## 1. Introduction

To create an integrated database of discrete water quality measurements in the San Francisco Estuary, we combined data from 11 boat-based surveys with the R statistical programming language (R Core Team 2020). The data integration code was packaged into the R package discretewq: <https://github.com/sbashevkin/discretewq>.

The surveys included in the integrated database are long-term monitoring surveys managed by federal agencies, state agencies, and the University of California, Davis. Eight surveys are primarily focused on collecting fish abundance data but collect water quality data alongside fish samples. These include the California Department of Fish and Wildlife (CDFW) Fall Midwater Trawl (FMWT), CDFW Summer Townet Survey (STN), CDFW Spring Kodiak Trawl (SKT), CDFW 20-mm Survey (20mm), CDFW San Francisco Bay Study (Bay Study), United States Fish and Wildlife Service (USFWS) Enhanced Delta Smelt Monitoring (EDSM), USFWS Delta Juvenile Fish Monitoring Program (DJFMP), and University of California, Davis Suisun Marsh Fish Study (Suisun Study). An additional 3 surveys are primarily focused on water quality data: the California Department of Water Resources Environmental Monitoring Program (EMP), United States Bureau of Reclamation Sacramento Deepwater Shipping Channel Survey (SDSCS), and the United States Geological Survey San Francisco Bay Survey (SFBS) (see Delta\_Integrated\_WQ\_metadata.csv).

The primary aim of this data integration was to combine datasets to facilitate analyses of water quality trends in the upper San Francisco Estuary. The focal water quality variables included water temperature, conductivity (or salinity), Secchi depth, *Microcystis* concentration, and chlorophyll concentration. These variables were all collected from the surface of the water column. In addition, water temperature from the bottom of the water column was retained when available. Not all surveys measured all focal variables. Some surveys (particularly the water quality surveys) measured more water quality variables than were retained in this integrated dataset.

While we describe some of the methods here, it is highly recommended to inspect the documentation of the component surveys (see provenance for citations) for more information on their methods.

## 2. Survey methods

Methods for measuring water quality variables were generally consistent among the component surveys, but there were slight differences. All surface water samples were collected within the upper 1 m, but the exact depth differed slightly among studies. SFBS collected some surface temperatures at depths of 2 m, but we only retained samples collected at 1 m or shallower for compatibility with the other studies. Bottom temperature samples were collected within 1 m of the bottom (see Delta\_Integrated\_WQ\_metadata.csv). More detailed methods and protocols for most component surveys can be found in the data source links in Delta\_Integrated\_WQ\_metadata.csv or the provenance citations.

### 2.1. Water temperature

While all surveys now measure water temperature with digital sensors, older surveys used less precise handheld thermometers in earlier years. More precise sensors were first used by FMWT in 1995, STN in 1994, and DJFMP in 2014. All other surveys used more precise methods to measure temperature since inception. SKT had notes on some temperature records that they were transcribed from a different monitoring program (CDEC) so these values were all removed.

### 2.2. Conductivity/Salinity

Most surveys reported specific conductivity except SFBS which reported salinity. DJFMP and EDSM could not verify their conductivity metric for data collected before June 2019 so conductivity values collected before that date are removed from the integrated dataset.

### 2.3. Secchi depth

Secchi depth was measured on the shady side of the boat (when possible) in all surveys that measured this variable. It is important to note that the Secchi data are right-censored, since in some cases the disk was still visible at the deepest depth to which it could be extended. In these cases, the maximum extension depth was usually recorded, even if the disk was still visible.

### 2.4. *Microcystis*

Concentration of the toxic microalga *Microcystis* was measured on the same 5-point qualitative scale (absent, low, medium, high, very high) by the 3 surveys that measured this variable. For a short period of time (2012-15), FMWT added a 6th level to the *Microcystis* scale to represent *Microcystis* presence in zooplankton net cod-ends. Outside this short time period, this was measured as a “low” on the 5-point scaled, so all records of this 6th level were converted to “low” for consistency with other surveys and time periods.

### 2.5. Chlorophyll

Chlorophyll-a methods differed slightly among surveys. EMP filtered water samples through a 1 µm glass fiber filter and measured Chlorophyll concentrations in the lab. SDSCS and SFBS used sonde probes to measure chlorophyll in the field but USGS calibrated these field measurements with filtered water samples collected and analyzed similar to EMP.

## 3. Data integration methods

From each dataset, we selected columns corresponding to the water quality variables of interest as well as important accessory information (date, time, station, latitude, longitude, depth, tide, and any notes). We then renamed variables for consistency and converted all variables to consistent units. Salinity was calculated from specific conductivity using the ec2pss function from the wql R package (Jassby et al. 2017). This function uses the Practical Salinity Scale 1978 for salinities between 2 and 42 (Fofonoff and Millard Jr 1983) and the extension of the Practical Salinity Scale (Hill et al. 1986) for salinities below 2. Conductivity data were also retained in the integrated dataset. In most cases, latitude and longitude coordinates of the fixed sampling stations were retained. When these coordinates were not available (e.g. for non-fixed stations), we retained any coordinates that were recorded during the field sampling. To remove duplicate values from the dataset, only one set of values was retained for each recorded date, time, and location.

## 4. Literature cited

Fofonoff, N. P., and R. C. Millard Jr. 1983. Algorithms for the computation of fundamental properties of seawater. UNESCO Technical Papers in Marine Science **44**.

Hill, K., T. Dauphinee, and D. Woods. 1986. The extension of the Practical Salinity Scale 1978 to low salinities. IEEE Journal of Oceanic Engineering **11**: 109–112.

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