Investigating the Potential for an Electronic Logbook for Oregon's Commercial Dungeness Crab Fishery

December 2021

Gway Kirchner, Shonene Scott, and Jena Carter

The Nature Conservancy

Preface

The Nature Conservancy (TNC) is a science-based, nonpartisan organization committed to conserving the lands and waters on which all life depends. In Oregon, TNC has over 80,000 supporters and members in every county. Based in communities around the state, we manage lands and waters in varied ecosystems and partner with ranchers, farmers, fishers, and timber and environmental interests on some of the most challenging conservation issues facing people and nature.

Around the world, TNC addresses the most pressing conservation threats at the largest scale and has built a record of success since our founding in 1951, which includes the following achievements:

- Protecting more than 125 million acres of land and thousands of miles of rivers worldwide and operating more than 100 marine conservation projects globally
- Advancing conservation in 72 countries spanning six continents and protecting habitats from grasslands to coral reefs, from Australia to Alaska to Zambia
- Conducting fisheries projects from the West Coast to Chile to Indonesia and bringing a collaborative, science-based approach to bear on the most critical fisheries issues facing our globe

For their expertise and contributions in preparing this report, TNC extends our thanks and appreciation to the crabbers of Oregon's ocean commercial Dungeness crab fishery, the Oregon Department of Fish and Wildlife, the Oregon Dungeness Crab Commission, Pacific States Marine Fisheries Commission, and the Oregon State Police. Special thanks go to the M&T Bank Foundation and private donors for funding this project. TNC also recognizes Matt Gibbons for his contribution to this project and Tracey Westfield from Horizon26 for editing this paper.

Suggested Citation

Kirchner, G., Scott, S., & Carter, J. (2021). *Investigating the potential for an electronic logbook for Oregon's commercial Dungeness crab fishery.* The Nature Conservancy.

Requests for further information about the research in this report can be directed to Gway Kirchner, gway.kirchner@tnc.org.

Cover photo: Crabbers aboard the commercial crab boat *Delma Ann* with a partial background photo of computer code (photo credits are provided at the end of this report; see Entry 1).

Table of Contents

List of Tables and Figures

Tables

Figures

List of Abbreviations

ACCSP	Atlantic Coast Cooperative Statistics Program
API	application programming interface
CC	Creative Commons
CDFW	California Department of Fish and Wildlife
cELB	Cellular Electronic Logbook
CPFV	commercial passenger fishing vessel
DNR	Department of Natural Resources
eCDS	Electronic Catch Documentation System
EFIN	Economics Fisheries Information Network
ELB	Electronic Logbook
ERS	electronic reporting system
E-Tix	West Coast E-Ticket System
eVTR	electronic vessel trip reporting
FACTS	Fishing Activity and Catch Tracking System
FLDRS	Fisheries Logbook and Data Recording Software
MRP	Marine Resources Program (ODFW)
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OAR	Oregon administrative rule
ODCC	Oregon Dungeness Crab Commission
ODFW	Oregon Department of Fish and Wildlife
OSP	Oregon State Police
PSMFC	Pacific States Marine Fisheries Commission
RFID	radio frequency identification
SAFIS	Standard Atlantic Fisheries Information System Database
VMS	vessel monitoring system
VTS	vessel tracking system

1 Introduction

In 2015, The Nature Conservancy (TNC) conducted an extensive outreach effort to explore what types of projects TNC could facilitate that would most benefit Oregon's essential marine resources and the fisheries and communities that depend on them. A primary theme arose from 100 conversations with fishers, processors, gear manufacturers and distributors, local government officials, and others. Namely, the tools available to collect fishery data, such as logbooks and fish receiving tickets, could be modernized using recent technologies (e.g., apps and smartphones) and submitted electronically to the state of Oregon. To move the fishery toward this goal, TNC explored the potential for an electronic logbook system for Oregon's Dungeness crab fishery, its key features and benefits, and qualified vendors. Drawing from two years of research, conversations with experts, and surveys of the fishing fleet, we crafted this report to assist stakeholders in evaluating and building a Dungeness Crab Electronic Logbook.

1.1 What Is an Electronic Logbook?

Advances in mobile, cellular, and GPS technologies have revolutionized how fisheries collect data and report it to management agencies. Fisheries worldwide can choose from many readily available digital solutions, and each can be designed for a specific fishery's needs. With these opportunities at the ready, the potential for Oregon's Dungeness crab fishery to employ an electronic logbook is high.

A *logbook* is defined as a tool for recording and sharing data about fishing activity. Commercial crabbers licensed to operate in Oregon's fishery are required by the state's administrative rules to complete a logbook documenting each trip's fishing locations, catch, and other information. This current logbook is a paper form, but an *electronic logbook* would allow crabbers to record data via a computer device (e.g., tablet or smartphone) and submit it digitally to a central database.

Using this type of logbook system, crabbers could more efficiently prepare records using prefilled fields and automatic data capture, and seafood dealers and processors could do the same for purchases. The Oregon Department of Fish and Wildlife (ODFW) could add the data to their database in real time with less error and effort. Alerts could be generated to benefit crabbers, such as avoiding areas with high whale activity or harmful algal blooms.

1.1.1 The Purpose of a Logbook

The use of an electronic logbook fulfills several purposes. One of its primary purposes is to measure the abundance of the fishery's Dungeness crabs (ODFW Marine Resources Program [MRP], 2014). Abundance measures and other data help determine whether the fishery is harvesting at a level that will allow for continued stock production over the long term. Oregon uses the catch-per-unit-effort approach (i.e., pounds of crab caught per pots fished), calculated from logbook data to determine the attainment of a limited reference point that defines sustainable harvest levels (ODFW MRP, 2014).

A sign on Newport's dock announces where to buy live crabs (2).

A second significant purpose of the electronic logbook system is to allow for spatial evaluation of the fishery. This assessment is critical to protecting human health. Domoic acid can build up in ocean environments during algal blooms, bioaccumulate in crab tissue, and cause neurotoxicity in humans. Businesses in Oregon's crab market chain must maintain records about who they bought crabs from and sold crabs to (ODFW MRP, 2018). By matching the logbooks' GPS locations to business records, crab catch can be traced to ensure it came from a safe harvest area. This information also aids in evaluating spatial management of the fishery or the ocean, such as fishing area closures or openings or marine spatial planning.

1.1.2 The Current Paper Logbook

Crabbers complete the current paper-based Oregon Commercial Crab Logbook by hand and submit it to ODFW. It captures data about a crabber's fishing vessel

and each string of crab pots, including the GPS locations of the string's beginning and end, the number of pots, soak time, and estimated pounds of crabs pulled. ODFW then consolidates the information in its central database. (See Appendix A for details.)

The commercial vessel *Timmy Boy* loaded with crab pots in Newport, OR (3).

This system has its issues. Some challenges are that paper logbooks struggle to stand up to the harsh conditions experienced aboard a commercial fishing vessel, information entered by hand is sometimes hard to read, and manual database entry is time-consuming and prone to error. Submissions are primarily collected at the vessel or by postal mail and entered manually into ODFW's database.

ODFW enters data into the database with support from the Pacific States Marine Fisheries Commission (PSMFC), and then checks for data accuracy and completeness, validates the data after entering it, and performs the *tripping* process, whereby logbook data are linked to fish tickets. A *fish ticket* is a paper or electronic landing receipt a dealer uses to report the sale or delivery of a commercial catch. Even though its logbook is paper-based, Oregon's crab fishery already uses an electronic fish ticket system, the West Coast E-Ticket System (E-Tix; Appendix B). (A *landing* is the offloading of catch from a fishing vessel. Once the transfer begins, all fish aboard are counted as part of the landing.)

1.1.3 How an Electronic Logbook is Different than Paper Logbooks

Fisheries' electronic logbooks typically consist of a software application, external GPS or satellite antenna, communication service, and remote computer server(s). The software—also referred to as a *user application*—runs on a fishing vessel's hardware device, such as a computer, tablet, or smartphone. The antenna automatically captures location data. The communication service transmits data to shore and can be a cellular service, satellite link, or Wi-Fi connection. Finally, a remote computer server(s) on land receives and processes the catch data.

In some applications, the data are received by a public-facing cloud service called a *data warehouse*, which transmits the data to a second, more secure server behind an agency's firewall. These cloud-based services are occasionally paired with a web-based *data portal* to provide fishers, agency staff, and others access to submitted data. Such a portal can optionally offer specialized features, such as a map of fishing activity, closure alerts for managed areas, a weather forecast, or other tools to enhance the user experience and incentivize program participation. Refer to Appendix B for details about the system's data flow.

1.2 Why Might an Electronic Logbook Be Useful in Oregon?

An electronic logbook has the potential to improve accuracy and efficiency if it is designed to meet crabbers' needs and the on-the-water conditions they work in. Depending on its design, the system can automatically collect locations via GPS without crabbers entering the coordinates. With a computerized interface, frequently used values can be stored and reused as field prefills or selection lists to speed entry and reduce data errors. Data checking and validation processes can automatically occur during data entry, rather than manual checks following submission. This user-friendly data capture can reduce the burden on crabbers, which is especially useful in the Dungeness crab fishery since the activity is more intense than in other fisheries. Plus, it can reduce ODFW and PSMFC's data entry and validation burdens. For example, entering a fish ticket number(s) in a logbook record before submission would eliminate the need to perform the tripping process afterward, making it easier to identify a catch with dangerous levels of domoic acid.

Beyond the advantages that crabbers and fishery managers might enjoy, the Dungeness Crab Electronic Logbook could benefit other stakeholders (Appendix C). Researchers could collect ecological or oceanographic data to better identify trends, such as oxygen levels in

Oregon's ocean waters. The logbook could help crabbers avoid whale entanglements by recording whale sightings and even alerting crabbers when their vessels are entering whales' high-traffic areas. At the very least, the logbook could link to an existing application, such as the Whale Alert app from the National Oceanographic and Atmospheric Administration (NOAA), which allows commercial fishers and other boaters to share real-time whale sightings.

2 Considerations

This report describes many decisions and options that must be weighed to develop and deploy the Dungeness Crab Electronic Logbook. TNC staff spoke with fishery managers, industry representatives, and software vendors to gather information for a future electronic logbook. We investigated pilot projects, journal articles, stakeholder reports, and online sources. This section summarizes the considerations that emerged.

When contemplating how an electronic logbook might be implemented for Oregon's Dungeness crab fishery, two initial questions must be answered: Who will build it? What features must it have?

The "who" refers to the *application manager*, meaning the organization that develops a plan and budget, hires a vendor, and oversees the development and deployment of the logbook system. This same application manager maintains the system after launch. However, the manager's maintenance responsibilities can vary depending on how many tasks are assigned to the vendor, as explained later in this section.

Two entities have been identified as leading candidates to fill the role of application manager: ODFW or PSMFC. ODFW is a logical choice since the department oversees the current paper-based system and executes Oregon's related administrative rules. Two factors suggest that PSMFC could also make a good application manager. First, the commission has experience managing an electronic reporting system: the E-Tix Portal. Second, PSMFC has an interstate mission; member states include California, Oregon, Washington, Idaho, and Alaska. A multistate logbook system would require more coordination and lengthier development but could allow the states to share costs and resources and look at fishery trends more holistically. It would also benefit crabbers who fish in multiple fisheries.

To help answer the question "What features must it have?," TNC compiled many considerations and ideas (Appendix C to Appendix H). Table 1 lists the most notable.

Crew members deploy temperature sensors in crab pots off the central Oregon coast as part of Oregon Sea Grant's Scientist and Fishermen Exchange Program (4).

Table 1
Considerations for the Dungeness Crab Electronic Logbook and Related Ideas

Consideration	Related Idea
System development	
Agree on system requirements first, before soliciting bids from vendors.	Work with stakeholders to prioritize features and separate must-haves from nice-to-haves. Does the electronic logbook have to run in parallel with the paper system? If yes, for how long? And how will ODFW incentivize the use of both systems? In other words, how will ODFW make it worthwhile for crabbers to do double the data entry, thus avoiding a situation where the majority of the fleet transfers to the new system only when the redundancy ends?
Define data standards and an *application programming interface* (API) before the user app. An API is a set of coded functions dictating how information is sent to and requested from the data warehouse. The advantage of an API is that it works with third-party apps, so other vendors' apps are compatible.	If needed, contract with a software expert so that they can inform the process of defining requirements. The Atlantic Coast Cooperative Statistics Program (ACCSP) or a vendor they recommend might be a good candidate because they have already built and still maintain a system (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020). Because of their API, New England and Mid-Atlantic commercial fishers can choose from six different reporting apps approved by the National Marine Fisheries Service (NMFS; some free) to submit trip reports electronically.
Decide on the fee structure for system implementation. Consider whether to enter into a subscription- or contract-based business model.	While it seems likely that the app manager will pay upfront development costs, there are options for how much of the total cost is baked into that upfront expenditure and how maintenance costs are divvied. A subscription model has lower upfront development costs and higher post-implementation costs. The reverse is true for a contract model. While the six vendors offering promising apps could not give TNC detailed cost estimates without system requirements, they did share some ballpark estimates. Development fees will likely cost from $50,000 to $100,000 or more. Among the six vendors, three operate on a subscription basis. Ongoing costs for such a subscription ranged from $10,000 to $15,000 per month for the fleet or from $300 to $600 per user per year. The upcoming section called "The Six Promising Candidates" provides more details about the six vendors and costs.
Determine the type of long-term support needed.	Users will need some level of software support, which may cover the user app, data warehouse, and/or data portal. Similarly, new users will need training (e.g., in-person classes, webinars, or user manuals).
Determine how system policies will be created and maintained.	The app manager may wish to form an oversight committee composed of representatives from different user groups and other interests. Alternatively, the manager may wish to form ad-hoc work groups when preparing for system upgrades. The app manager should determine how they will track and prioritize modifications and upgrades that users request. If the manager pays a vendor for long-term maintenance, much of the tracking may fall to the vendor. If most long-term costs are passed along to crabbers via a subscription, they may play a more significant role in prioritizing upgrades.
Investigate whether an existing system can be adapted.	Three of the six vendors that TNC identified as having promising application designs offer a base product that can be customized (see the upcoming section "What Software Applications Already Exist?"). Does one of them have a system close to what Oregon wants to keep costs low,? One of the two pilot projects described in Appendix F is Oregon's Digital Deck from 2012. Does Digital Deck meet most of today's needs? If so, what would it take to revive, perfect, and scale it?

Consideration	Related Idea
User app	
Automate as much data entry as possible. Crabbers and ODFW staff who spoke to TNC said efficient data entry was essential.	Use field prefills or selection lists so that frequently logged information is automatically entered or easier to enter. Allow crabbers to create user-specified default values. Allow for easy adjustments when crabbers need to reset a string of pots—either by changing the start or end location or by adding or reducing the number of pots. (The paper logbook specifies no standard for such changes.)
Capture GPS location data for automatic data entry. This consideration continues the previous one, but the experts we spoke with focused so much on improving location data that we separated it from the previous row.	Crabbers could push a button in the app to capture the GPS location at the start and end of setting a crab pot string. Catch data entered when the string is pulled would complete that particular logbook record. Also, investigate the most reliable way to capture GPS locations. Crabbers told TNC that external antennae have a more reliable signal and can store the data for integration into the user app once a strong satellite or cellular signal becomes available. Decide whether stakeholders want to integrate the electronic logbook with a *vessel tracking system* (VTS). Collecting additional GPS data would record points between the start and end of strings, allowing for a more accurate representation of fishing gear's location. A VTS is a hardware beacon (generally an affordable solar-powered unit) that automatically collects location data every few seconds via a satellite connection, independent of a fisher's actions. (See Appendix F for information on California's solar logger pilot project.)
Include quality checks.	Add automatic checks so that data needs less post-submission cleaning.
Digitally transmit logbook data to ODFW. With either Wi-Fi or a cell signal, send data from the user app to the data warehouse to be imported into the Commercial Dungeness Crab Logbook Database.	To account for both human and technological error, developers may want to build in a correction procedure allowing crabbers to edit records before and/or after submission. Crabbers who contributed to our research deemed a correction process to be essential. That said, there is a tension between ODFW's need for accurate and valid data pulled directly from a GPS antenna and the realities of a crabbing operation, which has limited time for and thus limited focus on data logging. This tension should be acknowledged in the development process, and stakeholders should collaborate to identify solutions offering compromises.
Consider what features can improve the fleet's business to incentivize complete and accurate data entry. (Details about crabbers' needs are listed in Appendix E.)	Add an export feature to integrate logbook data with crabbers' business software. Some crabbers already manually enter logbook records into their software, so an export function could save time. Include a notes section for each string—e.g., "stacked 20 pots off N end of string" or "reef here to avoid." Crabbers collect copious notes about various aspects of their operations. An electronic logbook need not replace all their notetaking, but some fields could be helpful. Record the fish ticket number to allow direct links to fish landing data. Also, automate calculations about the haul. For example, the logbook could provide a count-to-pounds conversion option, estimating poundage using the number caught and vessel's pounds-per-number trend for the season. Consider creating software that can operate on equipment crabbers already own and across multiple platforms (i.e., iOS, Android, and Windows), as different crews use different devices. The disadvantage is that fewer vendors support all operating systems, reducing the vendor pool. Also, development and maintenance costs may be higher for multi-platform products. The trade-offs must be weighed.

Consideration	Related Idea
Data warehouse	
Determine how ODFW wants to aggregate and process data.	ODFW could continue using their Commercial Dungeness Crab Logbook Database. Alternatively, ODFW could transition to the vendor's database, in which case ODFW would access data via an online portal. In the architecture illustrated in this report (see Figure B-1 in Appendix B), logbook data would be received and processed by a cloud-based warehouse that subsequently transmits it to ODFW's server for use in their database. However, when TNC spoke with ODFW (Appendix D) and crabbers (Appendix E), they said it was essential for the logbook system to ensure data security and confidence in data handling. To this end, ODFW has considered prohibiting cloud services from receiving or storing data.
Determine whether the application manager—ODFW or otherwise—wants to own the data warehouse once the system is deployed.	The manager could (1) establish an ongoing relationship with the vendor to completely maintain the data warehouse (i.e., the data is stored on the vendor's servers), (2) completely own the data warehouse once it is deployed, or (3) opt for a hybrid in which data is stored in the vendor's warehouse for crabber and public access but also passed to the app manager's servers for data validation, integration with other systems (e.g., E-Tix), or other activities.
Data portal	
Decide if the electronic logbook system will include a data portal.	The advantage is that many different users—crabbers, fishery managers, researchers, and the public—can access various features from a simple web-based interface customized by user profile. Depending on security concerns, the potential disadvantage is that some form of a cloud-based warehouse is needed to serve up the portal's display. The portal could offer maps and alerts about weather, fleet location, harvest areas, whale traffic (to prevent entanglements), and more. It could also allow crabbers to edit their records after submission and export revised records. If desired, the fishery managers could use the portal to access logbook data, manage user accounts and licenses, communicate with crabbers (e.g., emails, texts, notice boards), etc.
Modularity	
Consider whether the app manager wants to design and build a system that can support logbooks for additional Oregon fisheries and/or other states' crab fisheries.	Although modularity may require higher initial costs, savings over time could be significant as new modules are added. Also, since commercial fishers often submit logs for multiple fisheries, they would likely consider the system more efficient if they had a single user account to access several logbooks within one app and from one device. For the state government's decision-makers to invest in a modular electronic logbook system, they must predict how many of Oregon's nine fisheries will eventually transition to it and when they might do so.

3 Outreach and Research Methodology

The list of considerations in the previous section was derived from the outreach and research that TNC conducted. This section covers the methodology underpinning the report. TNC staff sought various perspectives on the pros and cons of an electronic logbook, including dialogues with ODFW, the Oregon Dungeness Crab Commission (ODCC), and the Oregon State Police (OSP). In addition, via a survey and one-on-one conversations, we reached out to on-the-water experts: the 421 crabbers who held Oregon permits for Dungeness crab at the time of the survey. We also researched two pilot projects, and we investigated the existing technologies available to commercial fishers and the vendors who supply them.

3.1 What Did Stakeholders and the Industry Say?

3.1.1 Stakeholder Conversations

Fishery stakeholders who spoke with TNC represented the Dungeness crab fishery's management and enforcement agencies, as well as its commodity commission (Appendix D). First, TNC had conversations with ODFW experts to understand how an electronic logbook might increase efficiency and enhance data-driven decision-making. They explained that the agency's main objectives for the logbook are (a) improving spatial data by automatically collecting location data (e.g., via a GPS unit), (b) providing system flexibility by ensuring the user application is supported on various devices and operating systems, (c) securing the system by protecting data and users' devices, and (d) integrating with ODFW's database.

Second, ODCC shared their thoughts as the crab fishery's commodity commission that advances marketing, research, and educational projects. ODCC responded favorably to TNC's research but proceeded cautiously in voicing support since opinions within the fleet vary widely. While ODCC staff members understand the usefulness and benefits of logbooks, they have not directly used logbook data and see limited utility for a logbook for the commission's work. Indirectly, research projects sponsored by ODCC have used and will continue to use logbook data.

Third, TNC spoke with an OSP officer. The OSP Fish and Wildlife Division enforces commercial fishing rules and regulations. The officer said that a Dungeness Crab Electronic Logbook could improve enforcement. The fishery's existing E-Tix Portal, operated by PSMFC, is a good example of an electronic system that has proven enforceable. As soon as the digital ticket starts through the system, PSMFC can access it in draft form, and OSP officers can view it. This early access boosts confidence in the data's reliability, and the officer recommended that the electronic logbook's designers look to the E-Tix Portal for ideas.

3.1.2 Industry Survey and Conversations

Through a fishery-wide survey and one-on-one conversations, TNC added to the research gathered for this report. The eight crabbers who spoke with TNC expressed qualified interest in an electronic logbook system, especially if it proved easier and more efficient than the paper logbook. Also, nine out of the 23 survey respondents were interested or very interested.

The feedback indicated that most crabbers are generally comfortable with technology, as they currently operate many onboard digital devices. Several participants expressed a willingness to participate in a future pilot project if one proceeds. And many of their ideas were incorporated into the previous "Considerations" section (with more listed in Appendix E).

The crabbers stressed that data entry must be simpler, more efficient, and less prone to errors than the paper logbook. Also, the system should link to the assortment of onboard devices already on a commercial fishing boat: chart plotters, multiple GPS devices, depth finders, marine radar scanners, computers, etc. If crabbers already have integrated electronic systems on their vessels, they can benefit from real efficiencies by integrating an electronic logbook with these systems.

While many crabbers spoke of an electronic logbook's benefits, they tempered their conversations with a few concerns. For example, they said that any electronic system must be secure. Some preferred the ease of a paper form and submitted responses such as the following: "Paper. If it gets wet it dries out and still works." and "Paper. No interest in learning new e-logbook. Concerns

over tracking/surveillance." (Complete responses are in Appendix E.) Most importantly, crabbers must be able to operate it without distracting from fishing or otherwise compromising the safety of the crew and vessel.

Dungeness crabs are unloaded from the *Sarah Belle* (5).

3.1.3 Pilot Projects

Another research avenue that TNC explored comprised two pilot projects to test electronic logbooks for West Coast crab fisheries. California's Solar Logger Pilot Project is currently underway, and Oregon's Digital Deck Pilot took place in 2012 (Appendix F).

The California pilot has placed solar-powered VTSs on commercial crabbing vessels, whale watch boats, and commercial passenger fishing vessels (CPFVs). The information collected describes fishing dynamics and whale concentrations to protect whale populations and the fishery. While the pilot's VTS is not designed to integrate with an electronic logbook, our research underscored the value of such a design: A user application could request real-time GPS locations from an onboard VTS device without any intervention by the crabbers.

Oregon's 2012 pilot project focused squarely on the type of electronic logbook that is the subject of this report. Digital Deck allowed crabbers to report their catch data on iOS and Android tablets and submit it wirelessly to a remote database. From lessons learned, the pilot's director, Charles Steinbeck, recommended a simple design that automates as much data entry as possible, mimics the crabber's workflow, and gives crabbers access to the data for their business needs. One suggested improvement over the Digital Deck design was to allow crabbers to modify string data once logged if the crabbers had to change the start or end of a string.

3.2 What Software Applications Already Exist?

TNC identified 24 electronic logbook and catch-reporting software applications available to fisheries. From 24, we selected six promising candidates for further investigation. (See Appendix G and Appendix H.)

3.2.1 The Six Promising Candidates

It is important to remember that technologies and vendors change over time. So, in this section, we focus on the essential attributes that must be considered when judging which application is best for Oregon's crab fishery.

