

Design goals, technical implementation and practical use of Another data entry system (Andes)

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ENTRY SYSTEM (ANDES)

by

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ABSTRACT

Ricard, D., Fishman, D., Beazley, L., Boivin, B., Emberley, J., Martin, R., Rolland, N., Sean-Fortin, D., Stoyel, Q. and Vergara, P. 2024. Design goals, technical implementation and practical use of Another data entry system (Andes). Can. Tech. Rep. Fish. Aquat. Sci. nnn: vi + 48 p.

An event logger and data entry system to facilitate the capture of information collected during scientific field work conducted by DFO Gulf Region was developed. The application, called “Another data entry system” (Andes) was implemented as a browser-based environment that facilitates its deployment in a variety of data capture scenarios. Here, we describe the design goals and implementation details of Andes, and present a number of usage cases. Although the system is tailored primarily for use on fishery-related ecosystem surveys, the flexibility of the application in terms of adapting to new gear types and deployment options promotes its use in a wide variety of applications. To promote transparency, longevity, endorsement and use of Andes by other scientific groups, the application utilizes Open Source software and a shared code development platform.

RÉSUMÉ

Ricard, D., Fishman, D., Beazley, L., Boivin, B., Emberley, J., Martin, R., Rolland, N., Sean-Fortin, D., Stoyel, Q. and Vergara, P. 2024. Design goals, technical implementation and practical use of Another data entry system (Andes). Can. Tech. Rep. Fish. Aquat. Sci. nnn: vi + 48 p.

Un système d'entrée de données pour faciliter la saisie des informations recueillies lors des activités scientifiques menées par la Région du Golfe du MPO a été développé. L'application, qui s'appelle "Another data entry system" (Andes), a été mise en œuvre en tant qu'environnement basé sur un fureteur, ce qui facilite son déploiement dans une variété de scénarios de saisie de données. Les objectifs de conception et les détails de mise en œuvre d'Andes sont décrits, et un certain nombre de cas d'utilisation sont présentés. Pour promouvoir l'utilisation d'Andes par d'autres groupes scientifiques et assurer la pérennité du projet, l'application s'appuie sur des logiciels code source ouvert et utilise une plate-forme de développement de code partagé.

1 Introduction

The scientific activities conducted by the Atlantic regions of Fisheries and Oceans Canada (DFO) include ecosystem surveys, oceanographic monitoring surveys, sentinel fisheries programs, coastal surveys, port sampling and many others where field data are collected. These monitoring programs require the collection of a wide variety of information on the marine environment and ecosystems, and are used to inform science-based decision-making. To support the collection of data and metadata during those surveys, paper-based systems were initially used during field work on research vessels, fishing vessels or at commercial ports. With the advent of computing capabilities, paper data sheets were digitized and the resulting data were stored for subsequent analyses. In the 1980s and early 2000s, a number of computer-based data entry systems were developed, in particular to support the activities of scientific ecosystem cruises where a variety of instruments are used to collect data. For scientific trawl surveys, this meant a tool that could support the activities associated with processing the catches from the net, and that could also be used to manage other survey activities while at sea. In the Maritimes and Gulf regions of DFO, the Groundfish Survey Entry (GSE) and later the Ecosystem Survey Entry (ESE) were deployed on workstations in the wet laboratory of research ships. These applications supported the capture of data on individual specimens, including the collection of length frequencies and more detailed sampling based on the survey goals and associated protocols. In the Québec Region of DFO, a similar tool called the "Module des Relevés de Recherche" (MRR) was developed and used to directly enter data in digital format on the research vessel.

The later versions of those data entry systems were built with Visual Basic for Applications (VBA) and relied on Microsoft Access databases. While highly functional, both the ESE and the MRR have important limitations:

- Despite being used over a local area network (LAN), these tools are not designed to work in a networked configuration.
- These tools are unilingual (French or English depending on the DFO region) and their infrastructure does not readily support multiple languages in their user interface.
- Pre-.NET Visual Basic (VB), the main development framework used to build the applications, is a dated programming language. To adapt the software so that modern libraries can be used and to develop an Application Programming Interface (API) in VB will become increasingly difficult over time.
- The use of a Version Control System (VCS) is incompatible with the Microsoft Access applications that VB applications rely on. The absence of a VCS presents serious challenges for managing, disseminating and troubleshooting versions of an application across multiple platforms and is a major impediment for a collaborative approach to development.
- While these applications were built by DFO, multiple attempts to obtain support for these tools from Information Management and Technology Services (IMTS) (now Chief Digital Officer Sector) were unsuccessful. This lack of support means that technicians often resort to either using a spreadsheet application such as Excel, or use a pen and paper to perform activities unsupported by the applications. Performing data entry using separate and

disconnected methods means that the data have to be manually consolidated at a later date which is time-consuming and prone to error.

- The lack of a true server-side application (e.g. web application) means that agile development is effectively impossible; especially in the context of a scientific mission that is underway.

While the status quo was meeting the immediate data capture needs of DFO scientists, a proactive stance towards addressing the above spurred the development of Andes. This project effectively began in the summer of 2018 and coincided with a need to provide application support for port sampling data collection. The first field deployment of Andes for an at-sea scientific mission took place in the fall of 2019 during the southern Gulf of St. Lawrence September ecosystem survey. In its pilot year, Andes was used in parallel to the ESE on board CCGS *Teleost* and was tested and modified to ensure that it performed as intended in supporting data entry during scientific activities.

This report documents the design principles that guided the development of Andes, provides technical details about its implementation and examines the usage cases encountered thus far. It provides guidelines for assessing the suitability of Andes for novel applications (e.g., other field activities and sampling programs) and discusses the ways in which the application could gain further adoption in supporting a diverse range of data collection activities within DFO.

2 Methods

The overall goals for the redevelopment of the data acquisition system used in the DFO Gulf Region were to utilize a contemporary software development environment, facilitate transparency through use of a shared code development environment, have the ability to support multiple languages, and to support flexible deployments. The envisioned application would be modularized into different consoles to allow for a diverse range of uses, while leveraging the same core features and infrastructure that the existing application was built on. As the starting point of Andes was the ESE which was used during the annual September survey conducted by the DFO Gulf Region, the replacement data entry software had to first replicate all the proven functional capabilities of the ESE. Early versions of Andes achieved those goals and the system was further developed throughout its usage by scientists in the Gulf Region.

The development of Andes coincided with the desire to revamp data collection procedures relating to commercial port sampling activities (Benoît and Daigle 2007). To provide an alternative to the paper-based forms, an application that could be deployed on field tablets for scientific staff was required. A typical usage case for such an application is to obtain length-frequency samples from commercial fisheries landings, either onboard fishing vessels, on wharves or in fish processing plants. Sampling protocols often include additional requirements such as length-stratified sampling of materials such as otoliths, or the collection of whole individuals for later processing in the laboratory. The data structure, protocol flexibility, and deployment requirements of this initial port sampling application provided many of the foundational components for other usage cases.

Andes was designed with 3 main uses in mind: 1) as the main data entry system for ecosystem

survey observations; 2) to track and capture data and metadata from oceanographic observations; and 3) for commercial port sampling activities. For use on the ecosystem surveys, the application must allow for the capture of all information and parameters detailed in the sampling protocols of the survey (e.g. Hurlbut and Clay (1990)). This entails the capture of all information related to fishing activities, plus ancillary variables such as weather, sea state, and water temperature. As catch contents are sorted and identified during the ecosystem surveys, the data entry application must support users in obtaining catch weights and abundance by taxon, individual observations of a specimen's length, weight, maturity status, etc. The application should also be designed to flag users when specimens are to be collected, or when additional sampling requirements are present (e.g. collecting fish otoliths, gonad samples, fin clips, etc.).

A large component of the ecosystem surveys conducted by the Gulf, Québec, Maritimes, and Newfoundland and Labrador Regions includes the collection of physical, chemical, and biological oceanographic data in support of the Atlantic Zone Monitoring Program (AZMP) (Therriault et al. 1998). A CTD/Rosette system is deployed at a subset of fishing stations where vertical profiles of conductivity (salinity), temperature, dissolved oxygen, chlorophyll and other parameters are collected. Water samples (e.g., nutrients, dissolved oxygen, salinity) are collected at predetermined depths using the Rosette system and attached Niskin bottles, and plankton samples are also collected via vertical ring net tows. These data support annual “state of the ocean” reporting conducted by the [AZMP](#), and are also used in various stock assessments and ecosystem research projects to provide additional ancillary variables for interpreting the captures data.

Historically, the event metadata associated with the deployment of oceanographic equipment on the ecosystem surveys was recorded using the Electronic Logbook (ELOG) system, a browser-based logging system developed by the Paul Scherrer Institute, Switzerland. However, ELOG was installed and operated in complete isolation from logging systems used for the biological data, making it difficult to merge the two datasets upon completion of a survey. Ideally, the new application would streamline the capture of oceanographic data and simplify its association with the corresponding biological data.

The following section outlines additional user requirements and design principles that also played a role in decision-making during the development of Andes.

2.1 Flexibility, scalability and reliability

The development environment used for the application must be a contemporary programming language with a proven track record for performance, usability and adaptability. Within the context of DFO Science, there are a high number of usage cases under which this application can be deployed. For example, the number of users might range from a single employee alone in the field to several dozen scientists, technicians and vessel personnel participating in a research cruise. Similarly, the application might need to be deployed on a stand-alone device or accessed from within a LAN or even over a wide area network (WAN). The application must be able to accommodate a wide range of practical scenarios.

2.2 Version control/source control

The utilization of a VCS is an indispensable component of a sustainable development workflow. Version management is especially important in the context of having concurrent instances of the application in production at any given time. Knowing the version of a production instance is necessary to resolve any issues that might arise. Similarly, databases and backup files are intimately linked to an application's version number. In order to successfully re-instantiate a backup file, the precise version under which it was produced must be known. The VCS will also provide an indispensable framework for the coordination, examination and integration of contributions from collaborators.

2.3 Unit Testing

The application performance needs to be reliable, especially considering its potential to be deployed in remote field environments. The implementation of unit tests is a practical way to ensure the maintenance of core functionality over time. At one extreme, the addition of any code can be preceded by the creation of unit tests (i.e., test-driven development). This approach will maximize the stability of an application, but can hinder the momentum of a project, especially in its early stages. At the other extreme, application development in the complete absence of unit testing occurs at a relatively fast pace but will result in a project that is vulnerable to breaking in unexpected ways and one that is difficult to maintain and to on-board new development team-members.

2.4 Backup strategy

In all deployment scenarios, data of high business value will be captured and there is little to no tolerance for data loss. Accordingly, the application must have a way to facilitate the implementation of a robust data-backup strategy. Capturing numerous snapshots of the application (and database) is ideal since doing so provides redundancy as well as the ability to revert to a specific point in time. If possible, the backup files and snapshots should be stored on storage volumes that have some form of redundancy.

2.5 Customizable protocols

The flexibility of scientific project leads to design, modify and report on their sampling protocols, without depending on developers, is very important. The application should allow users to provide a variety of detailed information based on their particular sampling protocols, without the need to change the application source code. Similarly, different protocols utilize different code conventions for the identification of biological catches. The application should offer the flexibility of users to utilize their preferred system of catch codes.

2.6 Quality control

The implementation of quality control checks in a data entry application is of paramount importance. For the usage case that supports a scientific fisheries survey, the following quality control checks must be part of the application:

Fishing sets The application should ensure all the required information about a fishing location have been filled in. Users should be warned if the fishing station start and/or end coordinates fall outside the expected sampling stratum (if applicable).

Catches The application should verify the validity of catches that do not have any specimen-level data entry associated with them. This validation is important to help identify catches that might have been entered accidentally.

Specimens The application should flag specimens whose length falls outside an acceptable range and should not allow blank values. Similarly, a validation of the specimen's length-to-weight ratio should be performed to warn users if a recorded measurement falls outside the expected range.

Observations Individual observations are characterized by an observation type. Observation types should have predefined data types such as integer, float, string or categorical. The application should ensure that inputted observation values respect the data type of the corresponding observation type, and falls within an allowable redefined range. In the case where an observation type (e.g., sex) has a set of defined categories (e.g., male, female, unknown), the application should ensure that any entered values fall within the set of available options.

2.7 User interface

The user interface of the application can have a significant impact on user experience and on-boarding. By ensuring the application has a modern and intuitive interface, the barriers related to on-boarding new users are significantly reduced. Furthermore, an intuitive interface will reduce the need for extensive help documentation. Wherever extra annotation is required, documentation should be inserted directly in the application in the form of tool tips and help bubbles. By appealing to the end users' intuitions and by providing in-situ help documentation, we reduce the likelihood that fields and features get used incorrectly.

2.8 Reactivity

In the context of being on a research vessel survey, data entry happens at a very high rate and on numerous devices; often with multiple transactions per second. Accordingly, it is imperative that the application does not create a bottleneck for data entry and is able to keep pace with experienced technicians. The usage of a reactive Javascript library (code execution on client devices) in conjunction with an API (code execution on the server) would allow data entry to occur without webpages having to constantly refresh.

