MSDS 25.5:
"A Modern Approach to Pacific Salmon Research: An Online Dashboard"

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1. ABSTRACT

People hear about Pacific salmon all the time in the Pacific Northwest, but their role goes way beyond just being a regional symbol. They're a vital part of both the local ecosystem and the economy. As environmental and habitat conditions continue to shift, it's become harder for scientists to access the kind of data they need to study and protect these fish. NOAA Fisheries, part of the National Oceanic and Atmospheric Administration (NOAA), focuses on managing sustainable fisheries and protecting marine species like Pacific salmon. As part of our capstone project, we partnered with their team to rebuild a key research tool: the Stressor Response Function (SRF) dashboard. The original version developed on an older platform was not compatible with NOAA Fisheries' current web infrastructure and no longer met the needs of the researchers using it. To solve this, we created a new dashboard using R Shiny, designed to integrate directly with NOAA's Posit Connect platform. The updated version adds important features like improved search and filtering, interactive visualizations, customizable data exports, a more intuitive interface, and a secure system for uploading and validating new SRF data. We also introduced improvements in data storage by transitioning from JSON to a more scalable SQLite database structure. By centralizing access to SRF data, the dashboard brings everything into one place, making it easier for researchers to work with SRF data and make more informed decisions. Rather than manually combing through articles, users can now compare environmental stressors, salmon life stages, and outcomes across studies—all within a few clicks. With more accessible tools and cleaner data, NOAA Fisheries is better positioned to carry out data-driven salmon conservation and habitat restoration efforts.

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2. INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA) is a U.S. government agency focused on ocean, climate, and environmental research. It plays a crucial role in conserving marine life, with key priorities around protecting and managing coastal and oceanic resources, as well as understanding how environmental changes affect these systems. One of its major objectives is supporting the sustainability of Pacific salmon populations. This project will specifically focus on helping researchers understand the impact of environmental changes on Pacific salmon.

NOAA Fisheries and its research collaborators use a modeling approach known as Life Cycle Modeling (LCM). These models help evaluate how salmon respond to environmental stressors such as changes in temperature, flow, or habitat and guide recovery strategies for threatened and endangered populations. At the heart of LCMs are stressor-response functions (SRFs), which describe how environmental variables relate to outcomes like egg survival or successful migration. Identifying the right SRFs for a specific region, species, or life stage is a major challenge, often because the supporting literature is scattered, inconsistently labeled, or difficult to compare.

To make this process easier, NOAA developed a dashboard to organize and explore SRF-related research. The original version, built using Drupal, eventually turned out to be incompatible with NOAA Fisheries' web infrastructure and no longer met researchers' evolving needs. It lacked important features like advanced filtering and smooth integration with NOAA's existing R-based tools. As a starting point for redevelopment, our team exported the data from the Drupal dashboard into a JSON file. This file containing SRF articles and metadata served as the basis for initial development. Later in the project, we transitioned to using SQLite databases for better performance and scalability.

In collaboration with NOAA Fisheries, our capstone team at Seattle University rebuilt the SRF dashboard using R Shiny, a framework that aligns well with NOAA's existing tools and infrastructure. The new dashboard includes advanced database searching and filtering options, interactive visualizations, data uploading functionality, and data exports in multiple formats. This approach is consistent with other R Shiny applications NOAA has developed to support environmental monitoring, such as dashboards for stream temperatures in the Willamette and Elwha rivers. By effectively addressing the limitations of the original dashboard and providing a more flexible and accessible platform, this project supports efficient data exploration and contributes to informed decision-making in Pacific salmon conservation.

3. LEGACY SYSTEM OVERVIEW

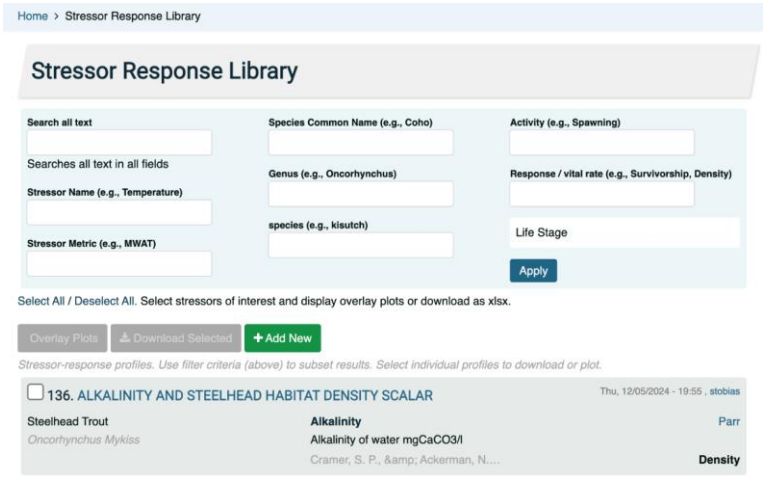
Before the current dashboard was developed, NOAA Fisheries used a custom-built Drupal application to manage and share information on stressor-response functions (SRFs) for Pacific salmon. Originally designed by M.J. Bayly, this earlier tool acted as a central resource for scientific literature linking environmental stressors such as changes in temperature and streamflow—to biological responses at different salmon life stages. Users can search and filter SRFs by species, stressors, or endpoint, generate overlay plots, and export data in multiple formats.