First, the six vendors employ one of two business models: subscription or contract, as shown in Table 2. The application manager must weigh a subscription's relatively lower upfront and higher ongoing costs against a contract's higher upfront and lower ongoing costs.

Second, some logbook applications are narrowly focused on electronic reporting. Others are fully integrated electronic monitoring solutions—for example, the logbook could be but one element of a sophisticated system also encompassing cameras, gear sensors, and a *vessel monitoring system* (VMSs), like the Woods Hole Group's product. A VMS is a satellite-based monitoring system that transmits a vessel's time-stamped location, course, and speed to authorities at regular time intervals, such as every two hours, allowing fisheries and environmental regulators to track and monitor commercial fishing activity. Generally, it is a more complex and expensive system than a VTS.

Third, electronic logbooks differ in how they aggregate and store data transmitted by the user application. There are a few possible paths for developing and maintaining the warehouse, and an application manager must decide which to pursue when seeking bids from vendors:

1. A subscription service where the vendor handles all database services as part of their recurring fee
2. A custom data warehouse built by the vendor and maintained under an ongoing contract
3. A custom data warehouse built by the vendor and maintained by the application manager

4. A data warehouse built and maintained by the application manager

Beyond these major attributes, the application manager should weigh how well each vendor addresses the needs and ideas in the previous "Considerations" section.

The six vendors that TNC spoke with provided general cost estimates for application development and ongoing support. Unsurprisingly, it was challenging for them to provide ballpark estimates without detailed system requirements. Still, it was clear that cost savings could be realized by selecting a vendor who already provides a reporting system similar to what Oregon needs, thus requiring only minimal customization. Table 2 summarizes each vendor's information, including their ballpark cost estimates. Appendix G provides more details. This information is a snapshot in time and can change quickly, but it offers examples of what exists as of 2021.

Table 2
Attributes of the Six Promising Candidates for the Dungeness Crab Electronic Logbook

App	Vendor	Business model	Base software?	Vendor warehouse?	Development costs [a]	Maintenance costs [a]	Example [b]
FACTS	Electric Edge Systems Group	(subscrip.)	Yes, customizable	Yes, via subscription	Part of the subscription	Subscription of $10K–$15K/ month/ fleet	FACTS by the Maryland Dept. of Natural Resources (DNR)
n/a	Elemental Methods	(contract)	No, custom product	No, owned by app manager	$30K–$60K for app, warehouse, and portal	Unknown	iSnapper for recreational for-hire and headboat captains; in TX, LA, FL, and AL
n/a	Harbor Light Software		No, custom product	No, connects to the app manager's existing database	$30K–$100K+	0%–18% of the development cost/ year	eTrips Mobile2 for New England and Mid-Atlantic fisheries
Deckhand	Real Time Data		Yes, customizable	Both; use app manager's database for fishery mgmt. and vendor's for extra features (with subscription)	$10K+ depending on customization	$600/ crabber with a minimum of 20–30 at startup	Deckhand in Australian fisheries
n/a	Teem Fish Monitoring		Yes, customizable	Either, but vendor warehouse recommended	$30K for the user app alone	Unknown	Elogs for New England and Mid-Atlantic fisheries
n/a	Woods Hole Group		Yes, customizable	Yes, integrated into their VMS	$10K for a customized app, $400/ vessel for a hybrid VMS beacon	$300/ user/ year for the hybrid VMS, integrated logbook app, and web portal	NEMO hybrid VMS beacon communicates either via satellite or a cellular network

[a] Costs are only rough estimates; details are in Appendix G.
[b] Details about the examples are in Appendix H.

3.2.2 Other Options

As mentioned previously, TNC compiled a list of 24 software applications available to fisheries for electronic data collection. For each, we researched application functions, data warehouse and portal features, supported operating systems, estimated costs, and more. The full list of the 24 applications is described in Appendix H, and screenshots of sample applications are presented in Appendix I.

4 Conclusion

4.1 Imagining the Future

Sometimes it can be helpful to imagine the end goal. What would the Dungeness Crab Electronic Logbook look like if the application manager, crabbers, fishery manager, and other interested parties worked together to create one for Oregon? This section envisions a seamless electronic logbook system that considers all stakeholder perspectives.

Let us follow the data flow, beginning with data entry: The user application respects crabbers' needs, making their day-to-day tasks safer and more efficient. Most of the data are prefilled or auto-populated. Locations are automatically collected by an external VTS solar logger that can communicate with the logbook—either by satellite while the vessel is on the water or newly installed free Wi-Fi provided at the dock. Other data are collected via an interface built for harsh ocean environments and hectic work schedules. For instance, crabbers merely push a button to note a string's beginning and end, matching the data to the VTS's GPS locations. A buzzer signals when to set pots along a string at predefined intervals. The software also includes an easy counter function, so as the crew hauls in pots and calls out counts of crab harvested, the captain can click a button to produce the string's running total.

Once a vessel lands, either a crew member or a seafood dealer enters the fish ticket number(s) into the logbook with easy device-to-device communication (e.g., a QR code on one device scanned by the other). The data are matched to Dungeness crab harvest areas to ensure domoic acid levels are within safe ranges. The entire seafood market chain's transactions are incorporated into the electronic system so that fishery managers and other oversight entities can track the catch from crab pot to plate.

The crew transmits logbooks via the free Wi-Fi service available at the docks, and records are stored in the software vendor's data warehouse, built for modularity so that other fisheries can join the system. The warehouse harmonizes all data into a unified dataset based on the standards of a stakeholder-driven oversight group. The standards help to ensure consistency across fisheries for apples-to-apples comparisons. And the harmonization allows researchers to use multiple datasets in large-scale analyses.

A web-based data portal gives researchers easy access to summarized datasets, following data confidentiality standards. Moreover, the researchers can use the portal to conduct studies by posting notices to call for industry volunteers, sending messages to study participants, and incentivizing participation by offsetting system costs. Generally, in this scenario, the crabbers and fishery managers share the cost of a subscription service. But the research projects can help defer a small portion of the costs in exchange for the crabbers' data collection efforts.

Beyond research, fishery managers use the portal for outreach and administration (e.g., communicate with crabbers, manage licenses, export data). They also use high-quality data to determine the attainment of limited reference points and evaluate spatial fishery and ocean management proposals.

Crabbers can edit the records they have submitted. Validation checks prevent conflicts between their revisions and the VTS logger's data or other recorded information. All users, even the public, can access maps and alerts about weather, whale activity, harvest areas, and fleet locations.

The electronic logbook improves crabbers' and fishery managers' processes so much that a subscription account is well worth the money. Most importantly, the health of the industry, ecosystem, species, human consumers, and local communities benefit from the Dungeness Crab Electronic Logbook.

4.2 In Closing

The information presented in this report is intended to spark dialogue and provide a framework for evaluating key questions to determine what will work best for Oregon's fisheries. TNC also recognizes that this information represents a snapshot in time and will evolve as technologies and circumstances change. We hope this compilation of research and thinking is helpful as stakeholders move forward together into an electronic future.

Sunrise over the Yaquina Bay Bridge in Newport, OR (6).

References

Alaska Department of Fish and Game, International Pacific Halibut Commission, & National Marine Fisheries Service. (n.d.). *eLandings user documentation*. https://elandings.atlassian.net/wiki/spaces/doc/overview

Atlantic Coast Cooperative Statistics Program. (n.d.-a). *Trip reporting applications for catch & effort data from harvesters*. https://www.accsp.org/what-we-do/safis/etrips/

Atlantic Coast Cooperative Statistics Program. (n.d.-b). *What do captains think of eTrips/Mobile?* [Video]. https://www.accsp.org/what-we-do/safis/etrips/

Atlantic Coast Cooperative Statistics Program. (2012). *Atlantic Coast fisheries data collection standards* (2012 ed.). https://www.accsp.org/wp-content/uploads/ACCSP_StandardsandAppendices2012_Final05082012.pdf

Atlantic Coast Cooperative Statistics Program. (2019). *SAFIS Unified API: Programmers API reference 7.0*.

Berube, P. (2018). *Solar logger pilot project: Informing the Risk Assessment and Mitigation Program (RAMP) of the Dungeness Crab Fishing Gear Working Group* (Item 6b1) [Staff recommendation]. California Ocean Protection Council. http://www.opc.ca.gov/webmaster/ftp/pdf/agenda_items/20181025/Item6b1_SolarLogger-Pilot-Project-Staff-Rec-Final.pdf

Business Queensland. (2017). *Reporting requirements for commercial fishers*. Queensland Government. https://www.farmtransparency.org/uploads/documents/2090-000000335-46f657cec6-reporting-requirements-commercial-fishers-ql.pdf

California Department of Fish and Wildlife. (n.d.). *Marine Fisheries Statistical Unit (MFSU)*. https://wildlife.ca.gov/Conservation/Marine/MFSU

California Department of Fish and Wildlife. (2017, March 13). *Marine Logs System CPFV training videos* [Playlist of videos]. YouTube. https://www.youtube.com/playlist?list=PL-PEXRYYBP1SVJBhhmbIvuxVuWTrLPRSO

California Department of Fish and Wildlife. (2018, February 6). *New electronic systems provide more timely and accessible fishery data, enhance enforcement capabilities* [Press release]. https://cdfwmarine.wordpress.com/2018/02/06/new-data-collection-systems/

Climatebase. (n.d.). *Pelagic Data Systems*. https://climatebase.org/company/7771/pelagic-data-systems

Ecotrust. (n.d.). *Digital Deck: Real-time mobile technology for fisheries management*. http://archive.ecotrust.org/marineplanning/downloads/Digital_Deck_factsheet.pdf

Ecotrust Canada. (n.d.). *Case study: Teem Fish Monitoring, Inc*. https://ecotrust.ca/innovation/social-enterprises/case-study-teem-fish-monitoring-inc/

Ecotrust Canada & Teem Fish Monitoring. (2019, May 1). *New social enterprise empowers local fisheries with affordable, world-class electronic monitoring technology* [Press release]. http://ecotrust.ca/wp-content/uploads/2019/05/Press-release_May-1-2019_Ecotrust-Canada-launches-new-social-enterprise.pdf

Harbor Light Software [Homepage]. (n.d.). https://www.harborlightsoftware.com/

Harbor Light Software. (2020a). *Overview of eTRIPS Mobile2 for tablets* [User guide]. https://www.harborlightsoftware.com/media/etrips2-phone-manual-final.pdf

Harbor Light Software. (2020b). *Overview of eTRIPS Mobile2 for Windows* [User guide]. https://www.harborlightsoftware.com/media/etrips2-uwp-manual-final.pdf

Lundeberg, S. (2021, September 8). *Ocean hypoxia off Pacific Northwest coast more troubling than ever, experts say*. Oregon State University. https://today.oregonstate.edu/news/ocean-hypoxia-pacific-northwest-coast-more-troubling-ever-experts-say

Maryland Department of Natural Resources. (2020). *E-Reporting with FACTS* [Training video]. https://dnr.maryland.gov/fisheries/Pages/e-reporting/video.aspx

Merrifield, M., Gleason, M., Bellquist, L., Kauer, K., Oberhoff, D., Burt, C., Reinecke, S., & Bell, M. (2019). eCatch: Enabling collaborative fisheries management with technology. *Ecological Informatics*, *52*, 82–93. https://doi.org/10.1016/j.ecoinf.2019.05.010

Mikol, R. (2004). Data collection methods and GIS uses to enhance catch and reduce bycatch in the North Pacific fisheries. In T. Nishida, P. J. Kailola, & C. E. Hollingworth (Eds.), *GIS/spatial analyses in fishery and aquatic sciences* (Vol. 2, pp. 607–614). Fishery and Aquatic GIS Research Group. http://www.esl.co.jp/Sympo/3rd/sample2.pdf

NFA to implement new "fish" system. (2014, June 23). *The National*. https://www.thenational.com.pg/nfa-to-implement-new-%E2%80%98fish%E2%80%99-system/

National Marine Fisheries Service. (n.d.). *Electronic reporting in Alaska fisheries*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov/alaska/resources-fishing/electronic-reporting-alaska-fisheries

National Marine Fisheries Service. (2013). *Electronic monitoring white papers*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. https://static1.squarespace.com/static/56c65ea3f2b77e3a78d3441e/t/5744ac95b6aa6050dff8f7cb/1464118426824/CCC_2013-02_023_K_NMFS_EM_WhitePapers.pdf

National Marine Fisheries Service. (2019). *Fish Online for iOS app: How-to card*. https://media.fisheries.noaa.gov/dam-migration/fishonlineapphowtocardrev202build2022.pdf

National Marine Fisheries Service. (2021, August 16). *Vessel trip reporting in the Greater Atlantic Region*. U.S. Department of Commerce, National Oceanic and Atmospheric Administration. https://www.fisheries.noaa.gov/new-england-mid-atlantic/resources-fishing/vessel-trip-reporting-greater-atlantic-region#electronic-vessel-trip-reporting

New England Fishery Management Council & Mid-Atlantic Fishery Management Council. (2020, January 29). *Councils approve omnibus commercial eVTR framework* [Press release]. https://static1.squarespace.com/static/511cdc7fe4b00307a2628ac6/t/5e31956d925807707335c2b6/1580307822558/pr20-04_NEFMC-MAFMC-Approve-Omnibus-Commercial-eVTR-Framework.pdf

OLRAC SPS. (2013). *Establishing an electronic data management model for South African fisheries*. http://www.rfalliance.org.za/wp-content/uploads/2017/06/Lallemand-2013-An-electronic-data-management-model-for-SA-fisheries.pdf

Oregon Administrative Rule 635-005-0240 (12) (2021). https://secure.sos.state.or.us/oard/view.action?ruleNumber=635-005-0240

Oregon Administrative Rule 635-005-0445 (2012). https://secure.sos.state.or.us/oard/view.action?ruleNumber=635-005-0445

Oregon Administrative Rule 635-005-0490 (2020). https://secure.sos.state.or.us/oard/view.action?ruleNumber=635-005-0490

Oregon Administrative Rule 635-006-0001 (21)(a) (2020). https://secure.sos.state.or.us/oard/view.action?ruleNumber=635-006-0001

Oregon Department of Fish and Wildlife Marine Resources Program. (2014). *Commercial ocean Dungeness crab fishery logbook CPUE preliminary assessment — 3rd iteration.* https://dfw.state.or.us/agency/commission/minutes/14/08_august/Exhibit%20F_Attachment%2011_Commercial%20Ocean%20Dungeness%20Crab%20Fishery%20Logbook.pdf

Oregon Department of Fish and Wildlife Marine Resources Program. (2018). [Policy brief on the permanent rules (OAR 635-006-0201) for expanded recordkeeping requirements for buying and selling Dungeness crab]. https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/2018/Crab%20Records%20Public%20Industry%20Notice%20FINAL%202018-0511.pdf

Oregon Department of Fish and Wildlife Marine Resources Program. (2021a). *Draft Oregon Dungeness crab fishery management plan*. https://www.dfw.state.or.us/MRP/shellfish/commercial/crab/docs/2021/Dungeness_Crab_FMP_Public_Draft.pdf

Oregon Department of Fish and Wildlife Marine Resources Program. (2021b). *Dungeness crab harvest area map*. https://www.dfw.state.or.us/mrp/shellfish/commercial/crab/docs/2021/CrabHarvestAreas_2021-02-08.pdf

Oregon Dungeness Crab Commission. (n.d.). *About the Oregon Dungeness Crab Commission*. https://oregondungeness.org/about-the-oregon-dungeness-crab-commission/

Oregon State Police Fish and Wildlife Division. (n.d.). *What we do*. https://www.oregon.gov/osp/programs/fw/Pages/about.aspx

Pacific States Marine Fisheries Commission. (n.d.). *E-Tix Portal*. https://etix.psmfc.org/Account/Login

Real Time Data. (n.d.). *Deckhand* [Homepage]. https://deckhandlogbook.com/

Resource Data. (n.d.). *Our work: Electronic fish ticket application*. https://www.resourcedata.com/our-work/project/electronic-fish-ticket-application

Rubec, P. J., White, M., Ashbaugh, C. F., Lashley, C., & Versaggi, S. (2016). Development of electronic logbooks linked to GPS, VMS and data loggers to support collection of geo-referenced catch, effort and environmental data on shrimp-fishing vessels. *GIS/Spatial Analyses in Fishery and Aquatic Sciences*, *6*, 183–208. https://www.researchgate.net/publication/305700806_Development_of_electronic_logbooks_linked_to_GPS_VMS_and_data_loggers_to_support_collection_od_geo-referenced_catch_effort_and_environmental_data_on_shrimp_fishing_vessels

Sportfish Center. (n.d.). *iSnapper app*. Texas A&M University – Corpus Christi, Harte Research Institute for Gulf of Mexico Studies. https://www.sportfishcenter.org/outreach/isnapper-app

World Wildlife Fund. (2018). *Fisheries factsheet: E-reporting and e-monitoring*. https://wwf.panda.org/knowledge_hub/?329492/Fisheries-Factsheet-e-Reporting-and-e-Monitoring

Photo Credits

1. Adapted from *Crab fishing*, by Oregon Sea Grant, 2010 (https://www.flickr.com/photos/oregonseagrant/24896451386/). Creative Commons (CC) license CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/). Also, adapted from an untitled image of sample computer code, by Markus Spiske, 2018 (https://unsplash.com/photos/4T5MTKMrjZg). Free to use under the Unsplash License (https://unsplash.com/license).
2. From *crabsign003TW*, by Tiffany Woods, Oregon Sea Grant, 2019 (https://www.flickr.com/photos/oregonseagrant/48683374858/). CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/).
3. From *crabboat009TW*, by Oregon Sea Grant, 2018 (https://www.flickr.com/photos/oregonseagrant/41266894600/). CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/).
4. From *Deploying temperature sensors in crab pots*, by Gregg Kleiner, Oregon Sea Grant, 2009 (https://www.flickr.com/photos/oregonseagrant/7184829323/). CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/).
5. From *SarahBelle002OSU*, by Oregon State Productions, 2019 (https://www.flickr.com/photos/oregonseagrant/48523697197/). CC BY-NC-SA 2.0 (https://creativecommons.org/licenses/by-nc-sa/2.0/).
6. From *yauina_sunrise_reesman_odfw*, by Martyne Reesman, ODFW, 2011 (https://www.flickr.com/photos/odfw/15618747715/). CC BY-SA 2.0 (https://creativecommons.org/licenses/by-sa/2.0/).
7. From *5245_dungeness_crab_munsel_odfw*, by Oregon Department of Fish and Wildlife, 2009 (https://www.flickr.com/photos/odfw/4420298023/). In the public domain.

Dungeness crab for sale on the Newport docks (7).

Appendices

A. Oregon Commercial Crab Logbook Data Management

The Current Paper Logbook

Crab fishery participants must complete a paper-based logbook documenting fishing location, catch, and other information for each fishing trip. An Oregon administrative rule (OAR 635-005-0445, 2012) governs logbook requirements. Currently provided by ODFW, the logbook must be completed prior to landing "to begin transfer of food fish from a vessel" (OAR 635-006-0001 (21)(a), 2020).

Data Collection

The logbook consists of white entry pages and yellow carbon copies. Each paper form has header fields and a section for recording fishing activity (Figure A-1), comprising the following sections:

- Header fields collect general information about the vessel and operation, such as vessel name, permit number, and ports of landing.
- For each pull of an individual string of pots, crabbers must fill out a row in the logbook's fishing activity section, with required fields that depend on the specific activity:
    - If a string of gear is not moved but reset in the same location and pulled again for crabs, a new row of information referencing the same string ID is added. However, the location information does not need to be copied down from the first row for that string ID.
    - Any fields that change with each pull (e.g., date, soak time, estimated pounds, comments) should be completed again with each pull record.
    - If the gear is moved or additional gear is set, crabbers must complete all the fields in the row, including the beginning and end string locations.
- A section is included at the bottom of the logbook for crabbers to note the recovery of derelict gear. This gear is defined as "Dungeness crab gear which was lost, forgotten, damaged, abandoned or otherwise deserted" (OAR 635-005-0240 (12), 2021). A state rule (OAR 635-005-0490, 2020) specifies how to collect derelict gear.

For each trip, crabbers complete all of the logbook's fields. If a trip uses more than the 14 rows of activity records (i.e., more than 14 pot strings are pulled during the trip), then another form must be used with all header fields completed again.

Logbook Submission

Crabbers must fill out the logbook in accordance with the instructions (Figure A-2) and return the yellow carbon copies to ODFW within 10 days following the end of the month of harvest (e.g., if harvest occurred on January 20, then the yellow copies would be due by February 10).

Figure A-1
The Oregon Dungeness Crab Fishery's Current Paper Logbook (ODFW MRP, 2021a, p. 18)

OREGON COMMERCIAL CRAB LOGBOOK

Office Use				
Date	Trip	Port	Ticket #	Lbs.

Vessel Name: _____ Oregon Crab Permit No: 96 _ _ _ Year: 20_ _

Federal or Oregon Vessel No: _____ Port(s) of Landing: _____

Date Pulled	String ID	Depth (fm)	Num Pots Pulled	Num Pots Lost	Soak Time (days)	Begin Location		End Location		Estimated Pounds	Comments
						Lat.	Lon.	Lat.	Lon.		

Bait(s) used:

Derelict Gear Retrieved: Date:_____ Num Pots:____ Lat:_____ Lon:_____

Date:_____ Num Pots:____ Lat:_____ Lon:_____ Date:_____ Num Pots:____ Lat:_____ Lon:_____

Date:_____ Num Pots:____ Lat:_____ Lon:_____ Date:_____ Num Pots:____ Lat:_____ Lon:_____

Signature:_____ No:

Figure A-2
Instructions for Filling Out the Paper Logbook (ODFW MRP, 2021a)

INSTRUCTIONS FOR THE COMMERCIAL CRAB LOGBOOK

Log books must be filled out completely, accurately and legibly prior to each landing. Place the instruction page under the yellow copy. Carbon paper is not required. Use a pencil or ballpoint pen to enter the following information using a separate line for each string of gear.

1. **Vessel Name** – Name of vessel harvesting crab.
2. **Federal or Oregon Vessel No.** – Federal vessel document or Oregon registration number.
3. **Oregon Crab Permit No.** – Oregon Dungeness crab limited entry permit number.
4. **Port(s) of Landing** – Port(s) in Oregon, Washington, or California in which crab were landed.
5. **Year** – Year of harvest.
6. **Date Pulled** – The month and day the gear is pulled.
7. **String ID** – Your identifying code for each particular string of pots.
8. **Depth (fm)** – The average bottom depth, in fathoms, where gear was set.
9. **Num Pots Pulled** – The number of pots pulled in the string.
10. **Num Pots Lost** – Estimated number of pots lost in string. DO NOT include pots you think the currents have down or think you will be able to retrieve at a later date.
11. **Soak Time (days)** – The length of time, in days (to the nearest half day), the gear was soaking.
12. **Begin Location** – Latitude and Longitude for the beginning of the string.
13. **End Location** – Latitude and Longitude for the end of the string.
14. **Estimated Pounds** – Your estimate, in pounds, of crab retained from each string.
15. **Comments** – Record miscellaneous information (i.e. shell conditions, % undersized crab, bycatch, weather, sea conditions, etc).
16. **Bait Used** – Type of bait used.
17. **Derelict Gear Retrieved** – Record the date, number of pots and location of all derelict gear retrieved.
18. **Signature** – Vessel operator must sign logbook pages to show he/she agrees to entries.
19. See the first page of this logbook for an example of how to complete a logbook entry. As shown in the example page, if you do not move your gear, but go through it again, you are not required to re-write all of the latitudes/longitudes associated with that same string. Just make sure to fill in the string number so we know which location data to attribute to each string and complete the fields that change with each pull of the gear.

ALL INFORMATION RECEIVED WILL BE STRICTLY CONFIDENTIAL

Return yellow copy of logbook pages within 10 days following the end of the month that harvest occurred to the address listed below. Leave the white copy intact in the logbook for your records. Additional logbooks may be obtained from ODFW offices in Astoria, Tillamook, Newport, Charleston, and Brookings.

OREGON
Fish & Wildlife

ODFW – Newport
Crab Logbook
2040 SE Marine Science Dr.
Newport, Oregon 97365
541-867-4741

Data Collection

Crabbers' data are collected in a central logbook database that is key for all aspects of Oregon Dungeness crab management. ODFW manages the database with support from PSMFC. Together, the two organizations check for data accuracy and completeness, enter data into the database, and perform the tripping process whereby logbook data are linked to data from fish tickets. Also, data analysts perform post-entry validation to ensure data were entered accurately.

