

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

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6 DESIGN GOALS, TECHNICAL IMPLEMENTATION AND PRACTICAL USE OF ANOTHER DATA 7 ENTRY SYSTEM (ANDES)

by

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ABSTRACT

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

RÉSUMÉ

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

101 1 Introduction

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

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

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

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

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

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

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

160 **2 Methods**

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

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

181 Andes was designed with 3 main usages in mind: A) as the main data entry system for

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

193 A large component of the ecosystem surveys conducted by the Gulf, Québec, Maritimes, and
194 Newfoundland and Labrador Regions includes the collection of physical, chemical, and biological
195 oceanographic data in support of the Atlantic Zone Monitoring Program (AZMP) (Therriault et al.
196 1998). A CTD/Rosette system is deployed at a subset of fishing stations where vertical profiles
197 of conductivity (salinity), temperature, dissolved oxygen, chlorophyll and other parameters
198 are collected. Water samples (e.g., nutrients, dissolved oxygen, salinity) are collected at
199 predetermined depths using the Rosette system and attached Niskin bottles, and plankton
200 samples are also collected via vertical ring net tows. These data support annual "state of the
201 ocean" reporting conducted by the [AZMP](#), and are also used in various stock assessments and
202 ecosystem research projects to provide additional ancillary variables for interpreting the captures
203 data.

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

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

213 **2.1 Flexibility, scalability and reliability**

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

222 **2.2 Version control/source control**

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

231 **2.3 Unit Testing**

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

241 **2.4 Backup strategy**

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

248 **2.5 Customizable protocols**

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

255 **2.6 Quality control**

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

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

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

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

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

276 **2.7 User interface**

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

284 **2.8 Reactivity**

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

291 **2.9 Multilingualism**

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

295 **3 Results**

296 **3.1 Architecture**

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

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

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

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

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

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

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

344 **3.2 Andes Modules**

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

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

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

360 **3.2.1 Bridge**

361 The Bridge module (Figure 3) is used by navigation and fishing officers in the wheelhouse
362 (usually on a tablet) to input fishing set metadata. The data entry occurs in two ways: 1) by
363 directly editing the set form (a.k.a. the set card); and/or 2) via the Fishing Console, which is
364 displayed in Figure 5. The Fishing Console can capture a number of different events that take
365 place during fishing as well as information coming from the sonar and trawl mensuration system
366 sensors (e.g., Scanmar system).

367 **3.2.2 Set manager**

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

373 **3.2.3 Ecosystem survey**

374 The Ecosystem Survey module is the main entry point that technicians will use to input survey
375 data. A depiction of the main tables involved in the Ecosystem Survey module, and their
376 relationships are displayed in Figure 6. This component of Andes replicates the capabilities of
377 the ESE for capturing detailed information on length, weight, ageing material, maturity, etc. about
378 fish and invertebrate specimens. This module, typically accessed from the wet laboratory of a
379 survey vessel, is used for all entry of data related to measurements and observations of marine
380 organisms. New catches are first entered into the Active Set page, as portrayed in Figure 7. The
381 Active Set page accepts regional catch codes as a way to input new catches into a set. If a code
382 is not known by the user, a search feature is available. Next, baskets and their corresponding
383 weights and statuses (e.g., sampled vs. not sampled) are then entered into the Catch Card page
384 (Figure 8). Finally, specimens are entered into the Data Entry page (Figure 9). As the data entry
385 progresses, users are dynamically prompted with observation fields that follow the catch-specific
386 sampling protocol. An overview of the sampling protocol is displayed on the right-hand side of
387 the Data Entry page.

388 **3.2.4 Shrimps**

389 The Shrimps module is an extension of the ecosystem survey module focused exclusively on
390 shrimps as it has different workflow requirements. This module allows the user to subsample a
391 total catch of shrimp into different species and maturity stages before collecting biological data
392 (cephalothorax length for all species and occasionally weight for *Pandalus borealis*).

393 **3.2.5 Charts**

394 The Charts module (Figure 10) leverages the [Bokeh](#) Python library to generate data visualization
395 of arbitrary length and weight observation variables that were attributed to specimens. The
396 module provides an interactive scatter plot of length vs weight as well as a length histogram.
397 The data can be filtered by species, set and sex (when available). This visual presentation of the
398 data is meant as a supplemental validation aid in identifying outliers that may have escaped the
399 quality controls. Should outlier points need further manual inspection/intervention, a direct link to
400 access/edit the specimen data is conveniently made available.

401 The user is also presented with option to include an empirical growth model together with weight

402 vs length scatter data. This option, which only applies for “official” length and weight observation
403 types, can be useful for tuning the tolerance band used for quality control (see Quality Control
404 section below).

405 **3.2.6 Oceanography**

406 The Oceanography module is a component of the Andes application that is capable of being
407 deployed independently of the Ecosystem Survey module. This module is used to track and
408 record the deployment of CTD/Rosette systems and plankton nets (Figure 11). Basic metadata,
409 such as the location and date/time of deployment, ‘on bottom’ and gear recovery events can
410 be collected. Additionally, the Oceanography module allows for users to enter which water
411 samples/parameters were collected from pre-determined depths after CTD/Rosette deployment
412 (Figure 12). The simplified Entity Relationship Diagram of the Oceanography module of Andes
413 is presented in Figure 13. Upon completion of a survey, Andes is designed to provide a series of
414 oceanographic summary reports that summarize aspects of the data collected:

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

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

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

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

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

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

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

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

439 **3.2.7 Forecasting utility modules**

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

444 **Cruise dashboard**

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

449 **Forecasting**

450 The forecasting tool is designed to provide real-time prognostics of survey completion targets
451 based on assumed transit speeds and time spent fishing and processing the trawl catches
452 (Figure 14). This feature provides a useful tool for the chief scientist to evaluate different
453 sampling objectives and to compare different survey route options. As the conditions change
454 regularly during a survey, this tool links with the set manager to provide an estimate of the
455 amount of time required to complete planned stations. This tool can be used for short-term
456 planning (i.e. a day's worth of sampling) or longer-term planning (i.e. a mission's worth of
457 sampling).

458 **Progress Map**

459 Another task-specific utility is the progress map which shows what strata have been completed
460 based on target and minimum number of sets per stratum. This map provides the chief
461 scientist with a clear visual depiction of what has been accomplished and what remains to be
462 accomplished during the survey. The number of sets conducted in each stratum is compared to
463 the minimum and target number of sets per stratum to determine the colour that each stratum will
464 appear in the progress map (Figure 15).