Although the platform met key needs at the time, it gradually became difficult to maintain and scale. Hosted externally and built with a custom Drupal module, the system couldn't be easily integrated with NOAA's internal infrastructure. Managing access was complicated, administrative controls were limited, and hosting costs fell outside NOAA's supported systems. These constraints made the tool less sustainable and harder for teams to adopt over time.

Another challenge was that the platform didn't support the level of interactivity researchers increasingly needed. As NOAA Fisheries started using more R-based tools, like those tracking Elwha and Willamette rivers' temperatures and modeling habitats, the old Drupal dashboard became harder to update without increasing costs. That led to the decision to phase out the legacy system and rebuild it using R Shiny, which will be hosted internally on NOAA's Posit Connect server in the future.

This project builds directly on the foundation of that earlier work. By recreating and expanding the key features of the original dashboard such as filtering, data visualization, export tools, and upload capabilities. We've aimed to preserve the functionality that users value while addressing the barriers that held the platform back.

Legacy Dashboard



4. SYSTEM REQUIREMENTS

This section describes the required specifications for the NOAA Fisheries SRF dashboard. To provide a structured approach to project execution and evaluation, the requirements are categorized into functional, non-functional, business, and technical.

Core Features & Functional Requirements:

The functional requirements are core functionalities that need to be incorporated into the project. These requirements are in turn divided into core and advanced features.

1. **Searchable & Filterable SRF Database:**
   Users must be able to search and filter the research articles that contain stressor-response function (SRF) data based on parameters like species, stressors, life stages, geographic region, and habitat conditions.

   - Assessment: Sample search queries will be used to test the search and filter features.

2. **Interactive Data Visualizations:**
   The dashboard must provide interactive data visualizations of stressor-response functions to illustrate how salmon survival relates to environmental conditions.

   - Assessment: Ensure individual articles have automated graphs created upon data upload. These graphs will be quality checked for hovering capabilities and clickable interactive features.

3. **Custom Data Export & Sharing:**
   Users must be able to export SRF data and graphs in multiple formats (CSV, JSON).

   - Assessment: JSON exports will be cross-checked for format accuracy using unit tests.

4. **Integration with NOAA's Integrated Toolbox:**
   The dashboard will become an essential tool in the NOAA Fisheries integrated toolbox, so it must be fully compatible with their Posit Connect toolbox on NOAA's website.

   - Assessment: The dashboard throughout production will be uploaded to Posit Connect to ensure functionality within NOAA's toolbox.

Advanced Good-to-have Features:

These features are additional addons that would further elevate the dashboard. They expand the overall functionality and utility of the dashboard.

1. **Customizable & Cross-comparable Graphs:**
   Users should be able to adjust filters dynamically and compare multiple SRFs within the same graph–overlay multiple SRFs on a plot.

   - Assessment: Overlay plots can be evaluated by creating them using multiple SRFs. Interactivity of the visualizations will be verified by confirming all interactive elements are being displayed as expected.

2. **Life Stage Dictionary:**
   Research articles should be grouped according to the life stages of salmon (e.g., young-of-the-year, juvenile), to standardize terminology across hundreds of articles.

   - Assessment: Life stage dictionary items will be integrated thoroughly into the filters and search functions. NOAA will confirm the accuracy of the implementation.

3. **Online Extraction of Data from Published Figures:**
   The dashboard should integrate or provide a third-party tool for extracting numerical data from published research figures. This will be an essential tool to help researchers in their efforts to digitize historical data.

   - Assessment: The extraction feature will be assessed by pulling data from current articles and ensuring accuracy, this will be further evaluated by pulling data from newer articles to the database.

