CalCOFI.io Docs

2025-09-30

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1 Process

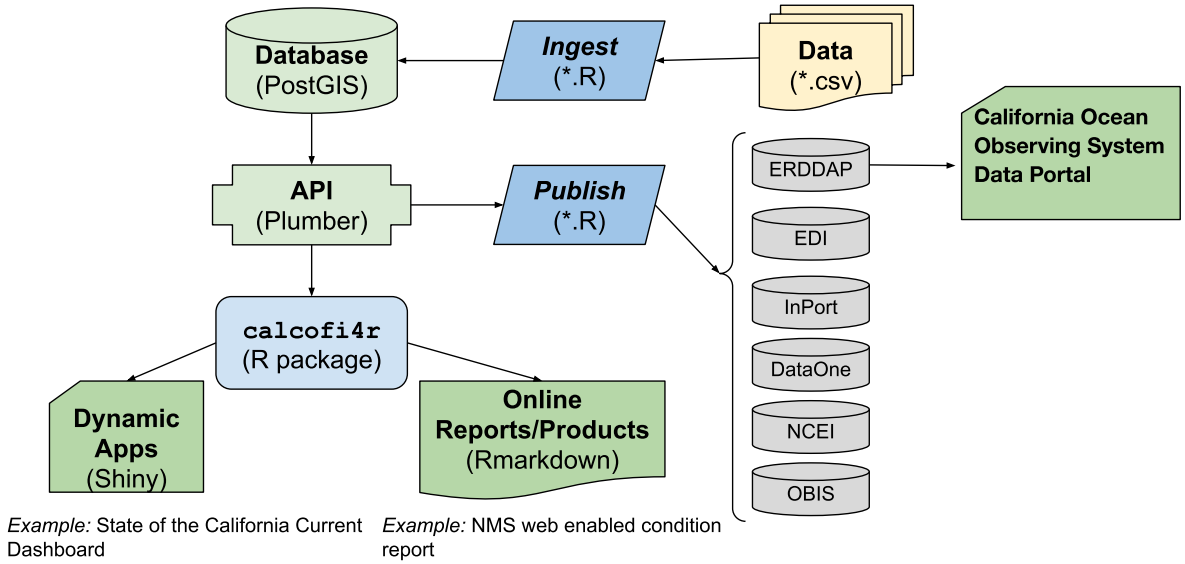


Figure 1.1: CalCOFI data workflow.

The original raw **data**, most often in tabular format [e.g., comma-separated value (*.csv)], gets **ingest**ed into the **database** by R scripts that use functions and lookup data tables in the R package `calcofi4r` where functions are organized into *Read*, *Analyze* and *Visualize* concepts. The application programming interface (**API**) provides a program-language-agnostic public interface for rendering subsets of data and custom visualizations given a set of documented input parameters for feeding interactive applications (**Apps**) using Shiny (or any other web application framework) and **reports** using Rmarkdown (or any other report templating framework). Finally, R scripts will **publish** metadata (as Ecological Metadata Language) and data packages (e.g., in Darwin format) for discovery on a variety of data ***portals*** oriented around slicing the tabular or gridded data (ERDDAP), biogeographic analysis (OBIS), long-term archive (DataOne, NCEI) or metadata discovery (InPort). The **database** will be spatially enabled by PostGIS for summarizing any and all data by ***Areas of Interest*** (AoIs), whether pre-defined (e.g., sanctuaries, MPAs, counties, etc.) or arbitrary new areas. (Figure 1.1)

2 Reports

2.1 Sanctuaries

- Channel Islands WebCR
  web-enabled Condition Report
  - Forage Fish
    example of using calcofi4r functions that pull from the API
- UCSB Student Capstone

3 Applications

- CalCOFI Oceanography
  oceanographic summarization by arbitrary area of interest and sampling period
- UCSB Student Capstone

4 API

The raw interface to the Application Programming Interface (API) is available at:

- api.calcofi.io

Here we will provide more guidance on how to use the API functions with documented input arguments, output results and examples of use.