2.9 Multilingualism

The ability for users to choose the language of their choice in the application is of considerable importance to this project. Previous tools that have been used were unilingual, and this by itself would have limited the scope of their use in a Canadian national context.

3 Results

3.1 Architecture

The architecture of Andes differs significantly from that of its predecessor (see Figure 1). The application and its associated services are centralized on one or several servers and include: 1) a web-service for handling HTTP requests and responses; 2) a database service for storing data associated with the application; 3) a file-sharing service for handling the storage of backups and related files; 4) a printing service used for printing out specimen labels; and 5) a message-brokering service for handling asynchronous tasks. Client devices, such as data-entry workstations, no longer require the installation of anything more than a modern web browser; i.e., one that is capable of supporting HTML5 and ECMAScript 2016 (Javascript). Accordingly, this increases the range of devices and operating systems that may be used for accessing the application. For instance, the switch to using Andes has allowed for the integration of mobile phones, tablets and linux workstations into the data entry workflow. Finally, the new configuration means multiple stations can simultaneously receive and enter data into the same Andes instance.

The [Django Web Framework](#) was selected for the backend of this application due to its modularized nature; virtually all aspects of the programming framework can be decoupled. Furthermore, the Django framework is written in pure Python language—an open-source, generalized object-oriented programming language that is popular for use in data-heavy applications. In addition to standard Django templates used to render HTML webpages to end-users, the web framework also contains an elaborate Representational state transfer (REST) Application programming interface (API) component. Django uses an Object Relational Model (ORM) to handle the data layer, and includes APIs for a variety of modern relational database management systems (i.e., PostgreSQL, MariaDB, MySQL, Oracle, SQLite, etc.). Several of the application's frontend templates contain reactive components implemented in Vue.js.

The frontend of the application is built in HTML5, JavaScript and Cascading Style Sheet (CSS). Most users will be familiar with the flow and functionality of a web browser and will be comfortable navigating and entering data into a website. Facilitated by the Django model and form classes, all controls (i.e., fields) on the website contain verbose descriptions and help text. The [Bootstrap v5.0](#) CSS and JavaScript libraries were utilized in order to give the application a sleek, modern look and to ensure compatibility with different types of devices (e.g., personal computers, tablets and mobile devices). The Bootstrap library also provides palatable styles for displaying help text in the form of popups and tool tips.

While web applications are most often used over a network, the Django library comes with a development web-server that permits users to serve and use the application locally. In

this scenario, a single computer acts simultaneously as server and client. While there are important limitations to the use of the Django development web-server in a full-scale production environment, the option to run and use Andes on a single device is an advantage for stand-alone, non-networked usage cases (e.g., field tablet used for port sampling).

The architecture used by Andes creates networking requirements that were not previously present in the ESE and MRR (i.e., under scenarios where they are not the same device). The server and the client devices must be connected to the same network. The network does not need to have access to the WAN (i.e., the internet) connection. As long as they are connected to the same LAN, they can be configured to work together. This suits the networking environment on board remote vessels that can have sporadic connection failures with the outside world.

The Andes application provides access to its various components based on an internal system of authentication and authorization. The credentials of a given user will affect what action they are able to do. For example, while the chief scientist is able to modify sampling requirements for the mission, other users are not.

3.2 Andes Modules

The main index page of the Andes user interface (Figure 2) allows users to access several different modules that loosely correspond to the main use cases defined in the above Methods section. Access to the different modules is determined by a system of authentication and authorization. Consequently, the index page will appear different to users depending on the permissions they have been granted.

While Andes has been implemented using a modular design, there is a core set of components that are used across modules. This is true at the level of the database, where in addition to a number of shared tables, submodules will have tables that are specific to a given use case. For example, while the Mission table is used across several modules, the Specimen table is specific to the Ecosystem Survey module.

Similarly, Andes has modules that are used across multiple user scenarios; in particular, the Bridge module (Figure 3) and the Cruise Dashboard (Figure 4). These modules display high-level information to end users such as queued stations, vessel speed, position, heading and various summaries of science activities that are underway or that have already taken place. All core pages of the application can be toggled to night mode, as desired.

Within the application's configuration settings, modules can be enabled and disabled at both the user-level and the mission-level. For example, on an ecosystem survey that is also conducting oceanography data collection, the oceanographic technician will have access to the Oceanography app while technician in the wetlab will not. On single-purpose missions, modules can be toggled on or off for all users, thereby essentially stripping unneeded components from the user interface.

3.2.1 Bridge

The Bridge module (Figure 3) is used by navigation and fishing officers in the wheelhouse (usually on a tablet) to input fishing set metadata. The data entry occurs in two ways: 1) by manually editing the set form (a.k.a. the set card); and/or 2) via the Fishing Console, which is displayed in Figure 5. The Fishing Console can directly capture a GPS feed to record the time and location of a number of different user-defined events that take place during fishing. Through the application settings, these events can be configured to trigger downstream actions, such as the starting/ending the capture of data from the sonar and trawl measurement system sensors (e.g., Scanmar system). The Bridge console also links directly to the Trawl Validation console which provide realtime feedback and validation of trawl measurement system sensors (Figure 6).

3.2.2 Set Manager

The Set Manager module is used to manage upcoming sets and review completed set cards. Typically accessed by the chief scientist and team leads, it provides the ability to select upcoming sampling locations and initialize the corresponding set cards. The Set Manager module is where sets can be activated and deactivated. Additionally, this module is where any quality assurance flags associated with a set and its catches can be reviewed and accepted.

3.2.3 Ecosystem Survey

The Ecosystem Survey module is the main entry point that technicians will use to input survey data. A depiction of the main tables involved in the Ecosystem Survey module, and their relationships are displayed in Figure 7. This component of Andes replicates the capabilities of the ESE for capturing detailed information on length, weight, ageing material, maturity, etc. about fish and invertebrate specimens. This module, typically accessed from the wet laboratory of a survey vessel, is used for all entry of data related to measurements and observations of marine organisms. New catches are first entered into the Active Catches page, as portrayed in Figure 8. The Active Catches page accepts user-defined catch codes as a way to input new catches into a set. If a code is not known by the user, a search feature is available. Next, baskets and their corresponding weights and statuses (e.g., sampled vs. not sampled) are then entered into the Catch Card page (Figure 9). Finally, specimens are entered into the Data Entry page (Figure 10). As the data entry progresses, users are dynamically prompted with observation fields that follow the catch-specific sampling protocol. An overview of the sampling protocol is displayed on the right-hand side of the Data Entry page.

3.2.4 Shrimps

The Shrimps module is an extension of the ecosystem survey module focused exclusively on shrimps as it has different workflow requirements (Figure 11). This module provides a special case of Andes' subsampling functionality, and allows the user to subsample a total catch of shrimp into different species and maturity stages before collecting biological data (cephalothorax

length for all species and occasionally weight for *Pandalus borealis*). Additional mission and protocol-level configurations are needed prior to this module being used.

3.2.5 Charts

The Charts module (Figure 12) leverages the [Bokeh](#) Python library to generate data visualization of arbitrary length and weight observation variables that were attributed to specimens. The module provides an interactive scatter plot of length vs weight as well as a length histogram. The data can be filtered by species, set and sex (when available). This visual presentation of the data is meant as a supplemental validation aid in identifying outliers that may have escaped the quality controls. Should outlier points need further manual inspection/intervention, a direct link to access/edit the specimen data is conveniently made available.

The user is also presented with options to include an empirical growth model together with weight vs length scatter data. This option, which only applies for “official” length and weight observation types, can be useful for tuning the tolerance band used for quality control (see Quality Control section below).

3.2.6 Oceanography

This module is used to track and record the deployment of oceanographic instruments such as CTD/Rosette systems, plankton nets and Argo floats (Figure 14). Following the conventions established by ELOG, the deployment of a given instrument is referred to as an “event”. A collection of events carried out at a point in time and space is referred to as an “oceanographic sample”. The Oceanography module is a component of the Andes application that is capable of being deployed independently of the Ecosystem Survey module.

The module’s primary purpose is to capture metadata pertaining to oceanographic samples and events. In the mission configuration, user-defined “actions” can be programmed in associated with each instrument type. Typical actions collected for CTDs and plankton tows are “deployed”, “on bottom”, “recovered” and “abort”. When an action button associated with an event is clicked or “fired”, the date/time and location of the occurrence is logged. Oceanographic actions are analogous to the fishing events described above however instead of being logged at the set / sample level, they are logged at the oceanographic event level.

Instrument-specific metadata is also collected. For CTD/Rosette deployments, details pertaining to what water samples/parameters were collected from what depths can be recorded (Figure 15). Certain parameters, such as eDNA and dissolved oxygen, allow additional observations to be captured in supplementary tables. For plankton tows, details pertaining to sample identification, mesh size, start depth and end depth can be recorded (Figure 16). The simplified Entity Relationship Diagram of the Oceanography module of Andes is presented in Figure 17.

Upon completion of a survey, Andes is designed to provide a series of oceanographic summary reports that summarize aspects of the data collected:

Mission instrument report Provides a summary of the oceanographic equipment used on the survey, including component type, model, serial number, and date of last calibration (for CTD sensors).

CTD metadata report For each fishing set and station where the CTD/Rosette system was deployed, the date, time, position, sounding, and bottle sample IDs are provided.

Hydrolog report For each fishing set and station number, a summary of the CTD/Rosette and ring net deployments are provided, including the event numbers corresponding to each gear deployment, comments entered into Andes regarding each gear deployment, summary information related to each set and station, including surface temperature, sounding, day of year, and date/time.

Plankton report This report provides a summary of the plankton net deployments conducted in relation to each fishing set and stratum. The wire out and wire angle, as well as flow meter start and end are provided.

Bottle report This report provides a detailed summary of each CTD/Rosette operation (e.g., altimeter height, bottle height and depth, max. CTD depth), the water samples/parameters collected, and also includes the results of the Winkler titrations for dissolved oxygen samples, if entered into the Oceanographic Activity detail page.

TS report This report provides a summary of the surface and bottom temperature and salinity data from each CTD cast in relation to each set, station, and stratum.

ELOG report This report emulates the .log summary report produced by ELOG. This report is required in order to upload the survey data into the Microsoft Access template used by AZMP to load data to BioChem, DFOs national repository for discrete and plankton data.

These reports facilitate the post-processing of the data, its integration into existing data repositories and its distribution and upload to various open data platforms.

3.2.7 Forecasting utility modules

There are a number of task-specific modules designed to assist in mission forecasting and planning. These modules are designed to provide timely information to scientific staff participating in a research cruise, and to also assist the chief scientist and watch leaders in the planning and execution of a mission.

Cruise dashboard

The cruise dashboard module is used to provide an overview of the current status of a mission to all Andes users (Figure 4). It provides a range of real-time statistics that are used for planning purposes, including current status (e.g., fishing, steaming, deploying/retrieving net), the list of upcoming stations, and data from the latest trawl.

Forecasting

The forecasting tool is designed to provide real-time prognostics of survey completion targets based on assumed transit speeds and time spent fishing and processing the trawl catches (Figure 18). This feature provides a useful tool for the chief scientist to evaluate different sampling objectives and to compare different survey route options. As the conditions change regularly during a survey, this tool links with the set manager to provide an estimate of the amount of time required to complete planned stations. This tool can be used for short-term planning (i.e., a day's worth of sampling) or longer-term planning (i.e. a mission's worth of sampling).

Progress Map

Another task-specific utility is the progress map which shows what strata have been completed based on target and minimum number of sets per stratum. This map provides the chief scientist with a clear visual depiction of what has been accomplished and what remains to be accomplished during the survey. The number of sets conducted in each stratum is compared to the minimum and target number of sets per stratum to determine the colour that each stratum will appear in the progress map (Figure 19).

3.2.8 Images

The images module is a component of the Andes application designed to streamline image management during surveys. The module enables images to be captured and stored directly from the application using a smartphone, tablet or webcam. Doing so allows images to be directly linked to the set, catch, or specimen that they represent, eliminating the need to manually create this link from a filename after data collection is complete. Images are queued during data collection based on various triggers (user request, rare catch, sampling protocols, etc.). The queued images are listed in the app allowing users to capture them on a camera-enabled device which can be separate from the one being used for data entry.

3.2.9 Port sampling

Andes was adapted from a previous port sampling module to support activities where technicians obtain length frequency samples from commercial fishing activities. The port sampling module of Andes is stand-alone and is typically used independently of other modules. Similar to the Ecosystem Survey module, sampling protocols can be defined and implemented for specific catches, however in its current state, the protocols used in the Port Sampling module are less intricate. Through these protocols, users are able to control collection quotas (e.g., "keep two specimens per bin"), the flow of data entry (e.g., which field should be displayed in the sample form) and the layout of the data entry page (e.g., length bins organized in a vertical or horizontal configuration) (see Figure 20). Typically, production instances of this module are deployed on ruggedized field tablets that are suitable for use in wet environments.

