Final Report

Pacific Salmon Commission Southern Endowment Fund

At-Sea Electronic Data Entry for Salmon Fisheries – The Last Mile?

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Project Description

1.1. Background

At-sea electronic data entry on large commercial fishing boats is relatively easy to implement. These boats are stable platforms with well-equipped wheelhouses, often including a standard PC. A crew member can use a keyboard and mouse to negotiate standard windows-based menus and data-entry screens, entering information relayed from the rear deck. In contrast, small boats typical to West Coast Salmon, albacore, and crab fisheries have cramped wheelhouses, exposed rear decks, and often no crew in the wheelhouse during fishing. Data would need to be entered from the deck or trolling pit by the same person who is running gear and processing catch. This places stringent demands on equipment, the data collection protocol, and the user interface. We have been working for over a decade to implement an affordable at-sea data entry system for small boats. Two technical developments, one in hardware, the other in software, now should make it possible to implement a functional system.

The system we are developing will serve Project CROOS (Collaborative Research on Oregon Ocean Salmon). Project CROOS was initiated in 2005 as a public/private partnership among the fishing industry, academic and agency scientists, fishery managers, and the general public. Spurred by the Klamath River fall Chinook disaster, Project CROOS seeks to use genetic stock identification (GSI) along with high-resolution spatial sampling to identify fine-scale stock distribution patterns and develop techniques to reduce by-catch of weak stocks. Project CROOS protocols were first implemented in Oregon in 2006, California in 2007, and Washington in 2009. Coordination and standardization is achieved through the West Coast Salmon Genetic Stock Identification (WCSGSI) Collaboration. Since 2006 Project CROOS and the WGSGSI Collaboration have worked with over 300 commercial salmon fishermen, with well over $2 million dollars paid directly to fishermen and more than 60,000 fish sampled. Project CROOS innovations include: (1) development and implementation of a protocol for at-sea sampling by commercial fishermen, (2) application of GSI technology to enable high-resolution determination of stock-specific distributions and migration patterns, and (3) implementation of the FishTrax web-based fishery information system.

At-sea sampling is conducted by experienced, trained fishermen during the normal course of commercial fishing. Fishermen are under contract to the state commodity commissions and receive compensation for their efforts. Data are collected using standardized methodologies developed and tested by the WCSGSI Collaboration. Currently, each sampling vessel is equipped with a hand-held GPS unit programmed to log fishing vessel location (latitude and longitude) and time in five-minute intervals. Catch sample locations and time are logged by marking a waypoint on the GPS unit as each fish is landed on the vessel. Fishermen collect tissue (fin-clip) and scale samples from each fish and place them in uniquely labeled envelopes for storage and transmittal to the laboratory. Vessel name, date, time, GPS waypoint, fork length of fish, and presence of adipose fin (an indicator of hatchery origin) are recorded on pre-printed envelope fields. Fishermen also record the estimated hooking depth in fathoms for each fish. Simultaneously, water temperature profiles are recorded by select boats equipped with oceanographic data loggers attached to their fishing gear.

On landing, each fisherman meets with a port liaison who enters trip data into the FishTrax database using a web-based form. Data are transcribed from the envelopes, the GPS file is uploaded and samples are correlated with waypoints. Physical samples in the envelopes are transmitted to the laboratory, where each record is verified and genetic analysis conducted. Results from genetic analysis are later associated with each sample in the database. This process has been used successfully since 2007. However, it is expensive to implement and requires multiple steps and error checking. Electronic data entry at sea would simplify and streamline the process, potentially simplify the fishing operation, and allow more rapid transmission of data from boat to shore.

1.2. History

We have been actively developing systems for at-sea data collection in small boats since 2005. We have evaluated several systems in the lab and at sea (Figure 1.), and conducted workshops and an AFS symposium (Steinberg et al. 2012; ir.library.oregonstate.edu/xmlui/handle/1957/33201) to investigate implementations of similar systems worldwide. We have tested a variety of prototypes, including commercial industrial portable computers, a touch-screen system using a monitor on deck wired to a laptop in the wheelhouse, a custom-built "deck box," and two systems using tablet computers. Through this process we have developed design criteria for small-boat systems.

Figure 1. Commercial data entry system tested in 2006. The user interface is complex, screen has poor visibility, battery life is short, and per-unit cost is high. Subsequent developments have

led to improved visibility and reduced complexity, but battery life remains inadequate to our needs, and cost are still high.

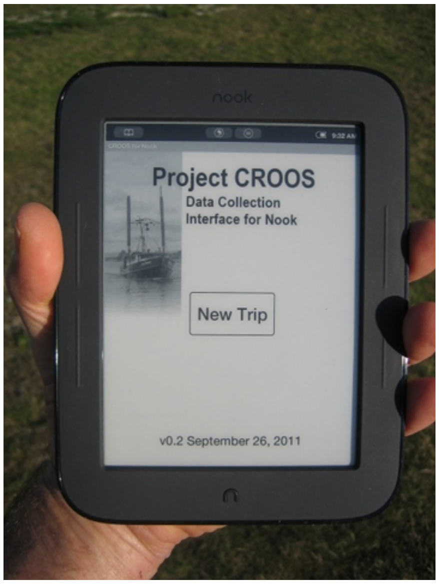


Figure 2. NOOK e-reader tablet showing visibility of E-Ink screen in full sunlight.

Important hardware considerations include:

- Waterproof and shock resistant
- Daylight-visible screen (Figure 2.)
- Touch screen that works with gloves
- Adequate battery life for a full day of fishing
- Integrated GPS and Wi-Fi communications
- Self-contained

Software considerations include:

- Turnkey operation
- Simple, clean user interface
- Can be operated with gloved hands
- Platform independent

In addition, we have learned that fishermen need immediate feedback for input actions and are not equipped to trouble-shoot systems that stop working. To achieve this, the processor needs to be relatively powerful and the system physically simple. A single, self-contained unit is the solution.