4.1 `/variables`: get list of variables for timeseries

Get list of variables for use in `/timeseries`

4.2 `/species_groups`: get species groups for larvae

Not yet working. Get list of species groups for use with variables `larvae_counts.count` in `/timeseries`

4.3 `/timeseries`: get time series data

4.4 `/cruises`: get list of cruises

Get list of cruises with summary stats as CSV table for time (`date_beg`)

4.5 `/raster`: get raster map of variable

Get raster of variable

4.6 `/cruise_lines`: get station lines from cruises

Get station lines from cruises (with more than one cast)

4.7 `/cruise_line_profile`

Get profile at depths for given variable of casts along line of stations

5 Database

5.1 Database naming conventions

> There are only two hard things in Computer Science: cache invalidation and naming things. – Phil Karlton (Netscape architect)

We're circling the wagons to come up with the best conventions for naming. Here are some ideas:

- Learn SQL: Naming Conventions
- Best Practices for Database Naming Conventions - Drygast.NET

5.1.1 Name tables

- Table names are singular and use all lower case.

5.1.2 Name columns

- To name columns, use **snake-case** (i.e., lower-case with underscores) so as to prevent the need to quote SQL statements. (TIP: Use `janitor::clean_names()` to convert a table.)
- Unique **identifiers** are suffixed with:
  - `*_id` for unique integer keys;
  - `*_uuid` for universally unique identifiers as defined by RFC 4122 and stored in Postgres as UUID Type.
  - `*_key` for unique string keys;
  - `*_seq` for auto-incrementing sequence integer keys.
- Suffix with **units** where applicable (e.g., `*_m` for meters, `*_km` for kilometers, `degc` for degrees Celsius). See units vignette.
- Set geometry column to `geom` (used by PostGIS spatial extension). If the table has multiple geometry columns, use `geom` for the default geometry column and `geom_{type}` for additional geometry columns (e.g., `geom_point`, `geom_line`, `geom_polygon`).

5.2 Use Unicode for text

The default character encoding for Postgresql is unicode (`UTF8`), which allows for international characters, accents and special characters. Improper encoding can royally mess up basic text.

Logging into the server, we can see this with the following command:

```
docker exec -it postgis psql -l
```

```
                                  List of databases
        Name         | Owner | Encoding |  Collate   |   Ctype    | Access privileges
---------------------+-------+----------+------------+------------+-------------------
 gis                 | admin | UTF8     | en_US.utf8 | en_US.utf8 | =Tc/admin         +
                     |       |          |            |            | admin=CTc/admin   +
                     |       |          |            |            | ro_user=c/admin
 lter_core_metabase  | admin | UTF8     | en_US.utf8 | en_US.utf8 | =Tc/admin         +
                     |       |          |            |            | admin=CTc/admin   +
                     |       |          |            |            | rw_user=c/admin
 postgres            | admin | UTF8     | en_US.utf8 | en_US.utf8 |
 template0           | admin | UTF8     | en_US.utf8 | en_US.utf8 | =c/admin          +
                     |       |          |            |            | admin=CTc/admin
 template1           | admin | UTF8     | en_US.utf8 | en_US.utf8 | =c/admin          +
                     |       |          |            |            | admin=CTc/admin
 template_postgis    | admin | UTF8     | en_US.utf8 | en_US.utf8 |
(6 rows)
```

Use Unicode (`utf-8` in Python or `UTF8` in Postgresql) encoding for all database text values to support international characters and documentation (i.e., tabs, etc for markdown conversion).

- In **Python**, use `pandas` to read (`read_csv()`) and write (`to_csv()`) with UTF-8 encoding (i.e., `encoding='utf-8'`).:

```
import pandas as pd
from sqlalchemy import create_engine
engine = create_engine('postgresql://user:password@localhost:5432/dbname')

# read from a csv file
df = pd.read_csv('file.csv', encoding='utf-8')

# write to PostgreSQL
df.to_sql('table_name', engine, if_exists='replace', index=False, method='multi', chunks
```

```python
# read from PostgreSQL
df = pd.read_sql('SELECT * FROM table_name', engine, encoding='utf-8')

# write to a csv file with UTF-8 encoding
df.to_csv('file.csv', index=False, encoding='utf-8')
```