4. **User Authentication:**
   Implement a simple login system to restrict access based on user roles (e.g., researchers, administrators).
   - Assessment: User login and Role-based access control will be assessed by creating dummy users and performing unauthorized data modifications.

5. **Upload of New SRFs:**
   Users with appropriate permissions should be able to upload new stressor-response functions securely, ensuring NOAA's database remains updated.

- Assessment: In the backend, new data uploads will go through a validation procedure. Files with defective JSON objects to see if an error is generated.

Non-Functional Requirements:

Non-functional requirement (NFR) describes a benchmark to judge the operations of the dashboard, rather than specific behaviors.

1. **Performance & Scalability:**
   Ensure the dashboard replicates the functionality of the existing Drupal app without performance degradation and ensure data queries and visualizations do not take too long to run for a smooth user experience for NOAA researchers.

   - Assessment: The dashboard's performance will be monitored when multiple filters are applied and as the size of the dataset increases over the next few months.

2. **User Experience:**
   The interface must be easy to access and quick to learn for researchers who currently use the Drupal App and must comply with NOAA's accessibility standards.

   - Assessment: The dashboard will be tested by the NOAA team once deployed, to confirm ease of navigation and clarity of data and metadata presentation.

Business Requirements:

These requirements ensure that the project is in-line with NOAA's broader mission.

1. **Replication of Existing Features:**
   To guarantee a smooth transition for NOAA Fisheries researchers, the new dashboard needs to duplicate every core feature of the current Drupal-based application as listed in the "core features" section of these requirements.

2. **Boost Data Accessibility:**
   The dashboard must serve as a centralized and searchable library of years of literature on stressor-response function (SRF) data.

3. **Long-Term Usability & Adoption:**
   The dashboard should be quick to learn, thoroughly documented through user manuals, and easy to integrate into the existing toolbox.

4. **Scalability:**

The dashboard should allow room for future enhancements throughout the lifecycle of the product such as increased data volume and further feature enhancements, i.e. “good-to-have" features that continue to need iteration.

Technical Requirements:

These describe technological attributes and constraints that should be implemented for the dashboard to work as it should.

1. **Technology Stack & Hosting:**
   The dashboard will be developed using R Shiny and hosted on Posit Connect, according to NOAA’s infrastructure guidelines.
   - Assessment: The dashboard will be tested in NOAA’s Posit Connect environment to confirm seamless hosting and integration with existing tools.

   Support for JSON data formats for compatibility with NOAA’s existing SRF datasets.
   - Assessment: The dashboard will be able to upload JSON formatted data that is in the current NOAA Drupal dashboard.

2. **Data Handling:**
   The dashboard must support efficient ingestion, indexing, and retrieval of research articles. All SRF data must be stored in a structured, searchable format, ensuring optimized queries.
   - Assessment: User testing will be utilized to assess the efficiency of gathering information from research articles.

Phase-Based Evaluation of Implementation:

These describe technological attributes and constraints that should be implemented for the dashboard to work as it should.

1. Core requirements define the Minimum Viable Product (MVP) and will be tested before full deployment.
2. Advanced features will be prioritized based on their feasibility, availability of resources, and NOAA’s feedback in later phases.
3. Accessability options to adhere to guidelines from NOAA and the government accessibility guidelines will be assessed throughout the project with a final pass towards the end. [3]

5. SYSTEM ARCHITECTURE & METHODLOGY

To address the deprecation of the legacy SRF dashboard, this project involved designing and implementing a fully interactive, scalable R Shiny application hosted on NOAA's Posit Connect server. This new dashboard replicates the functionality of the original Drupal app while introducing significant enhancements in usability, performance, and maintainability.

Architecture Overview

The system follows a modular structure, with separate components for data ingestion, filtering, visualization, uploading, and export. Initial development began by exporting all SRF data from the legacy Drupal app as a JSON file. However, given the need for more robust data handling particularly around upload validation and real-time filtering the team transitioned to using SQLite as the database solution. SQLite provides efficient querying, easy schema management, and is well-suited for R Shiny applications. This architecture allows for future migration to a more advanced NOAA-hosted database. The use of SQLite provides fast querying, reliable storage, and makes future migration to NOAA's internal systems easier.

All data interactions are managed using R's DBI [4] interface in combination with the RSQLite [5] package. This setup allows the dashboard to connect to the SQLite database, send and retrieve SQL queries, and maintain clean separation between the user interface and backend data logic.

Implementation of Key Features

The new SRF dashboard implements a range of essential and advanced features to support salmonid stressor-response research. These were developed incrementally and refined through feedback from NOAA Fisheries throughout the project timeline.