In 2012 we used a Pacific Salmon Commission Southern Endowment Fund grant, “At-Sea Data Entry System for Salmon Fisheries,” to develop SeaTab, adapting the Barnes and Noble NOOK Simple Touch e-reader tablet to address many of the problems with most off-the-shelf hardware; in particular the screen visibility and battery life issues. We succeeded in developing software for the NOOK as a proof of concept, but hardware limitations made it impractical to use our prototype at sea. The final report from the 2012 project is available at pacificfishtrax.org/media/SeaTab_Final_Report.pdf. We concluded that hardware was not available that would operate reliably under the difficult conditions on small boats at sea. One possible solution is the Earl Backcountry Survival Tablet which is under development (see www.meetearl.com). The Earl tablet promises to overcome the limitations we have identified, including a more responsive E-ink screen designed for gloved hands, waterproofing, built-in GPS, multiple connectivity options, and a solar panel to extend battery life, all at a cost of about $350 per unit.

We had hoped to be able to evaluate the Earl tablet for this project, but it continues to be delayed. We continue to see the Earl tablet as a likely platform to meet the challenges of small boat data entry at sea if it becomes available in a form similar to the original concept. Meanwhile, other devices are becoming more rugged, waterproof cases are available, and software tools have taken another step forward. We developed and tested a platform-independent (Android, iOS, Windows) application with flexibility and extensibility beyond what we have achieved in the past. As the hardware market matures we are positioned to track the state of the art in rugged devices. The application we have developed is specific to the needs of Project CROOS, but the underlying set of tools developed in the process is broadly useful for creating custom data collection systems focused on the needs of the marine fisheries community.

1.3. Overview

To develop a system that enables fishermen to collect data during the normal course of their fishing operations, we capitalized on our past experience, most recently with the Barnes and Noble Nook and Google Nexus 7 tablets and Mobile Mariner software. In concept, this system transmits data ashore and receives summary statistics and maps of fishery-relevant information such as quota tracking, open areas, bycatch summaries, and up to date weather and marine condition reports. Funds from the current proposal were used to rewrite the tablet software as an Android app and develop and test the foundation software on currently available mobile devices including the 7" Samsung Galaxy Tab 4 tablet and the 8" Samsung Galaxy Tab Active. These devices do not meet all our needs, but they are all currently in use for applications that are in many ways similar to ours. The chief limitations remain daylight visibility, battery life, and touch-screen function in a wet or slimy environment. Waterproofness has not been established, but manufacturers are continually improving in this area (e.g., Samsung Galaxy S7).

This product interfaces with the FishTrax database created for Project CROOS and the WCSGSI Collaboration. The data are individual records of fish sampled, vessel-specific trip information, and GPS-derived fishing tracks and catch locations, and are not appropriate for the FOSS database. Metadata for the FishTrax database are contained in InPort.

1.4. Objectives

The objectives of this project were to (1) develop a data entry application designed for mobile devices based on our experience with SeaTab, (2) test the application on an available platform at sea, and 3) create a solid foundation that will be the basis for continued development of the hardware and software, and for deployment of the system in the commercial salmon fleet and elsewhere.

We are developing a specific electronic solution to the problem of implementing ER on small boats, specifically salmon trollers. These boats also fish for albacore and Dungeness crab. The system we are developing will have application in all three fisheries. Development at this point is applied to the Project CROOS sampling protocol, but the boats in this fleet also have need for ER in other fisheries. We hope to promote efficiency and standardization by providing a single ER platform that can be used for data collection and reporting in multiple fisheries.

The development process was organized into six tasks:

1. Identify Mobile Platform: Given that the Earl tablet was not yet available we evaluated a variety of tablets as development platforms. Based on quality, screen brightness, price, and availability we chose the Samsung 7" Galaxy Tab 4 tablet as our target for this phase of development. Weather resistance was provided by a Survivor sealed and padded case. Choosing a single platform made for a simpler and more rapid development process by eliminating the need to accommodate a variety of screen resolutions and orientations and

other possible device-specific considerations. At the same time, we avoided using device-specific or OS-specific features so our product is as portable as possible, although we have not tested it with operating systems other than Android.

2. Re-specify the User Interface: We redesigned the user interface using our experience with SeaTab. The flow of data entry is basically the same, but the graphical design is based on the backlit screen. A high contrast interface with white text on a black background proved to be the most readable. A Wizard paradigm was used to standardize the user interface. Wizards are relatively easy to customize for different purposes, so this provides software flexibility.
3. Develop data model: The data model was not changed from previous software implementations. The FishTrax database has established data content and input format specifications that we followed.
4. Develop Mobile Application: Based on our design specifications we developed the application using the Microsoft Xamarin cross-platform development environment for mobile applications. This new development platform allows us to compile apps for Windows, iOS, and Android, giving us flexibility to utilize the best hardware available at any given time. The basic system architecture and user interface is described in Appendix 1.
5. Set Up Server-side Environment: To simplify development and to protect the existing FishTrax database we created an intermediate data storage area on Amazon's S3 cloud infrastructure where QA/QC can be done prior to uploading into the database.

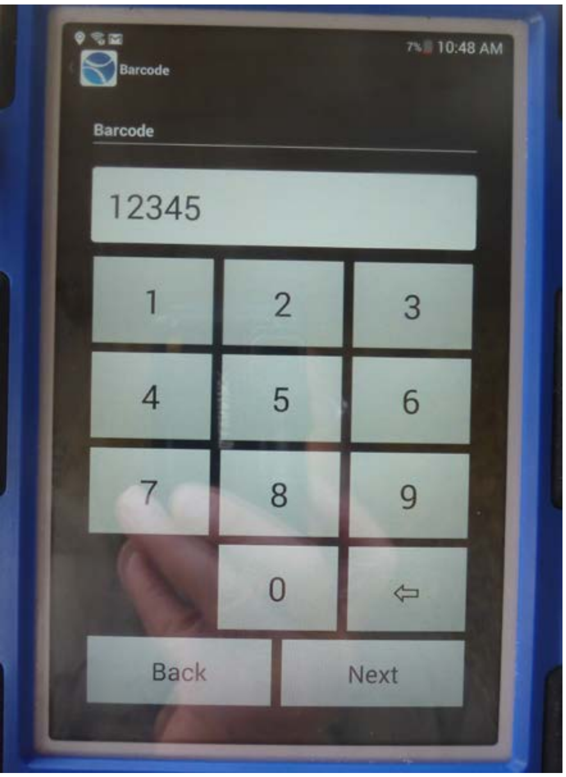
6. Test: We engaged three fishermen to test the system at sea. On 18 September 2015 two boats made a day trip with tablets for an initial test. Project developers were on board these boats as observers. Based on this experience a few adjustments were made. On 23 Septemeber 2015 three boats tested tablets without observers on board. Only a few fish were caught, but the tablets performed as designed. More importantly, in follow-up interviews the fishermen reported that they found the tablet interface as easy as, or easier than the pencil and paper method we have been using to collect samples. This was significant because the fishermen involved were not computer literate. All fish caught were successfully logged, and tracks were recorded. Due to a programming oversight the track points were not time-stamped. This prevented us from relating the tracks to the catch and has been corrected.