- In **R**, use `readr` to read (`read_csv()`) and write (`write_excel_csv()`) to force UTF-8 encoding.

```r
library(readr)
library(DBI)
library(RPostgres)

# connect to PostgreSQL
con <- dbConnect(RPostgres::Postgres(), dbname = "dbname", host = "localhost", port = 54

# read from a csv file
df <- read_csv('file.csv', locale = locale(encoding = 'UTF-8'))  # explicit
df <- read_csv('file.csv')                                       # implicit

# write to PostgreSQL
dbWriteTable(con, 'table_name', df, overwrite = TRUE)

# read from PostgreSQL
df <- dbReadTable(con, 'table_name')

# write to a csv file with UTF-8 encoding
write_excel_csv(df, 'file.csv', locale = locale(encoding = 'UTF-8'))  # explicit
write_excel_csv(df, 'file.csv')                                       # implicit
```

5.3 Integrated database ingestion strategy

5.3.1 Overview

The CalCOFI database uses a two-schema strategy for development and production:

- **`dev` schema**: Development schema where new datasets, tables, fields, and relationships are ingested and QA/QC'd. This schema is recreated fresh with each ingestion run using the master ingestion script.
- **`prod` schema**: Production schema for stable, versioned data used by public APIs, apps, and data portals (OBIS, EDI, ERDDAP). Once `dev` is validated, it's copied to `prod` with a version number.

5.3.2 Master ingestion workflow

All datasets are ingested using a single master Quarto script `calcofi4db/inst/ingest.qmd` that:

1. **Drops and recreates** the `dev` schema (fresh start each run)
2. **Ingests multiple datasets** from Google Drive source files (CSV, potentially SHP/NC in future)
3. **Applies transformations** using redefinition files (`tbls_redefine.csv`, `flds_redefine.csv`)
4. **Creates relationships** (primary keys, foreign keys, indexes)
5. **Records schema version** with metadata in `schema_version` table

Each dataset section in the master script handles:

- Reading CSV files from Google Drive
- Transforming data according to redefinition rules
- Loading into database tables
- Adding table/field comments with metadata