- **Searchable and Filterable Database:**

Users can search for SRF entries by using multiple metadata fields such as species, stressor, life stage, and more. Filters update results in real-time using reactive Shiny elements via dbplyr, allowing real-time query generation against the SQLite database. Complex filters such as multi-select dropdowns for life stages and stressors were also implemented to improve flexibility.

- **Interactive Data Visualizations:**

Stressor-response curves Graphs are created generated using ggplot2 and made interactive through plotly. These visualizations appear in the detailed SRF article view and are generated dynamically rendered based on each SRF'S input data. Recently, overlay plots were added (partially), allowing

users to compare multiple SRFs on a single graph. Hover labels and tooltips enhance usability for researchers.

- **Secure Data Upload and Validation:**

The dashboard includes a file upload system for administrators. This upload system takes a guided approach to submitting data by utilizing drop downs rather than just write in prompts. These dropdowns help with validation as they only allow inputs that are already in the database. These submitted SRFs go through validation checks for completeness, JSON structure, and metadata conformity. A secure upload system allows approved users to submit new SRFs. Inputs are validated by the user before submission via the preview button which brings a pop up of all inputs submitted by a user.

Commented [RS1]: This is not done, you can mention that we prevent the users from entering erroneous fields by letting them choose options from dropdowns rather than inputting invalid/duplicate strings in metadata fields

Commented [RS2]: Not there.

- **Data Export:**

Users can download selected SRFs in CSV or JSON format. Export logic is handled using readr::write_csv(), jsonlite, and custom rendering functions for formatted output. These export buttons reflect the current filter selection to ensure precise data extraction.

UI & UX Enhancements

The SRF dashboard prioritizes user experience by integrating modern interface elements and streamlining workflows for researchers accustomed to the legacy Drupal system. Several enhancements were introduced to make the interface more intuitive, accessible, and visually informative.

- **Multi-Select Dropdown Filters:**

The dashboard features multi-select dropdowns with checkbox support for key fields such as species, stressors, and life stages. These were implemented using a shiny widgets package called Picker Input to improve usability and allow researchers to construct complex queries easily.

Commented [RS3]: Avoid writing code

- **Collapsible Article View:**

Each article includes a collapside section that reveals detailed metadata, full citations, and associated visualizations. This approach keeps the main dashboard uncluttered while giving users quick access to in-depth content when needed.

- **Life Stage Dictionary Integration:**

To standardize terminology and improve searchability, life stage terms across SRF articles were mapped to a controlled vocabulary. This dictionary is reflected in the filter menus and helps unify articles with inconsistent or legacy labels.

- **Data Analysis Tab:**

An internal DA view was added to help NOAA reviewers monitor data quality. This section provides summary statistics and visual cues to flag inconsistencies or anomalies in the SRF dataset.

- **Accessibility and Design Considerations:**

The UI follows NOAA's accessibility guidelines, using high-contrast themes, scalable fonts, and keyboard-friendly navigation. All dropdowns, labels, and interactive elements were tested for clarity and responsiveness. Together, these enhancements deliver significantly improved user experience- ensuring that the dashboard is both powerful and easy to use across NOAA Fisheries' research teams. Several good-to-have features are integrated or in progress, including:

- Customizable comparison plots (multi-SRF overlay)
- Collapsible article detail's view
- Life stage dictionary integration for filter consistency
- Dropdowns with multi-select options
- An exploratory data analysis (EDA) tab for internal quality checks

All features are designed with accessibility and long-term usability in mind. Dropdowns, filters, and form fields reduce input variability and help enforce cleaner metadata standards compared to the previous system.

Tooling and Version Control

The team used RStudio for development and GitHub for version control. The codebase is modularized for easy future expansion. JavaScript was incorporated for client-side interactions like file upload feedback and error messages. The dashboard was tested iteratively by NOAA Fisheries throughout development to ensure alignment with user expectations.

Development Process

The development process followed a phase-based approach. Early work focused on establishing the data architecture and core functionality. As those features stabilized, the team shifted toward implementing advanced features and refining the user interface. Regular meetings and check-ins with NOAA Fisheries helped shape the dashboard through iterative feedback, ensuring the final product aligned with sponsor expectations. This collaborative process also allowed for prioritization of "good-to-have" features based on feasibility and impact.