1.5. Risk Assessment

Our experience has enabled us to evaluate several of the risks we identified and update our assessment. The biggest risk was that the system we develop would not be adopted by the fishermen. This is becoming increasingly unlikely as fishermen experience more refined versions of the product and begin to see what the benefits may be. In addition, workshops conducted subsequent to this project have identified several features that, if added to the tablets, would make them more attractive. Chief among these is to make the home screen a chart plotter. This additional work is being conducted under a Saltonstall-Kennedy grant to the Oregon Salmon Commission and a Fisheries Information Systems internal NOAA grant.

Screen visibility is much improved, with brighter screens becoming available. High-contrast interface design, with either black text on white or white text on black, enhances readability. Even so, visibility of transmissive screens in direct sunlight is not as good as the reflective e-ink screen. A Samsung Galaxy Active 8 screen with the Barcode entry wizard displayed is illustrated in Figure 3. Screen reflections can be a problem, but matte screen protectors may help with this.

Figure 3. Samsung Galaxy Tab Active in diffuse sunlight.



Consumer electronic devices have a short product life. Eventually the hardware we develop for will become obsolete and unavailable. To mitigate this risk we are using industry standard and open source software. As technology evolves the system should be portable to new hardware and software platforms.

This project assumes the availability of a low cost, daylight visible Android tablet like Earl.
Trends in consumer tablets include improved ruggedness, screen visibility, and battery life. Since this phase of the project was initiated in 2014 several new products have become available with increasing degrees of ruggedness, screen brightness, and battery life. We still plan to test the Earl tablet if and when it becomes available, but are focusing our development on existing hardware. In November 2015 the Earl web page claimed "Earl is still in heavy development and should be available towards the second half of 2016." Given past performance we give this statement a low probability of being fulfilled and, if it is, the tablet may no longer be as well suited to our purpose as other products.

Touch screen technologies vary widely in responsiveness, as well as sensitivity to dirt, water, and foreign objects on the screen. Capacitive touch screens are notoriously sensitive to water and other foreign materials. Other groups have attempted to solve this problem by developing speech interfaces. We deem this to be inappropriate for use by fishermen, and are committed to the touch screen interface. The Samsung tablets we have tested fail when the screen is wet unless there is an extra membrane over the screen. A wide variety of plastic sealed cases is available that work well to protect the device while providing touch screen functionality. We continue to rate this as a moderate risk because it is central to the concept and would be difficult to work around.

Battery life may not be long enough for a full day of fishing. Even with the efficient E-Ink screen promised for Earl, the GPS function of the tablet requires significant power that may result in limited battery life. We have obtained 8 hours of operation at sea using the Samsung Galaxy Tab Active. Earl is being developed with a hot-swappable battery, so this is a low risk with Earl, but perhaps higher with other tablets. If tablets are semi-permanently mounted on the back deck there is opportunity to hard-wire power. We see this as a viable option on many boats.