The design of the user interface is simple and intuitive, where each length bin is a large button on the display. As specimens are tallied, the corresponding buttons on the touchscreen are pushed. When the collection quota of a given length bin has been met, the color of the button changes from blue to green. A screenshot of the data entry page is presented in Figure 21. Data export reports which allow the data from the field tablets to be imported into external production / archival databases are also available. The various tables of the Port Sampling module and how they relate to one another are shown in Figure 22.

3.3 Technical Implementation of Other Design Goals

3.3.1 Version control/source control

[Git](#) was selected as the VCS for this project due to the fact it is widespread in use and open-source. The remote repository for this project is currently hosted as a private project on the [Gulf Science organizational GitHub account](#). The project is additionally making use of GitHub infrastructure including, pull requests, issue management (e.g., bugs, feature requests and general enhancement requests), security alerts and version releases. The Andes [online documentation](#) is served using GitHub Pages.

3.3.2 Unit testing

For Andes development, we use a mixture of test-driven development for critical components of the application, and are also continually adding unit tests for more user-specific components. Using the built-in Python/Django testing framework, this strikes a middle ground between the two approaches described in the above section. While the goal is not to impose test-driven development for the application, the use of unit tests is highly encouraged, especially to back up the core functionality of the application.

3.3.3 Backup strategy

The Andes application has the capability to perform manual and automatic backups. These backups consist of two parts: the full contents of the database (in JSON format, in raw SQL format, or a standalone SQLite database file) and metadata pertaining to the current version of the application (i.e., the git hash). The structure of the application models and associated data structure will change over time with development. Accordingly, in order to re-instantiate a particular data snapshot, it is critical to know the precise software version from which it originated. This combination of data export and git version number, gives users the perpetual ability to recreate the exact application environment from the time of the snapshot, no matter how much the application has changed in the interim. In the application, backups are automatically created upon closing sets. Moreover, users also have the ability to manually trigger a backup at anytime.

The backup strategy for mediafiles (i.e., sample and specimen images) are slightly different.

When images are captured, copies are automatically synced to the server's backup location, which is typically a mounted share folder pointing to a file server with a /gls{raid} configuration.

3.3.4 Customizable protocols

Andes provides project leads the ability to create and modify sampling protocols through the user interface. By doing so, project leads are able to shape the flow and control the behaviour of the application during data entry. This includes deciding which fields to display in a form (e.g., set cards), importing stations and other geographical features (e.g., sampling strata, Northwest Atlantic Fisheries Organisation areas, Marine Protected Area (MPA)s, etc.) and the quotas and observation fields associated with different catch items. Examples of catch-specific sampling requirements that can be programmed by project leads can be found in Table 1.

3.3.5 Quality control

Andes implements a suite of quality control checks. All quality control flags that are raised during data entry are appended to a report and require sign off before a set can be closed.

Sets

The Andes provides clear feedback regarding the completeness status of a given set. Flags are raised if a set's start and/or end coordinates are outside the expected sampling stratum. Additionally, an alarm is sounded in the bridge console module when deviating from the desired stratum in real-time. The bridge console also provides personnel with fishing timers and tow distance displays (see Figure 5).

Andes will create a flag when the tow distance as calculated by the cruise track, differs from the tow distance as calculated by a straight line between the start and end coordinates by more than 5%. Andes will flag when the start or stop coordinates of a set are not within the expected NAFO area (if applicable).

Catches

There are numerous flags that can be attributed to individual catches. Flags are generated for catches that do not have any data entry associated with them. In addition to this, Andes will flag when the weights entered for baskets are considered suspect. This is determined by either the default maximum basket weight (mission level), or the maximum basket weight for a given species. Andes will also flag when the difference of total weight of *sampled* basket differs by more than 25% from the total calculated specimen weight. The total calculated specimen weight is a combination of actual weights (when collected) and those which were estimated from length measurements. The latter is achieved by using regression coefficients estimated from historical length (L in centimeters) and weight (W in grams) observations using the model,

$$W = aL^b \quad (1)$$

where a and b are the regression coefficients for a given species. Andes offers the option to specify separate regression coefficients for males, females or unspecified individuals (as shown

in Figure 23). An additional optional layer of quality control allows project leads to assign allow-lists and restrict-lists, commonly known as “whitelists” and “blacklists”, to a mission or to a specific geographic feature (e.g., a stratum). In this way, the validity of each catch entered into a set can be assessed. For example, if a catch being recorded is *not* on the that set’s associated allow-lists, the end user will be notified that this is an unusual observation and will be prompted to collect documentation. Similarly, if a project lead adds a catch to the mission’s restrict-list, users who enter this catch will receive a warning message, asking them to double-check the assignment. This is useful when project leads want to limit the usage of certain taxa during data entry, e.g., *Alosa* sp. is preferred over the use of *Alosa pseudoharengus*.

Specimens

Specimen lengths and length-to-weight ratios are validated against the parameters entered into the sampling requirements for that catch. Acceptable length-to-weight ratios are assessed by comparing the actual weight to the estimated weight, as described by Equation 1 in the section above. Additionally, Andes will flag when there is a mismatch between fish maturity and somatic length. Project leads can specify mature length thresholds for males, females or unspecified individuals in the sampling requirement of a given species (as shown in Figure 24).

Observations

When entering observations, Andes enforces the data type of the corresponding observation type; invalid entries are not accepted. When entering an observation for a categorical observation type, Andes will display the list of options to the end user and inhibit users from entering invalid selections. Andes will also ensure observation types are not left blank. However, NaN entries are permitted when a particular observation is meant to be skipped. Certain observation types are meant to be unique, e.g., unique tag number. If this is flagged at the level of the observation type, end users will be notified if there is a violation of this structure.

3.3.6 Reactivity

The [Django REST framework](#) was used to construct the REST-API component of the application. The project takes a hybrid approach, combining the use of standard Django views and Vue.js frontend applications embedded in the templates. The latter, which offloads some code execution directly on client devices, was used to avoid the need for constantly reloading webpages and to optimize the flow of traffic across the network. Reactive javascript frontend applications also provide a better experience from the point of view of an end-user.

3.3.7 Multilingualism

The Django framework has excellent support for internationalization and localization, including the translation of text and the formatting of dates, times and numbers. It achieves this using a system of ‘hooks’ used by developers to indicate which parts of the code should be localized. See [Django - Internationalization and localization](#) for more details on this process. In our application, an end-user can toggle between English and French by simply clicking on a button. In this way, each client can view the application in the language of their choice.

4 Discussion

Since its initial deployment during the 2019 September ecosystem survey in the southern Gulf of St. Lawrence, the capabilities and performance of Andes have significantly improved. The software has also been adopted as the main logging software used during ecosystem surveys conducted by DFO Gulf, Maritimes and Québec Regions. The current capabilities of Andes have evolved over the course of the last five years as the system has been used to support diverse field activities.

The forecasting tool and progress map presented in this report were not in the original deployment of the application and were added during a cruise based on the needs of scientific and Canadian Coast Guard (CCG) personnel. The reporting facilities provided by Andes were developed to support the many consumers of the data collected during scientific activities. Two types of reports are available for Andes: 1) reports meant to be used during ongoing field activities and 2) reports meant to be used after field activities are completed.

If a vessel is located within range of cellular phone signals, it is possible to make Andes accessible via the internet. While this has some important advantages, exposing an IP to the internet comes with security risks that have to be mitigated.

Andes is designed so that data backups are immune to the potential pitfalls of relying on earlier versions of required packages. Having backups that are associated with a specific git version, which includes a comprehensive list of all dependencies and an exact match of the application data model, allows users to readily bring back Andes to where it was at the time of the backup. Users can then access the reporting features that will allow them to create a version of the required data that suits their needs and facilitates inclusion in existing relational database management systems or other types of data solutions.

When present, the client-server separation lends itself nicely to be adaptable to new requirements. One can potentially expand upon the *system* with minimal changes to Andes by interacting directly with its exposed REST-API. For example, an imaging system can be aware of current GPS coordinates or current Set/Station. Photos or videos acquired by such an imaging system could automatically append these as metadata, or even add media identifiers directly to the database as they are captured.

Most modern vessels will already provide the minimum networking infrastructure necessary for system deployment where connectivity between a dry laboratory, a wet laboratory and the ship's wheelhouse is necessary. In the case where static networking options are not available, this requirement can be met using inexpensive consumer-grade, portable networking equipment (wireless router, switch, etc.). However, as installing an ad-hoc network for scientific needs in a vessel may lead to code violations, we urge Andes users to collaborate with vessel management bodies like the CCG or chartering authority.

The addition of allow-lists and restrict-lists was an important addition to Andes that came out of a Regionalization workshop that took place in December 2022 at the Gulf Fisheries Center. While these features will help improve the quality of data collected, it is important that if utilized, they should be detailed explicitly in the survey sampling programme. For example, if project leads add certain catch items to the restrict-list, this should be mirrored in the survey sampling programme.

Andes also supports the use of various electronic tools such as calipers, electronic measuring boards and scales. Drivers for the measuring boards and scale were developed by the Gulf and Quebec regions and are available on Github. Such peripherals, which often masquerade as keyboard input, are typically configured on host clients and as such don't need special attention to work with Andes.

While there is always an effort to make the user interface intuitive and self-explanatory, there is still the need to maintain documentation for the project. The Andes docs are maintained through GitHub Pages and are publicly available here: <https://dfo-gulf-science.github.io/andes/>

4.1 Integration of Andes with Existing Data Repositories

Andes is a standalone application with an underlying relational database management system. The data collected during research activities must be extracted from the application and integrated into existing databases. This step has proven to be challenging but has also encouraged close inter-regional collaboration since the challenges associated with integration were shared by the different groups involved.

4.2 Atlantic Zone (Offshelf) Monitoring Program (AZMP/AZOMP) oceanographic surveys

Andes was first trialed in parallel to ELOG on a dedicated oceanographic survey led by the Maritimes Region AZMP in spring 2022, and was recently used as the sole event logger during the 2023 Atlantic Zone Offshelf Monitoring Program (AZOMP) survey. During its initial trial on the 2022 spring AZMP survey, a number of limitations were noted. ELOG assigns each gear deployment a sequential 3-digit 'event' number. In contrast, early versions of Andes grouped all gear deployments in relation to a Set number, which is a primarily fisheries-related term that is not applicable to oceanographic survey data collection. Another limitation in the initial version of Andes was that it was designed to primarily support two types of instruments: CTD/Rosette and ring net deployments. However, during AZMP and AZOMP surveys, a wider variety of gear types such as Argo floats, oceanographic buoys, moorings, multinet and secchi disks are routinely deployed. Furthermore, deployment sequences and workflows associated with each type of instrument must have flexibility; something which was not present in earlier versions of the module.

In a recent version release of Andes, the above limitations were addressed in the following ways:

Autonomy The Oceanography module can now be used in complete independence from the Ecosystem Survey module. A mission can be configured to be in "oceanography mode" which, in effect, strips away any aspects of the Ecosystem Survey module from the end-user's experience.

Terminology Activities carried out at a given station are no longer grouped under a "set number" but instead under an entity called an "oceanographic sample". Also, the module refers to the deployments of instruments as "events" in order to be consistent with the terminology used in the ELOG

Customization Users can decide what types of observations are collected at both the sample and event levels. Additionally, within the mission configuration, users can specify which observations and action types are should be collected for different instrument types. Observation types, instrument types and action types are now completely defined by the user. Due to these changes, the flow of data collection for each instrument type can now be customized and managed independently. (see Figure reffig:screenshot-oceanography-instrument-type-configuration)

Flexibility The order of events within an oceanographic sample can be shifted in a quick and convenient manner.

ELOG allows users to create various ‘logbooks’ that allow for custom recording of metadata. On AZMP surveys, a custom ELOG logbook was created to capture metadata related to samples collected from underway or flow-through thermosalinograph (TSG) systems used on these surveys. A submodule could be developed in the future to allow for a similar level of data capture using Andes.

Andes shows great promise for enhanced data recording and oceanographic sample tracking relative to ELOG. Future modifications of Andes could incorporate information on water budget requirement for each CTD cast, and could allow for the tracking of laboratory post-processing. However, making changes to Andes on the fly would not be possible on local installations (i.e., not on the custom servers permanently installed on the ecosystem survey vessels) of Andes without on-board developer support. With this, Andes could be adopted as the full-time event metadata logger on AZMP and AZOMP’s oceanographic surveys in the future.

Andes has been successfully used by a number of DFO regions and has proved to be a useful data entry application that fulfills its intended design goals. The infrastructure used in the development of the application also means that novel modules and functionalities can be implemented to support new user requirements. For example, adding functionality to add barcodes and QR codes to physical samples such as otoliths and tissue samples.

4.3 Governance

Andes does not currently have a well-defined governing body which makes the project vulnerable. To alleviate this situation, we ask that this technical document, as well as the developer’s guide, be considered when outsourcing development efforts towards Andes. This will ensure that the core vision is maintained and that software sustainability principles are upheld. We also hope that this report can stimulate the establishment of a governance structure for the development of the application, one that ensures regional participation and that facilitates collaborative efforts.