Database Management and Dataflow

Currently, ODFW receives paper logbook records through collection at the vessel or by postal mail, and a small number are submitted by email or fax. Data from the records are manually entered into a database called the Commercial Dungeness Crab Logbook Database. Annual entry rates have varied between 30% and 100% of records received. Currently, all records are entered to analyze the fishery's overlap with whales.

Logbook submissions are first error-coded. ODFW analysts review logbooks to determine data completeness. If possible, missing information is estimated based on past activity by the same fishing vessel. Additionally, the location format is converted to comply with database fields. Approved logbook submissions are forwarded to PSMFC specialists for database entry.

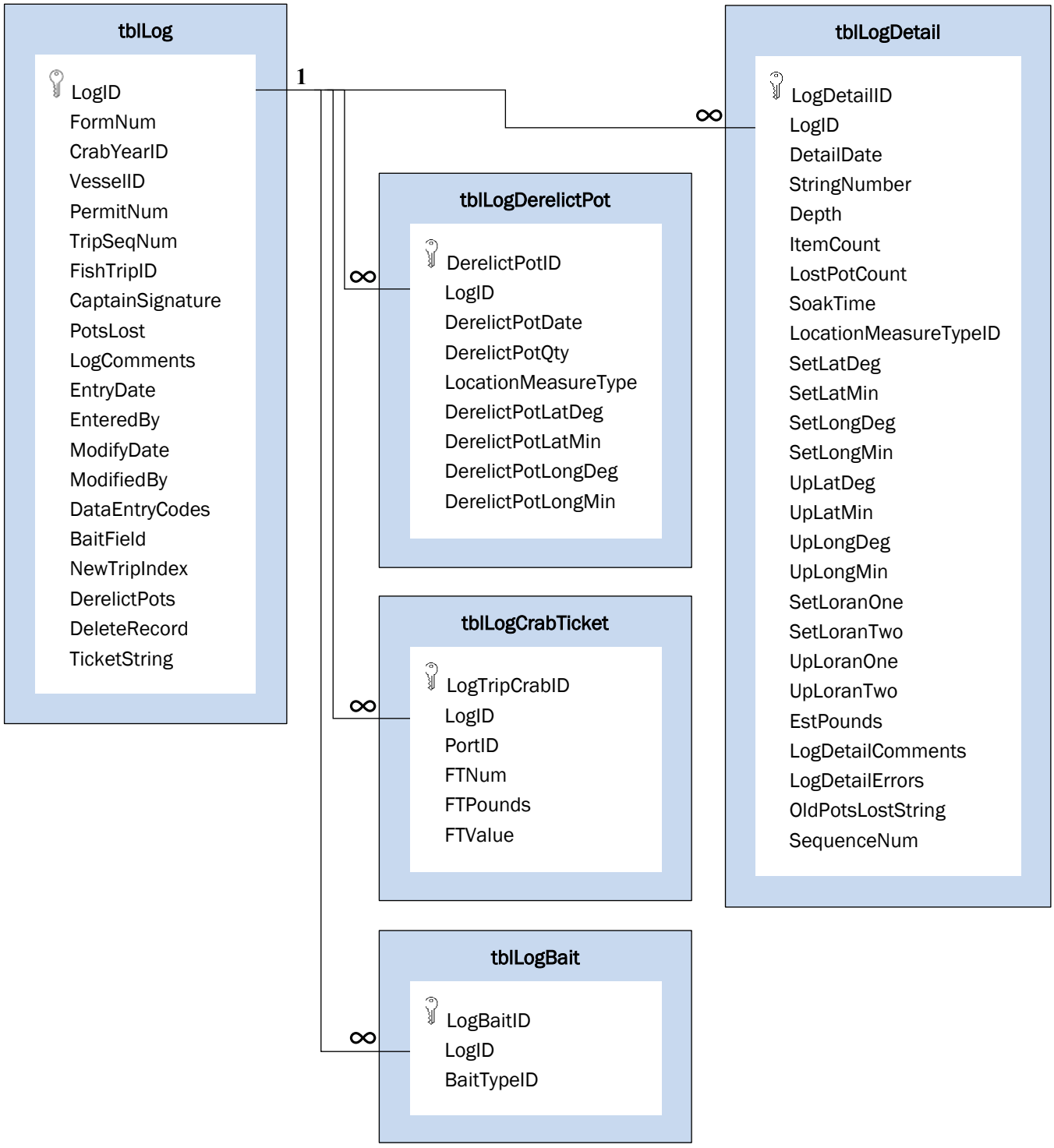
Once logbooks submissions are entered, analysts go through a *tripping* process to match the fishing information reported in the logbook submission with associated fish receiving tickets (fish tickets). Fish tickets are legally required documents that report the species, pounds, and value of the landing, in addition to other information such as the gross area fished. Landings are sometimes split between dealers, so there can be multiple fish tickets associated with each logbook submission. Fish ticket data are pulled into the logbook database in intervals and connected to logbook records using a unique combination of fields (data, vessel number, etc.). This process is important to provide managers with a fuller picture of fishing activity and to enforce logbook requirements.

After entry, all fields are evaluated for post-entry errors, such as locations or fields that are out of bounds and are trapped within the system. Errors are reported to analysts who refer to the physical logbook submission to determine the source of the error and either correct the error or flag the information.

Database Updates

The Commercial Dungeness Crab Logbook Database used Microsoft Access for most of its life, consisting of five related tables, each with data fields that reflect the paper logbook fields (Figure A-3). The database has recently transitioned from Access to SQL to allow direct connection to the fish ticket system and other improvements. The software runs on a local computer in the office.

Figure A-3
A Schematic of Tables, Data Fields, and Relationships in the ODFW Access Database

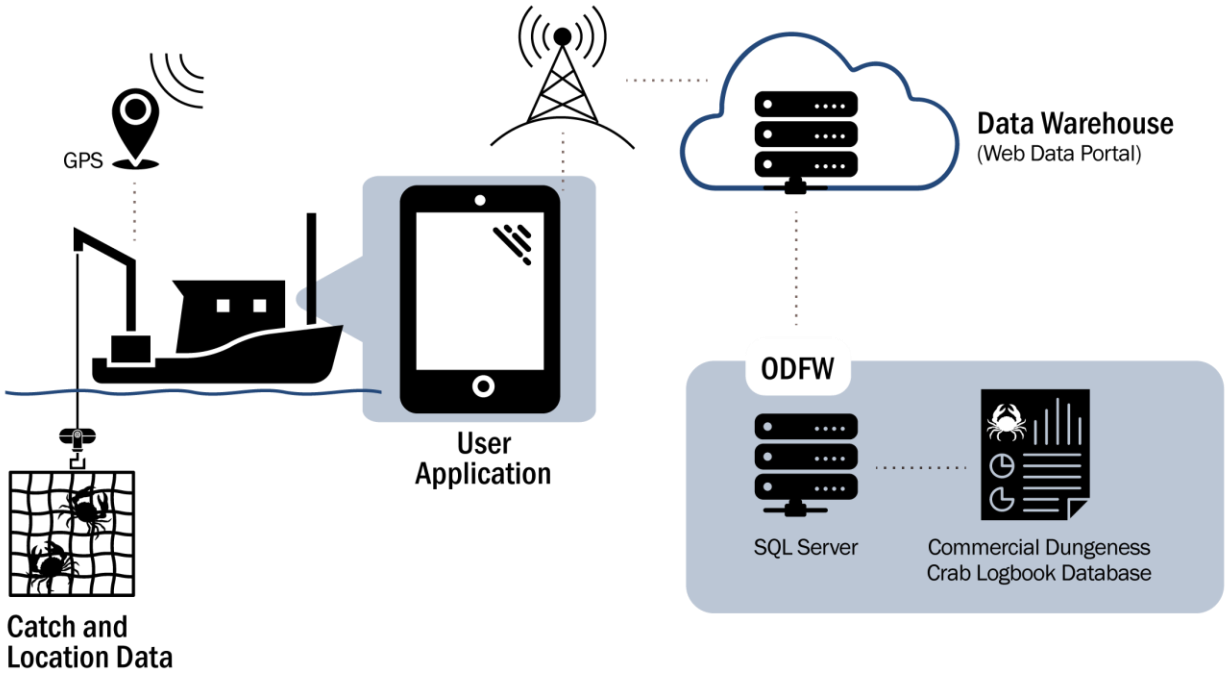


B. Architecture of Potential Electronic Logbook Solution

Advances in information and communication technologies have revolutionized fisheries' data collection and management. Fisheries worldwide can choose from many digital software solutions already available (Appendix H), each designed for the specific fishery's collection and reporting needs. The general framework proven effective in other application solutions provides a good starting point for understanding the component pieces and data flows needed in an electronic logbook system.

Figure B-1 provides a graphic representation of the data flow between components of a potential Dungeness Crab Electronic Logbook. As in other applications designed this way, catch and location data are captured at sea by crabbers using a user application on a tablet or similar device able to capture GPS locations. When the vessel returns to port, crabbers submit their data over a cellular connection, transmitting to a remote server and then on to ODFW servers and Commercial Dungeness Crab Logbook Database. Staff members are charged with managing fishery access to the data. An optional component for the Oregon solution would be a web-based data portal, where crabbers could view and possibly edit their submitted records. It could also be a convenient platform where ODFW could host other tools, such as license management, communication about the fishery, integration with other logbooks or fish ticket systems, or other features to incentivize the adoption and use of the electronic logbook system.

Figure B-1
Architecture and Data Flow of a Potential Dungeness Crab Electronic Logbook



User Application

Good ideas for designing and implementing an electronic logbook become apparent when comparing software solutions already available to fisheries. Each component of the general architecture will be described in this and subsequent subsections, along with design concepts gathered from the comparison.

A user application—i.e., the onboard electronic logbook software provided for commercial fishers in the applicable fishery—is frequently customized with features to increase data collection efficiency and accuracy, such as the direct capture of location data from a GPS antenna, user-specified default values for quick data entry, automatic data-quality checks, and the digital transmission of completed reports to the fishery's management

agency. Each user's application pairs vessel identification information with catch, effort, and location data, all while conforming to the data requirements set by the management agency. For any future Oregon electronic logbook, all fields required on the current paper logbook form (Figure A-1) could be accounted for in an easy-to-use interface. For example, vessel and permit information could be predefined and stored on the device, then tagged automatically to each logbook transmission, reducing the data entry required for each logbook.

Location Acquisition

When asked about how data collection and reporting could be improved, many of the crabbers who shared their thoughts with TNC said that there needs to be an easy and user-friendly way to capture location data. Now, a crabber writes the coordinates on the paper logbook form after consulting a plotter display, GPS display, or notes recorded in the crabber's private paper journal. This manual entry is time-consuming, prone to error, and can be forgotten when completing the logbook. ODFW staff expressed the importance of improved spatial data collection by automatically capturing location information on the vessel and limiting the opportunity for crabbers to manually enter coordinates. The potential for accidental or intentional misreporting can be avoided through GPS automation (NMFS, 2013).

The automatic collection of location coordinates from an external GPS is one of the key advantages of a digital logbook solution. For any future Oregon logbook, crabbers could push a button in the application at the start of placing a crab pot string and again at the end. The crabber could then enter catch data when the string is pulled, completing that particular logbook record.

While this automatic coordinate collection will work in most situations, steps in the location acquisition may be forgotten or triggered at incorrect times. To account for both human and technological error, designers should build in a correction procedure to allow the crabber to edit records before or after submission. All the crabbers we talked to already record location coordinates, either with a map plotter or in paper notes, and intend to continue doing so; therefore, the coordinate information is often available for entry after the fact. In effect, for GPS capture, there is a tension between an agency's need for accurate and valid data and the realities of a crabbing operation, which has limited time for and limited focus on data logging. This tension should be acknowledged in the development process, and stakeholders should work together to identify design solutions that offer compromises.

The logbook's software application can acquire GPS information from multiple sources:

- a GPS internal to the mobile device (tablet or phone)
- an external GPS antenna connected by cable to the mobile device or computer
- a Bluetooth-enabled GPS device for wireless connection between the application and the GPS antenna

Laptop and desktop computers, which may already be used on the vessel, generally lack GPS functionality and would need an external connection. Reliance on a GPS internal to the device will require on-vessel testing. During our conversations with crabbers who have experience with such a setup, we heard that the device often loses the GPS signal to its satellite due to its position relative to the wheelhouse and the vessel's movement at sea. Likewise, the choice of a Bluetooth-enabled GPS would require testing to determine if it is a viable option. The most time-tested method uses a physical, cabled connection between an antenna and the hardware.

Beyond the most basic coordinates for the start and end of a pot string, the application could be designed to collect more frequent location data at a set time or distance interval between string start and end locations. At present, when using the paper logbook, crabbers define the location of a string only using the straight line between the start and end coordinates. Collecting mid-string locations would give the fishery's management agency increased information about string shape and location in the ocean, which may better document fishing location or inform whale entanglement mitigation actions.

Alternatively, even more frequent location data could be acquired if the application were used in parallel with an onboard VTS. Post-processing algorithms could be devised to combine VTS location data with logbook data, thereby allowing for the validation of the logbook's user-triggered location data. Or a VTS could completely remove the need for the logbook to collect location data. The high temporal frequency of VTS data collection is

potentially useful for the crab fishery's other management objectives, such as avoiding endangered species and monitoring protected areas. While the potential value of VTS data is high, significant costs are associated with the data storage and processing necessary to make the information useful.

Data Warehouse

In TNC's conceptual design of the application, the logbook data are transmitted via cellular signals to the *data warehouse*, the term we use to collectively refer to the service receiving the data and the servers storing the data. The data warehouse is public-facing and may be in the cloud or on a private server. Data management processes, such as quality checking, may occur here.

If desired, a web-based data portal could provide easy access to administrators and users, allowing them to query and view submitted logbook data when an internet connection is available. Likely a browser-based application, the portal could offer crabbers the ability to view, export, and possibly edit previously submitted logbooks. Secure logins could be established to ensure data privacy and security, allowing a crabber to access only their logbooks. Data portals could also offer mapping and visualization features useful in understanding broader trends and patterns in the fleet's movements. Optionally, the portal could provide functionality for the fishery's management agency, such as managing user accounts, accessing logbook data, managing licenses, communicating with crabbers (e.g., emails, texts, notice boards), and even integrating with fish ticket systems.

Application vendors differ in whether they require integration with their own hosted warehouse or write to a warehouse built and maintained by the management agency (see the "Data Management" section in Appendix G). If an external vendor is selected to build the software, this point of negotiation will be an important consideration.

From a software design perspective, it is beneficial to establish an API and document data collection standards for interacting with the data warehouse before writing a user application. The advantage of using an API is that it allows communication and data transmission from third-party applications, so ODFW would not need to rely on a single contractor or logbook application.

The ACCSP (2019) provides an API, giving access to the Standard Atlantic Fisheries Information System Database (SAFIS). It is a model for the structure and content of such an API. Six separate electronic vessel trip reporting (eVTR) applications use it to allow commercial vessels to submit vessel trip reports electronically for the New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020). (The NOAA Greater Atlantic Region uses the term "vessel trip report" to refer to the report required for all federally permitted fishing vessels to record their catch. The report may be submitted in paper form or via an electronic system. Other entities call a similar report a "logbook.") In addition to the API, the ACCSP (2012) also predefined policies and standards for data collection and data management procedures that must be followed by all applications so that the final data meet the collective needs of all data users, including scientists, managers, and the industry. The data collection software system, SAFIS, was built based on the standards and accepts input from three types of source applications—trip reporting, dealer reporting, and voluntary reporting—each via the API. Such a complex collection system is unnecessary to implement a single-species, single-state electronic logbook application focused on catch reporting. Nevertheless, it provides an example of the best practices for constructing a system that can be extended over time to additional reporting applications, fisheries, and even states.

The New England and Mid-Atlantic system illustrates several important design features: the data collection standards, the system (SAFIS), and the API, each designed with data analysis and reporting needs in mind, and all established before the user application(s) that actually send data to the system. To ensure that data standards and the API meet users' requirements for system products and reports, developers must have both before developing any applications that submit or access the data (personal communication, Geoff White, ACCSP Director, February 2020). Furthermore, necessary stakeholders must be included in the data structure's design so that the data captured, analyzed, and made available is suitable for the fishery's management and other needs.

An analogous data collection standard and system is not presently in place for the West Coast. PSMFC may be the most appropriate entity to implement such a system flexibly, working across fisheries and states (Oregon,

Washington, and California). PSMFC's leadership may be especially suitable given their organizing role in the Dungeness crab tri-state process, as well as their responsibility for E-Tix, the West Coast's web interface system for submitting electronic fish tickets.

There is a willingness in PSMFC to build and manage the data warehouse (personal communication, Dave Colpo Economics Fisheries Information Network [EFIN] Senior Program Manager, May 2020), and potentially to design and implement the complete system for the Dungeness Crab Electronic Logbook (Figure B-1). This solution warrants further consideration and discussion. Besides the PSMFC staff's considerable expertise and knowledge of electronic data collection, other advantages exist: This path would free ODFW from the financial obligations of constructing and maintaining the warehouse (and possibly the logbook application) and would position the system for expansion to other fisheries' logbooks and other states.

ODFW Databases

In the proposed architecture (Figure B-1), logbook data are received and processed by the data warehouse then transmitted to the secure, internal-to-ODFW Commercial Dungeness Crab Logbook Database. This transmission process could take one of two pathways.

The first pathway is for data to be transmitted via automated processing to the ODFW server for the ODFW staff to use and manage via the Commercial Dungeness Crab Logbook Database. This database is not accessible to the general public, so the public-facing data warehouse is needed to serve as the intermediary between the logbook application used by crabbers and the database where ODFW manages the logbook data. Manual or automated processes would be necessary to allow the logbook data to be retrieved from the ODFW server and imported into the Commercial Dungeness Crab Logbook Database (currently a Microsoft Access database). This data flow would work similarly to the process now used to retrieve fish ticket landing data to associate the landing data with the catch data (a process that ODFW staff refer to as tripping).

The second pathway relies on a more manual process to move digital data. In this case, logbook data would be exported from the data warehouse to a file format suitable for import, shared with ODFW MRP staff via email or a file-sharing system (FTP or other), and imported into the Commercial Dungeness Crab Logbook Database using manual processes.

Other Design Considerations

What follows are two basic design features identified as important considerations during our research.

User Accounts

One essential element required of an electronic logbook system is secure user accounts for data privacy. A user account records information such as the crabber's name, permits, vessel, and other identification information necessary for reporting. For ease of use, each account is created just once and reused, only updated if the crabber's information changes. The account creates a substantial efficiency in data entry over the paper logbook since crabbers can avoid entering the same information each time they submit a logbook. Also, having secure and lasting user accounts facilitates the use of identification information across electronic logbooks for other fisheries if they come available.

An example of how user account registration could be handled is the approach implemented for eLogs by Fisheries Queensland (Business Queensland, 2017). In this approach, the fishers register to use the logbook application through an online system, which provides a security token. This security token is unique to the owner of each commercial fishing vessel license or the commercial harvest license. After software installation, the token is entered into the logbook application to register the user. The token later functions as the fisher's signature when submitting data from the logbook application to the database.

Ideally, if an approach such as the one used by Fisheries Queensland is implemented in Oregon, the website for user registration would integrate with the ODFW licensing process so that the system could list and verify licenses issued to the owner and confirm the correct owner and license relationship. Further, if multiple fishery logbook modules are implemented in the future, the registration and token system would tell the logbook application which fisheries the owner is licensed for.

Modularity

It would be advantageous to design and build the Dungeness Crab Electronic Logbook system so that

electronic logbooks for additional fisheries and possibly for other states' fisheries could be added over time. Although higher initial costs may be required to design for this modularity, the cost savings over time could be significant as new modules are added. This modularity would reduce the total cost over time to develop the full suite of Oregon's nine required logbooks. Additionally, since commercial fishers often submit logs for multiple fisheries, they would likely consider the system to be simpler if they had a single user account that could access multiple logbooks within one application and from one computer device. If this modular approach is chosen, the system could be given a more generic name, such as "OR-Catch," rather than the fishery-specific name "Dungeness Crab Electronic Logbook."

Designing for modularity up front need not imply that there is a rush to move other fisheries to electronic reporting. Each fishery module could be added as stakeholders adopt electronic reporting approaches and application modification funds are acquired.

C. Other Logbook Ideas

The utility of an electronic logbook for Oregon's commercial crabbers and associated management agencies is of paramount importance. However, many other fisheries, wildlife species, and stakeholders could benefit from an electronic logbook implemented with their needs in mind. This appendix explores how a logbook could be designed to support neighboring states' fisheries, research, whales, other state reporting requirements, and more.

Collaboration With Washington and California

Developing an Oregon logbook application that can also serve the needs of Washington and California offers potential synergies and efficiencies. Such a development process could follow different paths. One could be that the application's base intellectual property is developed for Oregon and then shared with the other states and/or modified to meet their specific needs. Another path could be that states proactively partner on the application's development and share ongoing system maintenance costs. Lastly, crabbers who fish in multiple states could streamline their recordkeeping by having one application that meets the logbook requirements of all three states. A multistate approach would require diligence and a lengthier development time but could allow the states to share costs, resources, and other synergies toward improving West Coast electronic reporting.

Research Data Collection

An electronic logbook could provide a platform for collecting scientific data, such as ecological or oceanographic information. Sensors could be added to fishing gear to gather specific data, which could then either be added manually to the logbook or synced through Bluetooth sensors linked to the gear. This data could be shared with researchers or agencies to further knowledge about scientific questions and/or trends over time.

As an example, Dr. Francis Chan from Oregon State University is a marine ecologist researching ocean acidification and hypoxia. He is interested in collecting oxygen levels across Oregon and has partnered with crabbers to place oxygen sensors on crab pots (one sensor per string) at various locations and depths off the coast (Lundeberg, 2021). Collected data can be used to map low oxygen zones (dead zones) across the ocean, which helps inform not only science but also crabbers since higher oxygen levels are key for crab survival. Now, Dr. Chan is collaborating with several fishers who use a specialized device to read the sensors after they are pulled up with a crab pot. The device must be delivered back to him to download and process the data, which has costs and may limit the number of sensors that can be implemented. If this data could be collected in a logbook application, data could be delivered over the cloud or by ODFW once the agency has collected logbooks' data in their database, creating efficiency and potentially allowing more sensors to be deployed and a much wider spatial coverage for the research.

Whale Sightings

An electronic logbook could collect data concerning whale locations to inform both crabbing operations and ODFW management. The collection process could range from a simple link to another application that already collects whale locations to a more complex in-app solution. For example, the logbook application could include a button that opens another application, such as NOAA's Whale Alert iPhone/iPad application that allows fishers and other boaters to share real-time whale sightings. This application usually uses cellular connections to send and receive whale data but can also use an onboard Automatic Identification System navigation device to receive and transmit information, with minor hardware modifications.

Alternatively, the logbook application could be designed to record whale sighting information. For example, in their Deckhand software for New Brunswick fisheries, the company Real Time Data provided a button that fishers press when they spot a right whale, which prompts them to enter the estimated distance, bearing, and condition of the whale. The data are transmitted instantaneously to all devices in the fleets to alert other fishers of whale presence. Also, since data are collected and archived across the fleet, the aggregated information can identify regular "whale highways," allowing fishers to avoid the whales' high-use areas.

Fish Ticket Linkages

It may be beneficial to directly link logbook records to the current fish ticket landing records. For example, one fisher suggested that a logbook application could ask for the fish ticket information (ticket number, pounds, etc.) so that estimated pounds for each string pulled could be adjusted to reflect the actual pounds realized at landing. Also, directly linking fish ticket records to electronic logbook records at a landing could alleviate some of the ODFW staff's post-processing work required in the paper logbook system and effectively link the logbook and fish ticket databases. The logbook application would have to account for the fact that logbook trip records are sometimes split across multiple landings and thus multiple fish tickets.

Crab Harvest Areas

ODFW uses a system of *crab harvest areas* to help manage and mitigate risk to the public from exposure to domoic acid (see the harvest areas' map provided by ODFW MRP [2021b].). In this system, Oregon's ocean is broken up into 12 crab harvest zones that are routinely tested for domoic acid in crabs and closed if levels are deemed unsafe for human consumption. Oregon monitors the domoic acid that can build up in ocean environments during algal blooms, can bioaccumulate in crab tissue, and is neurotoxic to humans. The state has a set of traceability rules that require each seafood business in the crab market chain to maintain records about who they bought crabs from and sold crabs to (ODFW MRP, 2018). The current paper logbook requires the GPS locations of strings so that any landing of crab can be traced to ensure it is coming from a safe harvest area.