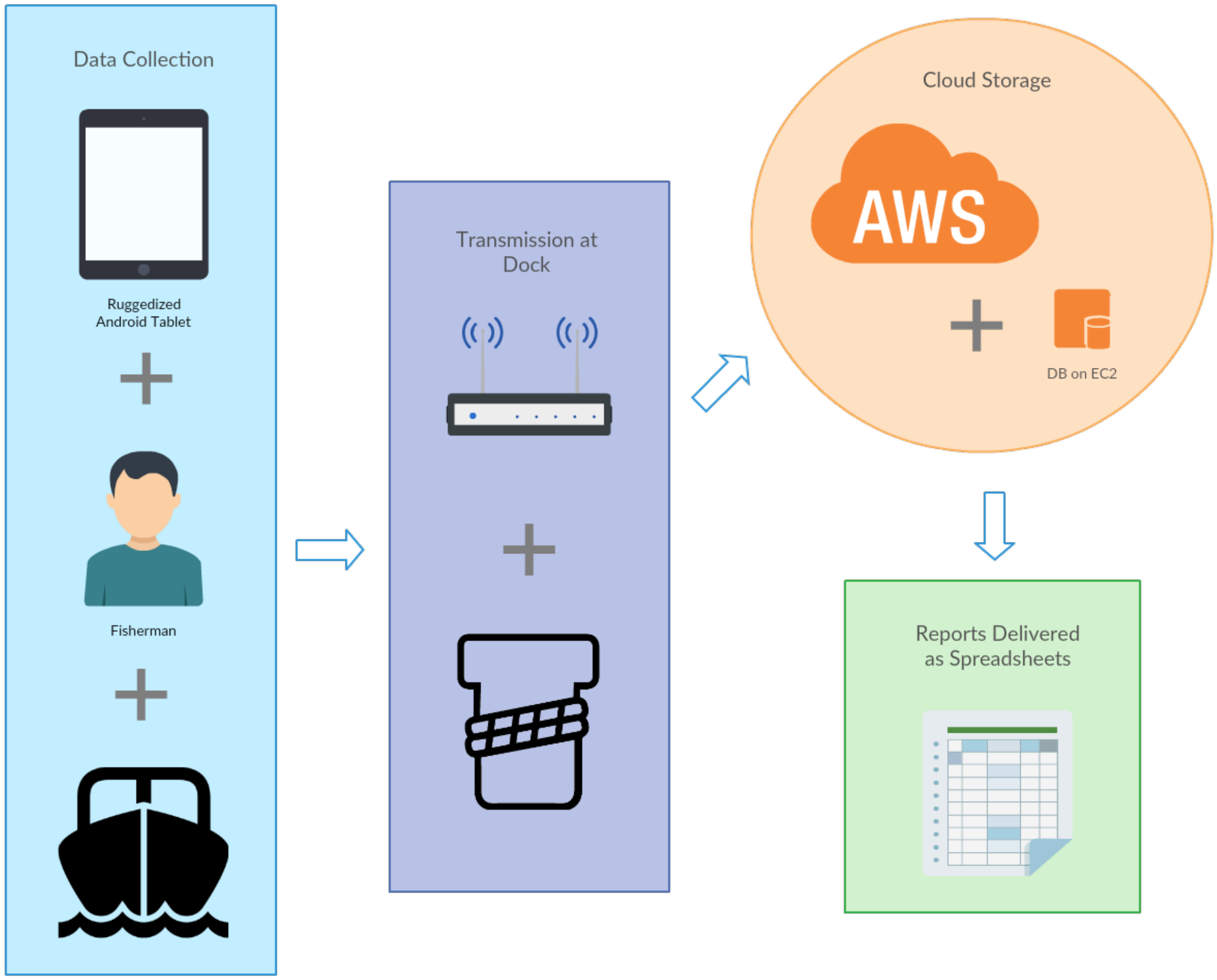
1.6. Data Documentation

Project CROOS (Collaborative Research on Oregon Ocean Salmon) metadata are available in InPort (Proj ID 921; DSet ID 14278).

1.7 Acknowledgements

Fishermen Corey Feldner, Kevin Bastien, and Al Townsend tested tablets at sea and provided valuable feedback and advice. This work was also supported by a grant to Peter Lawson from a National Marine Fisheries Service, Fisheries Information Systems fund.

Earl System Architecture



The Earl system is designed to achieve three objectives:

1. Capture trip and catch data from participant boats
2. Transmit and store that data on a cloud server
3. Provide reports on the data in a spreadsheet format

Capturing the data from participant boats is done through ruggedized Android tablets running the Earl app. The data is stored locally on the tablet until it returns to port and once again has access to the internet.

Users can then transmit trip data to an Amazon EC2 cloud server. From that server, the data can be processed into reports and presented as a spreadsheet.

Earl App Overview

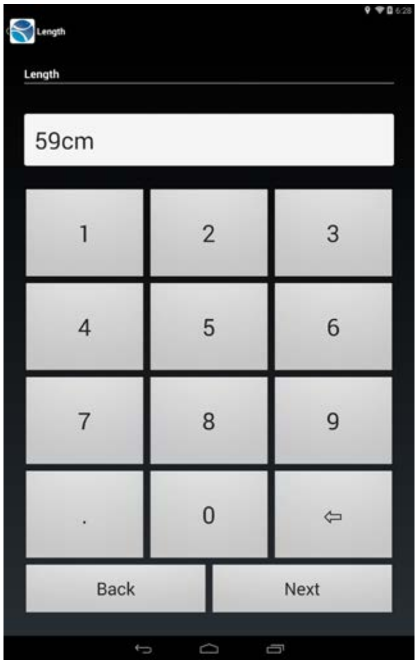
Earl is intended to make back deck data collection as simple and easy as possible. To do this, it employs several key features:

- GPS tracking logs location data for trip and catch mapping.
- Large interface buttons to reduce accidental selections and data entry.
- Large tap targets on all list views.
- Simple data entry screens that focus on one piece of data at a time.
- High-contrast color scheme for visibility in direct sunlight.
- Runs on Android tablets that can be placed in rugged cases.

The main objects users work with in the app are Trips. All catch and GPS data the app collects are contained within trips. A user starts a trip, indicates his gear is in the water, and then enters the desired data for each fish caught.

When a trip is completed, that trip is transmitted to the server and is locked from further editing on the app. These trips can still be reviewed, as can untransmitted trips, and users are able to see a list of their past trips right from the home screen.

The Wizard Paradigm



In touch-interface data entry applications, it can be difficult for users to fill out complex forms. To remedy this, we've decided to take users through a series of single screens with large buttons and inputs. Internally, we refer to each of these series of screens as a Wizard, as they're historically referred to in software applications.

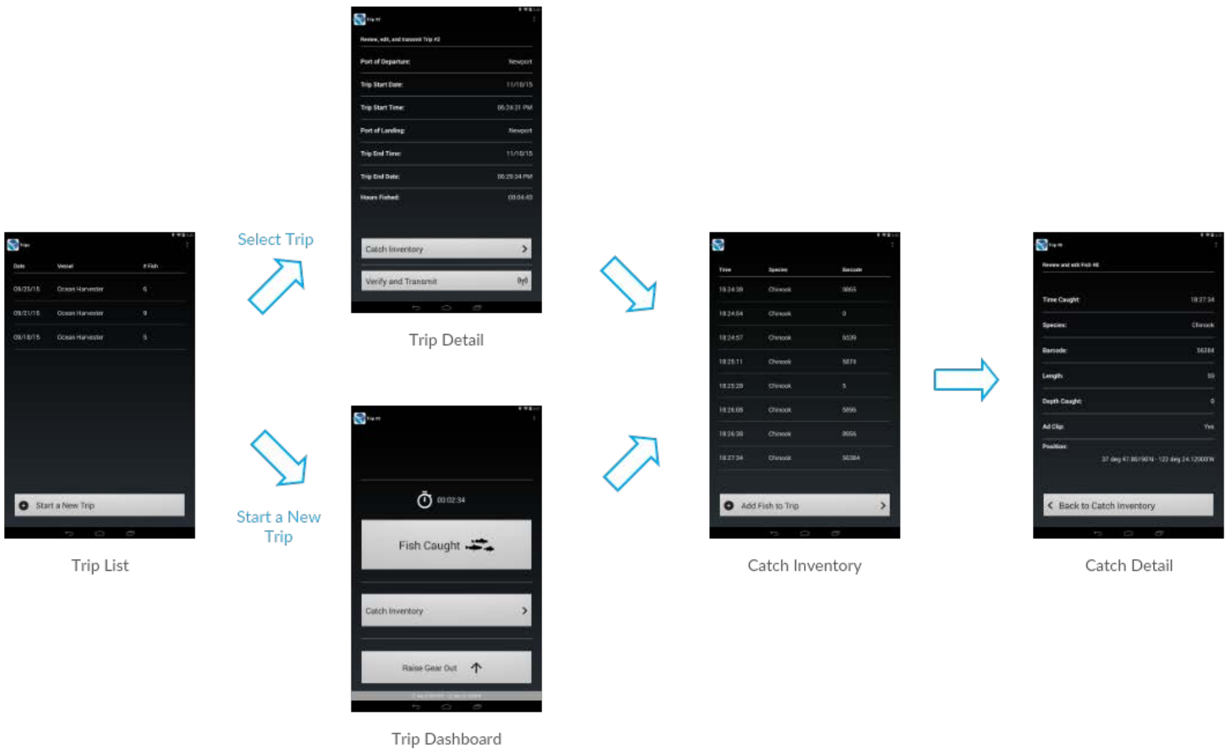
Whenever information is required of the user, Earl takes them through a wizard that collects the bare minimum of information in order for the user to continue in the app. For usability considerations, we allow users to always cancel out of a wizard or return to where they were, and default values are offered whenever possible.