465 **3.2.8 Images**

466 The images module is a component of the Andes application designed to streamline image
467 management during surveys. The module enables images to be captured and stored directly
468 from the application using a smart phone, tablet or webcam. Doing so allows images to be
469 directly linked to the set, catch, or specimen that they represent, eliminating the need to manually
470 create this link from a filename after data collection is complete. Images are queued during data

471 collection based on various triggers (user request, rare catch, sampling protocols, etc.). The
472 queued images are listed in the app allowing users to capture them on a camera-enabled device
473 which can be separate from the one being used for data entry.

474 **3.2.9 Port sampling**

475 Andes was adapted from a previous port sampling module to support activities where
476 technicians obtain length frequency samples from commercial fishing activities. The port
477 sampling module of Andes is fully stand-alone and is primarily used independently of all
478 other modules. The protocols used in the Port Sampling module are much simpler than those
479 belonging to the Ecosystem Survey module. Through these protocols, users are able to control
480 collection quotas (e.g., “keep two specimens per bin”), the flow of data entry (e.g., which field
481 should be displayed in the sample form) and the layout of the data entry page (e.g., length
482 bins organized in a vertical or horizontal configuration) (see Figure 16). Typically, production
483 instances of this module are deployed on rugged field tablets that are suitable for use in wet
484 environments.

485 The design of the user interface is simple and intuitive, where each length bin is a large button
486 on the display. As specimens are tallied, the corresponding buttons on the touchscreen are
487 pushed. When the collection quota of a given length bin has been met, the color of the button
488 changes from blue to green. A screenshot of the data entry page is presented in Figure 17. Data
489 export reports which allow the data from the field tablets to be imported into external production /
490 archival databases are also available. The various tables of the Port Sampling module and how
491 they relate to one another is shown in Figure 18.

492 **3.3 Technical Implementation of Other Design Goals**

493 **3.3.1 Version control/source control**

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

500 **3.3.2 Unit testing**

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

505 development for the application, the use of unit tests is highly encouraged, especially to back
506 up the core functionality of the application.

507 **3.3.3 Backup strategy**

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

519 **3.3.4 Customizable protocols**

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

527 **3.3.5 Quality control**

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

530 **Sets**

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

536 Andes will create a flag when the tow distance as calculated by the cruise track, differs from the
537 tow distance as calculated by a straight line between the start and end coordinates by more than
538 5%. Andes will flag when the start or stop coordinates of a set are not within the expected NAFO
539 area (if applicable).

540 **Catches**

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

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

550 where a and b are the regression coefficients for a given species. Andes offers the option to
551 specify separate regression coefficients for males, females or unspecified individuals (as shown
552 in Figure 19). An additional optional layer of quality control allows project leads to assign allow-
553 lists and restrict-lists, commonly known as “whitelists” and “blacklists”, to a mission or to a
554 specific geographic feature (e.g., a stratum). In this way, the validity of each catch entered into a
555 set can be assessed. For example, if a catch being recorded is *not* on the that set’s associated
556 allow-lists, the end user will be notified that this is an unusual observation and will be prompted
557 to collect documentation. Similarly, if a project lead adds a catch to the mission’s restrict-list,
558 users who enter this catch will receive a warning message, asking them to double-check the
559 assignment. This is useful when project leads want to limit the usage of certain taxa during data
560 entry, e.g., *Alosa* sp. is preferred over the use of *Alosa pseudoharengus*.

561 **Specimens**

562 Specimen lengths and length-to-weight ratios are validated against the parameters entered in
563 the sampling requirements for that catch. Acceptable length-to-weight ratios are assessed by
564 comparing the actual weight to the estimated weight, as described by Equation 1 in the section
565 above. Additionally, Andes will flag when there is a mismatch between fish maturity and somatic
566 length. Project leads can specify mature length thresholds for males, females or unspecified
567 individuals in the sampling requirement of a given species (as shown in Figure 20).

568 **Observations**

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

576 **3.3.6 Reactivity**

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

583 **3.3.7 Multilingualism**

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

590 **4 Discussion**

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

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

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

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

612 management systems or other types of data solutions.

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

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

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

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

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

639 **4.1 Integration of Andes with Existing Data Repositories**

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

645 **4.2 Future Direction**

646 Onboarding efforts for additional coastal surveys (scallop, sea-cucumber, whelk) and regions
647 is an ongoing process driven by Andes' success. A major, short-term developmental priority

648 for Andes is the implementation of bottom trawl survey validation protocols as defined by the
649 Northeast Fisheries Science Center (Politis et al. 2014).

650 **4.2.1 Atlantic Zone (Offshelf) Monitoring Program (AZMP/AZOMP) oceanographic**
651 **surveys**

652 Andes was first trialed in parallel to ELOG on a dedicated oceanographic survey led by the
653 Maritimes Region AZMP in the spring 2022, and was recently used as the sole event logger
654 during the 2023 Atlantic Zone Offshelf Monitoring Program (AZMP) survey. During its initial trial
655 on the 2022 spring AZMP survey, a number of limitations were noted. ELOG assigns each gear
656 deployment a sequential 3-digit ‘event’ number. In contrast, Andes groups all gear deployments
657 in relation to a Set number, which is a primarily fisheries-related term that is not applicable to
658 oceanographic survey data collection. However, Andes could easily be adapted to the AZMP’s
659 normal metadata naming convention by renaming Set to ‘station’, given that multiple sampling
660 events normally occur at the same AZMP station.

661 The initial version of Andes included only two oceanographic gear options: CTD/Rosette and
662 ring net deployments. However, Argo floats, oceanographic buoys, moorings, multinet, and other
663 gear are routinely deployed during AZMP and AZOMP surveys, and the order of operations must
664 be flexible. In previous versions of Andes, the order of operations under each Set could not be
665 modified between stations. With developer support, Andes was modified to allow for the inclusion
666 of additional gear options and the ability to toggle and select between gear types should the
667 order of operations change between stations.