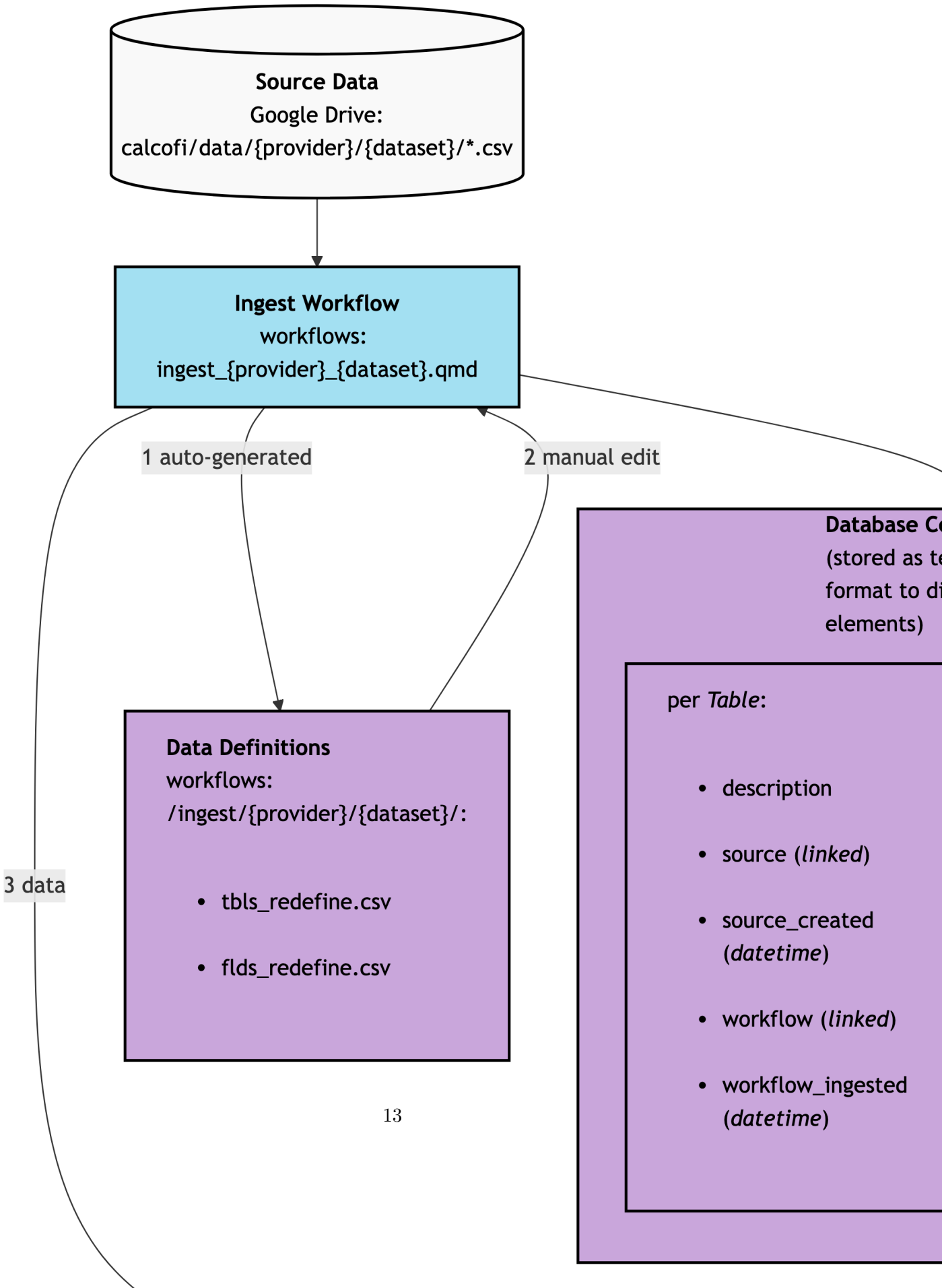
5.3.3 Using calcofi4db package

The calcofi4db package provides streamlined functions for dataset ingestion:

```
library(calcofi4db)
library(DBI)
library(RPostgres)

# Connect to database
con <- dbConnect(
  Postgres(),
  dbname = "gis",
  host = "localhost",
  port = 5432,
  user = "admin",
  password = "postgres"
)

# Read CSV files and metadata
d <- read_csv_files(
  provider = "swfsc.noaa.gov",
  dataset = "calcofi-db"
)
```


Source Data
Google Drive:
calcofi/data/{provider}/{dataset}/*.csv
Ingest Workflow
workflows:
ingest_{provider}_{dataset}.qmd
1 auto-generated
2 manual edit
3 data
Data Definitions
workflows:
/ingest/{provider}/{dataset}/:
tbls_redefine.csv
flds_redefine.csv
Database C
(stored as te
format to di
elements)
per Table:
description
source (linked)
source_created
(datetime)
workflow (linked)
workflow_ingested
(datetime)

```r
# Transform data according to redefinitions
transformed_data <- transform_data(d)

# Ingest into dev schema
ingest_csv_to_db(
  con = con,
  schema = "dev",
  transformed_data = transformed_data,
  d_flds_rd = d$d_flds_rd,
  d_gdata = d$d_gdata,
  workflow_info = d$workflow_info
)

# Record schema version
record_schema_version(
  con = con,
  schema = "dev",
  version = "1.0.0",
  description = "Initial ingestion of NOAA CalCOFI Database",
  script_permalink = "https://github.com/CalCOFI/calcofi4db/blob/main/inst/ingest.qmd"
)
```

5.3.4 Schema versioning

Each successful ingestion creates a new schema version recorded in the `schema_version` table with:

- **version**: Semantic version number (e.g., "1.0.0", "1.1.0")
- **description**: Changes introduced in this version
- **date_created**: Timestamp of ingestion
- **script_permalink**: GitHub permalink to the versioned ingestion script

Versions are also archived as SQL dumps in Google Drive for reproducibility.

5.3.5 Metadata and documentation

After ingestion, metadata is stored in PostgreSQL `COMMENT`s as JSON at the **table** level:

- **description**: General description and row uniqueness
- **source**: CSV file link to Google Drive
- **source_created**: Source file creation timestamp

- **workflow**: Link to rendered ingestion script
- **workflow_ingested**: Ingestion timestamp

And at the **field** level:

- **description**: Field description
- **units**: SI units where applicable

These comments are exposed via the API db_tables endpoint and rendered with calcofi4r::cc_db_catalog.

5.3.6 Publishing to portals

After `prod` schema is versioned, additional workflows publish data to Portals (ERDDAP, EDI, OBIS, NCEI) using ecological metadata language (EML) via the EML R package, pulling metadata directly from database comments.