App Flows

There are three main uses for the Earl app.

1. Creating a trip for data entry
2. Reviewing and editing trip and catch data
3. Verifying and transmitting data

The five main pages used for these flows can be seen here:

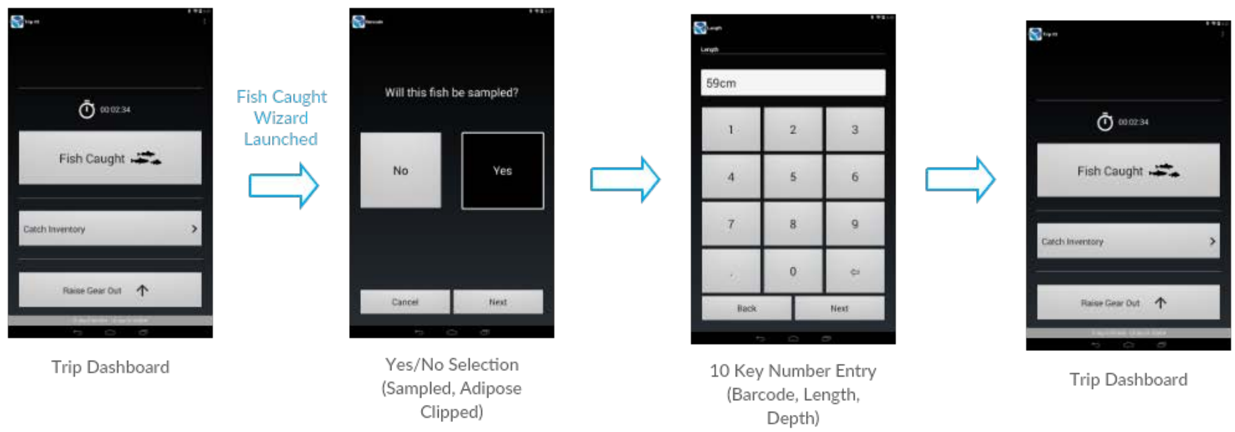


The Trip List page is the first page a user will see upon loading the app. From there he may start a new trip or tap on an old trip to review and/or transmit.

Both the Trip Detail and Trip Dashboard pages have access to the Catch Inventory page for that trip. From the Catch Inventory page, a user can tap any of the catches to view the details for that catch.

Creating a trip for data entry

To start a new trip, a user taps the Start a New Trip button from the Trip List screen. Once a new trip is started and the user taps Fish Caught from the Dashboard page, they are stepped through a wizard to collect data:

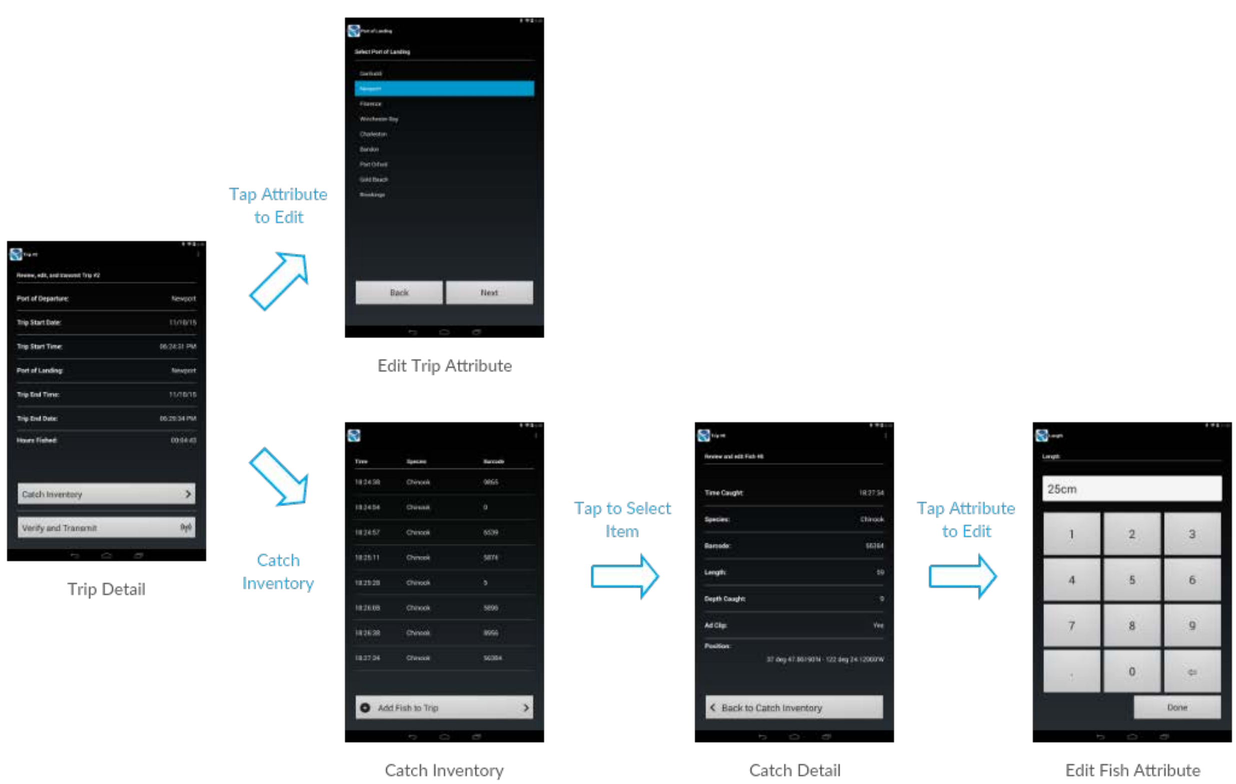


Once the wizard is completed, the user returns to the Dashboard and is able to add the next fish.