6. SYSTEM WALKTHROUGH

Main Page

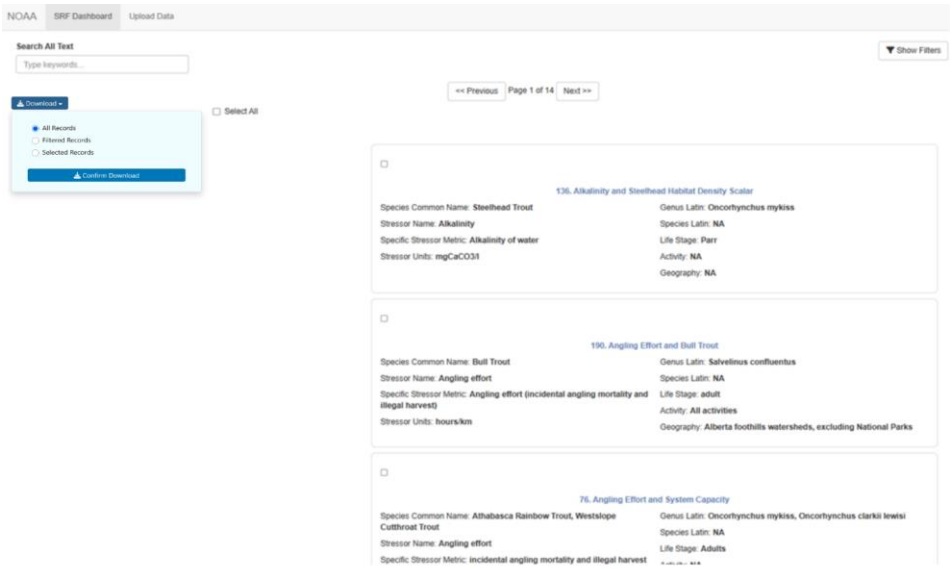


Figure 1: Main dashboard view with search bar, filter toggle, download/export options, and article result cards.

Dashboard Layout

When users first open the SRF Dashboard, they are presented with a clean and intuitive interface designed for immediate interaction. The top of the page features a free-text search bar labeled “Search All Text” allows users to query across all indexed article fields. A "Show Filters" button on the top right to toggle the advanced filter panel. A download button that includes options to download all records, filtered records, or selected records. A "Select All" checkbox for bulk selection of articles.

Below the search and action bar, article results are displayed as scrollable vertical cards, each summarizing metadata such as:

- Species common and Latin names
- Stressor name and metric
- Stressor units
- Life stage
- Activity
- Geography

Pagination controls appear at the top of the results, allowing users to move between pages.

Pagination and Load More Functionality

Figure 2: Bottom of dashboard showing result count, pagination controls, and Load More option.

At the bottom of the article results panel, the system displays a load More button which dynamically appends additional article cards to the current view without reloading the page, supporting infinite scroll behavior.

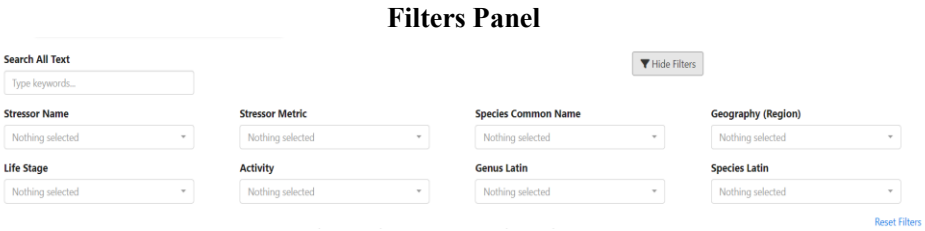


Figure 3: Expanded filtering panel with dropdown menus for advanced search refinement.

Filter Interface

Clicking the "Show Filters" button expands a panel containing multiple multi-select dropdown menus for refining article search results. The filters are laid out in a grid for easy scanning and include the following fields: Stressor Name, Broad Stressor Name, Stressor Metric, Species Common Name, Genus Latin, Species Latin, Life Stage, Activity, Geography (Region), Country, State/Province, Watershed/Lab, River/Creek, and Research Article Type. Each dropdown is pre-populated with selectable options and defaults to "All". A "Reset Filters" link at the bottom right clears all filter selections, returning the view to its default state.

Commented [RS4]: Include new filters that were added

Article Result Cards

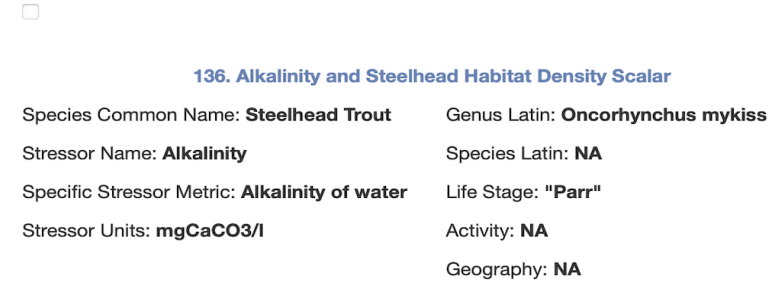


Figure 4: Article result card showing summary metadata for SRF articles.