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

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

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

685 **4.3 Governance**

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

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

696

5 Acknowledgments

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

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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

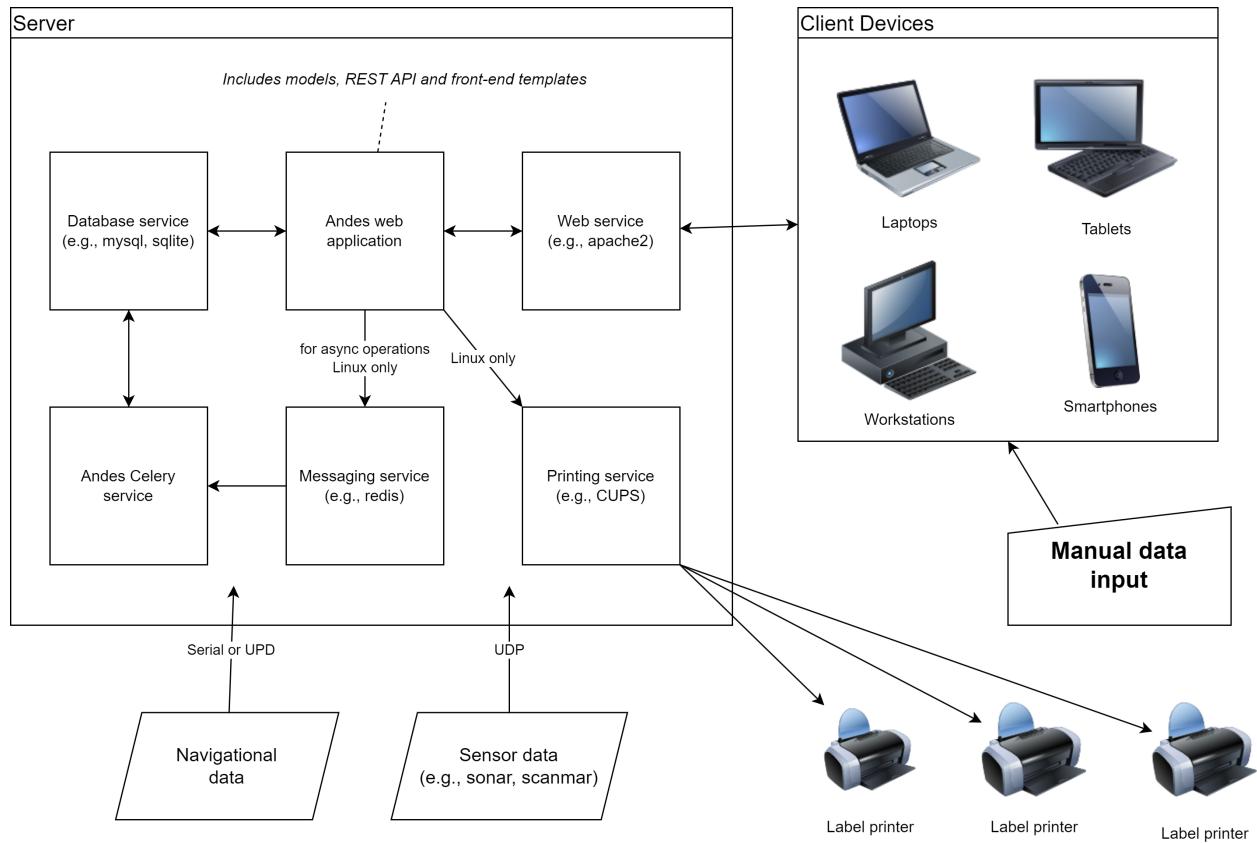


Figure 1. The generalized system architecture diagram of the Andes application and its associated services.

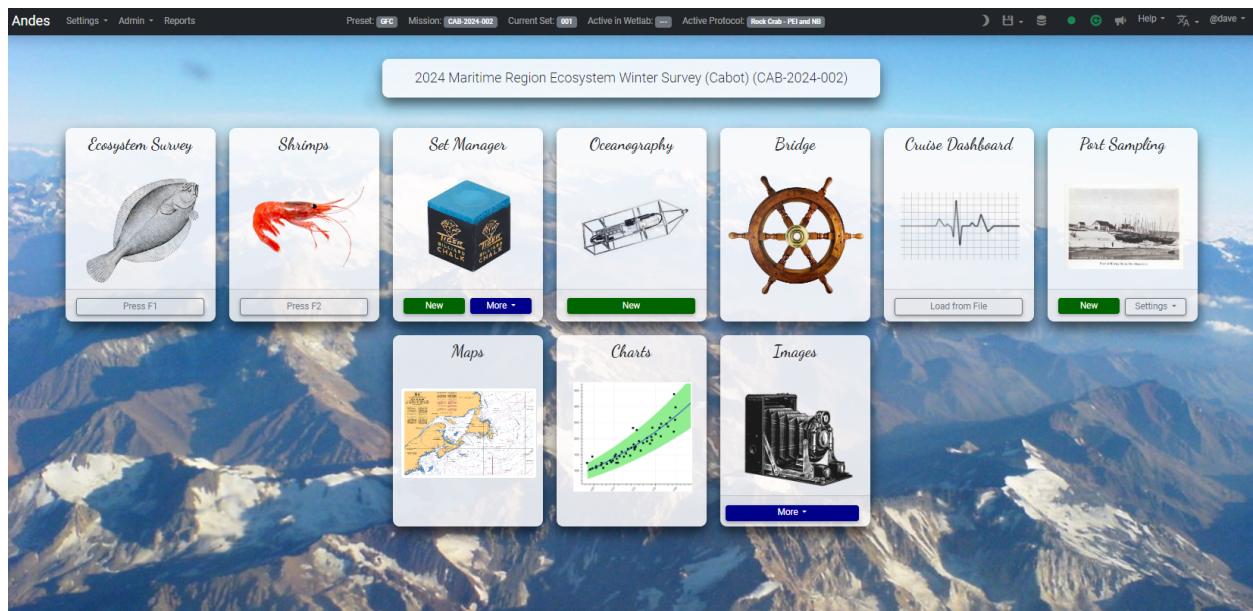


Figure 2. A screenshot of the main index page of Another data entry system (Andes) showing the principal modules of the application. What is displayed on the index page will depend both on the user's permissions and profile.

+
Fishing

✎
Set Card

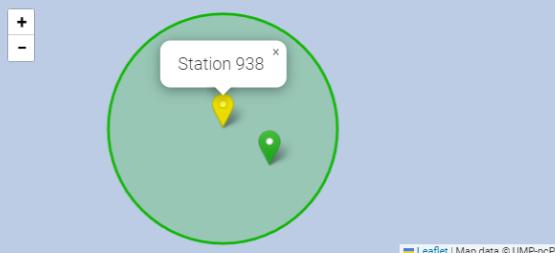
📍 **Current Set**

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><u>Created:</u> 2023-03-29 13:04:14 ADT by ryan_martin</small> <small><u>Updated:</u> 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.