Andes reached a critical point in its lifecycle. It has been used as the main data entry strategy for numerous missions over the span of a few years. Although new features can always be added, its core functional requirements can now be locked-in. These boundaries are now well-defined and described in this report.

4.4 Future Direction

Onboarding efforts for additional coastal surveys (scallop, sea-cucumber, whelk) and regions is an ongoing process driven by Andes' success. A major, short-term developmental priority for Andes is the implementation of bottom trawl survey validation protocols as defined by the Northeast Fisheries Science Center (Politis et al. 2014).

5 Acknowledgments

We thank all DFO and CCG personnel who were involved in the early testing and deployment of Andes prior to and during the 2019 southern Gulf of St. Lawrence ecosystem survey. Any success and momentum encountered by this project would not have been realized without the patience, open-mindedness and critical feedback from its user community, including management, lab technicians, chief scientists and CCG personnel. We thank the Gulf Region publications coordinator for his/her assistance with getting this document published.

6 References

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7 Tables

Table 1. Example of sampling requirements for five species that are regularly captured in the annual southern Gulf of St. Lawrence September survey.

Species	Example of sampling requirement
Atlantic Cod (<i>Gadus morhua</i>)	<p>Collect length, sex, weight, maturity.</p> <p>Collect otoliths from:</p> <ul style="list-style-type: none"> - one specimen per cm per set for specimens 25 cm and under; - two specimens per cm per set for specimens between 26-45 cm; - and three specimens per cm per set for specimens 46 cm and over. <p>Collect 10 specimens from the Banc des Américains MPA that are between 40-70 cm.</p>
Atlantic Herring (<i>Clupea harengus</i>)	Collect length from every specimen; preserve 2 specimens per every 5 mm length bin per set.
Atlantic Halibut (<i>Hippoglossus hippoglossus</i>)	<p>Collect length, sex, weight, maturity, stomach weight and otoliths from every specimen.</p> <p>Collect 300 fin clips per mission.</p> <p>Collect 25 female gonads per mission.</p>
American Lobster (<i>Homarus americanus</i>)	<p>Length and sex from one specimen per sex per 3 mm per set.</p> <p>If female, check for lobster eggs.</p> <p>If female size is greater than 70 mm, check molt stage and shell disease index.</p> <p>If female size is greater than 70 mm AND has eggs, check abdominal width, egg stage and clutch fullness rate.</p>
Winter Skate (<i>Leucoraja ocellata</i>)	Collect length, sex, weight, maturity, disk width and tail description from every specimen.

8 Figures

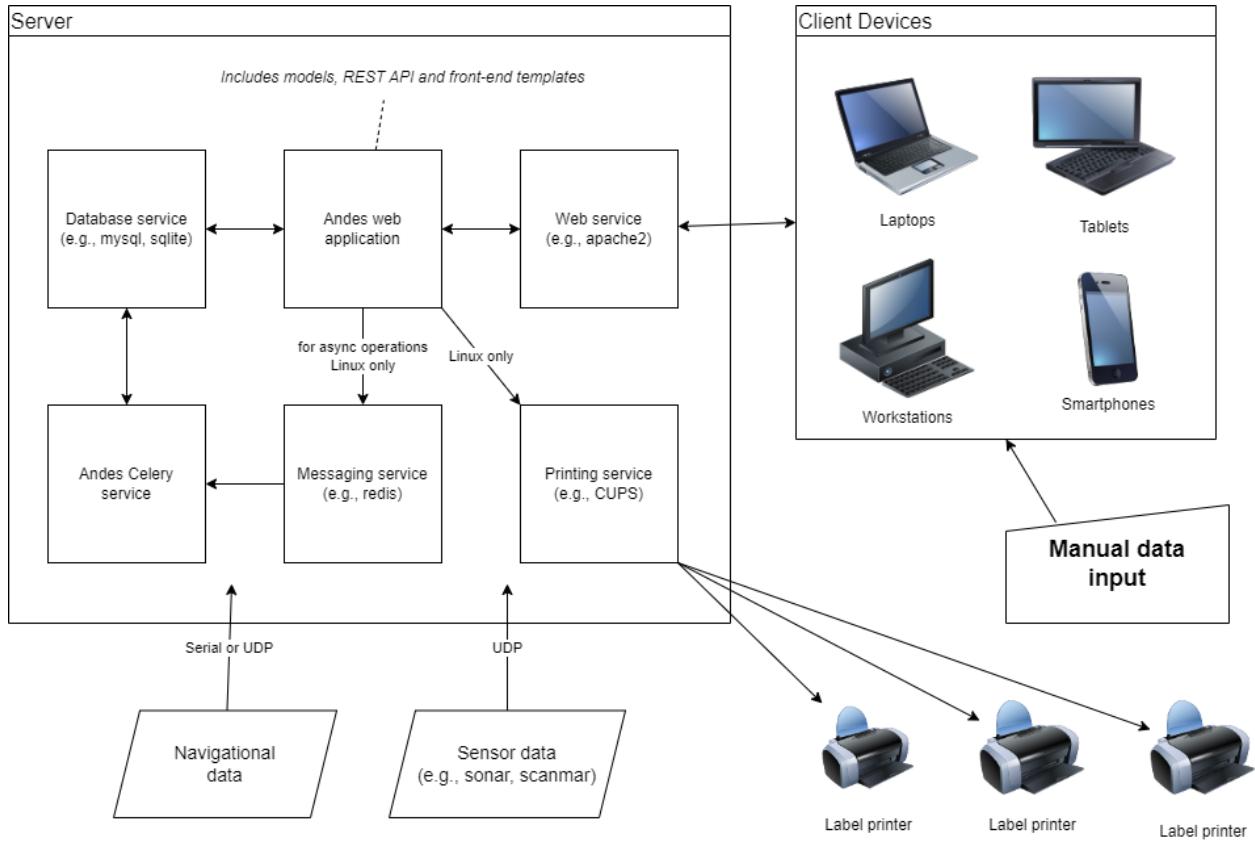


Figure 1. The generalized system architecture diagram of the Andes application and its associated services. The terms User Datagram Protocol (UDP) and Common UNIX Printing System (CUPS) are defined in the Glossary section.

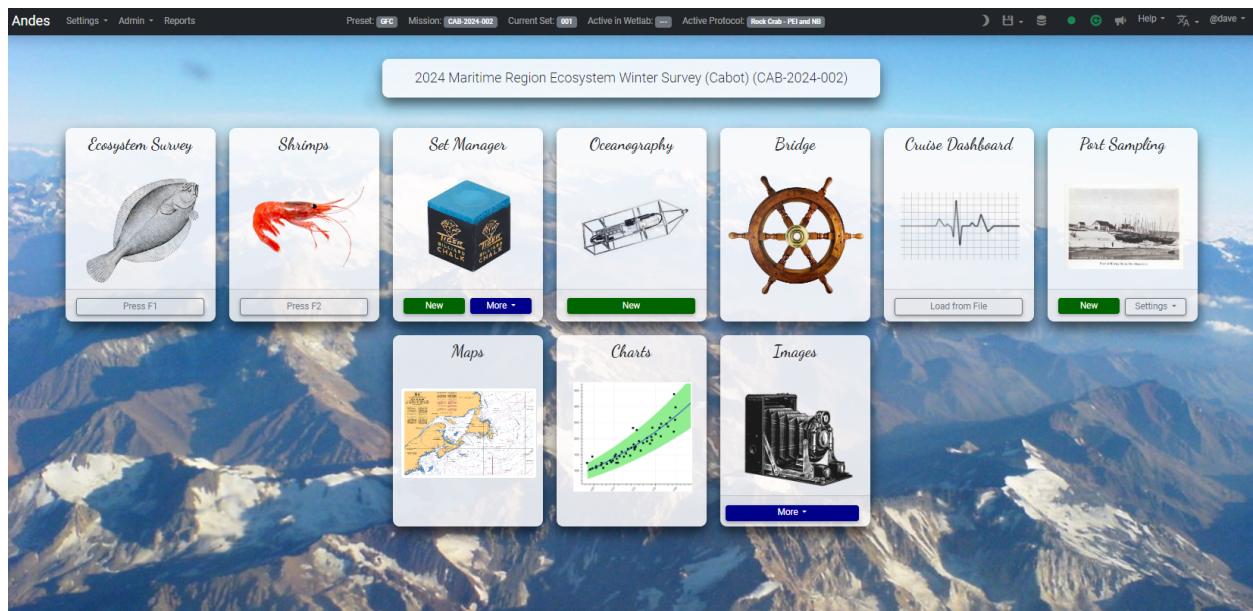


Figure 2. A screenshot of the main index page of Another data entry system (Andes) showing the principal modules of the application. What is displayed on the index page will depend both on the user's permissions and profile.

+
Fishing

✍
Set Card

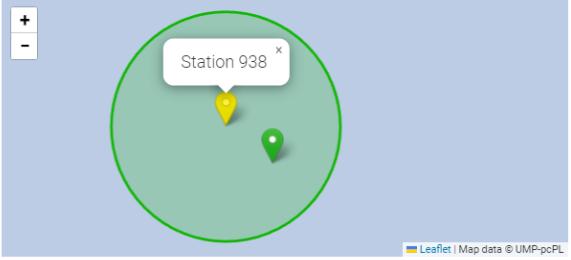
📍 **Current Set**

Set Number	169
Station / Stratum	Station 938 (Alternate) Stratum 472
Operations	Fish, ctd
Current Speed Over Ground	—
Current Course Over Ground	29.4°
Current Depth (true)	22.52m
Distance to Station (w/in radius)	—
ETA	Arrived on station.
Fishing Status	Fishing is underway (2 months ago)
Is Active in Wetlab?	No
Is Set Card Complete?	No
Last Specimen Entered in Wetlab	AMERICAN PLAICE (3 minutes ago)
Set Start Time (Canada/Atlantic)	2023-03-29 16:01:54 (2 months ago)
Starting Coordinates	43° 3.918000' / -63° 38.149000'
Set End Time (Canada/Atlantic)	n/a
Ending Coordinates	n/a
Calculated duration	n/a
Calculated distance	n/a
Calculated speed	3.08 kts
Metadata	<small>Created: 2023-03-29 13:04:14 ADT by ryan_martin Updated: 2023-06-12 09:17:13 ADT by dave</small>

⌚ **Stations**

Set	Station	Stratum	Depth Int.	Latitude	Longitude	Operations	Dist. to Next
167 ✓	203	498	367-732	42° 45.8916'	-63° 42.0180'	Fish, ctd	8 nm
168 ✗	950	478	184-366	42° 48.1044'	-63° 32.1960'	Fish, ctd	17 nm
169 ✓	938	472	91-183	43° 4.2358'	-63° 38.7053'	Fish, ctd	28 nm
170 ✓	940	473	<91	43° 20.2131'	-64° 9.9992'	Fish, ctd	7 nm
171 ✓	939	472	91-183	43° 21.9618'	-64° 1.3979'	Fish	62 nm
172 O	1001	460	91-183	44° 16.3300'	-63° 19.9300'	ctd, zoo	—

📍 **Current Set / Station**



Leaflet | Map data © UMP-pcPL

weathermap **Forecast Map**



Figure 3. A screenshot of the Andes Bridge console. This app is used by bridge personnel across multiple user scenarios. This dashboard is a critical link in the communication between the scientist and crew personnel. An example of this is the station list; as a chief scientist plans out his or her route, queued stations and the associated activities will appear in the Bridge console. The Bridge console is also used by bridge officers to trigger the start and end of operations and to input set metadata.