An electronic logbook could assist in this effort in several ways. It could, at a minimum, offer the state quick and easy access to the GPS locations of caught crabs compared to the current paper system. If there was a closure due to domoic acid, managers could quickly analyze the logbook data and know where in the ocean each landing was pulled from, link these to fish ticket records, and respond accordingly.

Moreover, an application could be designed to determine which harvest area a crab string is placed in based on spatial location and respond accordingly. For example, the logbook application could be used to notify crabbers of closed zones and alert them if they are within a closed zone. Further, if a crabber continues to fish and collect logbook data within a closed zone, the application could mark the corresponding records in a specific way to indicate that the catch was from within a closed zone. Similarly, to help standardize traceability, the logbook could automatically determine the crab harvest area associated with each logbook record, thereby allowing this information to be tracked on fish tickets after landing.

Linkages to Other Onboard Devices

Commercial fishers have an assortment of electronics on their boats: chart plotters, multiple GPS devices, depth finders, marine radar scanners, computers, etc. Data streams from these devices could serve the data collection needs of a logbook application. Integration with existing onboard electronics should be possible using the communication standard of the National Marine Electronics Association plus any necessary hardware converters, from a cabled system to USB, Bluetooth, or Wi-Fi. If crabbers already have integrated electronic systems on their boats, real efficiencies can be gained by integrating an electronic logbook with these systems.

Linkages to Other Oregon Logbooks

In addition to Dungeness crab, ODFW requires commercial fishers to use and submit paper logbooks for eight other Oregon fisheries, including those for anchovy bait, commercial shellfish, and shrimp trawl. An electronic logbook built for Dungeness crab reporting could be designed to link with or incorporate additional fishery logbooks in the future (for more information, see the "Modularity" section in Appendix B).

D. Management, Enforcement, and Commodity Commission Perspectives

The Nature Conservancy (TNC) spoke with state agencies and an industry association to understand their needs. Experts from ODFW, ODCC, and OSP shared their perspectives through meetings and other communication with TNC.

ODFW

ODFW is the state agency responsible for managing Oregon's fisheries, including the Dungeness crab fishery. ODFW also develops and implements fishery regulations, including those concerning the Oregon Commercial Crab Logbook (Figures A-1 and A-2). Through meetings and communications, TNC captured various objectives that ODFW regards as important in a future electronic logbook:

- **A concurrent paper logbook system** – Maintain the current paper logbook system in parallel with any potential electronic system. This necessary redundancy arises from the need for transition periods to allow:
  - crabbers to transition to electronic data collection methods when they are ready;
  - crabbers to continue reporting in the interim;
  - the state to adjust to and accommodate separate data streams; and
  - the state to provide a temporary backup system for catch data in the event of technology failures.
- **Data standards** – At a minimum, use the same data standards as the current paper logbook and include the same header and activity fields detailed in Appendix A.
- **Operating system flexibility** – Ensure the electronic application is compatible with various operating systems. At present, software is generally developed to run on one or more of the following three operating systems: iOS for Apple hardware devices, Android for most non-Apple hardware, and Microsoft Windows for laptops and personal computers.
- **Data management** – Ensure compatibility and integrability with ODFW's fisheries databases. ODFW staff discussed migrating the Commercial Dungeness Crab Database from Microsoft Access to SQL to make it easier to receive and incorporate data from an electronic application (Appendix B) and facilitate linkages to fish landing data (Appendix C). At the time of our conversations, the migration was only an idea for the future, but it is now complete.
- **Location data** – Automatically collect improved spatial data within the application. The time and position stamp of the fishing activity is critical. Here are two ways to improve the accuracy of location data and the frequency of its collection: (1) automatically collect locations via GPS and (2) limit the opportunities for users to manually enter coordinates. Ideally, a backup method would record the information in case the location data were not collected or forgotten, although this backup method should not be used frequently.
- **Data security** – Ensure data security and confidence in data handling. To this end, ODFW has considered prohibiting the use of cloud services from receiving or storing data for any potential electronic logbook.
- **A GPS location format** – Represent GPS locations as degrees, minutes, and seconds since this is the format most commercial fishers are accustomed to. The locations are stored in the crab database as decimal degrees.
- **A VTS** – Investigate the potential to integrate the electronic logbook's implementation with a solar-powered VTS (i.e., solar logger). The automated collection of spatial data, independent of a fisher's actions, allows for a greater level of monitoring of fishing activity. Researchers are currently investigating whether solar loggers can preclude the need for logbooks since logger location data can theoretically be analyzed for fishing activity and effort. Alternatively, ODFW staff are considering requiring more frequent data collections beyond the standard method. Currently, the paper logbook captures strings' start and end GPS locations. Collecting additional GPS data would record points between the start and end of strings, allowing for a more accurate representation of the location of fishing gear. (See Appendix F for information on California's solar logger pilot project and Pelagic Data Systems' VTS product.)

ODCC

Established in 1977, ODCC is one of 23 commodity commissions in Oregon and one of four commissions specifically focused on fisheries. The Oregon Department of Agriculture oversees the commodity commissions, and each commission serves as a forum to set policy and make decisions about commodity-specific marketing, research, and educational projects in the state.

The ODCC mission is to "enhance the image of the Oregon Dungeness crab fishery through promotion, education and research. … [supporting the fishery to maintain] the structure, productivity, function, and diversity of the ecosystem" (ODCC, n.d.). Their efforts focus on marketing Dungeness crab domestically and globally as well as participating in fishery monitoring and management as a key stakeholder. State statute mandates that harvesters pay assessments on Dungeness crab landed in the state, and those funds are allocated to ODCC to direct funds to key projects.

In September 2019, TNC first presented to ODCC our plans to research and scope a potential electronic logbook for Oregon's Dungeness crab fishery. We continued discussions at subsequent meetings in November 2019, March 2020, and May 2020. ODCC's response has generally been positive, and some ODCC board members are strong advocates for electronic logbooks. However, ODCC is proceeding cautiously in recognition of the wide variety of opinions within the fleet. While ODCC staff members understand the usefulness and benefits of logbooks, they have not directly used logbook data and do not see a need for it in the future. Indirectly, research projects sponsored by ODCC, such as a bioeconomic model used to evaluate changes to fishery regulations, have used and will continue to depend on logbook data.

OSP

OSP's Fish and Wildlife Division is charged with ensuring "compliance with the laws and regulations that protect and enhance the [long-term] health and equitable use of Oregon's fish and wildlife resources and the habitats upon which they depend" (OSP Fish and Wildlife Division, n.d.). The division is responsible for enforcing all commercial fishing rules and regulations, including logbook requirements. In October 2019, TNC met with Sergeant First Class Todd Thompson, lead of the Marine Fisheries Team, to discuss OSP's interests and needs in enforcing crab logbook requirements and how those needs might be different if the logbook were electronic. Key points emerging from that discussion include the following:

- OSP needs to be able to enforce logbook completion and submission requirements.
  - Currently, two methods allow OSP to verify logbook compliance: (1) examination of the physical paper logbook at the vessel and (2) an accounting of missing logbooks provided by ODFW. Officers have discretion in how they level charges for missing logbooks. They can provide education, warnings, or Class A violations. The latter can include a scheduled bail of $435 for "minor" infractions. And they can escalate to a Class A misdemeanor, with a maximum fine of $7,500 and a mandatory appearance before a judge, for habitual violators or those with a large volume of unsubmitted logbook pages.
- Logbook data are used to establish the occurrence of fishing activity in instances when other enforcement tools are in question (e.g., in federal fisheries that require an onboard VMS, and it is turned off) or there is a missing fish ticket. Additionally, logbook data can be useful to cross-validate VMS data or enforce closures in protected or biotoxin areas.
- Other electronic systems employed in Oregon can inform the development of an electronic logbook for the Dungeness crab fishery, especially when considering enforcement needs: (1) the electronic system for recreational hunting and fishing licenses and tags and (2) the electronic fish ticket system.
  - Sergeant Thompson considered the current electronic fish ticket system (E-Tix Portal), operated by PSMFC, to be a good example of an *electronic reporting system* (ERS) that has proven enforceable. (An ERS is a broad term for a system that includes electronic logbooks. An ERS can allow fishers to electronically record and report on their catches or dealers and processors to do the same for their purchases.) As soon as the digital ticket is started through the system, PSMFC can access it in draft form, and OSP officers can view it. This early access is helpful because it adds some confidence that industry members are not "messing with the

system." It would be useful if an electronic logbook could include similar features.

- There was concern about the existing language of the relevant administrative rules. They may not sufficiently allow for the greater level of intrusion necessary to examine crabbers' personal electronic devices. In other words, asking to look at crabbers' personal devices to examine their logbooks is more intrusive than asking to look at paper logbooks provided by the state. Unless another form of verification is deployed as part of the electronic logbook's implementation, rule language may need to be developed to allow OSP personnel to request access to personal phones, tablets, and computers.

E. Industry Perspectives

In addition to the agencies and associations that interact with the commercial Dungeness crab fishery, TNC consulted with the on-the-water experts: the 421 crabbers who held Oregon permits for Dungeness crab at the time of the survey.

Survey

In spring 2020, TNC collaborated with Oregon Sea Grant to issue a survey to Oregon's current commercial Dungeness crab permit holders. The survey's goal was to gauge industry opinion and interest in developing an electronic logbook. Surveys were mailed by way of the United States Postal Service. Respondents had the options of returning the paper survey, using provided envelopes with prepaid postage, or completing the survey using the Qualtrics online software, meaning crabbers completed and submitted it online. Twenty-three survey responses were received, seven submitted using the online option and 16 received by mail.

Structure and Questions

Participants answered the following questions:

In which state waters do you fish? Check all that apply:

- ☐ Oregon
- ☐ California
- ☐ Washington
- ☐ Alaska

In which states do you land seafood? Add percentage of your landings for each state:

- ☐ Oregon _____
- ☐ California _____
- ☐ Washington _____
- ☐ Alaska _____

If an electronic logbook were an option, how interested would you be in replacing the current paper Dungeness crab logbook with an electronic logbook?

- ☐ Very Interested
- ☐ Interested
- ☐ Not Interested
- ☐ No Opinion

If both paper and electronic logbook options were available, which one would you be more likely to choose? Why?

What is your level of comfort using a smartphone or tablet (e.g., iPhone, iPad, Android Phone, or Samsung Galaxy Tab)?

- ☐ I own one and use it every day
- ☐ I have one but don't use it frequently
- ☐ I have seen one used
- ☐ None

What type of smartphone or tablet do you have?

- ☐ iPhone
- ☐ Android
- ☐ Windows
- ☐ Other _____
- ☐ I don't have a smartphone or tablet

What electronic equipment do you typically have on board your vessel while fishing? Select all that apply:

- ☐ Computer
- ☐ Smart phone
- ☐ Tablet
- ☐ Chart Plotter
- ☐ GPS (Global Positioning System)
- ☐ VMS (Vessel Monitoring System)
- ☐ AIS (Automatic Identification System)
- ☐ Satellite Phone
- ☐ Other _____

If an electronic logbook were developed, what additional functions or options would you like it to include beyond the basic data collected in current paper logbooks? Examples may include: access to other fishery logbooks, being able to export catch data for your business needs, auto-calculations, etc.

Are you interested in participating in the development of the electronic logbook system? If so, can we contact you to learn more about how an electronic logbook would work best for you?

- ☐ Yes, I am interested
- ☐ No, I am not interested

What is the best way to contact you?

Full Name _____

Email Address _____

Phone Number _____

Once the electronic logbook is developed, are you interested in participating in the trial and testing period to help us improve the final version?

- ☐ Yes, I am interested
- ☐ No, I am not interested

What is the best way to contact you?

Full Name _____

Email Address _____

Phone Number _____

End of Survey: click forward arrow below to submit your answers.

Results

This section describes crabbers' answers to the questions presented in the previous section.

Of the 23 respondents, nine fish in more than one state, and only one landed the majority of their fish outside of Oregon (Table E-1).

Table E-1
Profile of Fishing Location (By State) for Each Respondent

	In which state waters do you fish? Check all that apply:				In which states do you land seafood? Add the percentage of your landings for each state:			
Respondent	Oregon	California	Washington	Alaska	Oregon	California	Washington	Alaska
1	X	X	X		80%	10%	10%	
2	X	X						
3	X				100%			
4	X				100%			
5	X							
6	X	X	X	X				
7	X							
8	X		X		90%		10%	
9	X				100%			
10	X				100%			
11	X				100%			
12	X				100%			
13	X		X		35%		65%	
14	X				100%			
15	X				100%			
16	X				100%			
17	X				100%			
18	X	X			100%			
19	X			X	50%			50%
20	X				100%			
21	X		X		80%		20%	
22	X			X	100% (crab)			100% (salmon)
23	X				100%			

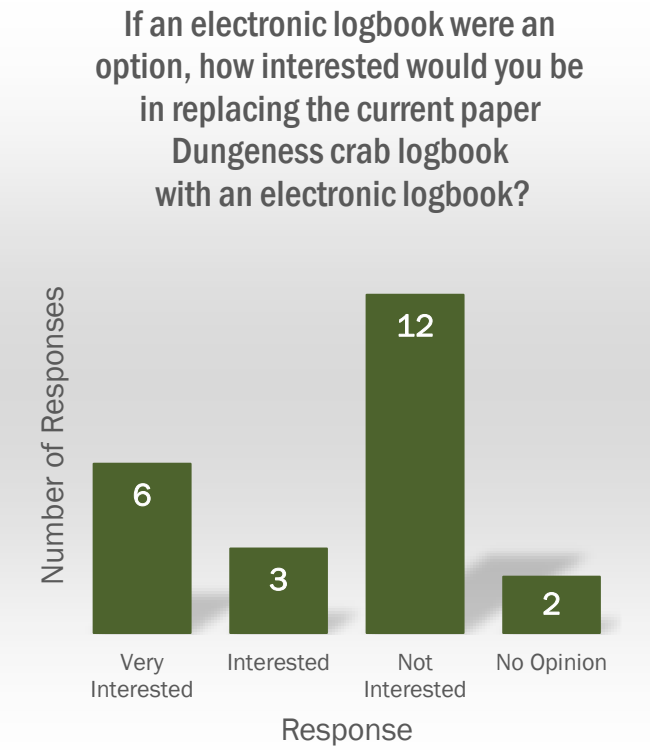
When asked which logbook option, paper or electronic, they would be more likely to choose, less than half (11) indicated that they would choose paper.

If both paper and electronic logbook options were available, which one would you be more likely to choose? Why?

- Paper
- Depending on how user friendly the electronic logbook would be to use compared to trying to write stuff out on a small moving boat I can see a big advance in just a few buttons
- Paper. If it gets wet it dries out and still works. Not everyone has fancy waterproof cabins
- electronic
- Depends on resulting product. Electronic has potential of being easier and possibly self-informative and provide something to aid fishing decisions.
- Paper
- Electronic if fast to use
- Paper
- I would prefer paper. On a larger boat an electronic logbook would probably work. But on a small vessel it can be very difficult to focus on a monitor and type when you're being tossed around by the sea.
- Paper- easy, don't need to increase my digital footprint. I prefer old school
- Paper: too hard to type in coordinates into small cell phone screen accurately when out on the ocean.
- Electronic
- Depending on specifics and how locations are reported, I might choose one over the other.
- Paper- it's easy
- Paper- no reliability issues
- Electronic- sounds easier/faster/more efficient
- Paper because I'm used to it. It is rough out there. I am hanging on for dear life half the time. Paper and pen don't break down.
- Paper. No interest in learning new e-logbook. Concerns over tracking/surveillance. Not swayed by the perspective that e-log would save staff time and therefore $. When processing the data they always collect, regardless of format.
- Computer. The data would then be available for spread sheets, etc. I enter all data into computer already, so this would save a step.
- Paper. I don't do well with computers

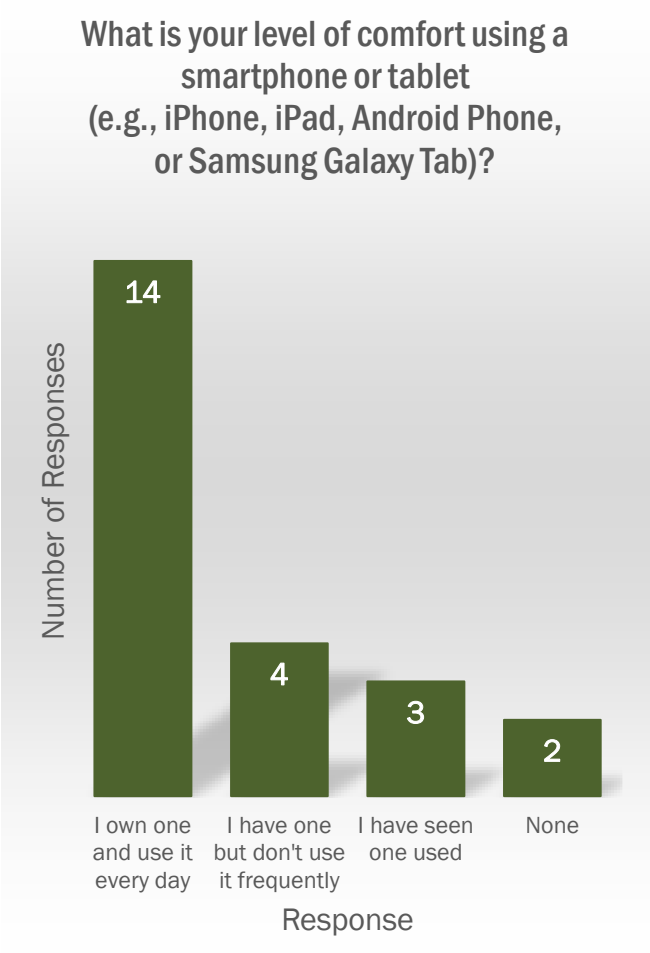
Of the 23 responses received, a little over one-third were very interested or interested in replacing the current paper logbook with an electronic option, with 12 not interested and two that had no opinion (Figure E-1).

Figure E-1
Interest in Replacing the Current Paper Dungeness Crab Logbook With an Electronic Logbook



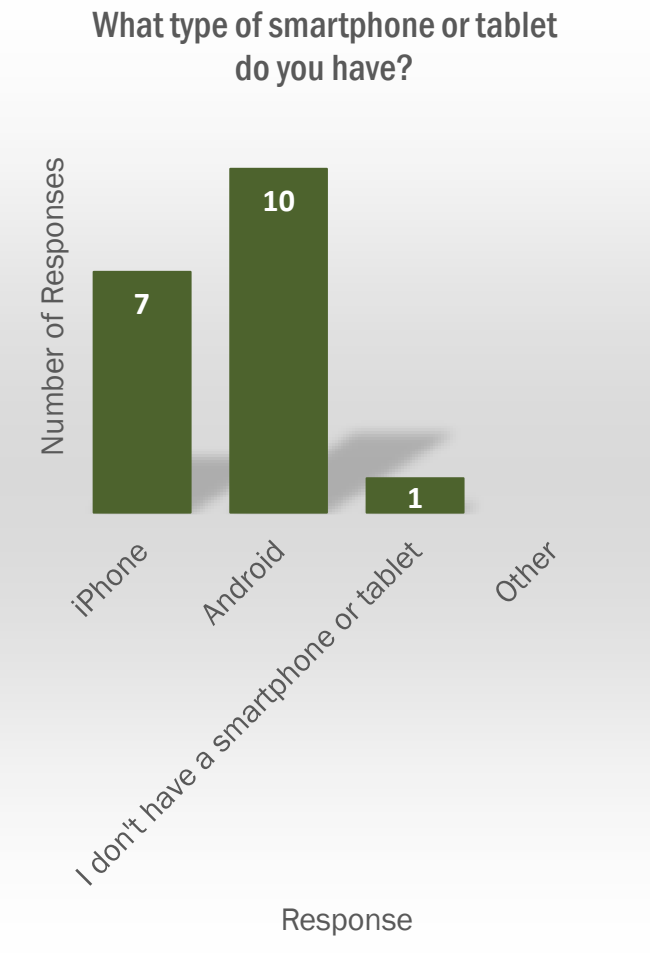
Of those, the majority (14) own smartphones and use them every day. Three have seen a smartphone being used, and two have no experience with smartphones (Figure E-2).

Figure E-2
Level of Comfort Using Smartphone or Tablet



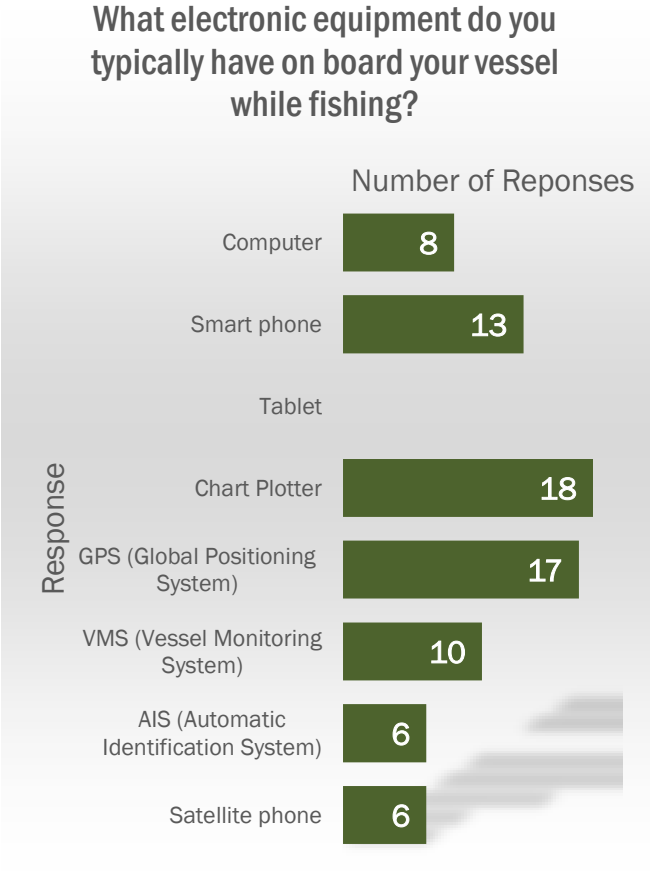
The following results were recorded on the survey's second page, which 18 respondents completed. The majority have Android devices, with fewer having iPhones. All but one have a smartphone or tablet (Figure E-3).

Figure E-3
Smartphone or Tablet Ownership



All respondents have chart plotters on the vessels, and all but one have GPS technologies. The majority of vessels have smartphones aboard, and fewer than half have computers (Figure E-4).

Figure E-4
Electronic Devices on Vessels



Several ideas were shared for additional functions or options that could be included in an electronic logbook.

If an electronic logbook were developed, what additional functions or options would you like it to include beyond the basic data collected in current paper logbooks?

- None
- Access to other logbooks could be nice instead of keeping track of 3 different books
- Auto-calculations, such as CPUE etc.
- Multiple fisheries would be good.
- I would NOT like to see functions that assist individuals. These devices may be purchased. Trap spacing is critical, but that knowledge comes from experience or investment. Access to other required logs would be great as well as catch data exporting. Sensors for ocean acidification and hypoxia would be very helpful but need to be private for institutional use. Oxygen levels can help locate crab. I think we want to be very careful with which data our logs will report to users and which functions should be included. In my view, less is more.
- Plotting tied to pot timer: currently we use a distance meter that sounds a horn to set each pot. If there were a mark made per pot we could grapple for lost pots with greater accuracy.
- No. Keep it simple.
- My husband seemed intrigued by the ideas ("export catch data for your business needs" and "data capture from specialized sensors"), however they are trumped by his skepticism over the motivation for going electronic period.
- Access to other fishery logbooks, being able to export catch data for your business needs, data capture from specialized sensors, a function to help with trap placement or spacing, exporting catch data, overlay onto Nobeltech Professional, individual crab pot placement and catch.

Conversations

TNC spoke with crabbers to understand the decisions and processes used to determine where to crab, how to record relevant catch data for their own use, and when and how the information is moved to the paper logbook to satisfy the required catch reporting. To capture variation in responses across operations, TNC talked to crabbers working from different ports, with both large and small boats, and with different opinions about electronic logbooks. We reached out to 17 crabbers and, in the end, engaged eight for conversations from March 12 to May 1, 2020. Individuals contacted were participants in stakeholder groups like ODCC or ODFW's Domoic Acid Rules Advisory Committee, or they were referred by other industry members.