22

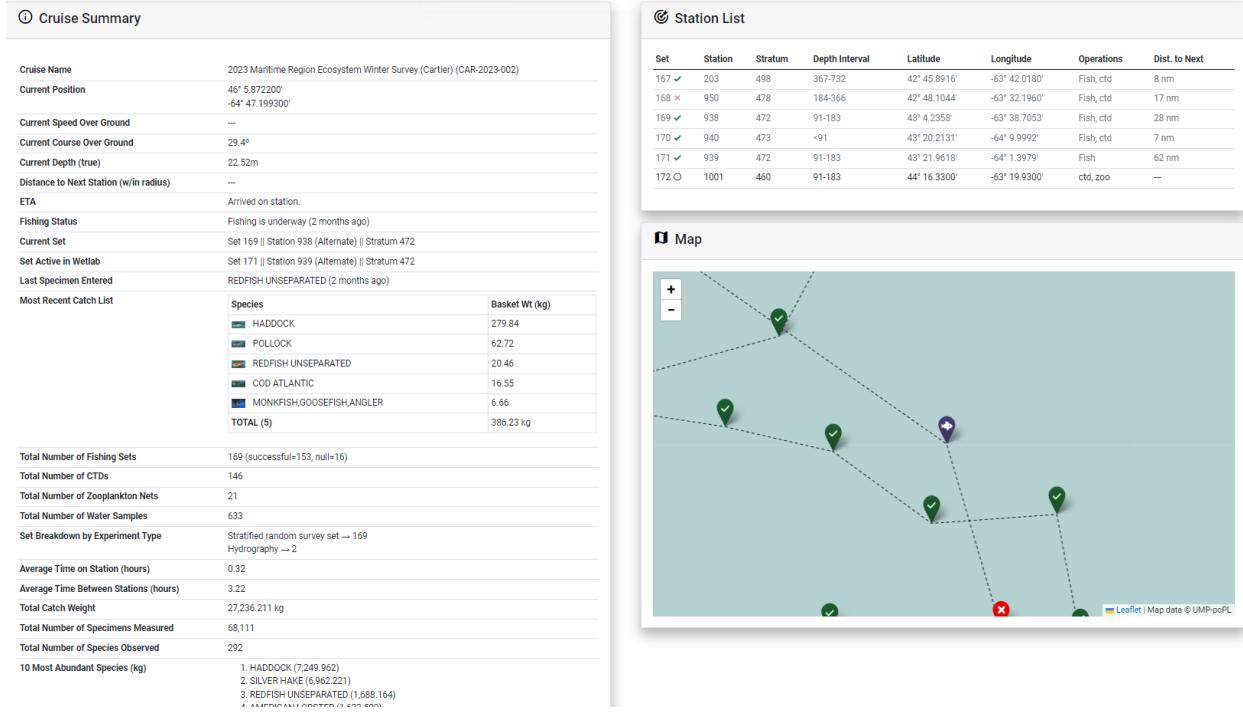


Figure 4. A screenshot of the Andes Cruise Dashboard. This dashboard helps to communicate queued stations, fishing activities underway and estimated times of arrival to science staff and crew personnel. The dashboard also displays high level summaries of Science activities that were conducted.

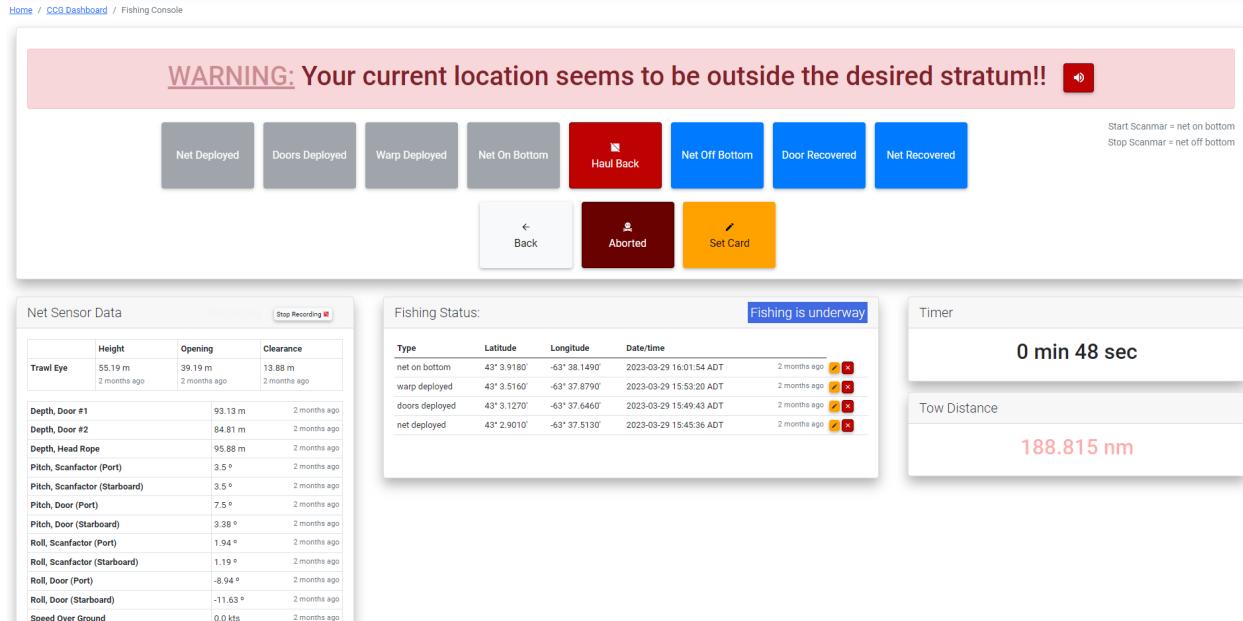


Figure 5. A screenshot of Andes Fishing Console within the Bridge module. This screenshot shows some quality control validation features including: the fishing timer, the distance display and an alarm message for when the vessel is travelling outside the targeted stratum. On the bottom left of the screenshot,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