Each article in the search results is displayed as an individual card, offering a compact summary of key metadata for quick review. These cards are vertically stacked and consistently formatted for easy scanning.
A checkbox at the top-left corner allows users to select individual articles for download using the "Download Selected" button.

Article Detailed View

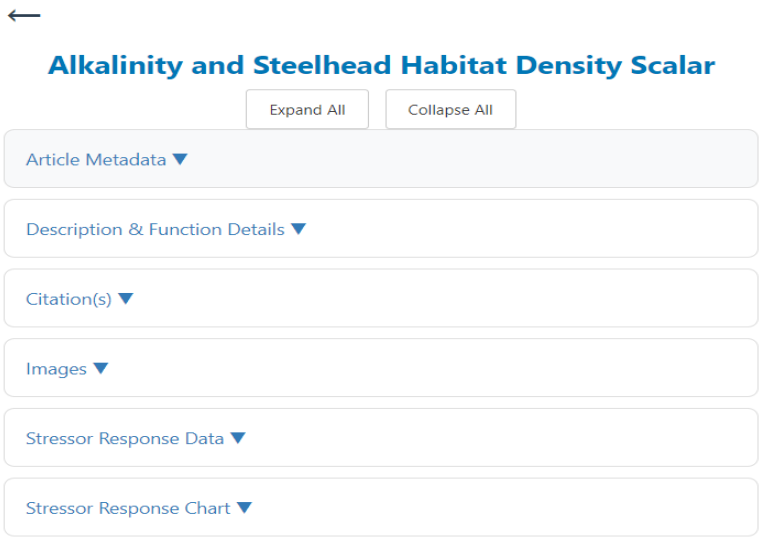


Figure 5: Collapsible article detail view showing modular data sections.

Expandable Section Layout

When a user clicks on an article title from the results list, a detailed article view opens. This view is structured into collapsible sections, allowing users to selectively explore specific types of information without overwhelming the screen.

The available sections include: Article Metadata, Description & Function Details, Citation(s), Images, Stressor Response Data, and an Interactive Stressor Response Chart.

At the top of the view, two buttons-Expand All and Collapse All will enable users to open or close all sections at once. This modular layout enhances user experience by providing both flexibility and organization in navigating dense data.

A back arrow in the top left corner allows users to return to the main dashboard view.

Interactive Visualization

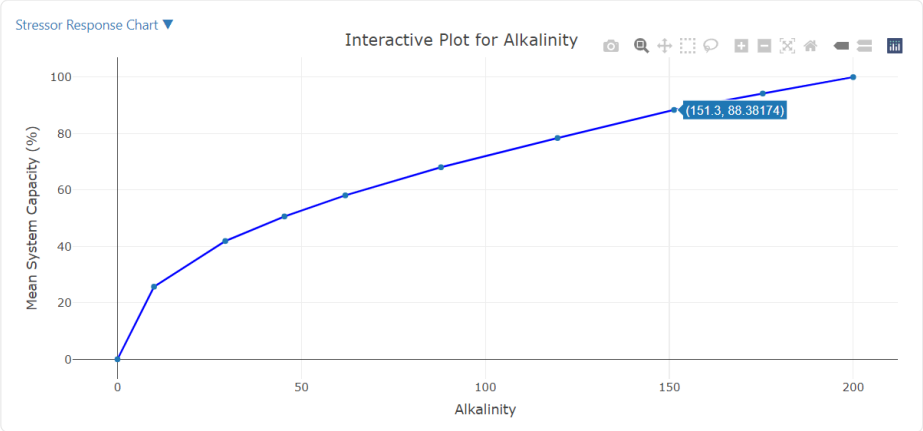


Figure 6: Interactive chart showing the sample article of stressor-response curve for Alkalinity.

Stressor-Response Chart

Within the “Stressor Response Chart” section of the detailed article view, each SRF includes an interactive plot generated using Plotly. This visualization displays the relationship between the X-axis: Stressor values (e.g., Alkalinity) and the Y-axis: Response outcome (e.g., Mean System Capacity).