The crabbers were homeported throughout the Oregon Coast, ranging from Brookings to Astoria. Many fished for Dungeness crab in multiple states—Oregon, Washington, and California. All fished in other commercial fisheries in addition to crab, such as pink shrimp, groundfish trawl, albacore tuna, sablefish fixed gear, and Pacific halibut. Their respective fleets ranged from one to three vessels, each with three to four crew members, and vessels were 48 to 66 feet in length. Crabbing activities occurred from the nearshore to 20 miles offshore and in depths up to 100 fathoms. Crabbing trips ranged from a day to a week.

Interest

Many of the participating crabbers expressed an interest in learning more about an electronic logbook for the crab fishery, especially if it proved easier and more efficient to use than the paper logbook. Most expressed a willingness to participate in a future pilot project if one proceeds. The reasons for their interest included the following potential benefits:

- Make logbook data entry simpler, more efficient, and less prone to errors.
- Allow ODFW to collect more accurate data, especially GPS locations.
- Reduce ODFW's effort and cost for data handling and processing.
- Make data submission easier than the current paper system (e.g., with a push of a button).
- Ensure quality records because logbooks are important for their business needs and legal records.
- Create synergies between a Dungeness crab logbook and the logbooks of other state-managed fisheries.

Hesitancy

Some crabbers expressed hesitancy about moving to electronic reporting:

- Any future electronic logbook should not be harder to use or more complicated than the paper logbook. It must be easier, user-friendly, and quick.
- Some in the Oregon crabbing fleet may be concerned about data privacy and doubt that electronic technology will sufficiently safeguard their information.
- Crabbers worried that some colleagues have gotten used to using paper logbooks and may not be inclined to adopt new technologies or might be skeptical about change.
- Logbooks are disliked in general and perceived as a hassle. Some crabbers may prefer to eliminate them altogether rather than transition to an electronic version.
- Crabbers may be leery of information being used against them.
- Some of the people we conversed with questioned what ODFW uses the data for and whether the state needs so many data.
- Safety is paramount, so using an electronic logbook should not be a distraction or take away focus from fishing and the safety of the crew and vessel.

Suggestions for Features

Participants made the following suggestions to improve data collection and reporting using an electronic crab logbook:

- Capture locations efficiently.
  - Provide an easy and user-friendly way to capture GPS locations in the logbook. For example, provide a button on the screen to press at the start of a string and again at the end.
  - The display and entry of GPS locations should look like it does on most GPS devices—with latitude on top of longitude instead of side by side.
- Build in features that make the crew's activities easier and safer.

- Developers need to consider the ocean environment's harsh conditions. Any device capturing data for the electronic logbook must be able to be secured while still being accessible to crew members for data entry while crabbing. Any device must also function in a wet environment.
- Include a notes section for each string—e.g., "stacked 20 pots off N end of string" or "reef here to avoid."
- Incorporate a buzzer to indicate when to set pots along a string. A crabber would predefine a pot interval, and the software would use GPS capabilities and sound a buzzer to inform the crew when to release pots for even spacing (e.g., TrapMaster; see trapmasterproducts.com).
- Crabbers should be able to use selection lists to reduce data entry and store frequently used field values, such as bait used or port of landing.
- Similarly, header information, such as vessel ID or permit number, could be entered only once during the account setup and stored within the logbook application to create efficiencies.
- Include the ability to enter the fish ticket number to allow logbook records to directly link to fish landing data. The application could automatically calculate soak time based on the last time the string was pulled.
- Include a feature that lets crabbers note whale sightings and perhaps receive alerts about whale traffic in an area to avoid setting pots there and reduce entanglement risk.
- The display on smartphones may be too small to easily enter data during a crabbing operation. Given this information and to ensure data accuracy more generally, TNC suggests that an electronic logbook capture as much data automatically as possible (e.g., GPS locations). Also, developers should consider how manually entered data can be input at a later time (e.g., from the wheelhouse whenever a crew member has time to sit at a computer).

- Automate calculations about the haul.
  - Provide a count-to-pounds conversion option. This function would allow the user to enter an estimate for pounds per number of crabs caught as the season progresses. The software would then use this estimate as a multiplier to estimate pounds caught when the user enters the number caught (count).
  - Provide a counter function. The user would optionally preset a count interval in the application settings. The crab counter would be activated when a start-haul function is initiated at the start of a pull. As the crew hauls pots on deck and calls out counts, the captain could click a software button to add incremental counts to a running total for the string. This optional function would be an alternative to manually entering a count at the end of a string after tallying counts on paper or via another method outside the software when pots are pulled.
  - Allow the crabbers to enter fish landing information (e.g., fish ticket number and pounds delivered) after landing and submitting the logbook. The software would then automatically adjust the pound estimates across strings (e.g., by percentage) so that they accumulate to the actual amount caught and landed.
  - Have the logbook application calculate and report the average number of crabs per pot per string (number of crabs/number of pots in a string), which is useful to understand the catch-per-unit effort.
- Ensure that the logbook can work seamlessly with crabbers' other data-entry needs.
  - Incorporate the ability to export records for business needs and analyses. Some crabbers already enter logbook records into their own electronic records, so an export function could save time.
  - The application could hold several fishery logbooks at one time to reduce complexity and increase efficiency. One fisher reported that they were managing five separate paper logbooks.
  - Every commercial fisher's electronics setup is different, so an electronic logbook should be able to operate on different digital platforms.
  - Some crabbers expressed that it would be ideal to run a logbook application on an existing computer in the wheelhouse (instead of purchasing new hardware).

Complexity in the Crab Fishery

The crabbers stressed the complexity in Dungeness crabbing operations and how this translates to difficulty

in properly filling out a logbook. These factors should be considered in application design:

- **String IDs** – Crabbers have their own systems for numbering strings.
- **String adjustments** – Crabbers frequently reset a previously set string, all while retaining the same string ID. There is no standard method to record such changes in the paper logbook. Crabbers need to be able to modify their strings on the fly while fishing—either by changing the start or end location or by adding or reducing the number of pots. Additionally, if a string is kept in the water for a long time, ocean current and waves can move the gear, making previously recorded GPS locations incorrect.
- **Notes and comment fields** – Crabbers collect copious data in various recording devices about various aspects of their operations. An electronic logbook application need not replace all their recordkeeping needs; however, some form of notetaking in the application could be helpful.
- **Field edits** – The hectic nature of crabbing may lead to empty data fields. Crabbers want to be able to go back to fields and manually enter or edit data before submission. They may have failed to capture GPS locations, pot numbers, or pounds of crab or recorded them elsewhere.
- **Crab counts** – Crabbers use different methods to count their crabs. Some keep a tally for each string reported to the captain, convert those tallies to pounds, and record the pounds in the logbook. Other crews may fill receptacles that hold a known quantity of crab, like a trash can, and the captain tracks the number of receptacles filled, subsequently estimating the total number of pounds from that. Still other crabbers may calculate pounds after the fact, using the total crabs caught in a day, total strings pulled, and pots per string to estimate pounds of crab per string. They will enter this number into the logbook instead of the actual weight of the crabs caught on a particular string. One crabber suggested to TNC that the TrapMaster counting system, which uses an infrared beam to count crabs, could be helpful.
- **Time limitations** – In some fisheries, the captain can put the boat on autopilot and take time to enter information or write notes. This type of data entry is not possible in the crab fishery, so ideally, the electronic logbook would be capable of capturing data while the boat is actively operated.

Challenges With the Current Paper Logbook

The crabbers who spoke with TNC shared their challenges with the current paper logbook system, some of which come from the inherent nature of a crabbing operation and not necessarily the paper form itself. Their points included the following:

- Data inaccuracies occur because:
  - Information is recorded sloppily or illegibly. Owners often ask crew members to interpret their handwriting.
  - Writing does not always transfer through onto the carbon copies.
  - Intense crabbing activity makes entering data in real time challenging. The logbook is often pushed aside and completed later, sometimes requiring crabbers to reconstruct the specifics of their fishing activity from memory as best they can.
  - Gear location and depth are often inaccurate because of incorrect data entry (e.g., crabbers transpose numbers).
  - When gear is moved—e.g., moving five pots from the end of one string to another—it often does not get captured.
- Data entry is inefficient because:
  - A crew must fill out the same form fields every time (e.g., GPS fields).
  - Paper forms are not durable at sea.
  - Tight gear configurations and rolling boats—due to waves, inclement weather, or rocks—make entering GPS locations on paper difficult.
  - The crabbing industry, in particular, places greater time constraints on crews. Other fishery logbooks are usually not as much of a challenge because the nature of the fishing allows commercial fishers more time to take notes and document conditions, weather, etc. With crab operations, crabbers are often just too busy to fully use a paper logbook.
- Data submission can be onerous because:
  - Crabbers do not always submit logbooks within the required period, leading to penalties.
  - Managing multiple paper logbooks from multiple fisheries can be over overwhelming.

Comfort Levels With Using Digital Technology

All crabbers who spoke with TNC had little to no reservations about using digital technology and thought that most crabbers would be fine incorporating a new technology on their boats:

- Most commercial fishers are not technologically challenged since they use many digital devices on their boats: GPS devices, chart plotters, marine radar scanners, depth finders, computers, VTSs, etc.
- Few boats have internet on board.
- Most fishers use smartphone technology and apps for personal and business use.
- Many fishers use a chart plotter to keep track of their string locations.
- Tablets relying on internal GPS may struggle to get signal in a wheelhouse and may need an external GPS antenna.
- One crabber participated in a trial of Ecotrust's Digital Deck application (Ecotrust, n.d.) and found it to have some useful features (for more information about the Ecotrust pilot, see Appendix F).

F. Dungeness Crab Pilot Projects

Two pilot projects—one currently underway in California and another from 2012 in Oregon—can shed light on the benefits and feasibility of implementing an electronic logbook for Oregon's commercial Dungeness crab fishery.

California Solar Logger Pilot Project

The Solar Logger Pilot Project is part of the Risk Assessment and Mitigation Program of the California Dungeness Crab Fishing Gear Working Group. The project's overall goal is to help conserve healthy whale populations and sustain the California Dungeness crab fishery for future generations. The project pursues this goal by increasing the information available about the co-occurrence of crabbing activity and whales to aid in decision-making about avoiding whale entanglements. The pilot project has placed solar-powered VTS devices (i.e., solar loggers) on commercial crabbing vessels, whale watch boats, and CPFVs in Northern California to "collect and analyze fishing dynamics and whale concentration data" (Berube, 2018).

The Solar Logger Pilot Project is working with Pelagic Data Systems (pelagicdata.com), which provides the VTS devices and develops the algorithms and online-map display tools to integrate the location data collected from various vessels. Pelagic Data Systems is focused on "improving the livelihoods of small-hold fisherman and coastal communities, enhancing the enforcement of marine protected areas, and providing the critical insight of activities to maritime administrative zones" (Climatebase, n.d.). Their devices are solar powered, can collect 600 locations per hour, and transmit data to the cloud via a cellular network connection. Location data can be viewed by fleet managers through a customized dashboard. The company also offers analytic services, such as maps of activities (weekly, monthly, etc.), zone detection, fishing activity detection, gear detection, and customized approaches (e.g., maps of whale sightings from recreational vessels, heat maps showing crabbing and whale-watching activity).

TNC talked with a representative from Pelagic Data Systems to better understand the capabilities of their VTS and the potential costs. The actual costs incurred when using a Pelagic VTS and the data collected depend on a monitoring project's specific needs. For a project to be implemented at present, it costs $150 per device, paid by the fishers or agency, with a minimum purchase of 50 units across the fleet. This cost does not cover the data algorithms, which are covered by a yearly recurring service cost and established based on project specifications. This cost includes project startup fees, location tracking, transmission and uploading, dashboard access, and analytics.

Initially, TNC thought there might be a direct synergy between Pelagic Data Systems' solar logger and a crab logbook. We thought the logbook application could request a real-time GPS location from the onboard VTS device, as needed, and store the location data in the logbook. This data sharing would allow for a match between the location data stored in the logbook and the locations sent to the Pelagic data stores in real time. Currently though, this type of data sharing is not possible. Still, in theory, the logbook application could run parallel to the VTS, each collecting location data separately, which ODFW could cross-check after processing the data for their management purposes. The catch location data that crabbers submit in a logbook could theoretically be monitored and verified through Pelagic Data Systems' data collection and analytics. However, asking Oregon's crabbing fleet to adopt two parallel systems and track their boats with a VTS has its own costs and pitfalls. In contrast, Woods Hole Group (see Appendix G) offers an integrated VTS and logbook solution that could be the nexus between electronic reporting and monitoring.

Digital Deck Pilot Project

In 2012, Ecotrust's Marine Consulting Initiative led a project to design and test an electronic logbook application for the Oregon Dungeness crab fishery. This application, called Digital Deck, was designed to "promote collaborative fishing efforts, track and manage fisheries data more efficiently, and provide information that informs harvest decisions" (Ecotrust, n.d.). Digital Deck allowed crabbers to report their catch data on iOS and Android tablet devices and submit it wirelessly to a remote database. TNC spoke with a crabber who was involved in field testing this product during his crabbing operation. Overall, he liked how the application

functioned and appreciated how easy it was to capture GPS locations for string starts and stops, enter catch information, and submit the data. One suggestion to improve Digital Deck was to allow crabbers to modify string data once they were logged if they had to change the start or end of a string. The trial period only lasted for the 2012 season, and the project ended without moving to adoption in Oregon.

From lessons learned, Charles Steinbeck, project director, recommended keeping things simple, automating as much of the information as possible, designing the logbook application to mimic the crabber's workflow, spending time with key testers to understand their feedback, and giving crabbers access to their data for their business needs.

G. The Six Promising Software Application Vendors, for Comparison

We researched electronic logbook and catch reporting software applications currently available for fisheries around the world. We identified candidate applications using online search engines, references pulled from articles and reports, and conversations with others familiar with fishery applications.

TNC identified 24 electronic logbook and catch-reporting software applications available to fisheries (Appendix H). From the list of 24, we selected six candidates for further investigation. We aimed to learn how each application addresses fishers' and fishery managers' reporting needs, what design and implementation ideas might work in Oregon, and the ballpark costs for application development and maintenance.

The six candidates are described in this appendix. This information is a snapshot in time and can change quickly, but it offers examples of what exists as of 2021. These six vendors were chosen for meeting one or more of the following criteria:

- provides an electronic logbook solution for a crab fishery
- provides an electronic catch reporting application for one or more other fisheries
- provides an electronic solution deployed for a West Coast fishery
- located on the West Coast
- has been a TNC partner previously
- was mentioned in conversation with TNC colleagues familiar with electronic technologies employed in fisheries management

Vendor Conversations

We set up phone conversations with the six selected vendors (Table G-1) to learn more about their business experience and practices, their approach to software design, examples of their work, and how they collaborate with clients and clients' potential users to identify system requirements.

Table G-1
Overviews of the Vendors Who TNC Spoke With

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Electric Edge Systems Group Vancouver, British Columbia, Canada	**Bryan Stevenson** bryan@fisheryfacts.com fisheryfacts.com	iOS, Android, and Microsoft Windows	Their Maryland blue crab logbook runs in parallel with the state's original paper logbook system (similar to what is needed for Oregon's Dungeness Crab Electronic Logbook).	See Appendix I for examples of the FACTS user interface. Maryland DNR blue crab and finfish logbooks. Michigan DNR logbooks.
About: The Electric Edge Systems Group was founded in 2010. Started with an electronic recreational license project and groundfish logbook project in British Columbia. Developed Easy Hails, a trip reporting system that evolved into FACTS. The latter is (1) a customizable electronic logbook solution, (2) highly organized with many administrative and reporting features, and (3) accessible via a straightforward user interface. Contracts with Maryland for managing their blue crab and finfish reporting and with Michigan for their wholesale, charter, and commercial fisheries				
Business model: Subscription. *For development*: Base software is customized for the specific client or fishery. The customization cost varies depending on complexity, database needs, and the number of fisheries. Costs could be minimal if few modifications are needed. *For data warehousing and maintenance:* A subscription service with cost varying by implementation. The product for Michigan is $10,000/month, and for Maryland, $13,000/month. The subscription cost covers the entire fleet, regardless of the number of users.				

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Elemental Methods Irving, Texas, U.S.	**Michael Christopher** mchristopher@elementalmethods.com elementalmobile.com	iOS, Android	The base app is Elemental Mobile. An example app called Tails n' Scales was developed for Mississippi to assess stocks and set quotas in their recreational sector. They designed an administration portal that shows all authorized trips for any day. A web map shows departure points, and the app collects fishing data	Texas A&M iSnapper app. iAngler app. Mississippi Department of Marine Resources (DMR) Tails n' Scales for charter- and private-boat fishing.

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
			and automatically registers the areas where fishing occurred.	
About: Elemental Methods has "extensive experience in the development and hosting of cloud and mobile systems for the collection of marine data" (personal communication, Michael Christopher, April 22, 2020). They develop a variety of mobile apps but have found a niche in fishery software, especially in the recreation realm. They have worked with various organizations and agencies, including Texas A&M, the Mississippi DMR, the South Atlantic Fisheries Management Council, and the Florida Angler Action Commission. They value discipline, methodology, and documentation in their app development and consider product testing with fishers as an essential part of the process.				
Business model: Contract for custom product. They create software solutions for agency or fishing association ownership. Their cost estimate for app development is $25,000–$60,000, which is broken down between a data warehouse with a web portal for $15,000–$30,000 and a user app for $10,000–$15,000 per software platform.				

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Harbor Light Software Bethlehem, Pennsylvania, U.S.	**Francine Karp** fkarp@harborlightsoftware.com harborlightsoftware.com	iOS, Android, Microsoft Windows	Experience building cross-platform functionality and an intuitive user interface. They are well-known in East Coast fisheries and were even recommended by Woods Hole Group as a possible third-party logbook solution to integrate with the Woods Hole Group VTS services.	See Appendix I for an example of the eTrips Mobile2 user interface. Products for other areas of fisheries management.
About: Harbor Light Software has eight years of experience in the electronic reporting realm and develops "easy-to-use and intuitive software for the fishing industry" (personal communication, Francine Karp and Bill Spain, February 10, 2020). Their primary catch-reporting product is the eTrips Mobile app built for the ACCSP. This cross-platform app allows fishers to collect data while at sea, disconnected from the internet. It communicates with the SAFIS database. The app is a free (for fishers) NMFS-approved trip reporting app for commercial vessels in New England and Mid-Atlantic fisheries.				
Business model: Contract for custom product. They develop electronic reporting software for agency or organization ownership. Theirs is not a subscription model, but they can provide maintenance, updates, and support under subsequent or ongoing contracts.				

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Real Time Data Bellingham, Washington, U.S., and Australia	**Lange Solberg** lange@deckhandlogbook.com deckhandlogbook.com	iOS only	In New Brunswick, they designed a button in the Deckhand app that fishers pressed when they spotted a right whale to collect the whale's estimated distance, bearing, and condition. The data transmit instantaneously to all devices to alert other fishers of whale presence, allowing the fishery to communicate about the whales' high-use areas.	Deckhand. See Appendix I for examples of the Maine lobster fishery logbook's user interface.

About: Real Time Data has been in the electronic logbook business since 2010 when they created Deckhand, a customizable e-logbook platform. They are founded on the principle that apps should incentivize fishers' use. They first deployed the Deckhand product in the Australian lobster fishery and have since expanded into New Zealand, Canadian, and U.S. fisheries. Deckhand's flexible software design makes it possible to incorporate any fishing gear type, provide adjustments for reporting requirements, and collect nonregulatory information that may benefit a fishery or stakeholder group. Deckhand transmits data first to a secure data warehouse, then to the client's database for fishery management; optionally, fishers can choose to subscribe to Deckhand's warehouse, called Fishbank, to access special features.

Business model:

Subscription. While the base software app is free from the Apple App Store, Oregon would require a customized version to meet fishery and agency requirements and to integrate with the specified back-end database. These customizations are paid for through an annual, ongoing subscription cost per fisher. While it is difficult to give a cost for customized solutions, the yearly subscription cost per fisher could be around $600. The yearly subscription price is based on an agreed-upon guarantee of some number of users (fishers), typically a minimum of 20–30 at startup. Alternatively, they will negotiate a group subscription cost for stakeholder groups or agencies who wish to incur the subscription costs instead of passing them on to individual fishers. A discount is offered if tablets are purchased with the software. The business model is intentionally tailored to fishers by having the user pay the subscription cost and by making the app as friendly as possible for the fishers.

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Teem Fish Monitoring Prince Rupert, British Columbia, Canada, and New Zealand	**Amanda Barney** amanda@teem.fish teem.fish	iOS, Android	Has a lot of experience creating integrated electronic monitoring and reporting solutions. Has incorporated artificial intelligence functions into some of their products.	In 2010, they partnered with the Area A Crab Association in Prince Rupert, British Columbia, to develop an electronic monitoring and reporting system. It consisted of a fishing activity sensor, onboard video cameras, a GPS receiver, a control box to integrate data streams, and a computer-based logbook. Developed an electronic whale interaction mitigation system for New Brunswick, Canada, to help managers and industry minimize whale interactions. They also developed an electronic monitoring solution for the Quinault Nation's Dungeness crab fleet.

About: Teem Fish delivers advanced electronic monitoring solutions for the efficient capture and reporting of unbiased and verifiable fisheries data. They describe their approach as a "social enterprise that leverages advanced technology and local partnerships" (personal communication, Amanda Barney, February 28, 2020). Teem Fish is a designated fishery monitoring service provider for U.S. federal fisheries and provides software solutions for states and Canadian fisheries. Their electronic logbook apps can be used either separately on a tablet or embedded in an electronic monitoring system. Their integrated monitoring solutions for fish harvesters, fish managers, and resource-dependent communities are built in partnership with Snap Information Technology (SnapIT, New Zealand), which provides the hardware. Teem Fish is a for-profit enterprise that was spun off from Ecotrust Canada. (An *electronic monitoring system* is a system that integrates electronic equipment systems—such as video cameras, winch sensors, catch logbook reporting software, and a VMS—and captures information on the fishing catch, discards, and locations.)

Business model: Contract for custom product. They can hand over full logbook data systems to agencies, but they stated that they are usually more successful if they remain as the data steward in the long term (i.e., via a contract). Costs are difficult to estimate since each app is custom built, though the cost may be around $30,000 for the user app, not including back-end data warehouse requirements.

Name Location	Contact Website	Operating system platforms	Highlight	Software examples
Woods Hole Group Bourne, Massachusetts, U.S.	**Jason Surma** jsurma@woodsholegroup.com woodsholegroup.com/pages/sustainable-fisheries-overview.html	Android only	Both the logbook catch data and GPS location data are transmitted by their hybrid VMS beacon through a web portal, where a management agency can instantly see the location of its entire fleet at any time. They offer a range of statistical, oceanographic, and meteorological data services that can be integrated into their service package.	Gulf of Mexico Charter E-Logbook. LA-Creel-Charter-E-Logbook-Project.

About: Woods Hole Group is a subsidiary of CLS (Collecte Localisation Satellites), a worldwide operator of satellite systems and provider of monitoring and surveillance solutions. Woods Hole Group "provides solutions to public and private stakeholders working in the fisheries and aquaculture sector" to preserve fish stocks and manage them in an "economically sustainable manner" (personal communication, Jason Surma, October 3, 2019). They are an NMFS-approved supplier for VMS, relying on satellite-based VMS communication in past solutions. They have worked with NOAA to develop a hybrid beacon (which they call NEMO) that can switch to a cellular signal when available. It is solar-powered, smaller, and less costly than a satellite-only device, all of which are important for smaller fishing vessels or those fishing closer to shore. The company can create customized e-logbook solutions per their clients' needs, including catch reporting and vessel monitoring. Currently, their software is deployed in over 40 fisheries in the U.S., each of which has different reporting requirements.

Business model: Subscription. Software solutions integrate with their VMS beacon. Costs include approximately $400 for each hybrid VMS beacon (maybe less depending on the number purchased for a fleet) and a $300 subscription fee per fisher per year, providing access to the logbook app plus cellular and satellite communication from the VMS. Development costs for a custom logbook app are a one-time expense and were estimated to be approximately $10,000.

Product and Vendor Comparison

Business Models

The six vendors who spoke with TNC essentially employ one of two business models: a subscription model (also referred to as "software as a service") or a contract model for a custom product. Woods Hole Group, Real Time Data, and Electric Edge Systems Group offer subscriptions, whereas Teem Fish Monitoring, Harbor Light Software, and Elemental Methods build custom products paid for through contracts.