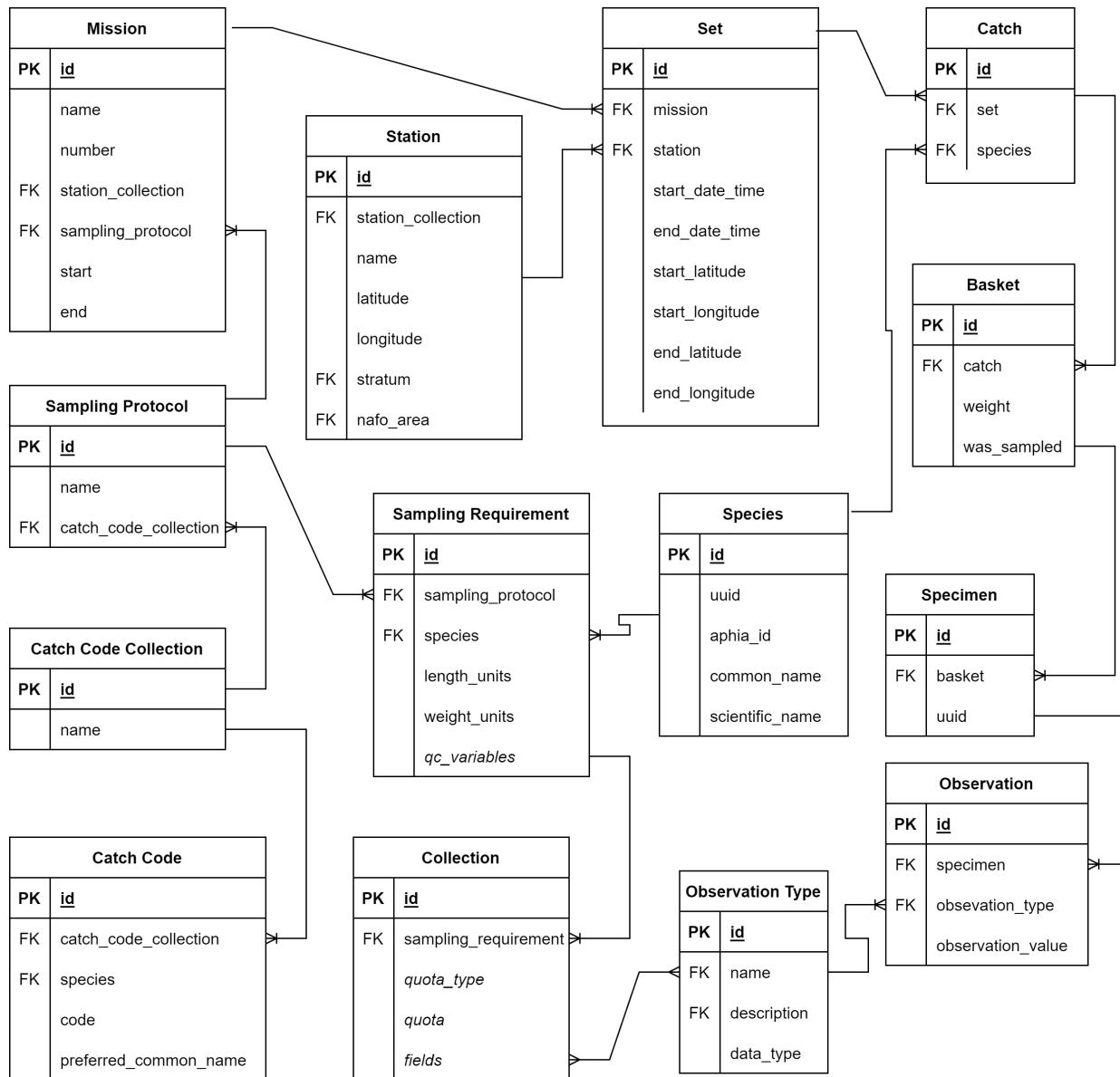


Figure 6. A simplified entity relationship diagram of the data model used by the Ecosystem Survey module of Andes.

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 argente – *Merluccius bilinearis*
(already added)

Figure 7. 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	
<input type="text" value="1"/>	1	yes	

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 8. 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 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 9. 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.

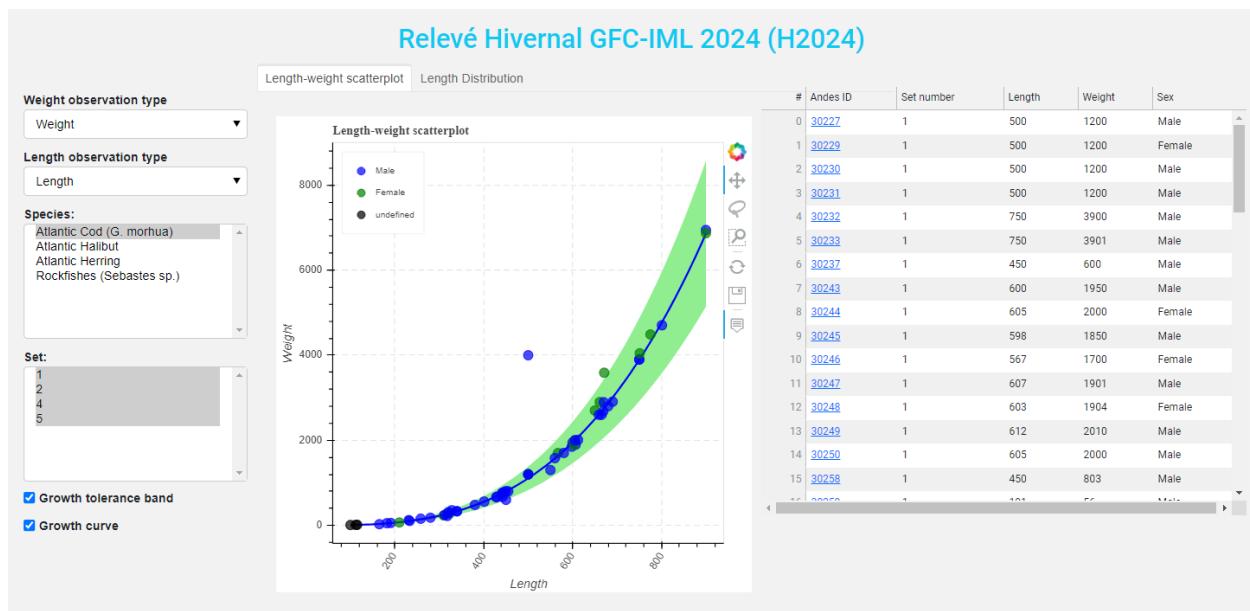


Figure 10. A screenshot of the Charts module showing the weight vs length scatter plot on top of its growth curve model.

Oceanographic Sample for Set 166 (CAR-2023-002)

Detail	
Set	Set 166 (CAR-2023-002)
Station	Station 205 (Primary) Stratum 498
Duration	104.77 min
Operator	kevin pauley
Metadata	<small>Created: 2023-03-29 00:14:59 ADT Updated: 2023-03-29 06:49:34 ADT by kevin</small>
Completion Status	Complete

Depth	
Ping	22.52 m
2 months ago	

Show Meteorological Information from Set Card

Activities									
Event number	Instrument	Duration	Number of bottles	Number of actions	Actions				
					Deploy	Bottom	Recovery	Abort	
164	Yellow Belly	57.9 min	8	3	✓	✓	✓	---	Yes
165	Plankton net (202µm)	34.42 min	0	3	✓	✓	✓	---	Yes

Add Activity

Station Map

A map showing the location of a research vessel at sea. A large green circle indicates the current position, and several smaller colored dots (green, orange, red) represent previous sampling locations along a path.

Figure 11. A screenshot of the Oceanographic Sample detail page from the Andes Oceanography module.