Key interactive features include: hover tooltips showing exact data point values, zoom and pan controls, export and reset tools for saving and resetting the view, and a responsive layout that adjusts to screen size. This dynamic visualization allows users to explore stressor-response behavior directly and supports deeper data interpretation without leaving the dashboard.

Upload Data

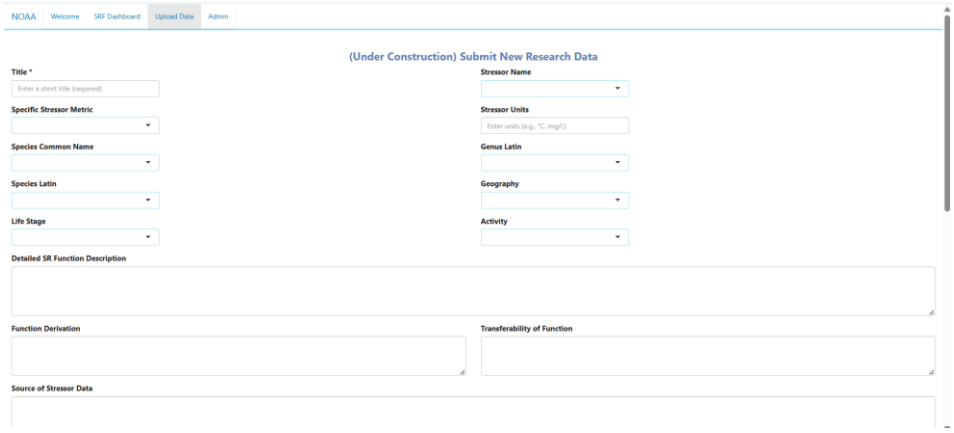


Figure 7: Top portion of the Upload Data tab displaying metadata fields for species, stressor, and contextual information**.**

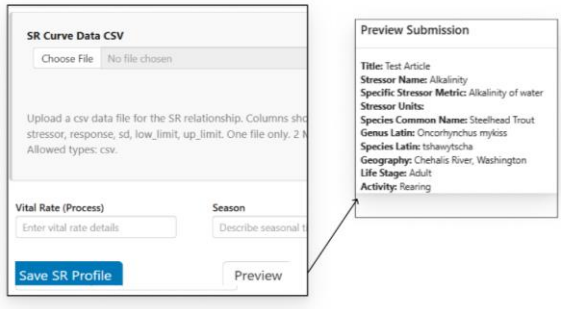


Figure 8: Bottom portion of the Upload Data tab showing CSV upload, response details, citation input, and revision tracking.

The Upload Data tab provides a comprehensive interface for submitting new Stressor-Response Function (SRF) data to the system. This form is designed to ensure standardized, complete, and well-documented entries from researchers and data contributors.

At the top of the form, users must enter a Title as required field, followed by key descriptors including Stressor Information such as Stressor Name, Specific Stressor Metric, and Stressor Units. Species Information such as Species Common Name, Latin Name, Genus (Latin), and Life

Stage. Contextual Metadata of Geography and Activity as well as a Detailed SR Function Description.

Users are also prompted to provide: Function Derivation – how the SR function was derived or modeled, Transferability of Function – notes on how the function may apply to other species or contexts, and Source of Stressor Data – citation or dataset origin details.

To support precise data entry, users can upload a CSV file containing the stressor-response data. The system specifies that this file must include column headers: stressor, response, sd, low_limit, and up_limit. A downloadable sample CSV is provided, and the file upload is limited to one .csv file with a 2MB maximum size.
Additional biological and contextual detail fields are provided such as Vital Rate (Process), Season and Activity.

Users can document their references using two formats: Citations (text) or Citations (links).
At the bottom of the form, a placeholder system tracks changes with: Revision Information and the Revision Log Message. This placeholder was requested by NOAA so the team can iterate on it in the future.

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Commented [GR6R5]: Added a note about it being a placeholder.

Finally, users can either preview their data submission or Save SR Profile once all fields are complete. This upload interface is designed to balance flexibility with data consistency, supporting high-quality SRF entries across diverse research contexts.