Reviewing and editing trip and catch data

From the Trip List page, a user can easily review past trips by tapping on the desired trip in the list.

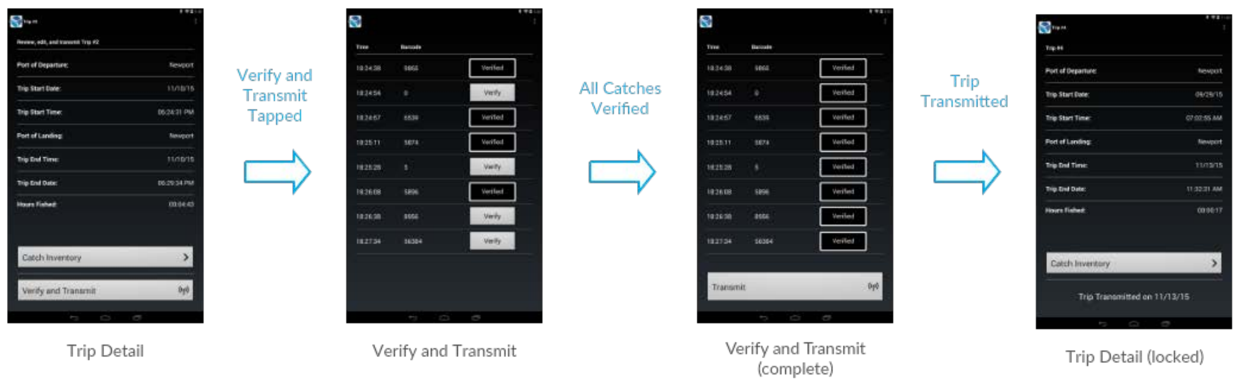
From there the user is taken to the Trip Detail page. Here he can edit any info that needs to be corrected or changed for the trip.



Catches can also be edited by visiting the Catch Inventory page. Here, new catches can be added, and attributes on existing fish can be changed.

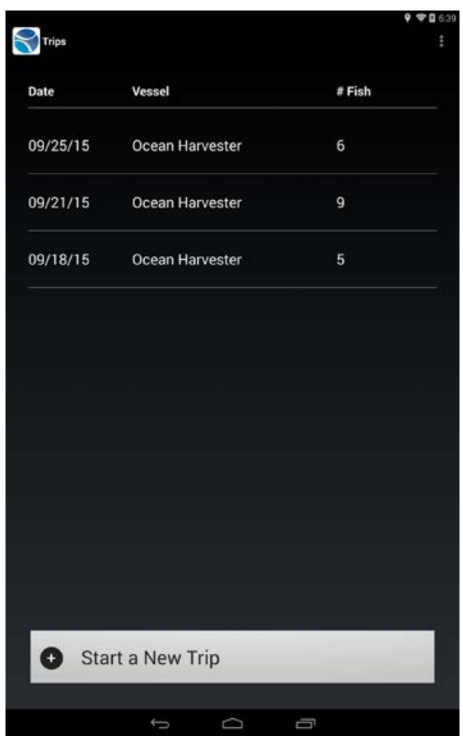
Verifying and transmitting data

Once all trip data is reviewed and edited as necessary, a user can verify all catches and transmit the trip to the server.



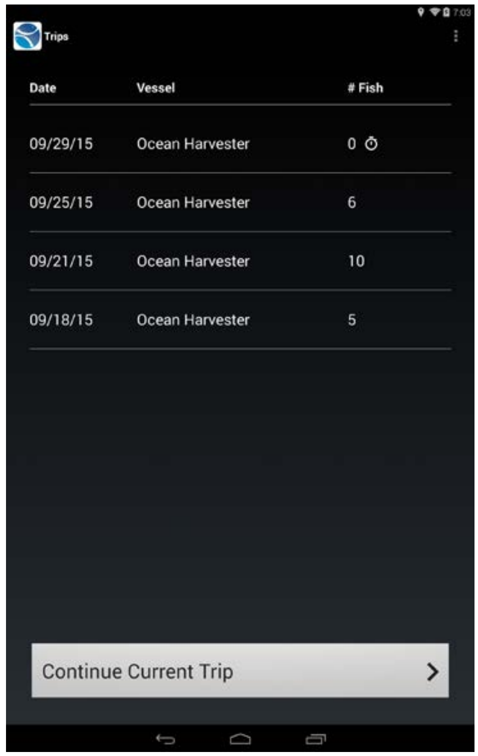
After transmission, the trip is locked from further editing.

Trip List page



For convenience, the app opens right to a list of trips contained on the device. There is a single, large button which will start a new trip if none are active, or take the user to a trip that is in progress.

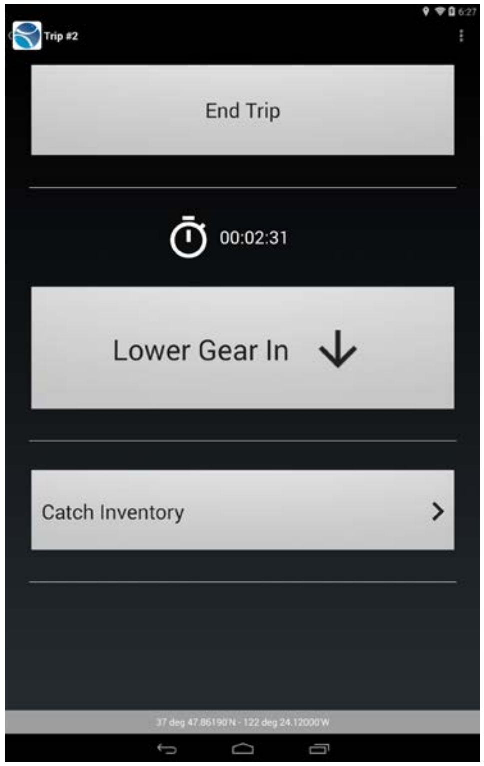
If a trip is still in progress, that trip will be the first item on the list with an indicator icon to signal that it's still unfinished.



If a user taps a completed trip in the list, he'll be taken to the Trip Detail page for that trip.

On first use of the app, users are immediately sent through a wizard to collect their home port of departure and the name of their vessel before being sent to the Trip List page.