164 - Yellow Belly

Detail									
Instrument	Yellow Belly	For CTDs Only:							
Event number	164	CTD filename	23002166.hex						
Duration	57.9 min	Min. altimeter height from bottom (m)	2						
Wire out (m)	688	Min. bottle height from bottom (m)	3						
Wire angle (degrees)	0	Max depth of CTD (m)	683						
Tow down speed (m/min)	30								
Tow up speed (m/min)	30								
Metadata	Created: 2023-03-29 00:14:59 ADT Updated: 2023-03-29 06:52:55 ADT by kevin	Temperature (°C)	5 meters Bottom						
Completion Status	Complete	4.59	5.69						
		Salinity	32.23 35.01						
Bottles		Saved							
		Add Bottle 5m							
Unique ID	Depth (m)	TIC/pH	Chlorophyll	Nutrients	Oxygen	Salinity	Phytoplankton	Comment	Complete?
496740	5	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496739	25	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496738	50	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496737	100	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496736	200	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496735	300	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496734	400	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		Yes X
496733	deepest bottle 683	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		Yes X
Oxygen Subsample									
Bottle	Operator	Winklers #1 (ml/L)	Winklers #2 (ml/L)	Winklers #3 (ml/L)	Comment	Complete?			
496740 @ 5	kevin	7.569				Yes			
496735 @ 300	kevin	3.29	3.302			Yes			
496733 @ 683	kevin	5.07	5.05			Yes			

Figure 12. A screenshot of the Oceanographic Activity detail page from the Andes Oceanography module. Note that 'Yellow Belly' refers to the colloquial name of the CTD/Rosette system.

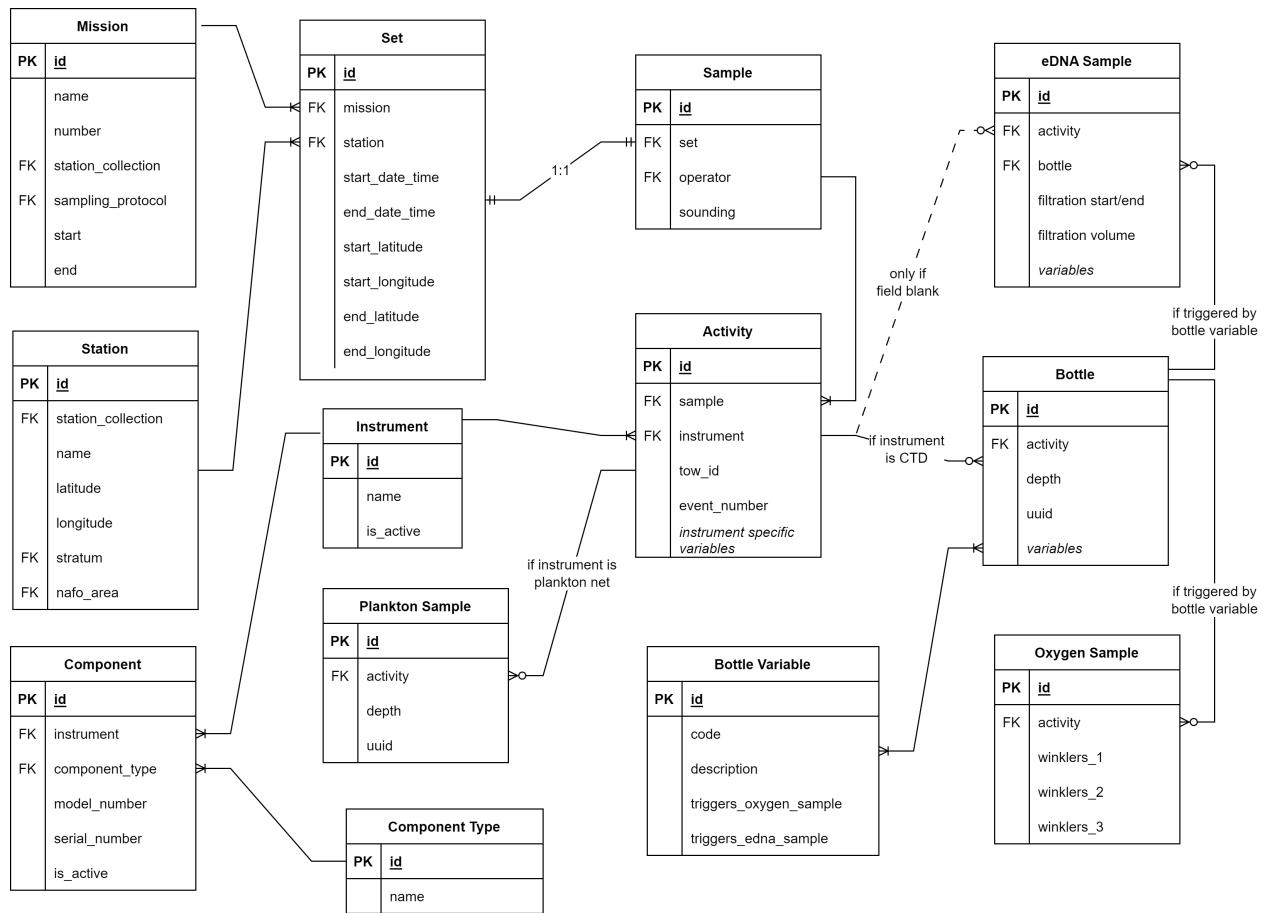


Figure 13. A simplified entity relationship diagram of the data model used by the Oceanography module of Andes.