23

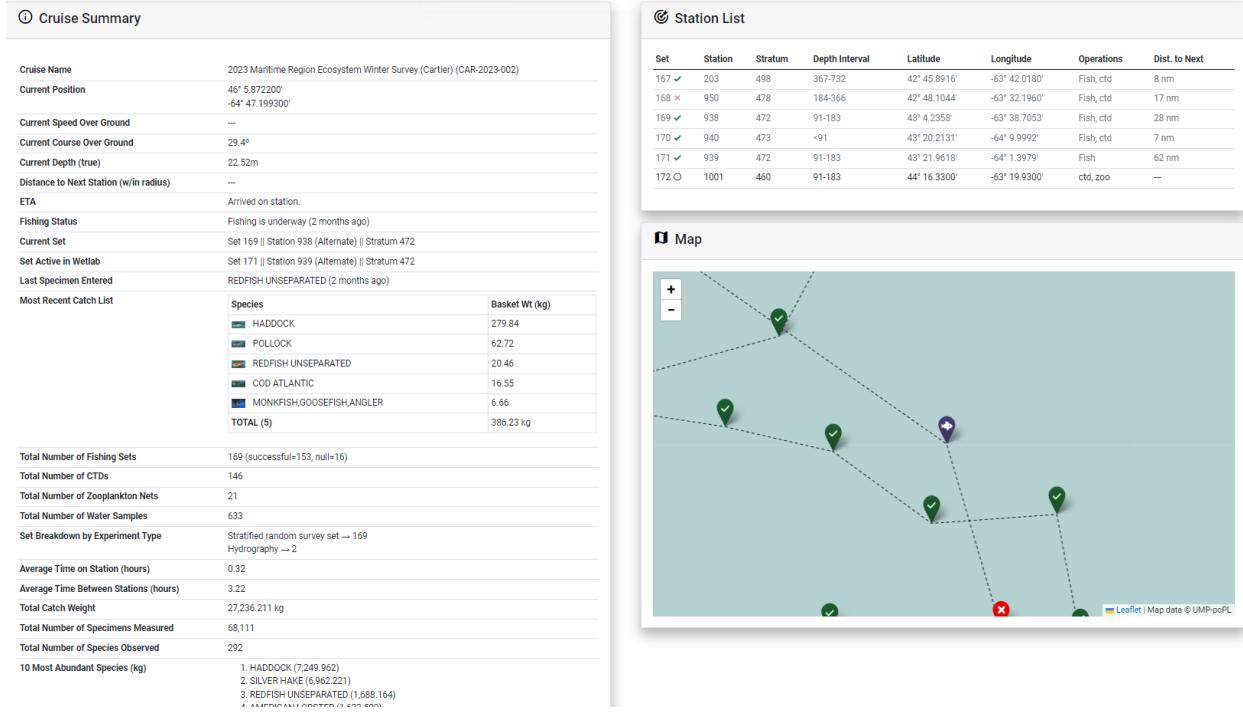


Figure 4. A screenshot of the Andes Cruise Dashboard. This dashboard helps to communicate queued stations, fishing activities underway and estimated times of arrival to science staff and crew personnel. The dashboard also displays high level summaries of Science activities that were conducted.

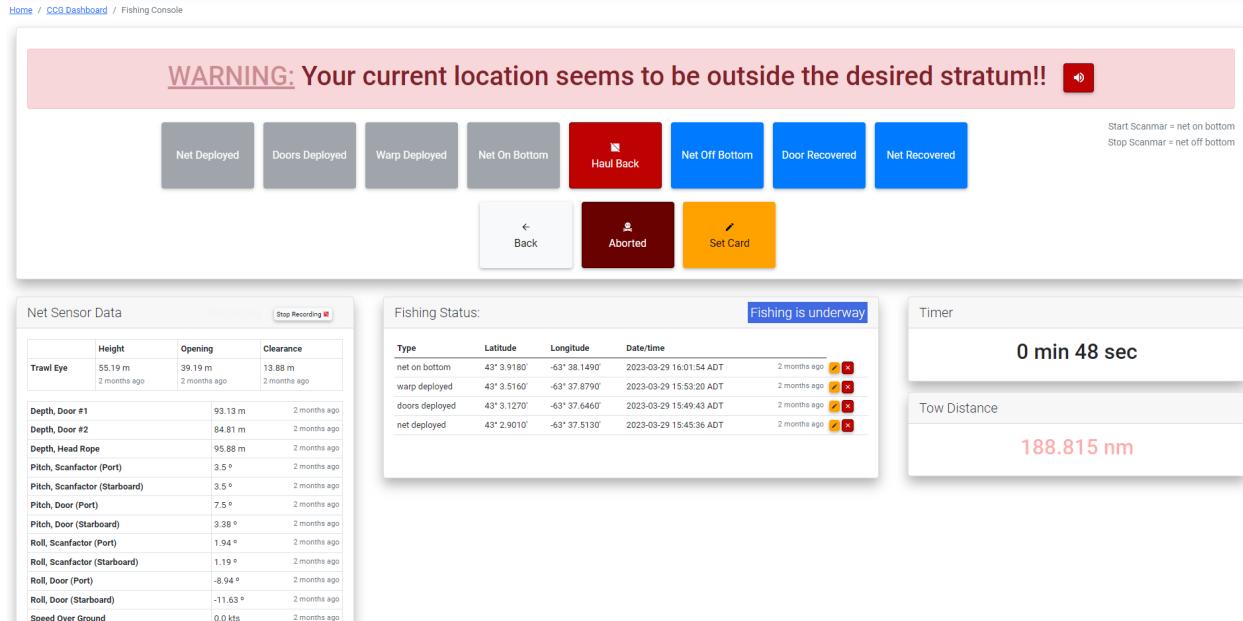


Figure 5. A screenshot of Andes Fishing Console within the Bridge module. This screenshot shows some quality control validation features including: the fishing timer, the distance display and an alarm message for when the vessel is travelling outside the targeted stratum. On the bottom left of the screenshot, output from the net monitoring system is displayed. The large buttons in the center of the display are used to trigger fishing events.

Validation for Set 139

[← Back](#) [Manage Sensors](#)

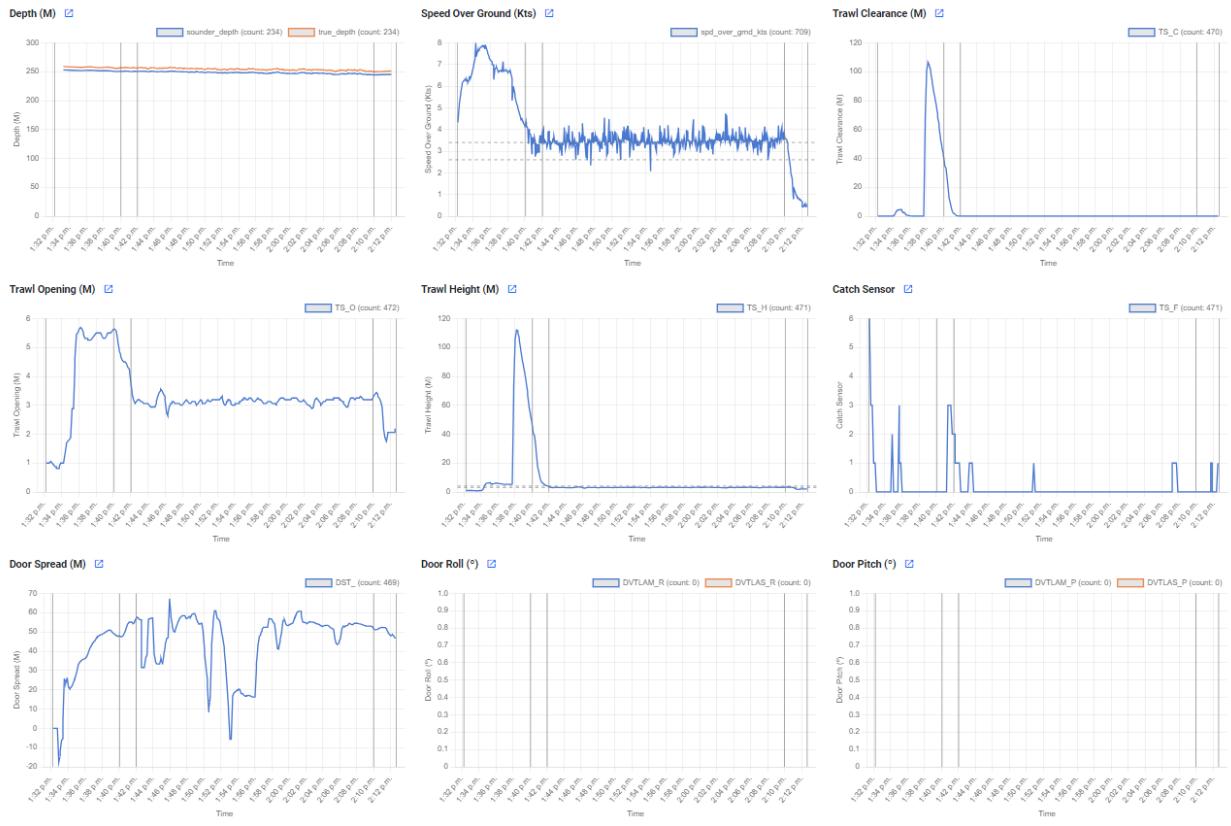


Figure 6. A screenshot of Andes Net Sensor Validation Console within the Bridge module. This screenshot shows the collected inputs from all the defined sensors over the course of a fishing set or sample. In each graph, the input values are plotted over time and vertical lines represent triggered events (e.g., net deployed, winches locked, etc.). This console is a valuable tool for fishing personnel, allow them to verify the adherence to protocols and ensure tow validity.

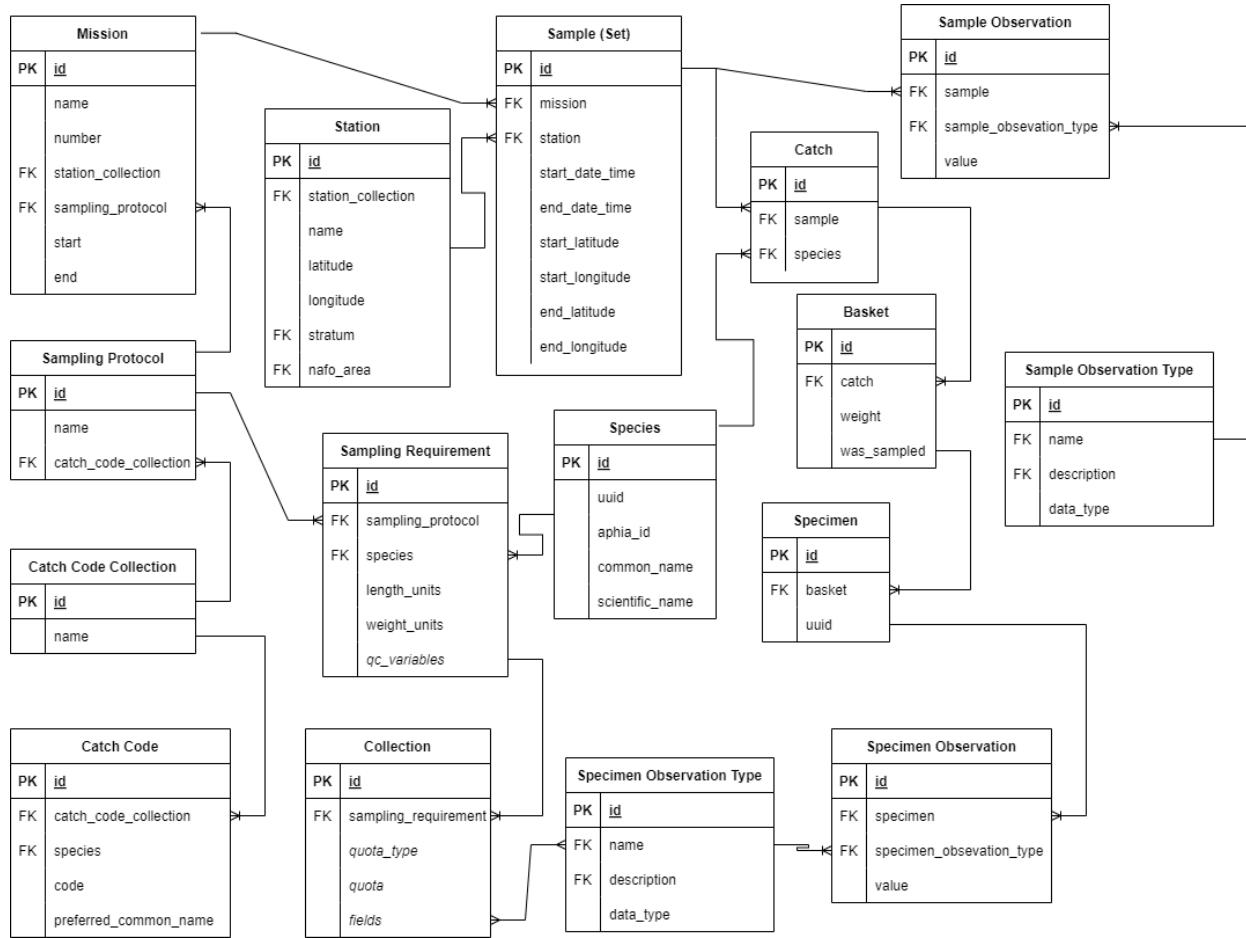


Figure 7. A simplified entity relationship diagram of the data model used by the Ecosystem Survey module of Andes.

Now Processing Set # 170

Station 940 (Alternate) || Stratum 473

Last Species Entered:
MAILED SCULPIN (304)

Enter the species code:

14

Code	Common name	Total basket weight (kg)	Specimens Expected?	Counts			
				Specimens (measured)	Specimens (unmeasured)	Baskets (weighed)	Baskets (unweighted)
10	COD ATLANTIC	15.380	Yes	9	---	1	---
11	HADDOCK	331.681	Yes	306	---	5	---
14	SILVER HAKE	0.062	Yes	4	---	2	---
16	POLLOCK	4.700	Yes	3	---	1	---
23	REDFISH UNSEPARATED	43.130	Yes	259	---	2	---
30	HALIBUT ATLANTIC	0.960	Yes	3	---	1	---
40	AMERICAN PLAICE	0.690	Yes	6	---	1	---
50	STRIPED ATLANTIC WOLFFISH	0.026	Yes	1	---	1	---
60	HERRING ATLANTIC	7.810	Yes	59	---	1	---
62	ALEWIFE	0.148	Yes	1	---	1	---

SILVER HAKE – Merlu argenté – *Merluccius bilinearis*
(already added)

Figure 8. A screenshot of the Active Set page. This page is a component of the Ecosystem Survey module. Users in the wet laboratory enter new catches into this page as they are identified.