5.3.7 OR Describe tables and columns directly

- Use the `COMMENT` clause to add descriptions to tables and columns, either through the GUI pgadmin.calcofi.io (by right-clicking on the table or column and selecting `Properties`) or with SQL. For example:

```
COMMENT ON TABLE public.aoi_fed_sanctuaries IS 'areas of interest (`aoi`) polygons for f
```

- Note the use of **markdown** for including links and formatting (e.g., bold, code, italics), such that the above SQL will render like so:

  > areas of interest (`aoi`) polygons for federal **National Marine Sanctuaries**; loaded by *workflow* load_sanctuaries

- It is especially helpful to link to any ***workflows*** that are responsible for the ingesting or updating of the input data.

5.3.8 Display tables and columns with metadata

- These descriptions can be viewed in the CalCOFI **API** api.calcofi.io as CSV tables (see code in calcofi/api: `plumber.R`):
  - api.calcofi.io/db_tables
    fields:
    - `schema`: (only "public" so far)

    - `table_type`: "table", "view", or "materialized view" (none yet)
    - `table`: name of table
    - `table_description`: description of table (possibly in markdown)
  - api.calcofi.io/`db_columns`
    fields:

    - `schema`: (only "public" so far)
    - `table_type`: "table", "view", or "materialized view" (none yet)
    - `table`: name of table
    - `column`: name of column
    - `column_type`: data type of column
    - `column_description`: description of column (possibly in markdown)

- Fetch and display these descriptions into an interactive table with `calcofi4r::cc_db_catalog()`.

5.4 Relationships between tables

- See calcofi/workflows: **clean_db**

- `TODO:` add calcofi/apps: db to show latest tables, columns and relationsips

5.5 Spatial Tips

- Use `ST_Subdivide()` when running spatial joins on large polygons.

6 Portals

6.1 Overview

CalCOFI data is available through various portals, each serving different purposes and user needs. This document outlines the main access points and their characteristics.

6.2 Data Flow

While it would be ideal for CalCOFI data to be available through a single portal, each portal has its strengths and limitations. The following diagram illustrates one possible realization of data flow between CalCOFI data and the portals: from raw data to the integrated database to portals and meta-portals.

In practice, CalCOFI is a partnership with various contributing members, so the authoritative dataset might flow differently, such as from EDI to the database to the other portals. The other portals, such as OBIS or ERDDAP, serve different audiences or purposes. The meta-portals like ODIS and Data.gov then index these portals to provide broader discovery of CalCOFI datasets.

6.3 Portals

While some portals serve as data repositories, others provide advanced data access and visualization tools. The following sections describe the main portals where CalCOFI data is available and their key features.

6.3.1 EDI

Environmental Data Initiative

- Complete dataset archives using DataOne software and EML metadata
- DOIs issued for all datasets ensuring citability
- Full archive allowing for any data file types
- Basic spatial and temporal filtering through web interface