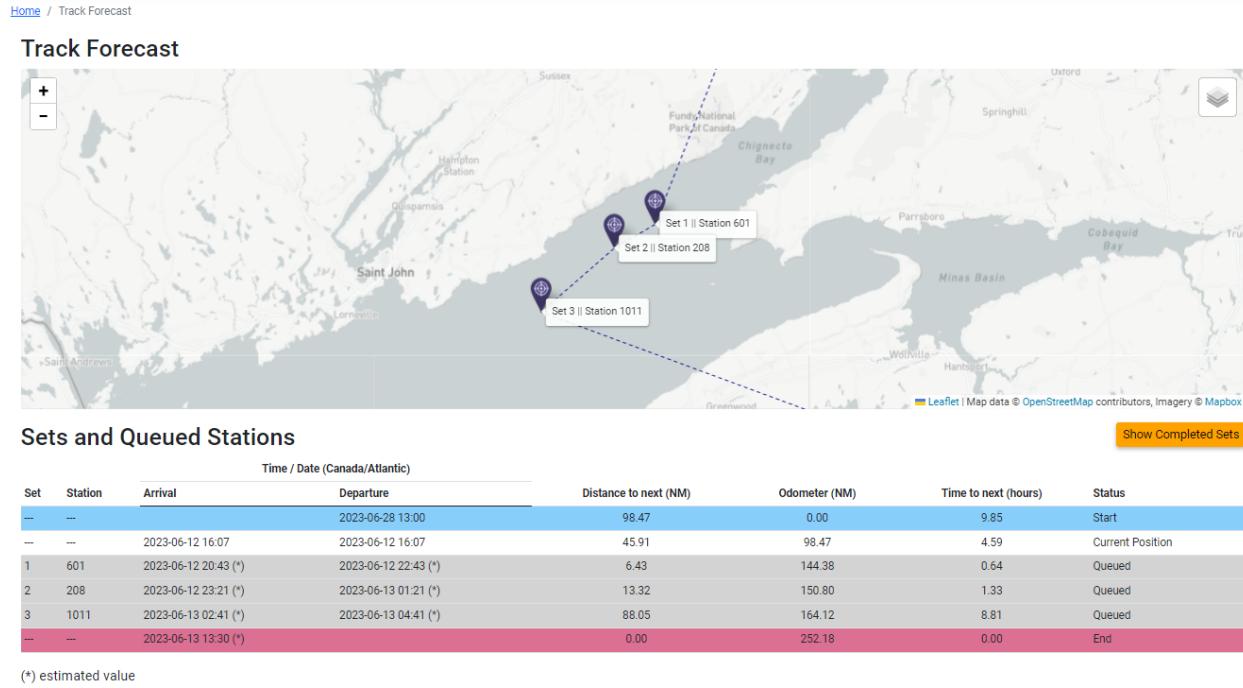


Figure 14. A screenshot of the Track Forecast tool.

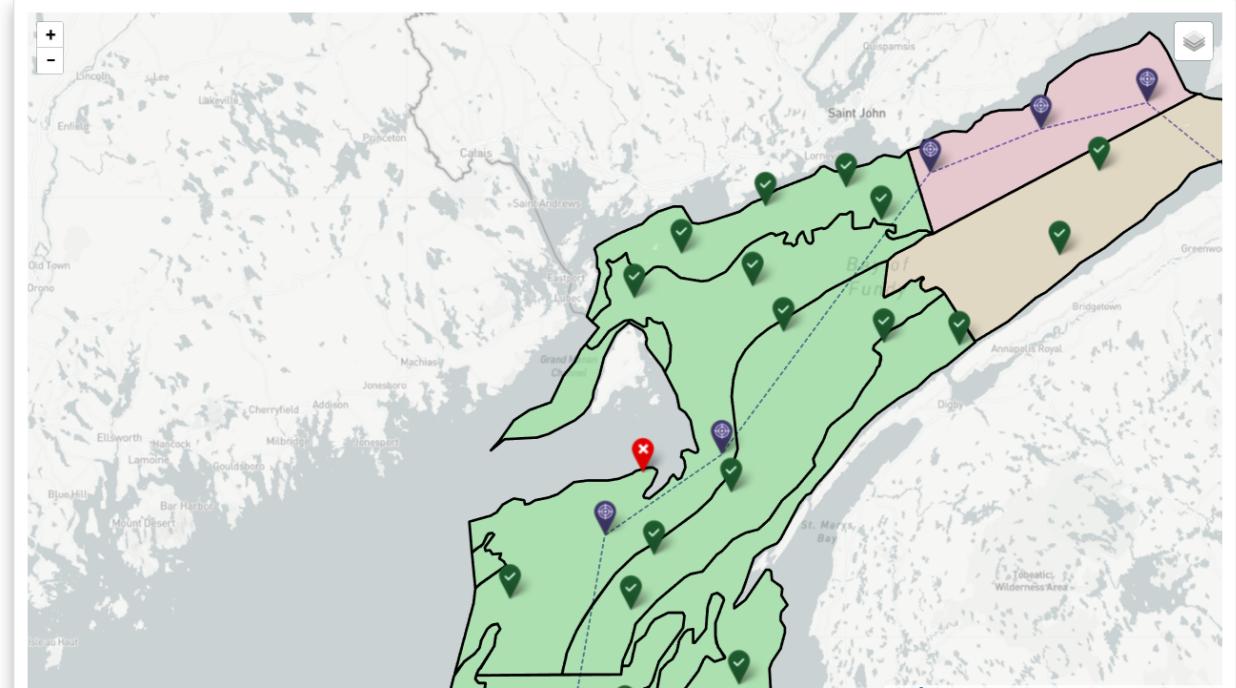
[Stations](#) [Show Track](#) [Hide Strata](#) [Show NAFO Areas](#)

Figure 15. 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 16. 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 17. 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.