In general, with the subscription model, a vendor meets a client's needs by customizing existing software products. Any customization costs incurred by the vendor for a new client are embedded in the ongoing subscription price. Woods Hole Group and Real Time Data have low subscription price points aimed toward fishers (though subscriptions for a portion of, or all of the fleet, could be paid for by the fishery's management agency). In comparison, Electric Edge Systems Group charges a larger monthly subscription price to cover an entire fishing collective or fishery fleet. The disadvantage of this business model is that the annual subscription fee—paid by either individual fishers or the broader fishing collective or agency—becomes an ongoing yearly or monthly expense. On the other hand, the advantage is that the subscription covers many costs that could be incurred after logbook deployment, such as software fixes and the addition of new features. These covered benefits could include help-desk services; the management and maintenance of a data warehouse hosted by the vendor; maintenance of a data transfer function to transmit data from the data warehouse to agency databases; and software fixes and enhancements. Notably, Real Time Data's subscription price is set intentionally low ($600/user/year) based on their desire to lessen the financial risk to agencies and fishing collectives by shifting the subscription costs to fishers. In their view, the fishers will readily recognize the value added by the software for their own business needs and willingly pay the yearly subscription fee in exchange for those benefits.

With the contract models offered by Teem Fish Monitoring, Harbor Light Software, and Elemental Methods, the client pays for an agreed-upon custom software product. The client owns the software product outright when it is completed. The advantages of this model are that, while there is a relatively large upfront development cost, the client may incur substantially lower ongoing costs than with a subscription and will own the product. The disadvantage is that the agency must address any post-deployment software changes itself or establish a new contract with the vendor (or a third party). These costs could include data warehouse maintenance, user training, help-desk services, software fixes and enhancements, and additional fishery logbook modules.

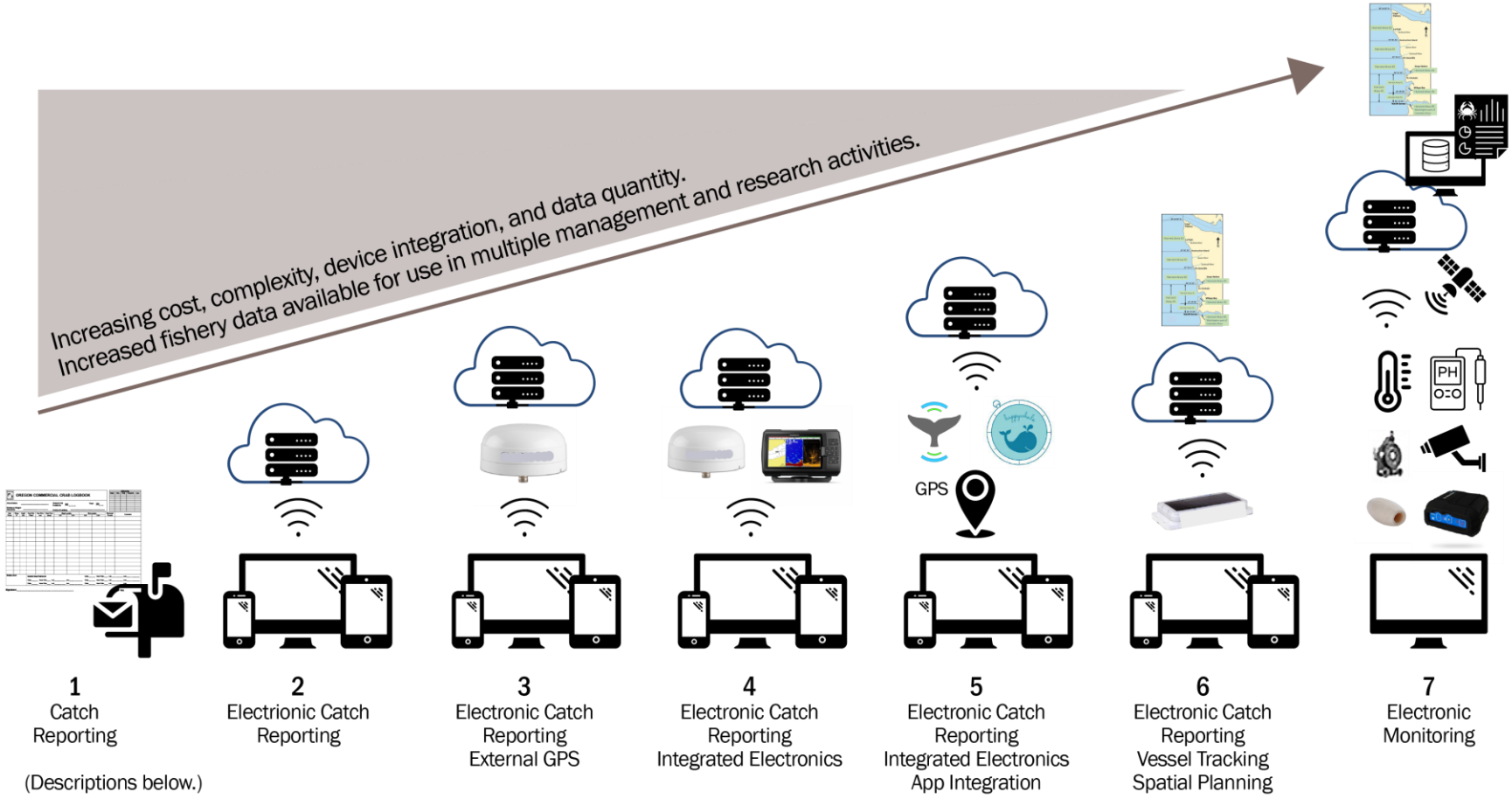
Product Complexity

Vendors differ in how they position their products in the market. The complexity of fishery data collection solutions ranges from simple catch reporting via a paper logbook to virtual observer cameras and sensors in a fully integrated electronic reporting and monitoring system (Figure G-1).

Teem Fish, originally Ecotrust Canada, builds fully integrated electronic monitoring solutions, which may combine cameras, gear sensors, VMSs, and catch reporting software. In fact, their mission is "to provide world-class electronic monitoring technology to local fisheries at an affordable price" (Ecotrust Canada & Teem Fish Monitoring, 2019).

Woods Hole Group, a subsidiary of a satellite communications company, focuses on VMS, especially for federal fisheries far offshore that must rely on satellite communication for real-time data transmission. Where needed, their system can include a catch logbook application that integrates with the VMS.

Figure G-1
Ranges of Complexity, Integration, and Cost for Electronic Systems, With Increases in Data Available for Multiple Fishery Management and Research Activities



1. **Catch Reporting** – Paper logbook. Manual entry of GPS locations. Paper submission.
2. **Electronic Catch Reporting** – Electronic logbook running as an application on a mobile device or computer. Device/computer uses internal GPS. Digital submission via a cell signal to a data service provider.
3. **Electronic Catch Reporting, External GPS** – Electronic logbook plus external GPS antenna for (potentially) more accurate location data.
4. **Electronic Catch Reporting, Integrated Electronics** – Electronic logbook plus integrated communication with onboard electronics, such as a chart plotter and depth gauge, to acquire GPS locations. Same electronics to potentially acquire depth (proof of concept not yet done). External GPS antenna for (potentially) more accurate location data.
5. **Electronic Catch Reporting, Integrated Electronics, App Integration** – Electronic logbook plus integration with other software, such as Whale Sightings Alerts, Happy Whale App, and SOS.

6. **Electronic Catch Reporting, Vessel Tracking, Spatial Planning** – Electronic logbook used in parallel with a VTS (such as Pelagic Data Systems) for high-frequency location collection (pings) and digital submission via a cell signal to a data service provider. High-frequency location data potentially analyzed and integrated with existing systems to manage the fishery area and assist in reducing whale entanglements. The same data could be used to validate logbook catch submissions.

7. **Electronic Monitoring** – Integrated system of data collection devices: VMS cameras, fishing activity sensors, environmental sensors, radio frequency identification (RFID) tags on buoys and trap tags, an RFID scanner, and an electronic logbook. Data collections and devices integrated with a computer control system. Near-real-time data transmitted via satellite or cell signal. Large data stream must undergo complex data review, analyses, and integration into existing systems before it is useful for management or research purposes.

Harbor Light Software and Real Time Data emphasize products designed to electronically report fisheries data rather electronic monitoring or VMS solutions. This distinguishing feature is clear from their product webpages. Real Time Data's Deckhand product is designed to be "a world-class data collection and management tool for seafood harvesters" (Real Time Data, n.d.). The company provides "easy-to-use marine data collection software" (*Harbor Light Software*, n.d.).

Electric Edge Systems Group's project list varies more. They have developed fisheries-related software products that meet different needs, including quota management, electronic catch monitoring, a recreational fishing license system, the FACTS software reviewed herein, and others.

These differences should be considered in a contracting process since they indicate each vendor's experience and focus and may contribute to how successful the vendor is in developing a high-quality logbook application at a reasonable price.

Data Management

One key difference in vendors' products and services is whether there is flexibility in designing how the database receives data from the user application. Refer to Appendix B for a detailed discussion of the data flow from user application to data warehouse and database.

Electric Edge Systems Group, Real Time Data, and Woods Hole Group build products to integrate with the vendor's data warehouse and web portal. Teem Fish Monitoring provides a fully integrated solution, including the data warehouse plus staff and expertise to steward the data; however, they would build an application to interface with an agency's database if asked.

Harbor Light Software's application is specifically designed to interface with the ACCSP SAFIS database using the SAFIS API (see Appendix H for details). During TNC's conversation with their representative, they stated that, if requested, they would build a user application for Oregon that would interface with a data warehouse provided by ODFW (or its partner) to best leverage their existing application framework.

The approach taken by Elemental Methods is a hybrid of the other approaches. They design and build a custom software solution for the user application and build a custom data warehouse to receive data and meet the client's reporting and data needs. Their custom solution can optionally include a web portal to allow web-based access to the warehouse's data. The warehouse and portal transfer to the client once the system is built.

In all cases, the vendors will build in a function to transmit the logbook data to the regulatory agency's database(s). For Oregon, a vendor would provide a data transfer service that sends data to the ODFW SQL server (refer back to Figure B-1 for an illustration of the data flow).

When making implementation decisions, it will be critical to understand the data flow from the user application to the necessary database(s) and who builds and manages those databases. If ODFW elected to use an outside vendor to host and maintain the database services, ODFW would incur a recurring financial cost (subscription fee or contract) for the service and may have restricted access to the raw logbook information. Although, a vendor who provides the database services

would bear the costs of hardware purchases, system maintenance, and IT staff.

There are a few possible paths for developing and maintaining the data warehouse for Oregon's electronic logbook system:

1. a subscription service where the vendor handles all database services as part of their subscription fee
2. a custom data warehouse built by the vendor and maintained under an ongoing contract
3. a custom data warehouse built by the vendor and maintained by ODFW or PSMFC
4. a data warehouse built and maintained by PSMFC or ODFW

Operating System Support

Vendors support different operating systems, with their offerings apparently based largely on preference, current product suite, and in-house technical expertise. ODFW has expressed a desire for a multi-platform (iOS, Android, Microsoft Windows) Dungeness crab logbook solution, which would allow crabbers to use their existing hardware or a hardware solution of their choice. The disadvantage of a multi-platform product is that fewer vendors support all three operating systems, reducing the pool of potential vendors available for hire. Additionally, initial development and maintenance costs may be higher for products that support multiple operating systems. This trade-off should be recognized as a potential long-term cost and balanced with the need to have access on all three platforms.

User Support and Training

A successful electronic logbook program must provide users with some level of software support. The extent of the support needed, and for whom, will depend on the product solution and may include support for the user application, a web portal, and the data warehouse, the latter of which may need to be accessed for reporting. Similarly, new users will need training, which could be in the form of in-person classes, prerecorded webinars, or written user manuals. Vendors differ in how they provide user support and training.

Three of the six vendors gave TNC information about user support. The type of support can differ by the application's complexity and the number of users. Electric Edge Systems Group has provided different types of support in the two projects they describe. To provide support and training for Maryland's commercial finfish and blue crab catch reporting software (FACTS), the state of Maryland created a staff position called the E-Business Coordinator. This person provides all training to the system's 600 users, staffs the helpline number, and does outreach to the industry. Electric Edge Systems Group supports the coordinator with access to a call center. In contrast, instead of a staffed support position, Electric Edge Systems Group wrote a user guide for the small number of fishers using the Michigan DNR application.

Harbor Light Software offers an optional-but-recommended support agreement that includes help-desk support for fishers (24 hours a day, every day, via email or a 1-800 number). The contact for Harbor Light Software, Francine Karp, explained that this agreement includes user support as well as software maintenance costs in the range of "six-figures per year" (personal communication, Francine Karp, February 10, 2020; see Table G-1 for details). Karp further explained that the help-desk support is good for both customer relations and user feedback about software issues and product improvements.

Real Time Data's subscription fee for their Deckhand application includes software updates and support with voice-over-internet service to Australia.

Vendor Cost Estimates

Overall, costs for developing and maintaining an ERS can vary, be difficult to estimate, and greatly depend upon the chosen project specifications. From TNC's conversations with vendors, developing a system (i.e., application, warehouse, etc.) for a Dungeness Crab Electronic Logbook will likely cost from $30,000 to $100,000 or more. This price range does not include staff time for the agency's many management tasks, such as creating policies and standards and producing and sharing communication and training materials. Also, it omits the costs of printing and distributing the materials. Ongoing annual maintenance costs are for server hardware, staff payroll for data entry tasks, and maintenance.

Crabbers might also incur costs using an electronic logbook. Their upfront costs could range from $400 to $1,000 or more depending on the computer or tablet

purchased and the extent of equipment integration aboard the crabber's vessel.

Table G-2 provides general cost estimates from the six vendors selected as promising candidates to develop and/or maintain the logbook system. Vendors include different services in their costs, making a comparison across vendors challenging. These are only ballpark estimates, and actual costs will depend on application specifications and functionality. Still, it was clear that cost savings could be realized by selecting a vendor who already provides a product similar to what is needed, thus requiring only minimal customization for the Dungeness crab fishery.

In general, upfront costs are lower for products with subscription pricing; however, these products have higher ongoing costs than products developed under contract pricing. If state officials are reluctant to enter into an ongoing subscription plan, then solutions by vendors such as Harbor Light Software would be more appropriate. Ongoing maintenance costs for Harbor Light Software products range from 0% to 18% of the build cost (Table G-2).

While the costs to develop and maintain an electronic logbook solution are substantial, it is worth noting that using an electronic logbook can result in cost savings. The obvious costs savings would be recouped from reductions in the current staff costs allocated to data entry and correction of the paper logbooks (e.g., tracking down logbooks from crabbers who did not mail them on time, correcting missing or illegible information).

Table G-2
The Six Vendors' Cost Estimates for Initial Application Development and Ongoing Maintenance

Business model and costs		Electric Edge Systems	Elemental Methods	Harbor Light Software	Real Time Data	Teem Fish Monitoring	Woods Hole Group
Model type		 (subscription)  (retains ownership of software)	 (contract)  (builds software for agency ownership)	 	 	  or  Primary product focus is electronic monitoring.	  Requires the use of their specific VMS hardware.
Development cost		Built into the subscription cost.	$30K–$60K+ for mobile app, cloud-based data warehouse, and web-based portal.	$30K–$100K+	$10K+ depending on customization and data needs. May be possible to defer this cost and roll it into the subscription fee. Requires a minimum number of users in the fleet.	$30K+ for the user app alone	Depends on the customization needed but estimated at $10K. One-time cost of $400/unit for their unique VMS hardware.
Maintenance costs	Subscription	$10K–$15K/month for the fleet. Depends on complexity and the number of modules.	None.	None.	$600/user/year. Can be paid by crabbers or the agency. Based on an initial commitment ≥ 20–30 users. $100 discount/user with a tablet purchase.	None.	$300/user/year for the hybrid VMS, integrated logbook app, and a web portal. The portal allows the agency to see fleet locations at any time.
	Data management	Included in the subscription cost.	Ongoing hosting cost unknown.	Not included.	Included in the subscription cost.	Not included.	Included in the subscription cost.
	Data warehouse and/or user app maintenance	Included in the subscription cost.	Unknown.	0%–18% of the development cost/year.	Included in the subscription cost.	Unknown.	Included in the subscription cost.

System Costs

In addition to initial, one-time development costs—including application design, programming, and deployment—other ongoing costs may be incurred by ODFW or another application manager tasked with overall application management (e.g., PSMFC). These costs include fees for data storage, system maintenance, user support, and others. When estimating the total costs expected to deliver an electronic logbook solution, it is helpful to separate the application manager's expenses into two categories: development and maintenance. Table G-3 provides examples of products and services in each category, specifying whether each is a one-time or ongoing expense. Additionally, Table G-3 gives examples of the initial and ongoing costs potentially incurred by crabbers interested in using an electronic logbook.

Table G-3
Examples of Costs for the Application Manager and Crabbers, Categorized by Implementation Stage and Frequency

	Category	Example	App manager	Crabbers
Development	Design	ID specific needs for data, reporting, database structure	 (one-time cost)	
		Define policies, standards, and procedures		
		Determine the user app's final design		
		Optionally, design a web-based data portal		
	Programming	Develop the data warehouse		
		Develop the user app		
		Develop the service to transmit data from the data warehouse to the ODFW database(s)		
		Optionally, develop a web-based data portal		
	Hardware procurement	*Manager*: purchase necessary hardware or subscriptions cloud-based service(s) *Crabbers*: Purchase computer hardware (tablet or computer) to run the user app on		
		Ruggedize and secure hardware in the wheelhouse		
	User testing	Execute a pilot program to test and improve functionality, likely followed by refinements to the data warehouse, user app, etc.		
	Deployment	Train agency staff in how to use the new system and data and, potentially, how to provide crabbers with help-desk support		
		Manager: Train crabbers in how to use the app *Crabbers*: Learn the user app and, potentially, the web-based data portal		
		Perform outreach to the fleet to increase adoption		

	Category	Example	App manager	Crabbers
		Integrate the app with the onboard GPS antenna and, if designed to do so, with any onboard electronics, such as a map plotter or depth sounder		
Maintenance	Ongoing implementation	Pay for the software subscription(s), depending on the vendor's product pricing model (see this appendix's "Business Models" section)	∞ (ongoing cost)	∞
		Pay cellular or internet service costs for data transmission		∞
		Manage post-submission data validation and cleaning	∞	
	Help desk	Provide user support for both fishers and agency staff, including training for new users	∞	
	Programming & hardware fixes	Support and maintain the data warehouse—either its cloud storage or in-house servers and the in-house IT staff to run and maintain them	∞	
		Optionally, support and maintain a web-based data portal	∞	
		Modify the user app (not including incorporating additional fisheries' logbooks); adjust the software per changes in operating systems (iOS, Android, Microsoft Windows)	∞	
	Management oversight	Execute data archiving procedures and retention policies	∞	
		Periodically review and potentially update all policies, standards, and procedures	∞	
		Oversee and renew contracts, as needed	∞	

H. A Review of 24 Available Software Applications

TNC spoke with fishery application experts and searched articles, reports, and online sources to identify electronic logbook and catch reporting software applications currently available to fisheries around the world. We compiled a list of 24 applications (Table H-1), each of which is described in this appendix. For each, we researched the following:

- what the application does and how it functions
- whether it stands alone or is one part of a larger integrated software platform
- how the collected data are managed and where they are stored
- which operating systems are supported
- how the user interface functions
- what the estimated costs are for software development, maintenance, and user support

Table H-1
Catch Reporting Software Applications

App name plus vendor/organization, location, and website	Description
A suite of electronic reporting tools, including Marlin Pro, FISHLOG, and NEMO Woods Hole Group, a CLS Company Borne, Massachusetts, U.S. clsamerica.com/sustainable-marine-resources fisheries.groupcls.com	Provides custom-built solutions to public and private stakeholders to collect data needed for sustainable fisheries management. Catch reporting software (for Android) optionally integrates with their VMS to upload data via satellite communication in real time. Customization meets the specific needs of the client, which could include compliance with regulations, fishing fleet optimization, marine resource management, protected area monitoring and control, and illegal fishing reduction efforts. Provides customized data solutions and integration for full paper-to-electronic workflow migration. Their NEMO beacon is a hybrid VMS, which communicates either via satellite or a cellular network, reducing the costs of data transmission. Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G).
CatchLog CatchLog Trading Pty. Ltd. Queensland, Australia catchlog.com	An onboard system for electronic logbook reporting and vessel management used in Australian fisheries, with the potential for use in any fishery around the world. Allows commercial fishers to submit catch and effort information, record logbook information for species of conservation interest, submit quota information, and collect information to better understand fishing activity and inform business operations, such as operating costs and prices of products sold. Includes species information for 4,000 target species, bycatch species, and protected species and has the capacity to add new species. Key functions include automatic entry of trap points and standard functions for recording catch history, onboard products, uploads, wages, etc. The user can see a detailed snapshot of each fishing season with graphed data. CatchLog is certified in the European Union, in the United Kingdom, and for some fisheries in Australia.

App name plus vendor/organization, location, and website	Description
cELB (Cellular Electronic Logbooks) Gulf of Mexico Marine Fisheries Council, NOAA Southeast Tampa, Florida, U.S. fisheries.noaa.gov/southeast/commercial-fishing/electronic-logbook-gulf-mexico-shrimp-permit	Provided for each Gulf of Mexico shrimp permit. Provides data on Gulf shrimp fishing effort critical to annual assessments of shrimp stocks. Records the vessel's location every 10 minutes using VMS GPS technology. Data are transmitted to the National Coastal Data Development Center (NOAA Southeast), where distance and speed between data points are calculated to determine the amount of time fished by location (effort). Fishing effort data are then matched to the number of pounds of shrimp catch uploaded at the dock (landings) based on date. Environmental data from a conductivity-temperature-depth data logger mounted on the trawl net door, which is deployed during each trawl haul and retrieved at the end of each tow, automatically downloads data to the cELB using a wireless connection. Catch, effort, and associated data (temperature, salinity, depth, date, time, latitude, and longitude) are uplinked through a VMS via Orbcomm satellites to the shrimp company's headquarters and to the Florida Fish and Wildlife Conservation Commission's Fish and Wildlife Research Institute (Rubec et al., 2016).
CPFV Logs (Commercial Passenger Fishing Vessel Logs) California Department of Fish and Wildlife (CDFW) Sacramento, California, U.S. apps.wildlife.ca.gov/marinelogs/cpfv	Web-based app. Allows license holders for CPFVs to manage accounts for vessel(s). Allows CPFV license holders and operators to electronically create, complete, submit, and view their logs for fishing activity. Data are entered on a portable, internet-enabled device. If a cellular data connection is unreliable, electronic logs can be completed offline and then submitted online once a connection is available. Logbooks, logbook data, and the electronic app are part of the Marine Logs System, provided by the CDFW Marine Fisheries Statistical Unit. References: Training videos (CDFW, 2017), press release (CDFW, 2018), and information about the Marine Fisheries Statistical Unit (CDFW, n.d.).
Deckhand Electronic Logbook Real Time Data North America, LLC Bellingham, Washington, U.S., and Adelaide, Australia deckhandlogbook.com	Key features: Designed for data entry as it occurs on deck; for any vessel size and those with an open deck or full wheelhouse; and for use with any gear type. Automatically maps trips and activities. Uploads and delivers data. Users can view and compare historical catch and effort data online in a Crowsnest's interactive map. Data are sent to a secure data warehouse, then on to a government back-end database. Supported for several iPad models running iOS 12+ operating systems. Communicates via Wi-Fi and cellular, and optionally via satellite when a compatible VMS device is available. The app is free and available in Apple's App Store. Commercial users can purchase Real Time Data's Fishbank account, which turns Deckhand into a full-featured data collection, analysis, and reporting tool. Fishbank is available under a subscription model. Australian commercial fishers have used Deckhand for over four years. It recently launched in New Zealand (FINNZ Deckhand NZ electronic reporting solution) and in North America. Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G).
eCatch The Nature Conservancy in California San Francisco, California, U.S. ecatch.org	A digital fisheries logbook app developed by The Nature Conservancy for California for groundfish management. Allows fishers to collect, map, and selectively share their fishing information. Promotes the avoidance of sensitive species and habitats and provides quantitative reporting on related performance metrics. Uses location-aware mobile devices, cloud-based computing, data visualization, and geographic data queries over the web. Available in Apple's App Store (Merrifield et al., 2019).