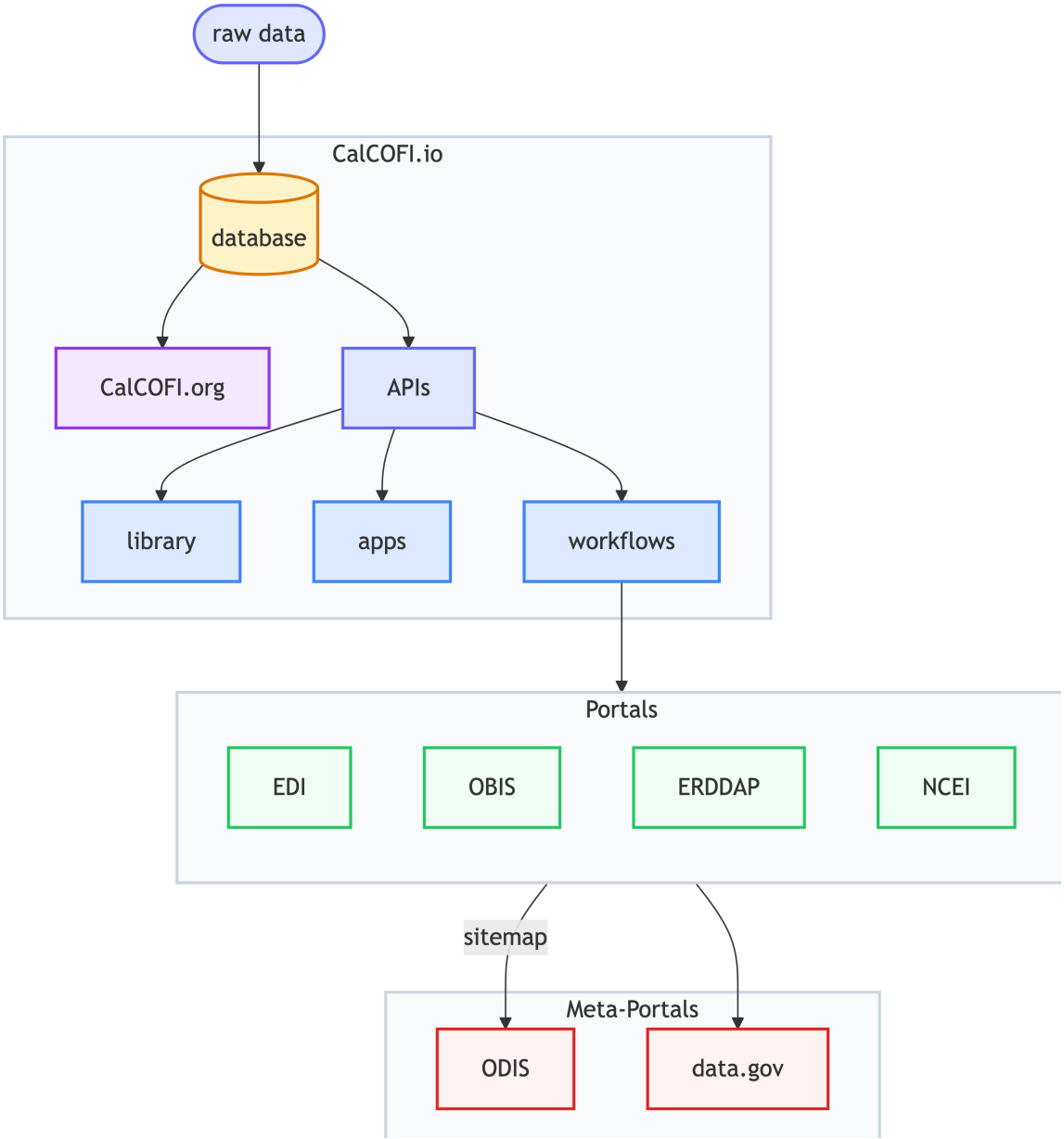


Figure 6.1: Flow of data from raw to database to portals and meta-portals.

Table 6.1: Portal Capabilities.

	Full Archive	Versioning	DOI Issued	Query by xyt	Query by taxa	Multiple formats
EDI						
NCEI						
OBIS						
ERDDAP						

Capability Legend: = full, = partial, = none

- Download in original formats with metadata
- Access through DataOne API
- Links:
  - EDIrepository.org
  - CalCOFI datasets: EDI query "CalCOFI"

6.3.2 NCEI

National Centers for Environmental Information

- Long-term archival of oceanographic data
- DOIs issued for dataset submissions
- Standardized metadata using ISO 19115-2
- Basic search interface with geographic and temporal filtering
- Data preserved in original submission formats
- Access through NCEI API services
- Links:
  - NCEI Ocean Archive
  - CalCOFI datasets: NCEI search "CalCOFI"

6.3.3 OBIS

Ocean Biodiversity Information System

- Specialized in marine biodiversity data
- Standardized using DarwinCore fields
- Extended measurements supported via extendedMeasurementOrFact
- Powerful filtering by space, time, and taxonomic parameters
- Multiple download formats (CSV, JSON, Darwin Core Archive)
- Full REST API access

- Links:
  - OBIS.org
  - CalCOFI datasets: obis.org/dataset + "calcofi" Keyword

6.3.4 ERDDAP

Environmental Research Division Data Access Program

- Tabular and gridded data server
- Advanced subsetting by space, time, and parameters
- Multiple output formats (CSV, JSON, NetCDF, etc.)
- RESTful API with direct data access
- Built-in data visualization tools
- No persistent identifiers but stable URLs
- Links:
  - ERDDAP
  - CalCOFI datasets:
    - ERDDAP, OceanView - CalCOFI seabirds
    - ERDDAP, CoastWatch - CalCOFI oceanographic

6.4 Metadata

The Ecological Metadata Language (EML) (and using R package EML in workflows) serves as a key standard for describing ecological and environmental data. For CalCOFI, EML metadata files are generated alongside data files, providing structured documentation that enables interoperability across different data portals. This metadata-driven approach allows automated ingestion into various data systems while maintaining data integrity and provenance.

