project Costs	Detail (use additional page for details if needed)	Total	In-Kind & Cash	PSC Amount	ADFG Actual
Travel (do not include to & from work)	Travel to Symposia, Training, and to deploy hardware			10,280	5,488
Small Tools & Equipment					
Site Supplies & Materials	Software and computer supplies				1,420
Equipment Rental					
Work & Safety Gear					
Repairs & Maintenace					
Permits					
Technical Monitoring					
Other site costs	Shipping and misc				718
	Total Site / Project Costs			10,280	7,626

Appendix A.1. Continued (Page 2 of 2).

ELIGIBLE COSTS				BUDGET	OTHER FUNDING	CONTRIBUTION FUNDING	
Training (e.g Swiftwater, bear aware, electrofishing, etc).				Total (PSC + In-kind + cash)	In-Kind & Cash	PSC Amount	ADFG Actual Expenditure - Final
Name of course	# of crew	# of days					
OFWIM Symposia Fee	2	5					520
Oracle DBA Fundamentals II	1	5				2,500	
Oracle 10g Application Development Frame	1	5				2,500	
Mentored Java Application Development	6	5				15,000	
			Total Training Costs			20,000	520

NF Capital Costs / Assets **Detail (use additional page for details if needed)**

Items of value that have an initial cost of $250 CAN or more and which can be readily misappropriated for personal use or gain or which are not, or will not be, fully consumed during the term of the project.

			Total (PSC + In-kind + cash)	In-Kind & Cash	PSC Amount	ADFG Actual Expenditure - Final
Handheld Computer Purchases	10				17,000	17,361
Bar Code Label Printer	1				2,500	3,043
Experimental Handheld Computer Purchase	2				3,800	
Misc. Hardware (cradles, comm. Cables, wi	1				1,200	
		Total NF Capital Costs			24,500	20,404

Overhead / Indirect Costs (not to exceed 20% of PSC Amount)

		Total (PSC + In-kind + cash)	In-Kind & Cash	PSC Amount	ADFG Actual Expenditure - Final	
Office space; including utilities, etc.						
Insurance						
Office supplies						
Telephone & long Distance						
Photocopies & printing						
Other overhead costs	ADF&G indirect costs at 13.5% of all costs			14,139	14,368	estimated
	except AK Capital Costs (greater than $5000 USD).					
	Total Overhead Costs			14,139	14,368	

AK Capital Costs / Assets **Detail (use additional page for details if needed)**

Items of value that have an initial cost of $5000 USD or more and which can be readily misappropriated for personal use or gain or which are not, or will not be, fully consumed during the term of the project.

		Total (PSC + In-kind + cash)	In-Kind & Cash	PSC Amount	ADFG Actual Expenditure - Final
	Total AK Capital Costs			-	-
	Project Total Costs			118,876	120,801

Budget Summary

(PSC + in-kind + cash)

	Anticipated	Expended
Total Labour Costs	49,957	77,883
Total Site / Project Costs	10,280	7,626
Total Training Costs	20,000	520
Total NF Capital Costs	24,500	20,404
Overhead Cost Basis	104,737	106,432
Total Overhead Costs	14,139	14,368
Total AK Capital Costs	-	-
Project Total	118,876	120,801

Page 2 of 2