App name plus vendor/organization, location, and website	Description
eCDS (Electronic Catch Documentation System) Quick Access Computing Eureka, Australia National Fish Authority Papua New Guinea quickaccesscomputing.com.au	For onboard fisheries observers. Facilitates real-time input on Android tablets of fisheries catch data. Transmits the data via satellite directly to regional and national databases, where they can be used to cross-reference and validate the catch. Intended to increase the quality, integrity, reliability, and timeliness of critical fisheries information. The system provides observers their own independent source of two-way communication back to shore, including SOS location tracking in case of an emergency. The system was created for Papua New Guinea and other Pacific Island countries. Reference: Newspaper article from Papua New Guinea ("NFA to implement new 'fish' system," 2014).
ELB (Electronic Logbook) APICDA Joint Ventures Inc., doing business as OceanLogic Juneau, Alaska, U.S. oceanlogic.com	Certified by the NMFS Alaska Region for use in the trawl catcher vessel fleet for the North Pacific (Alaska) groundfish and in the Bering Sea pollock fishery. Provides a fishing activity database and accepts GPS input to keep a historical vessel track. Hauls are entered daily, and the combination of GPS and user input is used to print paper logbook pages, electronic exports for NMFS, and reports for skippers and report managers. Other software apps are available. CatchPlotter allows the user to map vessel tracks imported from the ELB and Vessel Verification System and fishing history over a variety of standard maps for the North Pacific. CatchPoint is designed for use by catcher processors and mother fishing vessels. It imports files created by fisheries observers and uses them to recreate species compositions for each haul to compare against quotas. In the Bering Sea pollock fishery, ELB features allow for salmon avoidance (Mikol, 2004).
Electronic Catch Logbook Trackwell Reykjavik, Iceland vmsfisheries.com/electronic-reporting-system-ers	Part of an optional Trackwell ERS that is fully integrated with the Trackwell VMS environment. The ERS handles the Electronic Catch Logbook and the catch and effort reports from local and foreign vessels. With the Trackwell ERS system, users can record, report, process, and store data, as well as send the fisheries data (catch, landing, sales, and transshipment) to the authorities. All data are stored in the system database. By integrating the VMS and ERS systems, users can compare ERS and VMS data to identify potential misreporting. The Electronic Catch Logbook can be connected to a variety of sensor devices, including GPS, weather sensors, and echo sounders. The Trackwell VMS system supports many transponder models and/or service providers' gateways.
eLogbook Alaska Department of Fish and Game International Pacific Halibut Commission NMFS, NOAA Juneau, Alaska, U.S. elandings.alaska.gov	Available through the eLandings app of the Interagency Electronic Reporting System, the collaborative effort of the three natural resource agencies (Alaska Department of Fish and Game, International Pacific Halibut Commission, and NOAA NMFS – Alaska Region) tasked with commercial fisheries management in Alaska. The eLandings system is a web-based ERS that consolidates reporting for landings, production, individual fishing quotas, and electronic vessel logbooks for commercial fish and shellfish. eLogook supports electronic reporting from the at-sea fleet and is designed for longline or pot gear catchers and processors. References: NOAA's electronic reporting in Alaska (NMFS, n.d.) and eLandings user documentation (Alaska Department of Fish and Game, International Pacific Halibut Commission, & NOAA NMFS, n.d.).
Elogs Teem Fish Monitoring, Inc. Vancouver, British Columbia, Canada teem.fish/elogs	A free NMFS-approved eVTR app for use by commercial vessels required to submit vessel trip reports electronically in New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020). Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G). Reference: Ecotrust Canada (n.d.) webpage

App name plus vendor/organization, location, and website	Description
e-Reporting World Wildlife Fund Gland, Switzerland	Developed by WWF to reduce illegal, unreported, and unregulated fishing and bolster supply chain transparency and traceability. Designed for electronic reporting and monitoring on commercial tuna boats in the Pacific. Provides real-time verification and validation of fish deliveries from sea to port. Runs on tablet computers and sends data using Rock7 Satellite Personal Communication Devices. Complemented by the Observer eReporting App for onboard fisheries observers. e-Monitoring is also available (World Wildlife Fund, 2018).
eReporting Shellcatch Miami, Florida, U.S. web.shellcatch.com	A web platform for fishing fleet reporting and management that enables governments, nongovernmental organizations, and communities to communicate and track fishing data efficiently. Features include fishing season settings by species, fisher alerts, fishing locations, general species management, dashboard reports, fisher logs, and license management. The mobile app runs on Android and Apple devices. A pilot version was developed in 2019 for Puerto Rico's Department of Natural and Environmental Resources with support from The Nature Conservancy.
E-Tix Resource Data Portland, Oregon, U.S. etix.psmfc.org/Account/Login	The electronic fish ticket system for the Pacific Coast commercial groundfish fishery. A web-based form used by participants who land or purchase fish. Resource Data worked with PSMFC, NMFS, and FinSight LLC (acquired by Resource Data in 2016) to design and build the web-based system for commercial fish buyers to submit, review, and manage their data in a central database and print receipts for fishers involved in the Oregon, Washington, and California groundfish fishery. References: Descriptions from Resource Data (n.d.) and the E-Tix Portal (PSMFC, n.d.).
eTrips Mobile2 Harbor Light Software Bethlehem, Pennsylvania, U.S. harborlightsoftware.com	The ACCSP's mobile tablet app that allows captains to capture catch and effort data while at sea, independent of a full-time internet connection. Available for iOS and Android tablets. Communicates with the SAFIS database using the SAFIS API (ACCSP, 2019; Harbor Light Software, 2020a). eTrips Mobile2 is a free NMFS-approved eVTR app for commercial vessels required to submit vessel trip reports electronically in New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020). Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G). Reference: Online description (ACCSP, n.d.-a) and video (ACCSP, n.d.-b).
FACTS Electric Edge Systems Group Victoria, British Columbia, Canada fisheryfacts.com electricedgesystems.com/index.cfm?pg=projects	An integrated fishery management platform comprised of six software modules and a central online portal for reporting data after they are received, managing settings, and exporting data. The six platform modules include Hails, Landings, Logbooks, Quota, Licensing, and Administration. Fishers use the Logbooks module to record and send catch log data either directly from the vessel or from shore. Data collected about the trip is tied directly to it in real time, an advantage over the standard practice of "matching" datasets during post-trip processing. FACTS is used by the Maryland DNR for voluntary, real-time, online harvest reporting by the charter fleet (Maryland DNR, 2020). Electric Edge Systems Group has completed a variety of other fishery-related software products. Electric Edge Systems Group no longer provides support for FACTS. Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G).

App name plus vendor/organization, location, and website	Description
Fish Online iOS NOAA Washington, DC, U.S. https://apps.apple.com/us/app/noaa-fish-online/id980681084	One option for federally permitted commercial vessels to report their catch on a VTR for each fishing trip in NMFS' Greater Atlantic Region (NMFS, 2019). May be used on Apple tablets and iPhones. A free NMFS-approved eVTR app for commercial vessels required to submit vessel trip reports electronically in New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020).
Fish Trax Fish Trax Systems, Inc. Lincoln City, Oregon, U.S. fishtrax.org	An electronic fishery information system that helps members of the industry, marketers, and fishery managers collect, analyze, and share information critical for the success of their fishery. Enables fish tracking from boat to end consumer (i.e., product traceability). Consists of a database and web-based portals for data entry and for data viewing and analysis, each for different audiences.
FLDRS (Fisheries Logbook and Data Recording Software) Northeast Fishery Science Center (NEFSC), NOAA Woods Hole, Massachusetts, U.S. fisheries.noaa.gov/new-england-mid-atlantic/science-data/cooperative-research-northeast	Used for vessel trip reporting to research/study fleet vessels in NMFS's Greater Atlantic Region. All federally permitted commercial vessels must report their catch on a VTR for each fishing trip, either electronically or by paper. FLDRS is designed to collect high-resolution fisheries data for research while satisfying eVTR requirements. A free NMFS-approved eVTR app for commercial vessels required to submit vessel trip reports electronically in New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020).
iSnapper Elemental Methods Irving, Texas, U.S. elementalmobile.com/isnapper	Designed for recreational for-hire and headboat captains in Texas, Louisiana, Florida, and Alabama. Elemental Methods has developed several mobile apps used by for-hire captains and commercial and recreational fishers to record and submit catch information. Chosen as one of the six promising vendors selected for more detailed analysis (see Appendix G). Reference: Online information from the Sportfish Center (n.d.).
JOBEL Jobel Chandler, Quebec, Canada jobel.ca/en/about	An electronic logbook for commercial catch data. Created for Fisheries and Oceans Canada. Modules are available for snow crab, lobster, and herring. Cost per user is Can$65 per year per fishery.
Marine Logs CDFW Sacramento, California, U.S. apps.wildlife.ca.gov/marinelogs/cpfv	Includes a web-based app that allows CPFV (i.e., party/charter boat) operators to record and submit fishing data to CDFW electronically. Operators record fishing data on a portable, internet-enabled device, even when lacking an internet connection, and then electronically submit the information to CDFW at the conclusion of their trip when a connection becomes available. Reference: Press release (CDFW, 2018).
NOAA Fish Online Greater Atlantic Regional Fisheries Office, NMFS, NOAA Gloucester, Massachusetts, U.S. apps.apple.com/us/app/noaa-fish-online/id980681084	An eVTR app compatible with iPhone or iPad, or a web browser. NOAA Fish Online is a free NMFS-approved eVTR app for commercial vessels required to submit vessel trip reports electronically in New England and Mid-Atlantic fisheries (New England Fishery Management Council & Mid-Atlantic Fishery Management Council, 2020). Reference: A webpage from NMFS (2021).

App name plus vendor/organization, location, and website	Description
Olrac Electronic Logbook (eLog) OLSPS South Africa Cape Town, South Africa marine.olsps.com/fisheries-electronic-logbook-solutions elog.olsps.com	A multilevel electronic logbook for recording, reporting, and managing commercial fishing data. Can be customized to include any number of fish species, fish products and grades, fishing methods, and fisheries management regimes. Used globally by fisheries, companies, fishing fleets, and sector managers in fisheries of various sizes. Olrac provides three core products: Olrac Dynamic Data Logger (OlracDDL) for recording, and reporting, and managing commercial fishing data; Olrac Dynamic Data Manager (OlracDDM), web-based data and report management software for use alongside OlracDDL that provides maps of vessel activities; and Olrac Electronic Monitoring (OlracEM), a fully integrated electronic monitoring and reporting system. Olrac provides several other add-on products to enhance the core components, including an offline mapping utility and a bycatch avoidance system (OLRAC SPS, 2013).
VESL Bluefin Data Baton Rouge, Louisiana, U.S. bluefindata.com	An ERS for the seafood industry, including the next generation of the Trip Ticket system for the Gulf and Atlantic Coasts, which is their data collection program for commercial catch landing data. The vendor develops and manages ERSs for 11 states through the VESL system. Logbook data typically are reported on electronic forms provided by the company, securely transmitted to a Bluefin-controlled FTP site, and then uploaded to state or federal databases.

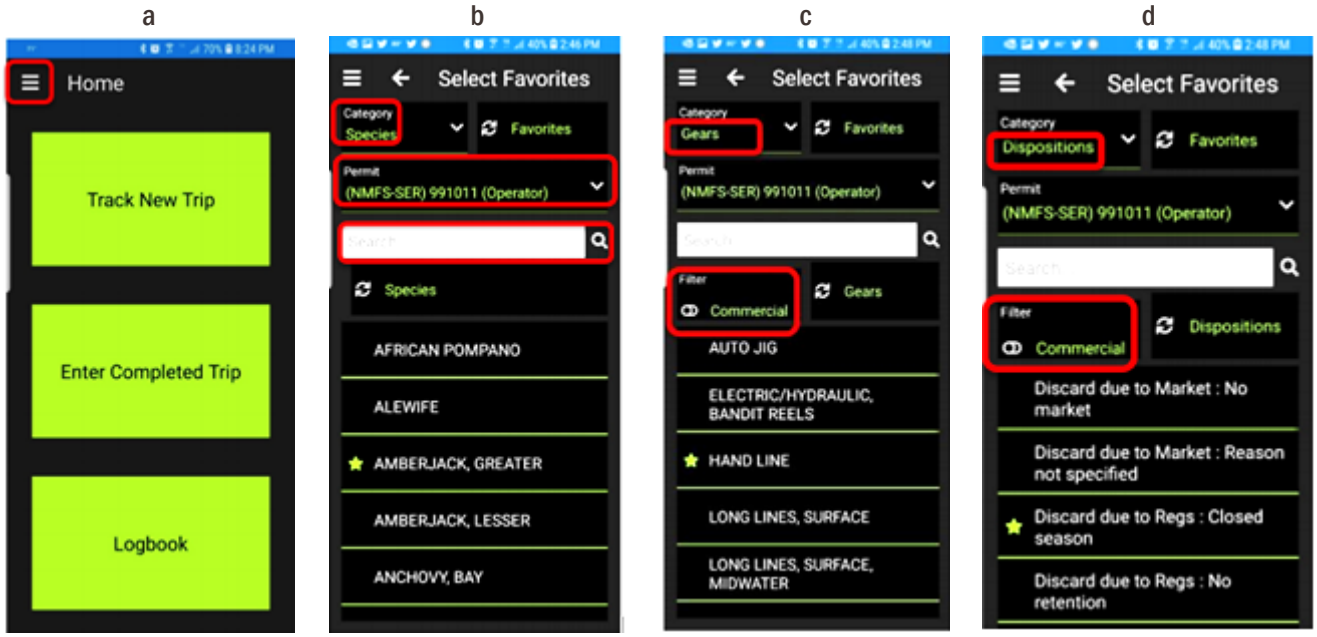
I. Examples of User Interfaces

This appendix provides screenshots of the software user interface of three vendor applications. They offer examples of what is possible for Oregon's Dungeness Crab Electronic Logbook.

eTrips Mobile2 by Harbor Light Software

The following screenshots are from Harbor Light Software's manual for eTrips Mobile2 for Windows (Harbor Light Software, 2020b). The user interface uses large buttons to make the application's functions easier to select in rough conditions at sea (Figure I-1). Before leaving port, the user enters general information, including their federal or state permit number. Next, the user can predefine frequently selected choices ("favorites") for many fields to speed up data entry later. These favorites, such as the names of commonly caught fish species or gear types, are customizable and stored for each permit number (Figure I-1b). This information is retained in the system and available each time the eTrips Mobile2 application is used. Categories of favorites include species, gear, areas fished, ports, dispositions, vessels, licenses, and dealers.

Figure I-1
eTrips Mobile2: The Main Entry Screen and System Favorites



The user moves through a series of screens to enter a new trip, selecting values from the predefined lists for trip type (commercial or for-hire) and favorites. Trip notes, such as weather conditions, can be entered in the designated text box and are retained for the fisher's personal use without being submitted with the trip data (Figure I-2). Next, fishing effort details are entered for the trip (Figure I-3). Once the trip report is complete, the fisher electronically signs and submits it (Figure I-4).

Figure I-2
eTrips Mobile2: Trip Setup

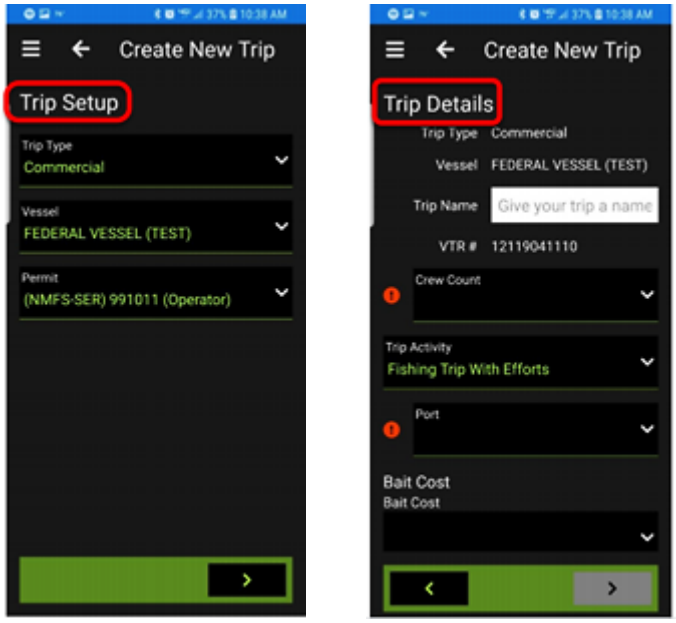


Figure I-3
eTrips Mobile2: Effort and Catch Details

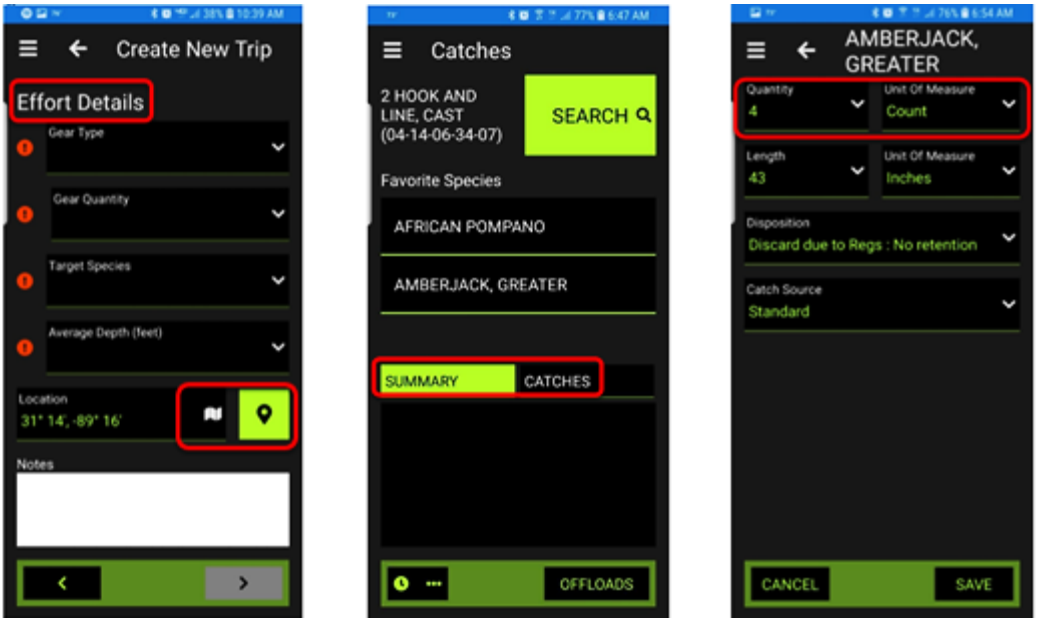
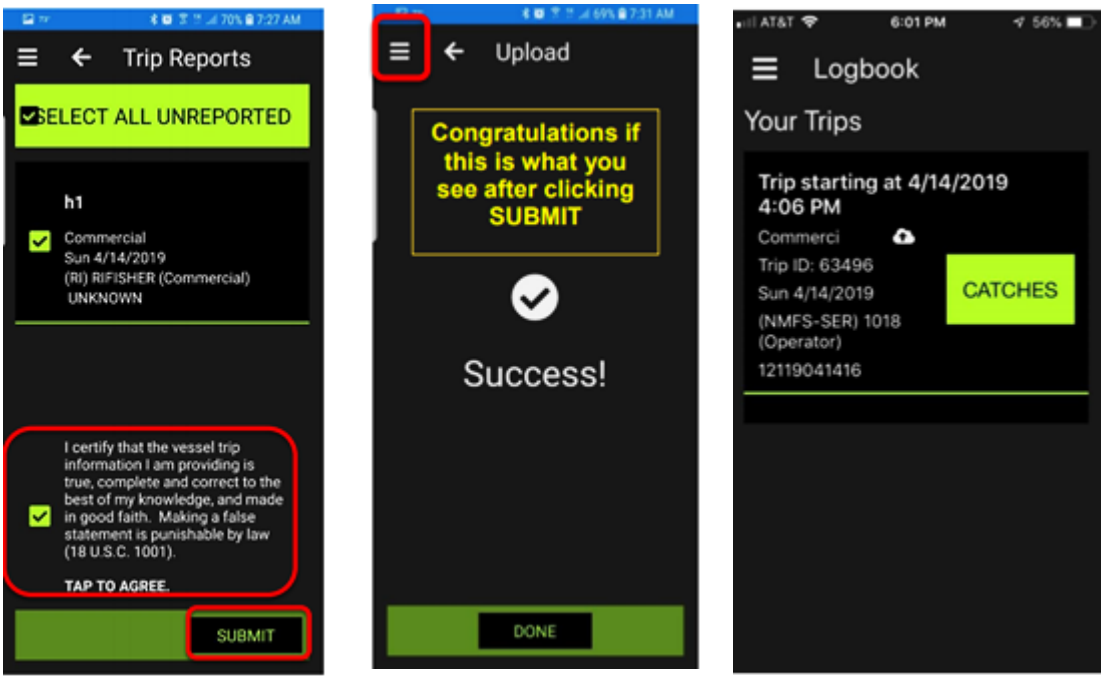


Figure I-4
eTrips Mobile2: The Signature and Submission Screens for the Trip Report



Note. The cloud with the up-arrow indicates the report was successfully submitted

FACTS by Electric Edge Systems Group

The following screenshots are from the FACTS application by Electric Edge Systems Group. FACTS is designed to collect catch and effort data for the Northeast groundfish fishery. To start collecting logbook records, the user starts what the application calls a Hail to indicate the start of a fishing trip (Figure I-5) and then selects the button called Set-Up Trip Logbook Data (Figure I-6). Once the logbook data are set up, effort (Figure I-7) and catch (Figure I-8) are recorded. Additional effort and catch data can be added when the gear type or fishing area changes.