Admin

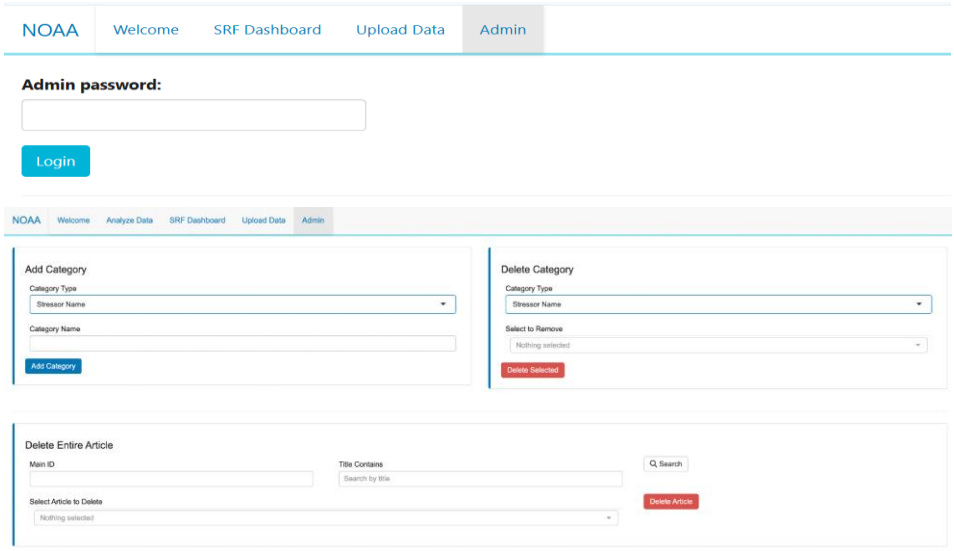

Figure 9: Admin login page showing a password input field and login button. Access is restricted to designated database managers.

The admin tab is a password-protected interface intended solely for authorized personnel responsible for maintaining and managing the SRF database. When accessed, users are prompted to enter an administrative password to proceed. This security measure ensures that only verified users can perform sensitive tasks such as editing or deleting database entries and articles, managing user submissions, or configuring system settings.

Commented [RS7]: Include screesnhot, and mention that articles can be deleted too.

7.

DISCUSSION

The new SRF dashboard was developed to significantly improve access to stressor-response function (SRF) literature and resolve the usability and infrastructure limitations that hindered the previous Drupal-based system. Informed by ongoing feedback and iterative testing with NOAA Fisheries, the dashboard successfully delivers its core functional goals. Researchers can now search and filter entries multiple metadata fields, visualize SRFs through interactive plots, securely upload new data with built-in validation, and export selected information in a variety of formats. These capabilities result in a far more responsive and streamlined experience for users engaging in SRF data.

One of the most impactful technical upgrades was the migration from a static JSON file to a structured SQLite database. This transition has enabled faster and more reliable querying, improved data validation, and better overall system performance- especially when users apply multiple filters or conduct repetitive searches. While some advanced features, such as customizable multi-SRF comparison plots, are still in the early stages of development, the modular architecture of the application ensures that these can be integrated later without significant restructuring. However, given time constraints and the need to prioritize stability, these may not be fully implemented in this version. Thanks to the modular structure of the dashboard, they can be easily added in the future without major rework.

Overall, the dashboard meets the original goal of creating a centralized, user-friendly platform for exploring SRFs. It replaces a fragmented and outdated process with an interactive tool that enables researchers to locate, evaluate, and apply environmental stressor data more effectively. The final deliverables – a fully functional R Shiny application, integrated SQLite backend, interactive visualizations, validated upload systems, and flexible data exports- form a robust and extensible resource that fits seamlessly into NOAA's broader scientific ecosystem. This platform is well-positioned to grow and evolve alongside future research needs and technological updates.

8.

CONCLUSION

Pacific salmon plays a vital role in both the ecosystem and the broader environmental mission of NOAA Fisheries. Ensuring that researchers have continued access to high-quality, well-organized literature is essential to supporting efforts in salmon conservation and informed environmental management. This project aimed to support that goal by building a centralized, interactive dashboard focused on stressor-response functions (SRFs) and life cycle modeling.

By aggregating research articles and SRF data into one user-friendly platform, the new dashboard improves how researchers explore, compare, and extract relevant information. The team not only recreated the core features of the original Drupal app, but also introduced modern enhancements such as interactive visualizations, structured data uploads, export capabilities, and a transition to a scalable SQLite backend. These updates support stronger data organization and enable a more efficient, streamlined user experience.

Importantly, the dashboard is designed to grow with NOAA's evolving needs. Its modular structure makes it easy to incorporate future features such as cross-SRF comparisons, automated figure tracing, and improved authentication. Once fully hosted on NOAA's Posit Connect server, this tool will become a key part of the Integrated Toolbox addressing the limitations of the former system and helping NOAA Fisheries stay at the forefront of salmon research and conservation.

9. REFERENCES

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