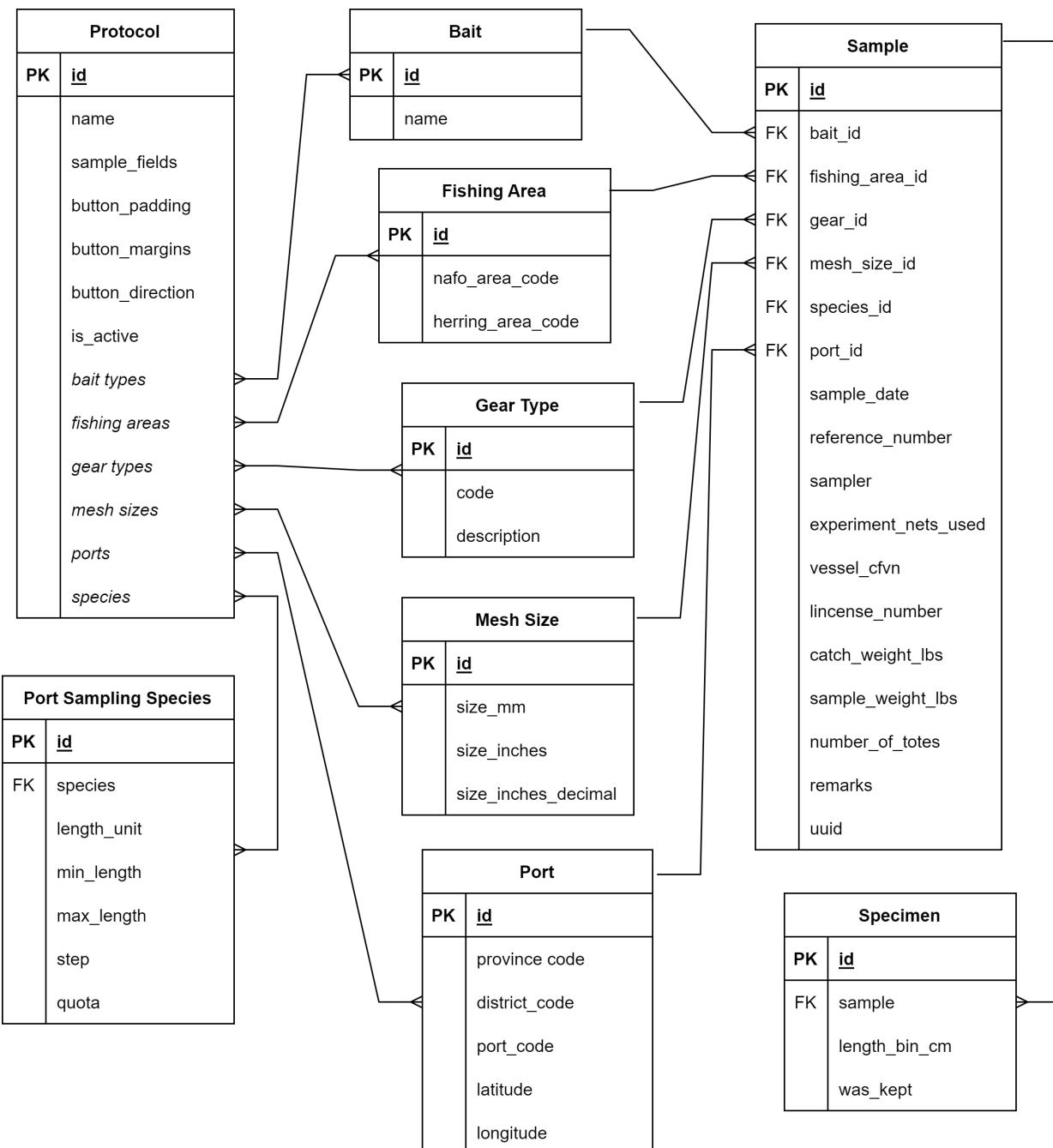


Figure 18. A simplified entity relationship diagram of the data model used by the Port Sampling module of Andes.

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 19. 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

This screenshot shows the 'Mature Length' section of a sampling requirement form. At the top, there's a blue header bar with the title 'Mature Length'. Below it, a table is used to specify 'Mature length threshold' for different categories: 'Unspecified', 'Male', and 'Female'. The 'Unspecified' row contains the value '30' and a note asking what the minimum length of a mature individual of the species is before a warning is issued. The 'Male' and 'Female' rows have empty input fields labeled 'Mature length (male)' and 'Mature length (female)' respectively. Below the table, there's a section for 'Maturity observation type' with a dropdown menu showing 'Maturity'. Underneath that, there's a field for 'Code used to signal an immature specimen' containing the value '1', with a note stating it's only applicable if a maturity observation type is provided. The entire form is contained within a light gray box.

Figure 20. 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

- 719 **Andes** Another data entry system.
- 720 **API** Application Programming Interface.
- 721 **AZMP** Atlantic Zone Monitoring Program.
- 722 **AZOMP** Atlantic Zone Offshelf Monitoring Program.
- 723 **CDOS** Chief Digital Officer Sector.
- 724 **CSS** Cascading Style Sheet.
- 725 **DFO** Fisheries and Oceans Canada, formerly the Department of Fisheries and Oceans.
- 726 **ERD** Entity Relationship Diagram.
- 727 **ESE** Ecosystem Survey Entry.
- 728 **GSE** Groundfish Survey Entry.
- 729 **html5** Hypertext Markup Language.
- 730 **IMTS** Information Management and Technology Services.
- 731 **LAN** Local Area Network.
- 732 **MPA** Marine Protected Area.
- 733 **MRR** Module des Relevés de Recherche.
- 734 **NAFO** Northwest Atlantic Fisheries Organisation.
- 735 **REST** Representational state transfer (REST).
- 736 **REST-API** Representational state transfer (REST) Application programming interface (API).
- 737 **VCS** Version Control System.
- 738 **WAN** Wide Area Network.

739

10 Glossary

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

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

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

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

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

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

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

762 **Catch Card** Catch details recorded prior to detailed sampling.

763 **CCG** The Canadian Coast Guard.

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

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

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

770 **Cruise** Same as Mission.

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

773 **CTD** Conductivity, salinity and density.

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

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

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

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

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

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

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

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

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

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

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

797 **Mission** Same as Cruise .

798 **NAFO** Northwest Atlantic Fisheries Organisation.

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

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

804 **Port Sampling** Scientific program collecting samples from commercial fishing activities.

- 805 **REST-API** Representational state transfer (REST) Application programming interface (API) is
806 an API that follows the REST software architectural style, created to guide the design and
807 development of the architecture for the World Wide Web.
- 808 **Sampling Requirements** The species-specific requirements for samples to be collected during
809 a scientific cruise.
- 810 **Sampling Protocol** The detailed description of what data is to be collected during a scientific
811 cruise.
- 812 **Set** A Set contains all fishing activity and sampling results for a particular Station .
- 813 **Set Flag** A flag used to indicate that the data contained within the set has failed to pass a
814 specific validation tests. Closing an Open Set with active flags can be done by overriding
815 the validation mechanism.
- 816 **Species** An identifiable taxon that can be assigned to a species code.
- 817 **Station** A target location specified by coordinates where a scientific activity is to take place.
- 818 **VB** Pre-.NET Visual Basic for Applications is the early version of Microsoft VBA and is no longer
819 supported or updated by Microsoft.
- 820 **VBA** Visual Basic for Applications is a programming language built into most desktop Microsoft
821 Office applications. More details can be found on the Wikipedia page for this programming
822 language and from Microsoft.
- 823 **VCS** A Version Control System records changes to a file or set of files over time so that specific
824 versions can be recalled later. For example, git is a VSC.
- 825 **Vue.js** A JavaScript framework for building reactive user interfaces. <https://vuejs.org/>.
- 826 **WAN** A telecommunications network that extends over a large geographic area, such as the
827 internet.

828

APPENDIX A Tasks for administrative user

829 Prior to a survey, a number of configurations must be done for Andes to function as intended.
830 At a minimum, the following information must be provided and ingested by Andes in order for
831 a mission to take place:

832 **Strata polygons**

833 **List of stations**

834 **Species list**

835 **Sampling requirements**

836

APPENDIX B Further resources about Andes

837 The main git repository supporting the development of the application is hosted by IMTS. The
838 following resources can be found there:

- 839 • deployment checklist
- 840 • species lists for Gulf, Maritimes and Québec regions
- 841 • strata polygons
- 842 • sampling requirements from previous surveys