Active Set / Catch Card

Stats F4 Refresh F5 Comment F6 More Operations... F8 Toggle Fullscreen F11 Print F12 Delete Ctrl-Backspace Back Esc

COD ATLANTIC – *Gadus morhua* (10)

Set 170 || Station 940 || Stratum 473



View Species Identification Card (Ctrl-H)

New Basket

Basket weight (kg)	Size class	Sample → F3 to toggle yes	Specimens
15.3800	1	Yes	9
TOTAL	15.3800 (Total) 15.3800 (Sampled)	--	9

Baskets

Basket #	Weight (kg)	Size class	Sampled?	Specimens
1	15.3800	1	Yes	9
TOTAL	15.3800 (Total) 15.3800 (Sampled)	--	--	9

Catch Summary:

Total basket weight	15.38 kg
Total sampled basket weight	15.38 kg
Total number of unweighted baskets	0
Total specimen count, unmeasured	0
Total specimen count, measured	9
Total specimen weight, measured	15312 g
Calculated basket weight	15312 g
Calculated specimen weight / sampled basket weight	100%
Comments	---

Sampling Requirement for COD ATLANTIC

Length: → Fork length, centimeters (cm)
 Weight: → Total, grams (g)
 Minimum length: → n/a
 Maximum length: → 140 cm
 Mature length: →
 Rounding rule: → round up to the nearest whole
 Always collect sex? → No

There is 6 collections under this requirement.
 Press F3 to view the details.

Figure 9. A screenshot of the Catch Card page of the Ecosystem Survey module of Andes. This is where new baskets and their associated weights are entered. This example shows the catch card of Atlantic Cod from a Maritimes Region survey of the George Bank.

Active Set / AMERICAN PLAICE (40) / Observations

Previous Stats Comment Print Delete New PgDn List Refresh Back

AMERICAN PLAICE – *Hippoglossoides platessoides* (40)

Set 170 || Station 940 || Stratum 473

Specimen #7 (Size Class 1) → Andes ID 72277

Ctrl+Delete → delete an observation

Length	2	cm – round up to the nearest whole – Fork length	
Sex	1	0-Undetermined 1-Male 2-Female	
Weight	2	g – Total	

Collections:

Standard

Fields: Length, Sex, Weight
Quota: 1 per sex, per cm, per set.
Is applicable for specimen? Yes

Stomach Sampling

Fields: Stomach Fullness, Collect Stomach
Quota: 2 per 5cm, per set.
Is applicable for specimen? Yes

Genetic Sampling 4X (NAFO areas 4XL, 4XM, 4XN, 4XO...)

Fields: Fin Clip
Quota: 100 per mission. Up to a maximum of 100 per mission.
Is applicable for specimen? No

Sample Vial Number (WHEN Fin Clip = [...)

Fields: Sample Vial Number
Quota: unlimited
Is applicable for specimen? No

Figure 10. A screenshot of the specimen data entry interface of the Ecosystem Survey module of Andes. The specimen observations are edited on the left-hand side while the sampling collections are displayed on the right-hand side.

Home

Shrimp - All Catch

Set 222 || Station 16



New Basket

Basket weight (kg)	Sample weight (kg)
1	0

Baskets

Basket #	Weight (kg)	Sample weight (kg)
1	0.842	0.842

Catch Summary:

Name	Code	Total species weight (g)	Debris weight (g)	Number of stades	Sum of stade weight (g)	Real catch weight (kg)
Lebbeus polaris	8093	4.40	0.00	1	4.40	0.00
Pandalus borealis	8111	698.40	470.00	1	228.40	0.70
Pandalus montagui	8112	129.25	10.50	1	112.75	0.12
	9995	16.30	16.30	0	0.00	0.02

Quality control:

Subject	Difference
Sampled baskets weight (0.84 kg) vs Total species weight (0.84 kg)	0.04 %

Figure 11. A screenshot displaying the Shrimps module user interface. This is the page where baskets of shrimps are entered and subsequently detailed according to their various protocols.

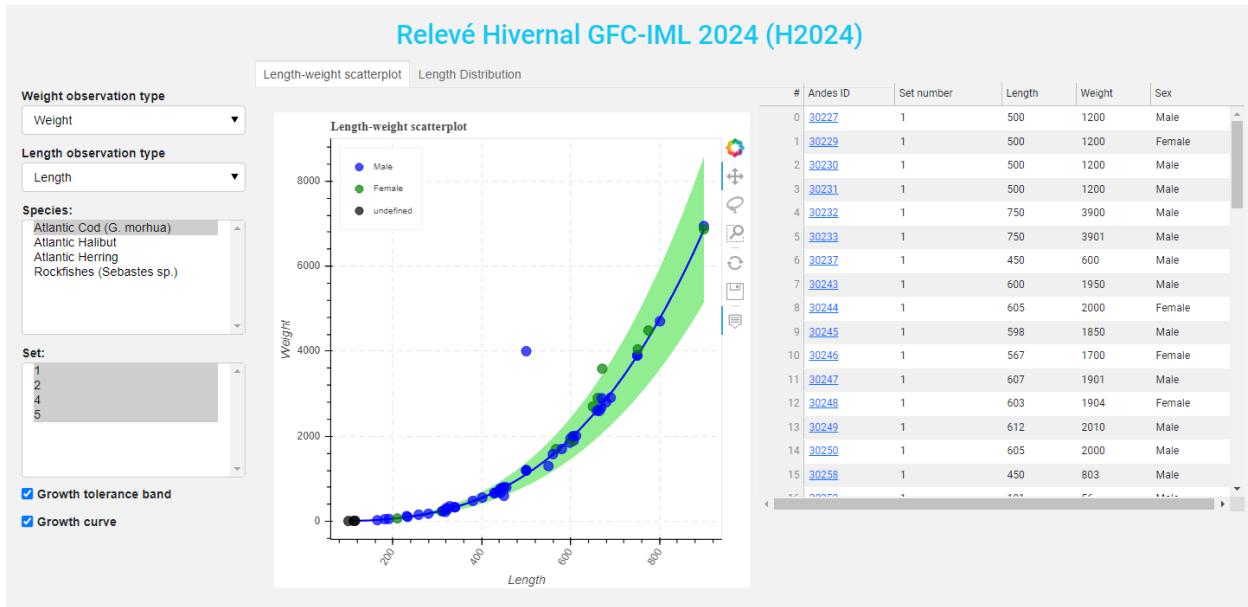


Figure 12. A screenshot of the Charts module showing the weight vs length scatter plot on top of its growth curve model.

Plankton Net Event Configuration

Manage actions: Plankton Net

Action name	Deploy?	Bottom?	Recovery?	Abort?	Is required?	Change order	Remove
Deploy	Yes	No	No	No	Yes	TOP ↑ ↓ BOTTOM	X
Bottom	No	Yes	No	No	No	TOP ↑ ↓ BOTTOM	X
Recovery	No	No	Yes	No	Yes	TOP ↑ ↓ BOTTOM	X
Abort	No	No	No	Yes	No	TOP ↑ ↓ BOTTOM	X

Add an action type: New Clear all

Manage fields: Plankton Net

Observation type	Grouping	Mandatory?	Default value	Change order	Remove
Wire out (m)	ocean activity	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
Wire angle (degrees)	ocean activity	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
Tow down speed (m/min)	ocean activity	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
Tow up speed (m/min)	ocean activity	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
Tow ID ★ 🐚 ★	Oceanographic events	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
Start reading on flowmeter ★ 🐚 ★	Oceanographic events	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X
End reading on flowmeter ★ 🐚 ★	Oceanographic events	Yes	<input type="text"/>	TOP ↑ ↓ BOTTOM	X

Add an observation type: New Clear all

Figure 13. A screenshot portraying how the configuration of “oceanographic events” associated with a certain type of instrument can be customized. In this example, the configuration for plankton nets are being displayed. The box on above contains a list of user-defined “actions types” that will be associated with the event. Action types can be set to optional or mandatory. The lower box displays the list of user-defined fields that will be collected for all plankton nets. Fields can be set to be optional or mandatory and default values can be specified.

Oceanographic Sample 009

Detail

Sample number	009
Station	Station HL_04 (AZMP)
Operator	dave
Did the sample have a valid outcome?	Yes
NOAA weather code	---
Swell height (m)	---
Sounding (m)	---
Surface temperature (°C)	---
Remarks	---
Sample card complete?	no
Operations complete?	no
Metadata	<small>Created: 2024-05-14 11:23:24 UTC by dave</small> <small>Updated: 2024-05-14 11:23:24 UTC</small>

Depth Record to Sample Ping

11514.815 m

an hour ago

Events Add Event

Event number	Type	Instrument	Duration	Reminders	Actions	Completed?
016	CTD	CTD AZOMP 2024 (11 x 11)	---		Deploy Bottom Recovery Abort	No
017	Plankton Net	Bongo Net (335 + 750 µm)	---		Deploy Bottom Recovery Abort	No
018	ARGO	Argo (BIO AZOMP)	---		Deploy	No
019	Mooring	Mooring	---	---	Deploy	Yes

Station Map

Figure 14. A screenshot of the Oceanographic Sample detail page from the Andes Oceanography module. The top-most box contains high-level information about the sample, such as the sequential sample number, station name and meteorological information collected at the time of sampling. These fields are user-defined and can be customized in the mission configuration. The middle box contains a list of events that are associated with the sample. The event number, event status, reminders and available actions are displayed for each row of the event. Actions can be triggered either manually or by clicking on the button associated with that action. The event table also contains convenient buttons (left-hand side) for quickly adjusting the order of an event.

34

016 - CTD AZOMP 2024

Detail

Event number	016	CTD Specific:
Instrument	CTD AZOMP 2024	Edit Delete
Duration (min)	--	
Event complete?	<input checked="" type="checkbox"/>	--
Metadata	Created: 2024-05-14 11:23:43 UTC by dave Updated: 2024-05-14 11:23:43 UTC by dave	

Bottles (11) Saved [Clear all](#) [Manual add](#)

Shortcuts: [Bottom](#) [4000 m](#) [3000 m](#) [2500 m](#) [2000 m](#) [1250 m](#) [1000 m](#) [750 m](#) [500 m](#) [250 m](#) [200 m](#) [150 m](#) [125 m](#) [100 m](#) [80 m](#) [60 m](#) [50 m](#) [40 m](#) [30 m](#) [25 m](#) [20 m](#) [10 m](#) [1 m](#) [Surface](#)

Unique ID	Depth (m)	129/738U	14C	180	AB5	CDOM	Chl	DIC/TA	D02*	F gyro	HPLC	Isotope	Nutr	POC	SF6/CFC	Salinity	eDNA*	pCO2	pH	Comment	Complete?		
22		<input type="checkbox"/>	Surface	No	Print	X																	
21	1	<input type="checkbox"/>		No	Print	X																	
20	10	<input type="checkbox"/>		No	Print	X																	
19	20	<input type="checkbox"/>		No	Print	X																	
18	25	<input type="checkbox"/>		No	Print	X																	
17	30	<input type="checkbox"/>		No	Print	X																	
16	40	<input type="checkbox"/>		No	Print	X																	
15	50	<input type="checkbox"/>		No	Print	X																	
14	60	<input type="checkbox"/>		No	Print	X																	
13	80	<input type="checkbox"/>		No	Print	X																	
12	100	<input type="checkbox"/>		No	Print	X																	
deepest bottle																							

Oxygen Subsample

Bottle	Operator	Winklers #1 (mL/L)	Winklers #2 (mL/L)	Winklers #3 (mL/L)	Comment	Complete?
22	dave					No
21 @ 1.0	dave					No

Figure 15. A screenshot from the Andes Oceanography module of the event detail page for a CTD/Rosette system. The event being portrayed has the event number 016 and the name of the instrument being used is “CTD AZOMP 2024”. The top-most box contains high-level information associated with the event that is specific to the instrument type (i.e., CTD). These fields are user-defined and can be customized in the mission configuration. Below this is a table of water samples (i.e., “bottles”) associated with this event. The unique identifier, depth and which variables were measured are displayed for each row of the table. Lower down on this page (not displayed) is a table of the actions that were logged from this event.