The EML specification provides detailed structure for describing datasets, including:

- Dataset identification and citation
- Geographic and temporal coverage
- Variable definitions and units
- Methods and protocols
- Quality control procedures
- Access and usage rights

This standardized metadata enables automated data transformation and ingestion into various portal systems while preserving the original data context and quality information.

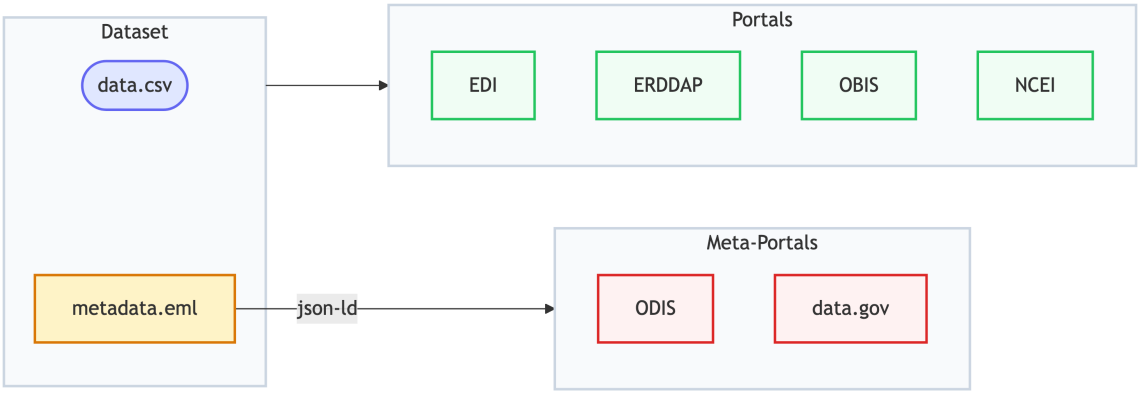


Figure 6.2: Metadata in the form of ecological metadata language (EML) is used to describe the dataset in a consistent manner that can be ingested by the portals.

6.5 Meta-Portals

6.5.1 Google Dataset Search

The JSON-LD metadata in the Portal dataset web pages get indexed by Google Dataset Search through schema.org metadata. This ensures that CalCOFI data is discoverable through Google search and other search engines.

6.5.2 ODIS

Ocean Data Information System

ODIS uses the same technology as Google Dataset Search (schema.org, JSON-LD), but focuses on ocean data. CalCOFI curates a sitemap of authoritative datasets to server to ODIS.org

This federated approach ensures that CalCOFI data remains:

- Discoverable through multiple channels
- Properly cited and attributed
- Integrated with global ocean data systems

6.6 CalCOFI.io Tools

CalCOFI is also developing an integrated database and tools that enable efficient data access and analysis:

6.6.1 APIs

- RESTful endpoints for programmatic access
- Filtering by space, time, and taxonomic parameters
- Relationship queries across tables
- Links:
  - api.calcofi.io
  - tile.calcofi.io

6.6.2 Library

- Direct data access from R
- Built-in analysis functions
- Integration with tidyverse ecosystem
- Link:
  - calcofi.io/calcofi4r

6.6.3 Apps

- Interactive data exploration with Shiny applications
- User-friendly interfaces
- Subset and download data
- Link:
  - calcofi.io, App button

7 Status

8 Status

8.1 2025-07-01

This report summarizes the key development activities, major accomplishments, and ongoing work for the first 6 monhts of 2025 across the CalCOFI GitHub repositories: **api, apps, calcofi4db, calcofi4r, docs, server, workflows**. The findings are based on issues and commits from January–July 2025.