Figure I-5
FACTS: My Trips Page Showing a Hail Was Sent and Preparing for the Trip Logbook Data Setup

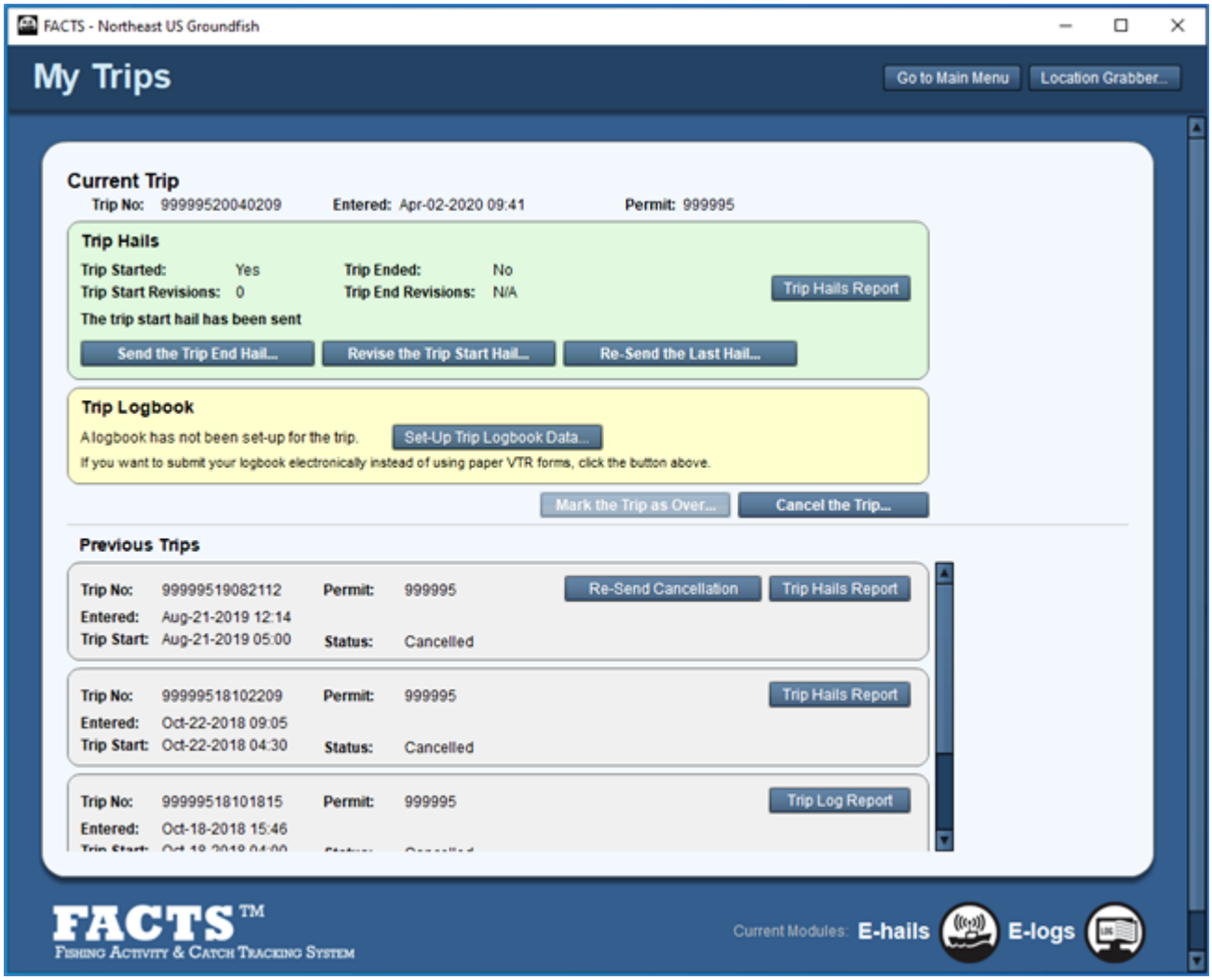


Figure I-6
FACTS: Trip Logbook Data Setup

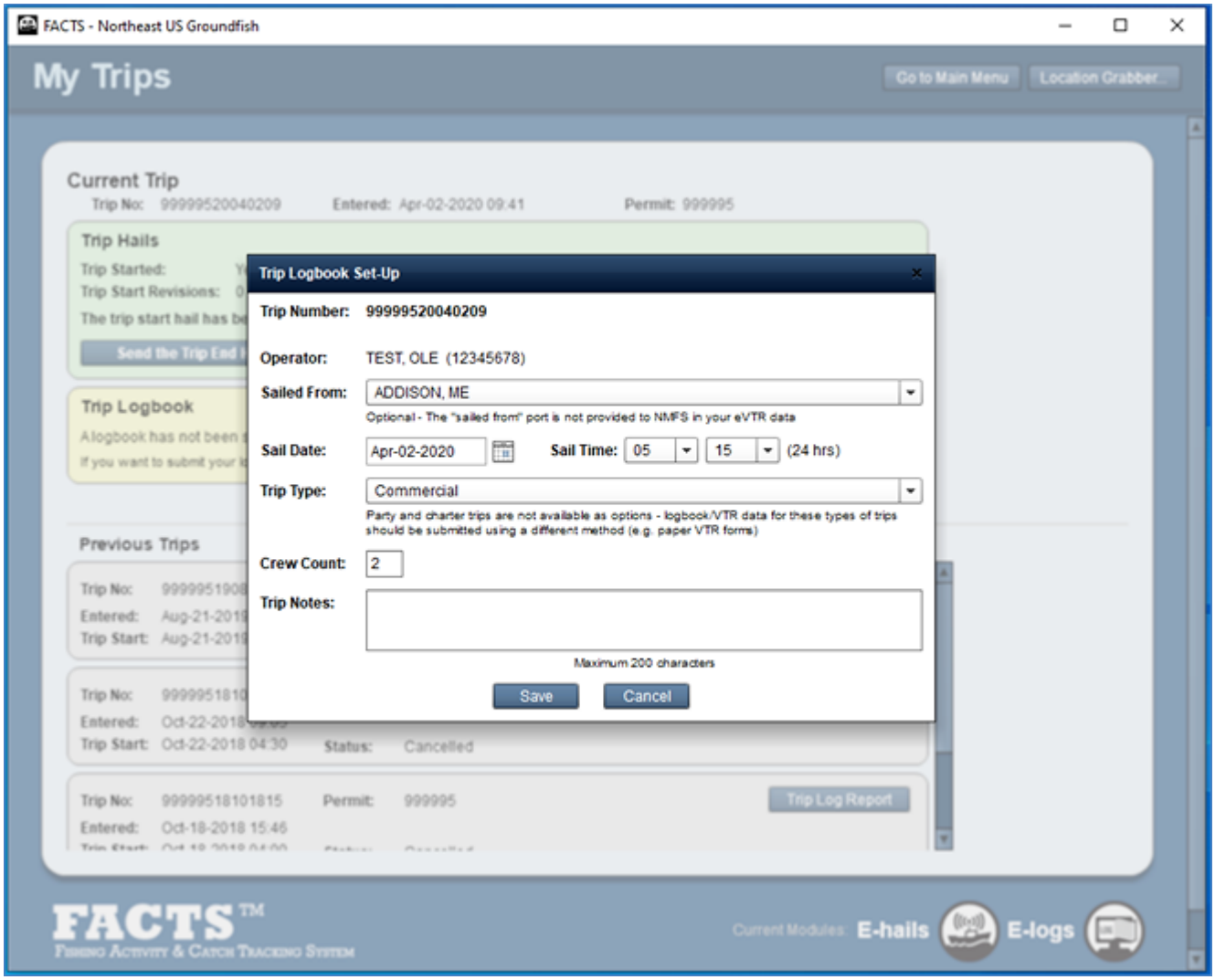


Figure I-7
FACTS: The Logbook's Data Entry Screen for Effort Details

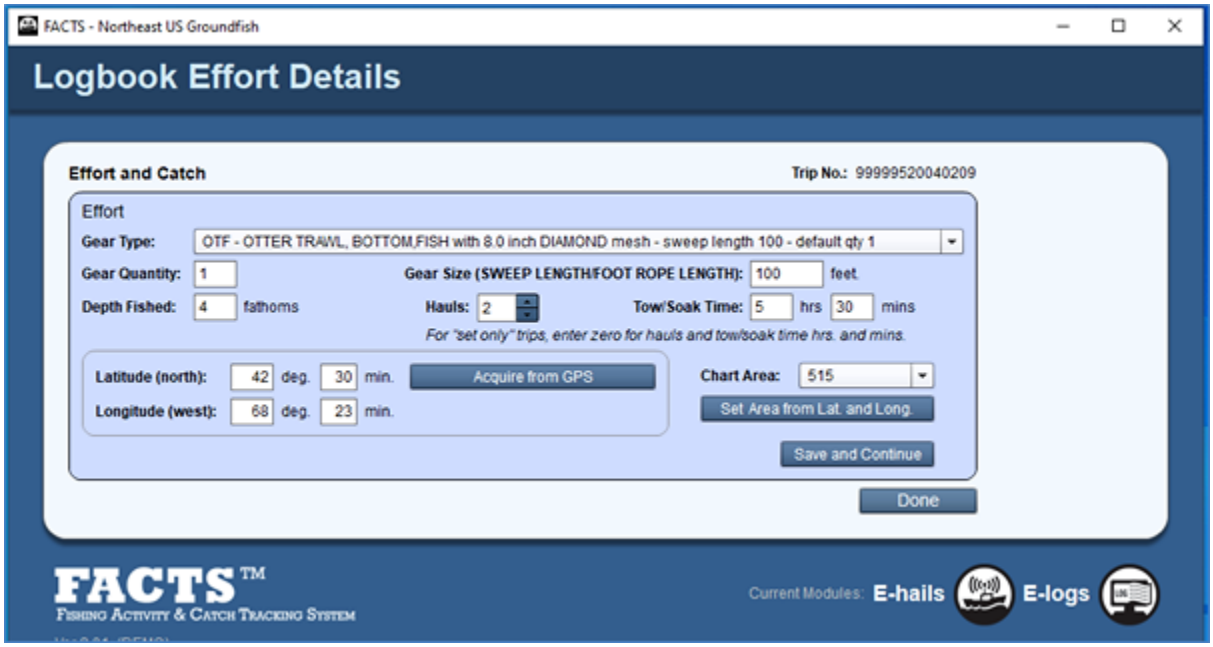
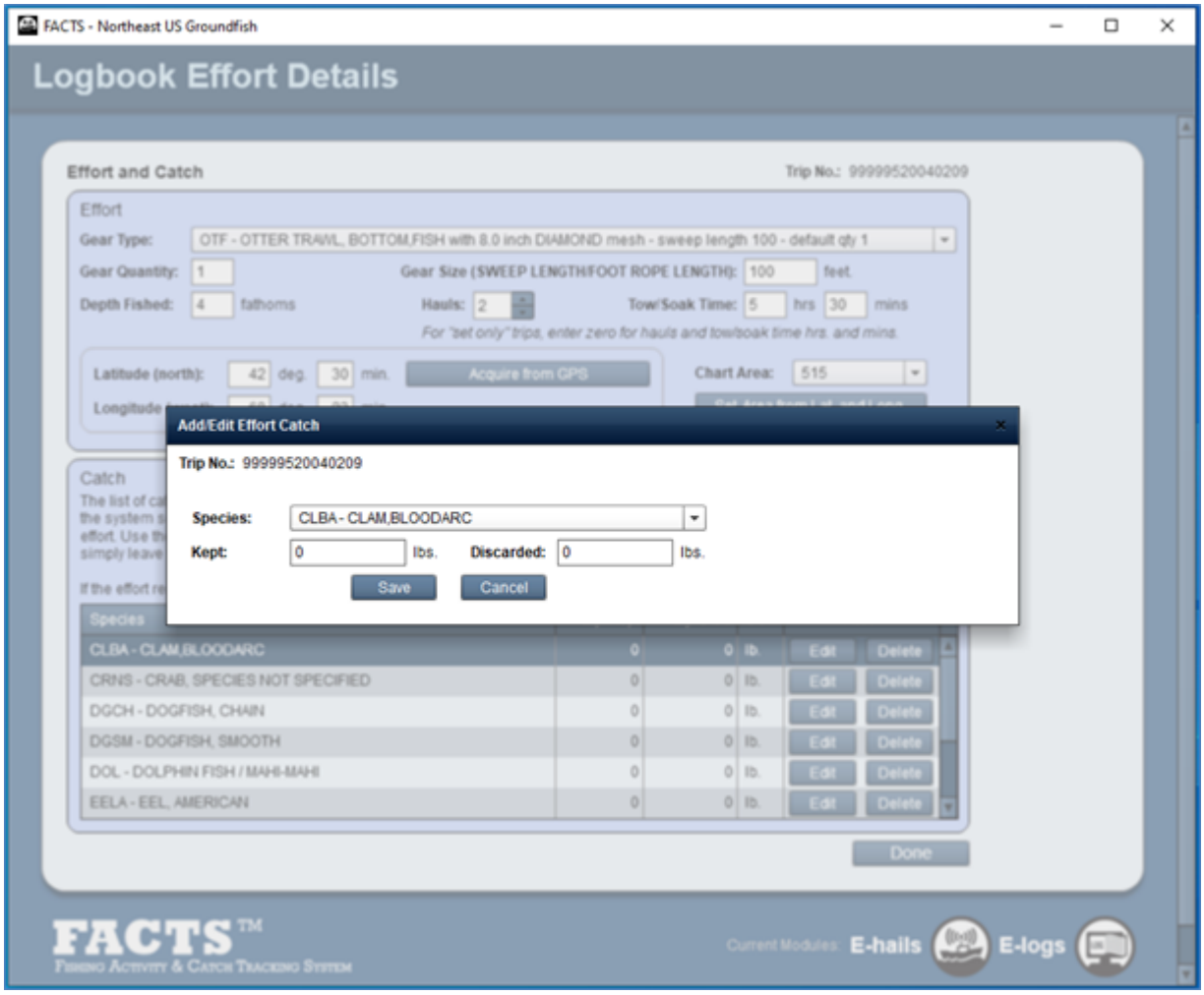


Figure I-8
FACTS: The Logbook's Data Entry Screen for Catch Details



When the trip is complete, landing details are entered to indicate the dealers to which the catch was sold (Figure I-9). Finally, the logbook records are submitted (Figure I-10).

Figure I-9
FACTS: Landings Data Setup

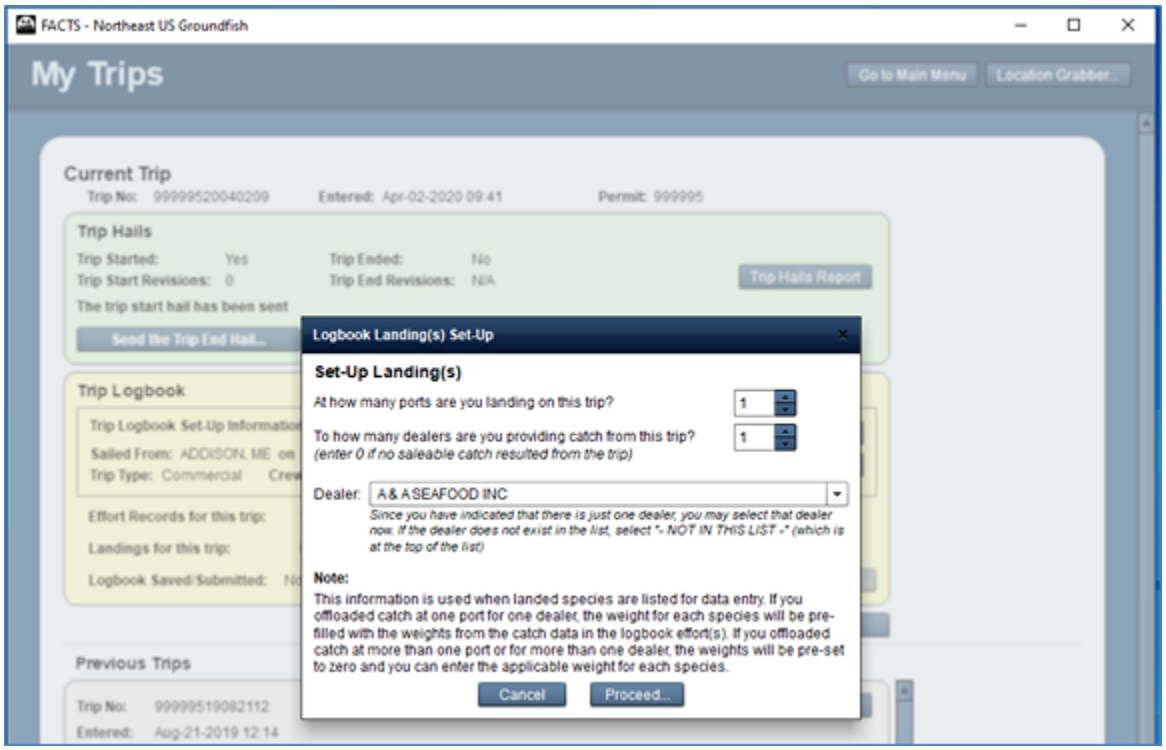
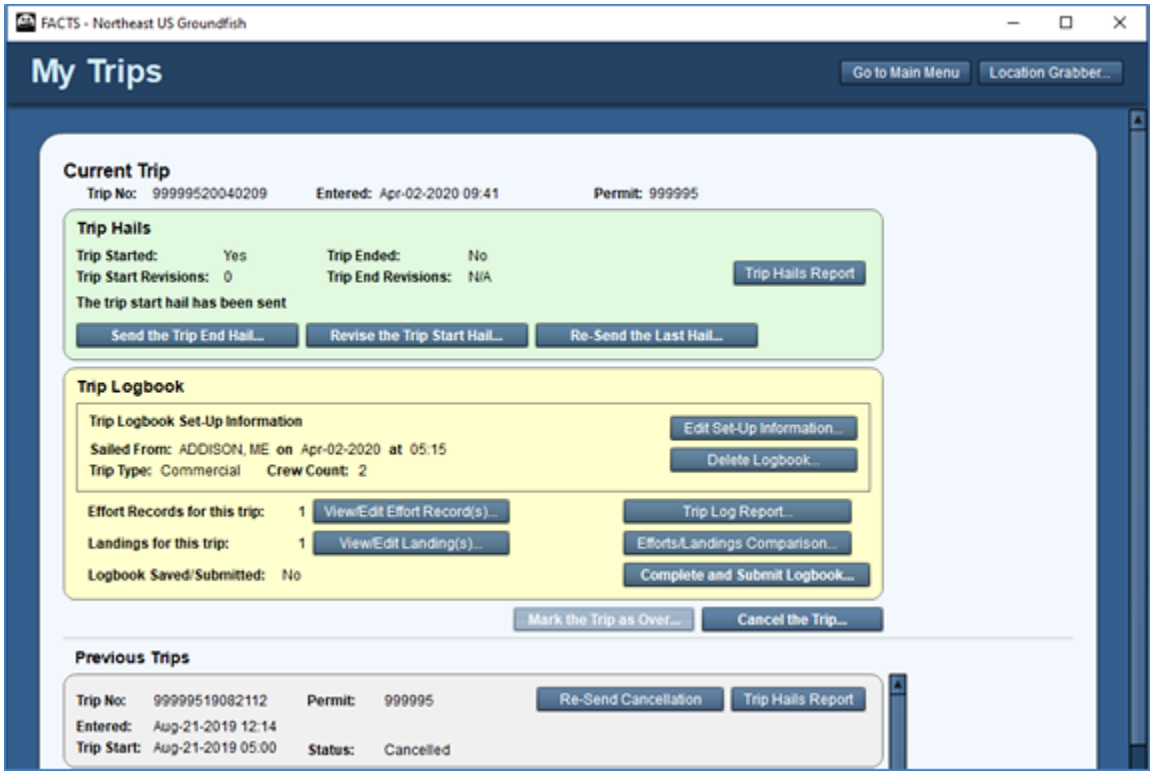


Figure I-10
FACTS: The My Trips Screen Where Logbook Data Are Entered and Submitted Once Complete



Deckhand by Real Time Data Inc.

The following screenshots (Figures I-11 through I-16) are of the Deckhand application developed for use by the Maine lobster fishery.

Figure I-11
The Deckhand Application On a Mounted iPad in a Lobster Boat's Wheelhouse

Figure I-12
Deckhand: The User Information Screen to Enter Name; Permit, Landing, and Phone Numbers; and Vessel

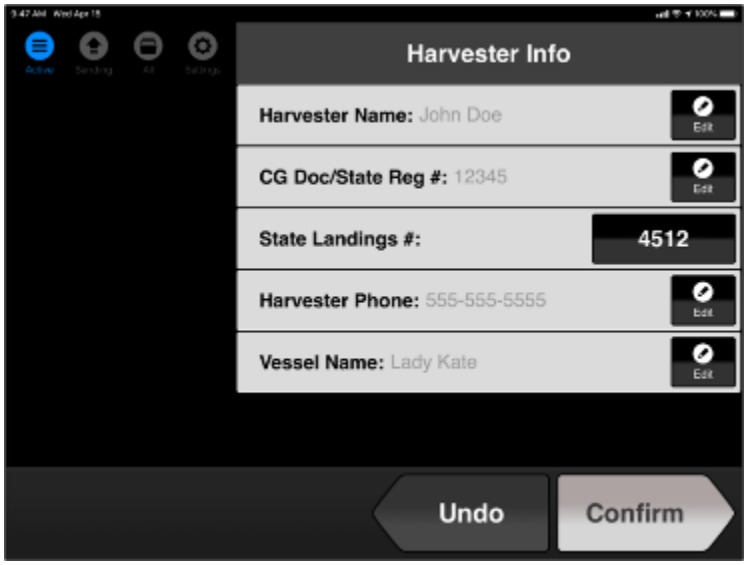


Figure I-13
Deckhand: The Start Screen to Starting a Trip

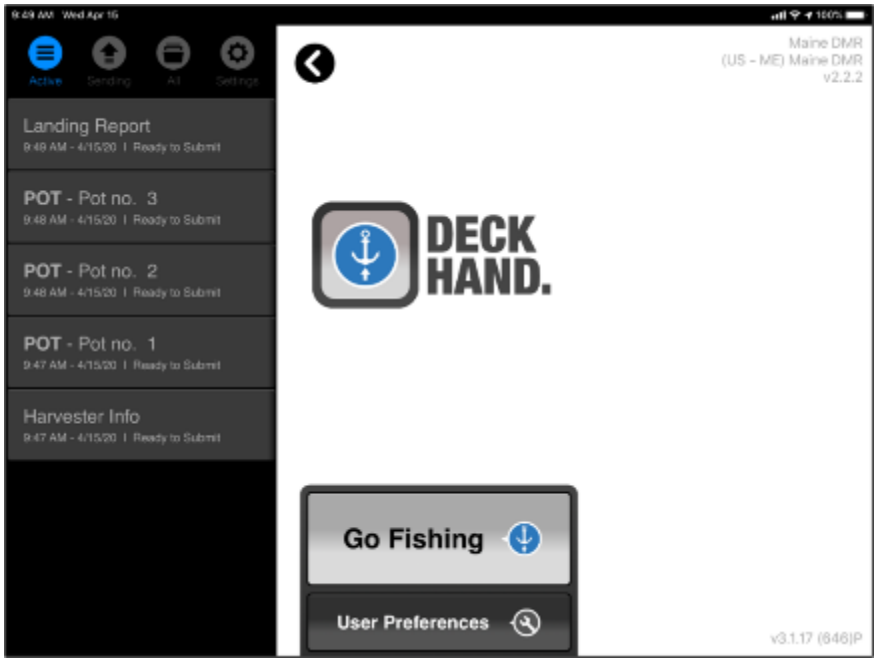


Figure I-14
Deckhand: The Interface Where Fishers Enter Lobster Pot Data

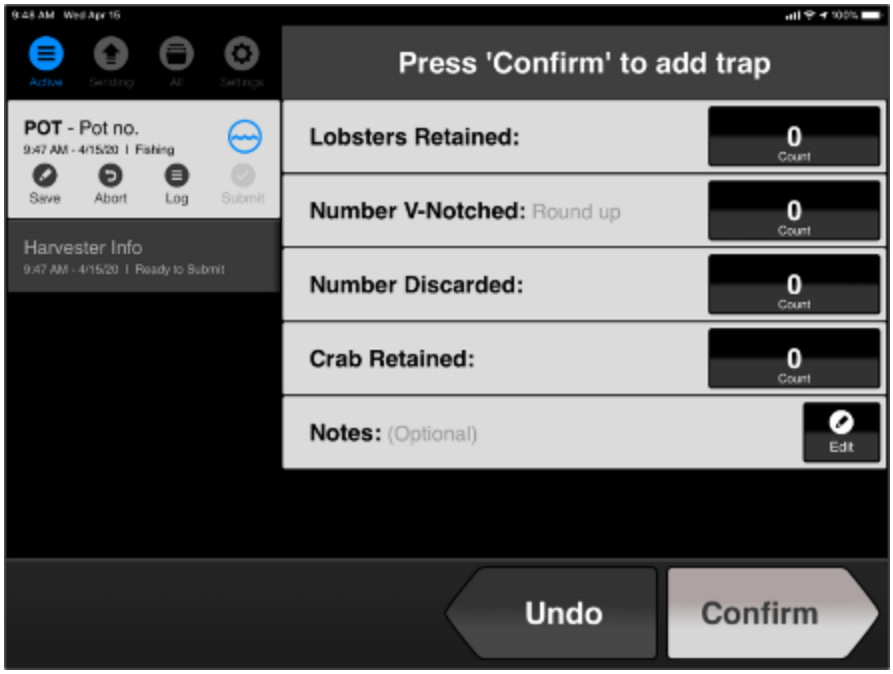


Figure I-15
Deckhand: The Top Portion of the Landing Report, Showing Total Pounds, Gear Type, and Gear Quantity

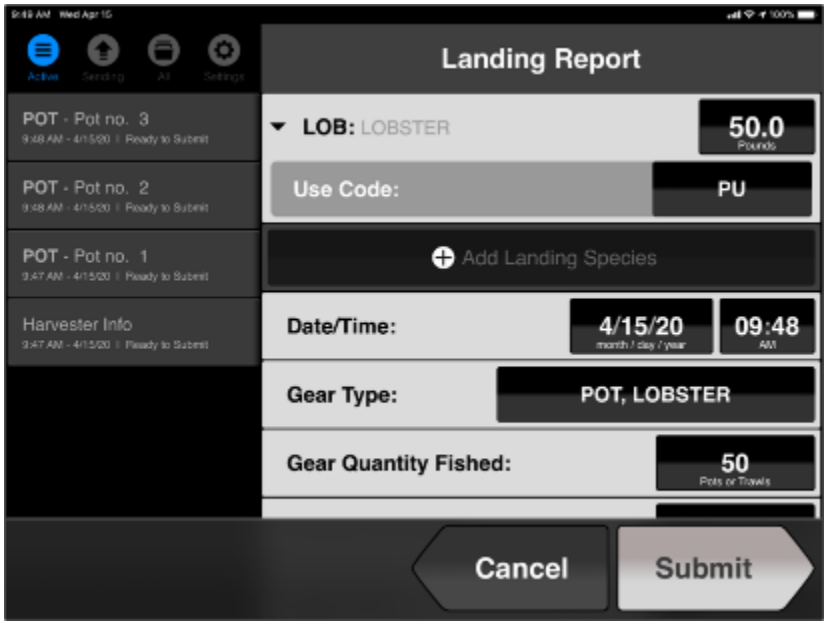


Figure I-16
Deckhand: Landing Report After Scrolling Down to the Bottom Portion, Showing the Number of Hauls and Soak Time