006 - Plankton net (202μm)

Detail

Event number	006	ZoopTow Specific:	
Instrument	Plankton net (202μm) Edit	Wire out (m)	100 m
Duration (min)	2.87 min	Wire angle (degrees)	10 degrees
Event complete?	yes	Tow down speed (m/min)	30 m/min
Metadata	Created: 2024-05-07 09:16:09 UTC by jeff Updated: 2024-05-07 12:38:41 UTC by jeff	Tow up speed (m/min)	30 m/min
		Tow ID	234580
		Start reading on flowmeter	5745
		End reading on flowmeter	5860

Zooplankton Samples

Saved [Add Sample](#)

Unique identifier	Net mesh size (μm)	Specify a depth interval	Start depth (m)	End depth (m)	Comment	Complete?	Metadata	
234580-1	202	<input checked="" type="checkbox"/>	100	0		Yes	<input type="radio"/>	<input checked="" type="checkbox"/>
234580-2	76	<input checked="" type="checkbox"/>	100	0		Yes	<input type="radio"/>	<input checked="" type="checkbox"/>

Actions

[Add Action](#)

Type	Latitude	Longitude	Date/time	Metadata
Deploy	68.38829	-87.325848	2024-05-07 09:18:29 UTC	<input type="radio"/> <input checked="" type="checkbox"/>
Bottom	68.388378	-87.325952	2024-05-07 09:18:34 UTC	<input type="radio"/> <input checked="" type="checkbox"/>
Recovery	68.391563	-87.329046	2024-05-07 09:21:22 UTC	<input type="radio"/> <input checked="" type="checkbox"/>

Cleared Reminders

Description	Date/time	Created by
Make sure you record the start position of the flowmeter	6 days, 9 hours ago	jeff X

Figure 16. A screenshot from the Andes Oceanography module of the event detail page for a plankton net. The event being portrayed has the event number 006 and the name of the instrument being used is “Plankton Net (202μm)”. The top-most box contains high-level information associated with the event that is specific to the instrument type (i.e., plankton net). These fields are user-defined and can be customized in the mission configuration. Below this is a table of collected zooplankton samples associated with this event. The unique identifier, net mesh size and depth interval are displayed for each row of the table. Further down the page, is a table listing all the actions logged from this event.

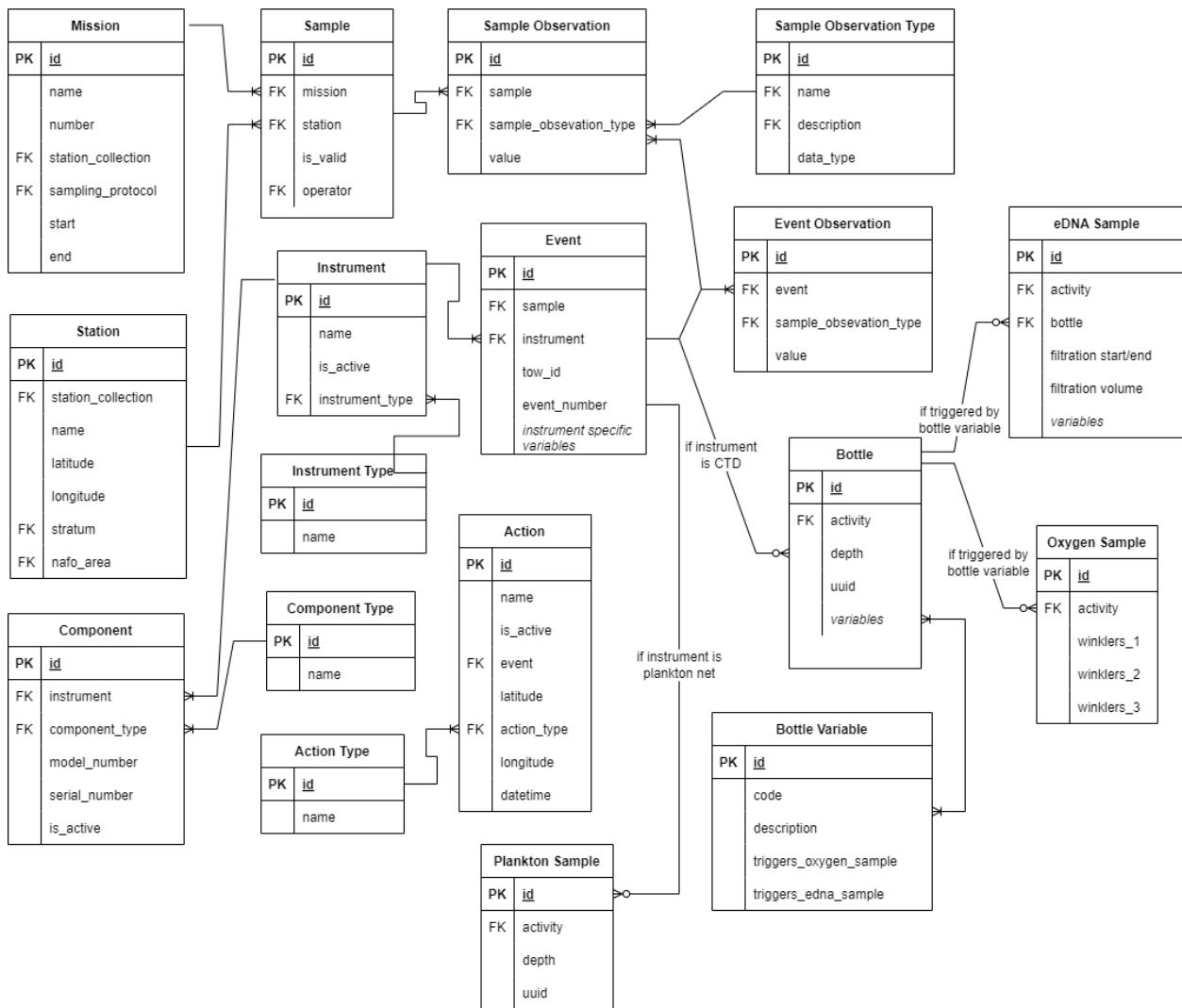


Figure 17. A simplified entity relationship diagram of the data model used by the Oceanography module of Andes.

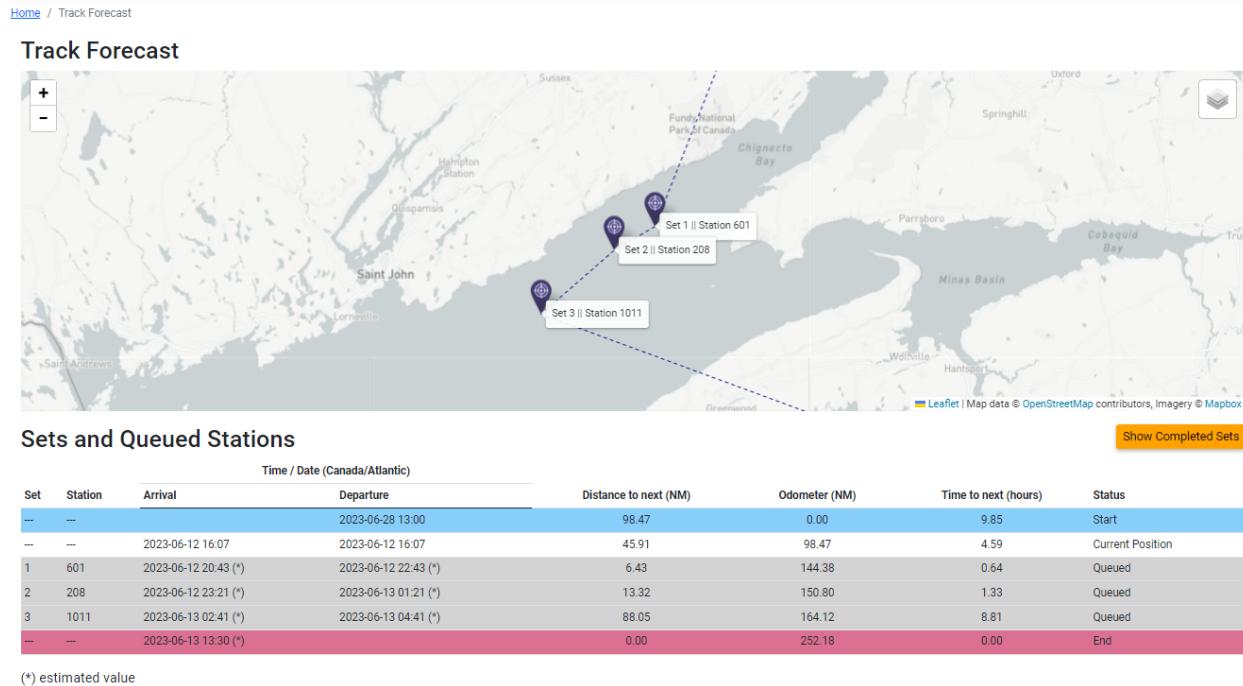


Figure 18. A screenshot of the Track Forecast tool.

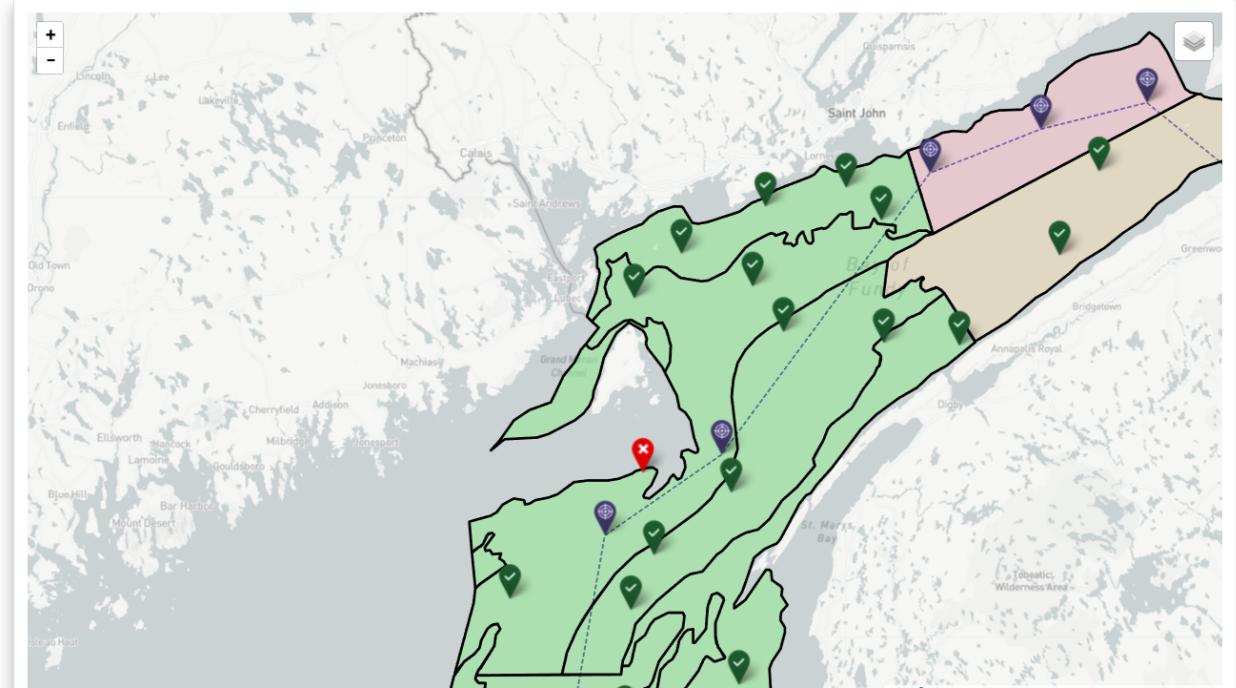
[Stations](#) [Show Track](#) [Hide Strata](#) [Show NAFO Areas](#)

Figure 19. A screenshot of the Andes Progress map. The map colors strata by the status of their set quotas. The green strata are those which have met their specified targets of set conducted; those in yellow have not met the target but have surpassed the minimum; and those in red have not conducted the minimum specified number of sets.

Edit Port Sampling Protocol

Name

Herring NB

Species

HERRING ATLANTIC X

Ports

Select multiple

Fishing areas

4T X 4TG/16G X 4TH X 4TJ X 4TK X 4TL X 4TM/16B X 4TN X

Gears

FPN - Traps: Stationary uncovered point-nets X GNC - Gillnets and entangling nets: Encircling gillnets X GND - Gillnets and entangling nets: Drift nets X GNS - Gillnets and entangling nets: Set gillnets (anchored) X
GTN - Gillnets and entangling nets: Combined gillnets-trammel nets X GTR - Gillnets and entangling nets: Trammel nets X SDN - Seine Nets: Boat or vessel seines; - Danish seines X
SPR - Seine Nets: Boat or vessel seines; - Pair seines X SSC - Seine Nets: Boat or vessel seines; - Scottish seines X SV - Seine Nets: Boat or vessel seines X

Mesh sizes

1.25" / 32 mm X 2" / 51 mm X 2.25" / 57 mm X 2.5" / 64 mm X 2.63" (2-5/8") / 67 mm X 2.75" / 70 mm X

Bait types

Select multiple

Sample fields

Vessel CFVN X Catch weight (lbs) X Sample weight (lbs) X Experimental net used X

Vertical padding of data entry buttons

XS



Vertical margins of data entry buttons

XS



Direction of bins on buttons

horizontal



Figure 20. A screenshot displaying the Port Sampling module protocol form. The selections made in this form will affect the behaviour of the module during data entry.