8.1.1 API Enhancements

8.1.1.1 New Features & Data Integration

- **Expanded API Options**
  - Added ability to include bottle data and use relaxed criteria for net-to-cast matching (commit).
  - Supported upcast/downcast data downloads (commit).
  - Added Zooplankton biomass and improved ichthyodata output (commit).
- **Performance & Maintenance**
  - Implemented docker compose restart for Plumber API service (commit).
- **Ongoing Work**
  - Migration of database contouring functions to API/app level for improved caching and rendering efficiency.
  - Development of a robust, user-friendly API for seamless DB integration (issue).

8.1.2 Apps Development

8.1.2.1 Visualization & User Interface

- **Continuous Improvements**
  - Multiple commits indicate ongoing enhancement, likely focused on UI, data visualization, and integration with the API (see recent commit log).
  - Close coordination between API and Apps for improved workflows and data access.

8.1.3 calcofi4db: R Package & Data Management

8.1.3.1 R Package Initialization & Data Ingestion

- **New R Package: calcofi4db**
  - Initial commit and setup (commit), including functions for ingesting CSV datasets and metadata.
  - Refined change detection logic for source CSV files, improving tracking of table/field changes (commit).
  - Enhanced documentation and site via pkgdown.
  - Improved function naming and structure for ingestion (commits, commit).

8.1.4 calcofi4r: Spatial & Ecological Data Tools

8.1.4.1 Data Layers, Analysis, and Bug Fixes

- **Spatial Management Layers**
  - Ongoing integration of BOEM Wind Planning Areas, Marine Protected Areas, and SCCWRP management regions (issue, issue).
- **Analysis Functions**
  - Improved packages for ecological and spatial analysis, including new dependencies (commit).
- **User Feedback**
  - Addressing user-reported bugs such as deprecated function calls (issue).

8.1.5 Documentation (docs)

8.1.5.1 Infrastructure & Environment

- **Documentation Site Updates**
  - Added documentation for new packages and ingestion workflows (commit).
  - Improved environment handling for rendering with Quarto and Chromium (multiple commits Jan-Mar 2025).
  - Updated diagrams and edge labels for database documentation.

8.1.6 Server

8.1.6.1 Backend Infrastructure

- **Backend Maintenance**
  - Numerous commits for improving server reliability, configuration, and deployment.
  - Indicates active backend support for API and Apps.

8.1.7 Workflows

8.1.7.1 Data Pipeline, Integration, and Registration

- **Workflow Automation**
  - Multiple commits show ongoing development of data ingestion, harmonization, and visualization workflows (commit, commit).
- **ODIS Registration**
  - Registering datasets with ODIS (using JSON-LD) for broader interoperability (issue).
- **Integration with External Data**
  - Ongoing work to load and harmonize diverse ecological datasets (bottle data, larvae, zooplankton, etc.).
- **Spatial Data Management**

- Continued development of AOI (areas of interest), spatial buffer creation, and integration of management regions.

8.1.8 Key Themes & Impact

8.1.8.1 Integration & Interoperability

- Strong focus on connecting API, Apps, R packages, and backend infrastructure for seamless data access and visualization.
- Enhanced interoperability through ODIS registration and harmonized workflows.

8.1.8.2 Data Accessibility & Usability

- Improvements to API and Apps make ecological data more accessible to researchers and managers.
- Expanded support for spatial management areas and ecological datasets.

8.1.8.3 Infrastructure & Sustainability

- Investments in documentation, backend reliability, and workflow automation contribute to long-term sustainability and reproducibility.

8.1.9 For More Details

- Some results may be incomplete due to API limits.

- To view all commits/issues for 2025, visit each repository's GitHub UI and filter by year.

9 References

9.1 R packages

- API: plumber (Schloerke and Allen 2024)
- docs: Quarto (Allaire and Dervieux 2024)
- apps: Shiny (Chang et al. 2024)

Allaire, JJ, and Christophe Dervieux. 2024. *Quarto: R Interface to Quarto Markdown Publishing System*. https://github.com/quarto-dev/quarto-r.

Chang, Winston, Joe Cheng, JJ Allaire, Carson Sievert, Barret Schloerke, Yihui Xie, Jeff Allen, Jonathan McPherson, Alan Dipert, and Barbara Borges. 2024. *Shiny: Web Application Framework for r*. https://shiny.posit.co/.

Schloerke, Barret, and Jeff Allen. 2024. *Plumber: An API Generator for r*. https://www.rplumber.io.