Trip Dashboard page

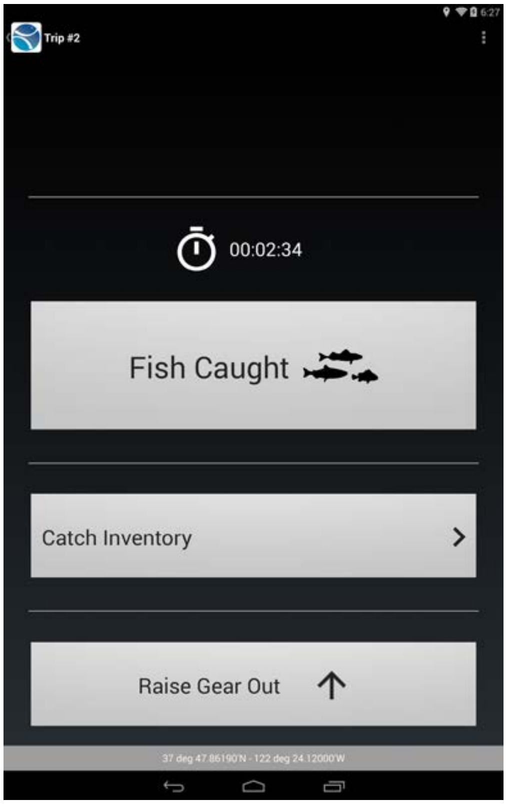


When a new trip is started, users are taken through a wizard to collect the necessary info. This includes Start Date (defaults to current day), Start Time (defaults to current time), and Port of Departure (defaults to home port).

Once the wizard is completed, the user is taken to a Dashboard screen for the trip. Here they'll see three buttons: End Trip, Lower Gear In, and Catch Inventory. The device's current GPS coordinates are also displayed at the bottom of the page and are updated in real time for convenience.

Gear In/Out

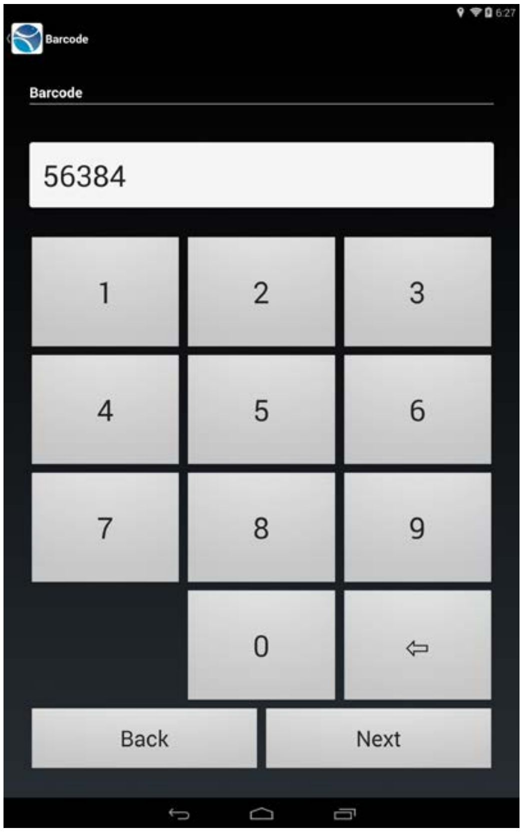
Since fish cannot be caught without gear in the water, a Fish Caught button is not visible until the user taps the Lower Gear In button. Once they do that, the timer starts, which keeps track of the total time that gear is in the water for the trip. A Raise Gear Out button also becomes visible, on a different part of the screen to prevent tapping it by mistake.



In this state, the End Trip button has also disappeared since it's not possible to end a trip without raising the gear out of the water first.

Adding Catches

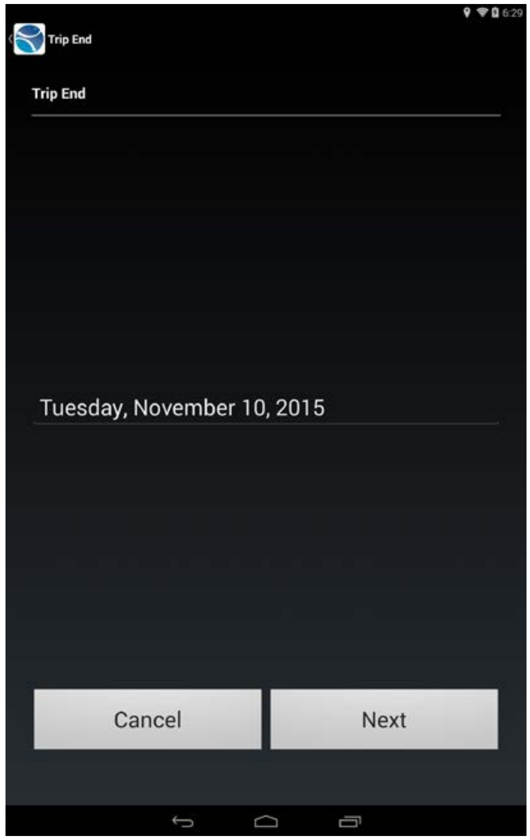
The Fish Caught button will take the user through a wizard that collects the following info: Whether the fish is to be sampled (defaults to Yes), the barcode of the fish, the length, the depth caught, and whether the Adipose fin is clipped.



If the user says that a fish will not be sampled, the rest of the wizard is skipped and he is returned to the Dashboard.

Upon completing the wizard, the user is taken back to the Trip Dashboard page and is able to add more fish as necessary. The catch data collected so far on the trip can be viewed by tapping the Catch Inventory button, which takes the user to the Catch Inventory page (outlined later in this document).

Ending the Trip



When a user wants to end the trip, they must tap the Raise Gear Out button to reveal the End Trip button, and then tap it. This will launch a wizard that will prompt the user for an End Date (defaults to current day), an End Time (defaults to current time), and a Port of Landing (defaults to Port of Departure).