Andes Settings Admin Preset: GFC Active Protocol: Herring NB Help français @dave

Select a size (cm)

Delete Mode View Summary Manual Mode

5	5.5	6	6.5	7	7.5	8	8.5	9	9.5 1
10	10.5 1	11	11.5	12	12.5 1	13	13.5	14	14.5
15	15.5	16 1	16.5 1	17 2	17.5 1	18 1	18.5 1	19 1	19.5 1
20 1	20.5 2	21 5	21.5 5	22 6	22.5 3	23 4	23.5 4	24 4	24.5 3
25 3	25.5 3	26 2	26.5 3	27 2	27.5 2	28 1	28.5 1	29 1	29.5 1
30 1	30.5 1	31 1	31.5	32	32.5	33	33.5	34	34.5
35	35.5	36	36.5	37	37.5	38	38.5 2	39	39.5
40	40.5	41	41.5	42	42.5	43	43.5	44	44.5
45	45.5	46	46.5	47	47.5	48	48.5	49	49.5
50									

MEASURED: 73 / KEPT: 52

[Back to Sample](#)

Figure 21. A screenshot displaying the Port Sampling data entry page. A button is presented for each length bin, as defined in the protocol. The number in the black circle on the right-hand side of the button is the current count for that length bin. Button colors change from blue to green as the collection protocol for that bin is satisfied.

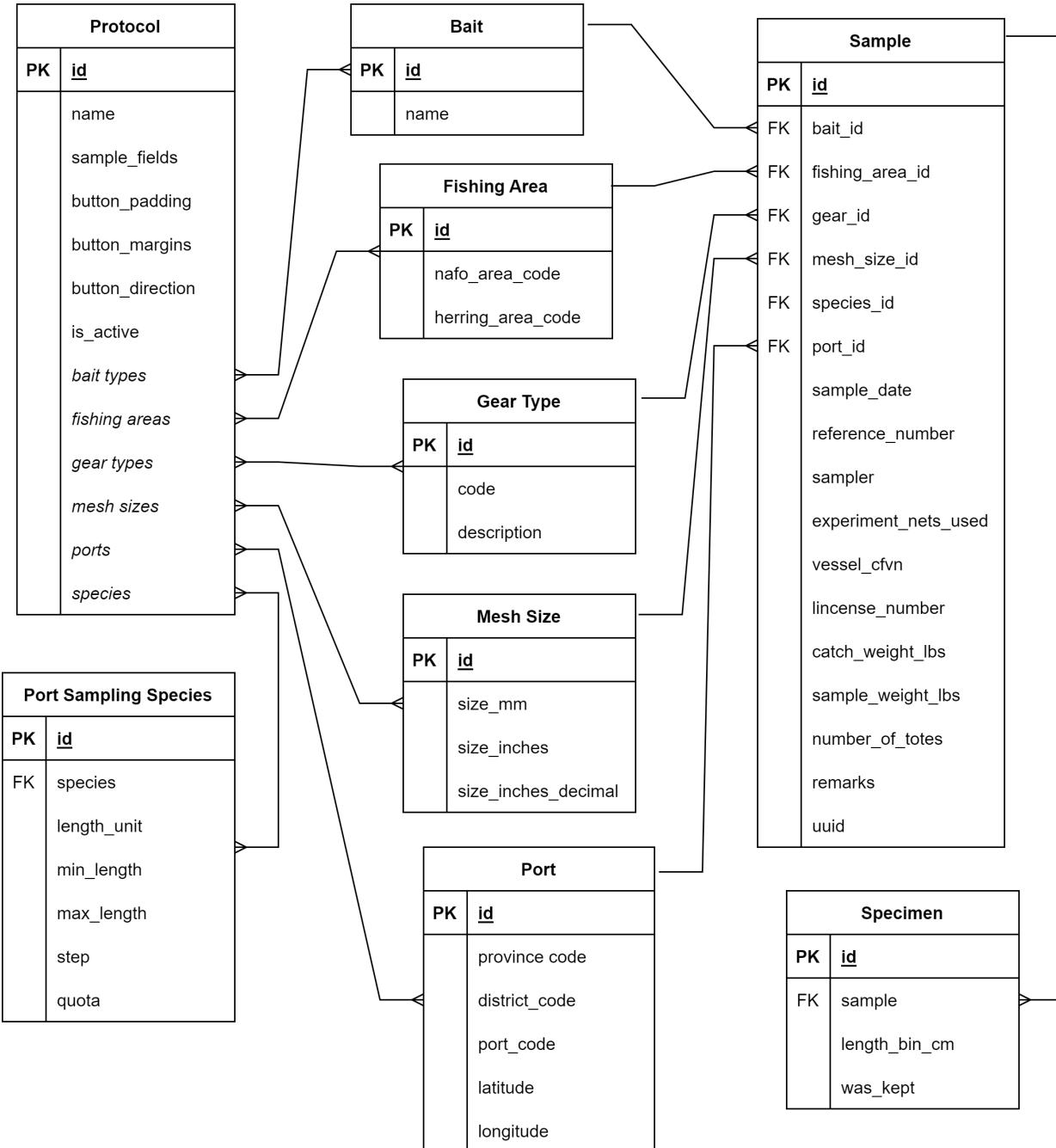


Figure 22. A simplified entity relationship diagram of the data model used by the Port Sampling module of Andes.

Length-to-Weight Ratio

A+B coefficients (weight = a × length^b)

	A	B
Unspecified	0.00561 The A regression coefficient in the relationship between length and weight for unspecified sex.	3.125999999 The B regression coefficient in the relationship between length and weight for unspecified sex.
Male	0.006227218 The A regression coefficient in the relationship between male length and weight.	3.096902077 The B regression coefficient in the relationship between male length and weight.
Female	0.006141017 The A regression coefficient in the relationship between female length and weight.	3.101193464 The B regression coefficient in the relationship between female length and weight.

Tolerance threshold for length-to-weight ratio (%)

25

The higher the threshold, the more relaxed Andes will be in raising warnings

Wait for sex before testing length-to-weight ratio? If this is set to true, Andes will only check length-to-weight ratio after sex has been observed.

Figure 23. A screenshot of the “Length-to-Weight Ratio” section of the sampling requirement form. Andes offers the option to specify regression coefficients for males, females or unspecified individuals to be used in quality control.

Mature Length

Mature length threshold

Unspecified	30 What is the min length of a mature individual of this species before which a user should receive a warning?
Male	Mature length (male)
Female	Mature length (female)

Maturity observation type

Maturity

Code used to signal an immature specimen

1
Only applicable if a maturity observation type is provided above

Figure 24. A screenshot of the “Mature Length” section of the sampling requirement form. Andes offers the option to specify mature length thresholds for males, females or unspecified individuals to be used in quality control.

9 Acronyms

Andes Another data entry system.

API Application Programming Interface.

AZMP Atlantic Zone Monitoring Program.

AZOMP Atlantic Zone Offshelf Monitoring Program.

CDOS Chief Digital Officer Sector.

CSS Cascading Style Sheet.

CUPS Common UNIX Printing System.

DFO Fisheries and Oceans Canada, formerly the Department of Fisheries and Oceans.

ELOG Electronic Logbook.

ERD Entity Relationship Diagram.

ESE Ecosystem Survey Entry.

GSE Groundfish Survey Entry.

html5 Hypertext Markup Language.

IMTS Information Management and Technology Services.

LAN Local Area Network.

MPA Marine Protected Area.

MRR Module des Relevés de Recherche.

NAFO Northwest Atlantic Fisheries Organisation.

RAID redundant array of inexpensive disks.

REST Representational state transfer (REST).

REST-API Representational state transfer (REST) Application programming interface (API).

UDP User Datagram Protocol.

VCS Version Control System.

WAN Wide Area Network.

10 Glossary

Andes Another data entry system is an application developed by Fisheries and Oceans Canada to support data collection for a variety of scientific programs.

Andes lead A person with a functional understanding of the inner workings of Andes. This person has the knowledge and user-rights that permit them to configure a Mission, define a Sampling Protocol, Sampling Requirements, etc.

API An Application Programming Interface (API) is a particular set of rules and specifications that a software program can follow to access and make use of the services and resources provided by another particular software program that implements that API.

AZMP The Atlantic Zone Monitoring Program collects and analyses the biological, chemical and physical oceanographic field data in the four Altantic regions of Fisheries and Oceans Canada.

AZOMP The Atlantic Zone Offshelf Monitoring Program collects and analyses the biological, chemical and physical oceanographic field data in the four Offshelf Altantic regions of Fisheries and Oceans Canada.

Bridge The Bridge app is meant to be used by the navigation officer while the fishing officer deploys and retrieves the trawl. The operator inputs fishing events (eg., net deployed, doors deployed, winches locked, net on bottom, haul back, net off bottom, doors recovered, net recovered) or actions (eg., net on/off bottom) directly to Andes via the Bridge app. .

Catch A table of the Ecosystem Surveys app. A Catch table contains a link to Set and Species entries, as well as an optional: specimen count, unweighted baskets, relative abundance category and an invertabrate catch ratio. Catches can be subdivided into sub-catches having a parent-children relationship.

Catch Card Catch details recorded prior to detailed sampling.

CCG The Canadian Coast Guard.

CDOS The Chief Digital Officer Sector is the IT branch of DFO.

Closed Set An Open Set Can be closed if the data it contains (eg, from Catch Card) does not trigger a Set Flag.

Configuration Preset Configuration for a particular deployment scenario. Configuration presets include details on the backup locations, and peripherals like GPS, sonars, label printers, etc. .

Cruise Same as Mission.

CSS A Cascading Style Sheet is a style sheet language used for describing the presentation of a document written in a markup language such as HTML or XML.

CTD Conductivity, temperature and depth.

CUPS CUPS (formerly an acronym for Common UNIX Printing System) is a modular printing system for Unix-like computer operating systems which allows a computer to act as a print server.

Current Set The Set that is currently occurring in time. It has begun and is not finished. There can only be one Current Set at a time.

DFO Fisheries and Oceans Canada is a department of the Government of Canada that is responsible for developing and implementing policies and programs in support of Canada's economic, ecological and scientific interests in oceans and inland waters.

Ecosystem Survey The Ecosystem Survey app is used to as the main data input interface. .

ELOG Electronic Logbook (ELOG) is part of a family of applications known as weblogs. (see website <https://elog.psi.ch/elog/>).

ESE The Ecosystem Survey Entry replaced the GSE in the early 2000s.

Fishing Event An event related to fishing activity of Set. Metadata such as GPS coordinates and time to are associated with the following event types: *net deployed*, *doors deployed*, *warp deployed*, *net on bottom*, *haul back*, *net off bottom*, *door recovered*, *net recovered*, and *aborted*. A Set may contain a list of such event types. The Fishing Events are added to the Set by a crewmember using the Bridge application. .

GSE The GSE is a data entry tool developed in the 1980s.

html5 The Hypertext Markup Language is the standard markup language for documents designed to be displayed in a web browser.

IMTS Information Management and Technology Services is the IT branch of DFO.

JavaScript Javascript is a programming language that is one of the core technologies of the World Wide Web, alongside HTML and CSS.

JSON JavaScript Object Notation. The JSON format is a popular way to serialize data and is an alternative to the CSV (comma-separated values) and XML (eXtensible Markup Language) formats.

LAN A series of computers connected to each other and capable of communicating with each other over wired or wireless connections.

Mission A mission defines a single activity where data collection will take place. Same as Cruise. .

NAFO Northwest Atlantic Fisheries Organisation.

Open Set A Set that has not been closed. All new Sets will start in an open state and will remain so until closed. Sets that are activated will automatically be opened. The Current Set is always open.

ORM Object Relational Mapping are an abstraction of relational entities (database tables) as objects.

Port Sampling Scientific program collecting samples from commercial fishing activities.

REST-API Representational state transfer (REST) Application programming interface (API) is an API that follows the REST software architectural style, created to guide the design and development of the architecture for the World Wide Web.

Sampling Requirements The species-specific requirements for samples to be collected during a scientific cruise.

Sampling Protocol The detailed description of what data is to be collected during a scientific cruise.

Set A Set contains all fishing activity and sampling results for a particular Station .

Set Flag A flag used to indicate that the data contained within the set has failed to pass a specific validation tests. Closing an Open Set with active flags can be done by overriding the validation mechanism.

Species An identifiable taxon that can be assigned to a species code.

Station A target location specified by coordinates where a scientific activity is to take place.

UDP The User Datagram Protocol is one of the core communication protocols of the Internet protocol suite used to send messages (transported as datagrams in packets) to other hosts on an Internet Protocol (IP) network.

VB Pre-.NET Visual Basic for Applications is the early version of Microsoft VBA and is no longer supported or updated by Microsoft.

VBA Visual Basic for Applications is a programming language built into most desktop Microsoft Office applications. More details can be found on the Wikipedia page for this programming language and from Microsoft.

VCS A Version Control System records changes to a file or set of files over time so that specific versions can be recalled later. For example, git is a VSC.

Vue.js A JavaScript framework for building reactive user interfaces. <https://vuejs.org/>.

WAN A telecommunications network that extends over a large geographic area, such as the internet.