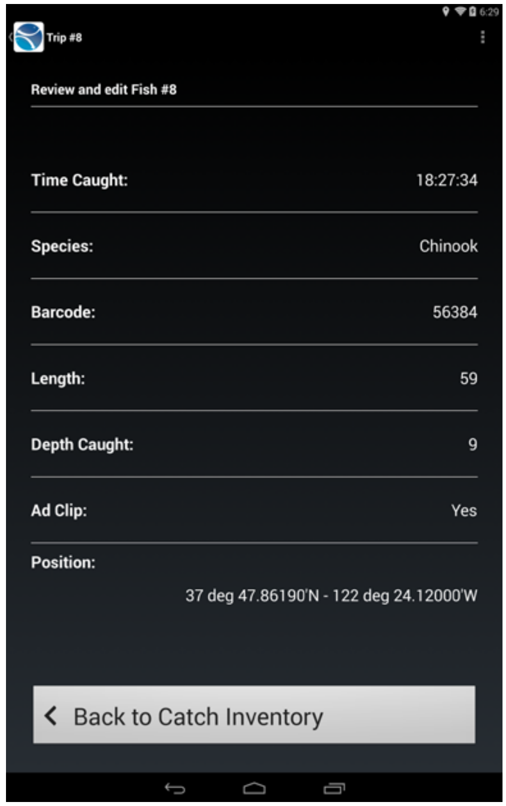
Catch Inventory page

The Catch Inventory allows a user to review all the catches associated with a Trip, as well as make any necessary changes to the catch. To edit a catch, a user simply taps the desired item from the list and is taken to the Catch Detail page (outlined below).

From the Trip Detail Page

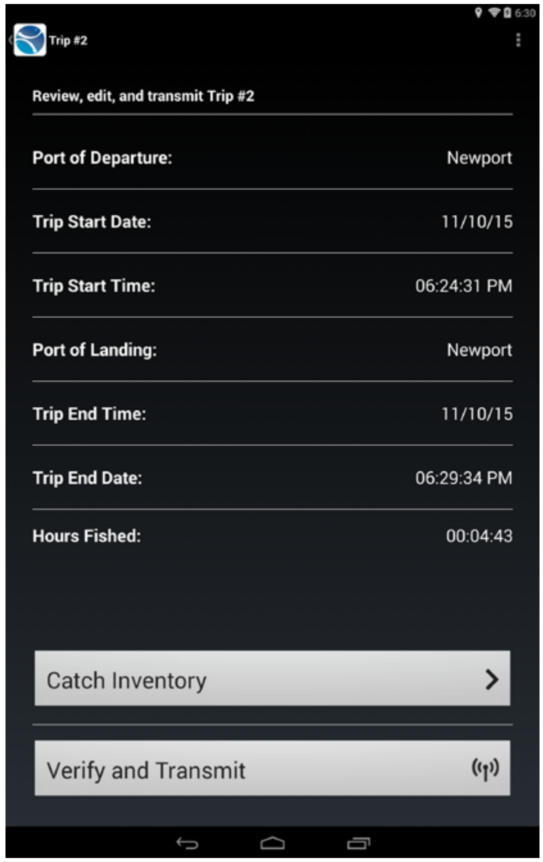
If the Inventory page is visited from the Trip Detail page, the user can also add catches that may have been missed during the trip, via an Add Fish to Trip button.

Catch Detail page



The Catch Detail page shows all the data that has been collected for a fish. If the fish is part of a Trip that has not yet been transmitted, the user can also edit any of the attributes by tapping on them.

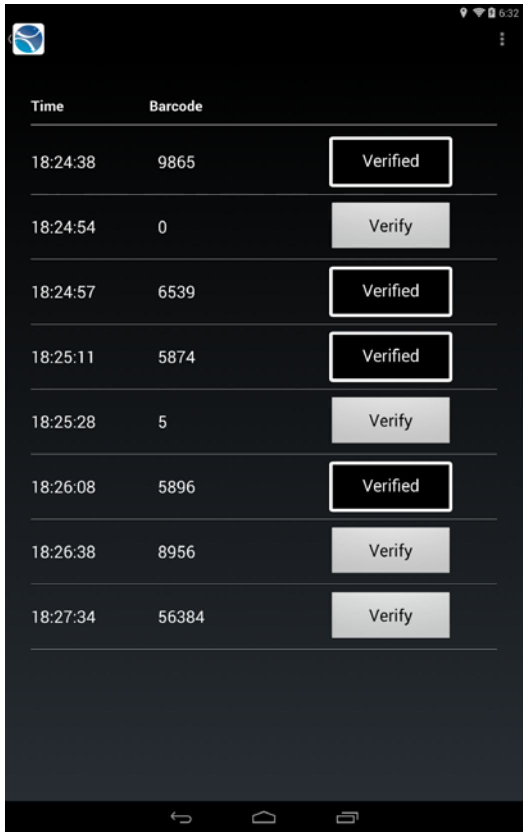
Trip Detail page



This page shows all data collected about a given Trip. From here a user can also review the Catch Inventory for the selected trip by tapping the Catch Inventory button. If the Trip has not been transmitted, the attributes can be edited by tapping on the desired item.

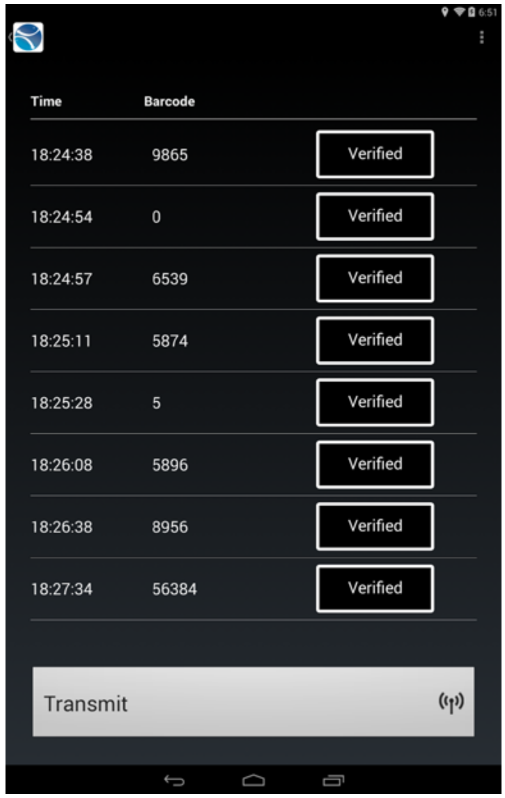
Here is where the user may start the transmit process by tapping Verify and Transmit.

Verify and Transmit page



All fish must be verified by the user before transmitting the Trip data to the server, which this screen prompts them to do.

Large Verify buttons turn to clearly selected "Verified" when tapped, allowing the user to quickly verify a long list of catches.



When all catches are marked Verified, a Transmit button appears at the bottom of the screen. That button will then send all Trip data to the server.