Metadata template[[1]](#footnote-1) for datasets of L&O-Letters articles

**Table 1.** Description of the fields needed to describe the creation of your dataset.

|  |  |
| --- | --- |
| **Title of dataset** | Dataset: Impact of salinization on lake stratification and spring mixing |
| **URL of dataset** | Forthcoming upon decision at the review stage |
| **Abstract** | Anthropogenic freshwater salinization is predicted to affect thousands of lakes worldwide. High salt concentrations are detrimental to aquatic ecology, but can also affect lake mixing and stratification regimes, which in turn have large consequences on lake biogeochemistry and habitability. While there have been case studies which have documented a change in lake mixing regimes due to high salt inputs, little is known about how salt concentrations may shift timing of lake stratification and mixing, and at what thresholds lakes may shift from dimictic regimes to monomictic or meromictic regimes. Here, we take a three-fold approach to investigate the impact of salinization on mixing in Lake Mendota and Monona, Wisconsin, USA, by deploying under-ice buoys to record salinity gradients, using an analytical approach to quantify the critical salt threshold that prevents spring mixing, and running an ensemble of vertical one-dimensional hydrodynamic lake models (GLM, GOTM and Simstrat) to investigate the long-term impact of salt loading on mixing and stratification. We found that at ice-off both lakes have an EC gradient between surface and bottom waters that persists up to a month after ice-off, and that theory predicts a salinity gradient of 1.3-1.4 g kg-1 would prevent spring mixing. Numerical models project that salt loading delays spring mixing and increases water column stability, with ramifications for oxygenation of bottom waters and lake habitability. |
| **Keywords** | Lake Mendota; Lake Monona; Salinization; Freshwater lake; Lake modeling; GLM; GOTM; Simstrat |
| **Lead author for the dataset** | Robert Ladwig |
| **Title and position of lead author** | Post-Doctoral Researcher |
| **Organization and address of lead author** | Center for Limnology, University of Wisconsin-Madison, 680 N. Park Street, Madison, 53706 WI, USA |
| **Email address of lead author** | rladwig2@wisc.edu |
| **Additional authors or contributors to the dataset** | Linnea Rock, Hilary A. Dugan |
| **Organization associated with the data** | Center for Limnology, University of Wisconsin-Madison |
| **Funding** | United States National Science Foundation ABI development grant (#DBI 1759865) |
| **License** | GPL-2.0 License |
| **Geographic location – verbal description** | Lake Mendota and Lake Monona in Dane County, WI, USA |
| **Geographic coverage bounding coordinates** | Mendota: -89.405, 43.099  Monona: -89.361, 43.063 |
| **Time frame - Begin date** | 1995-01-01 |
| **Time frame - End date** | 2015-31-12 |
| **General study design** | Three-fold approach to investigate the impact of salinization on mixing in Lake Mendota and Monona, Wisconsin, USA, by deploying under-ice buoys to record salinity gradients, using an analytical approach to quantify the critical salt threshold that prevents spring mixing, and running an ensemble of vertical one-dimensional hydrodynamic lake models (GLM, GOTM and Simstrat) to investigate the long-term impact of salt loading on mixing and stratification. |
| **Methods description** | HOBO electrical conductivity loggers on under-ice buoys for conductivity monitoring. Numerical solution by running the LakeEnsemblR-package in R using GLM, GOTM and Simstrat an 1D vertical hydrodynamic ensemble members. |
| **Laboratory, field, or other analytical methods** | HOBO electrical conductivity loggers on under-ice buoys for conductivity monitoring. Deployment happened prior to ice-on and retrieval occurred soon after ice-off. First surface logger at approx. 1 m below surface, and second logger at 1 m from the lake bottom. |
| **Taxonomic species or groups** | - |
| **Quality control** | Electrical conductivity data were calibrated using in-situ absolute electrical conductivity measurements |
| **Additional information** | - |
|  |  |

**Table 2.** Data dictionary: description of the variables (i.e., columns) in EACH dataset. You must provide sufficient detail for another user to understand and use the data. If there are 10 variables (i.e., columns) in the dataset, then there should be 10 rows in this table that describe each column. Be sure to include all relevant information for your dataset, including the unique identifiers for your dataset or system, dates, replicate numbers, latitude and longitude of sampling locations, etc.

Dataset filename: /analytical/[lake\_id]\_bathymetry.csv

Dataset description: Bathymetry data (area over depth data)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| Depth\_meter | Depth from the surface | m | - | Integer | NA |
| Area\_meterSquared | Area | m squared | - | Double | NA |

Dataset filename: /NTL\_data/Lake[lake\_id]\_Dane\_WI\_VIII.csv

Dataset description: Observed chloride data

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| Organization | Organization who monitored data | - | CiteofMadison refers to sampling by Madison city officials; Richard C. Lathrop refers to sampling done by Richard C. Lathrop (DNR); Wisconsin Department of Natural Resources refers to sampling done by the WI DNR; LTER refers to sampling done by UW-Madison | String | NA |
| Station.ID | Sampling station identification | - | CityofMadison refers to sampling site by City of Madison, WI\_DNR and WIDNR-WQX refer to DNR sampling site; LTER refers to UW-Madison sampling site | String | NA |
| Sample.Date | Sampling Date | YYYY-MM-DD | - | Date format | NA |
| Sample.Depth\_m | Sampling depth from the surface | m | - | Integer | NA |
| Sodium\_mgL | Sodium concentration | mg per liter | - | Double | NA |
| Chloride\_mgL | Chloride concentration | mg per liter | - | Double | NA |
| Sulfate\_mgL | Sulfate concentration | mg per liter | - | Double | NA |

Dataset filename: /data/ntl\_icedatescombo.csv

Dataset description: Ice data for NTL-LTER lakes

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| year | Year | YYYY | - | Date format | NA |
| lakeid | Identification letter of NTL-LTER study site | - | ME – Mendota, MO - Monona | Character | NA |
| ice\_duration | Duration of ice cover for that winter period | days | - | Integer | NA |
| firstice | Date of ice-on date | YYYY-MM-DD | - | Date format | NA |
| lastice | Date of ice-breakup date | YYYY-MM-DD | - | Date format | NA |
| firsticeYDAY | Date of ice-on date | Day of the year | - | Integer | NA |
| lasticeYDAY | Date of ice-breakup date | Day of the year | - | Integer | NA |

Dataset filename: /data/USWOOO14837\_DaneCountyAirport.csv

Dataset description: Meteorological data from Dane County Airport

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| STATION | Year | YYYY | - | Date format | NA |
| NAME | Identification letter of NTL-LTER study site | - | ME – Mendota, MO - Monona | Character | NA |
| LATITUDE | Duration of ice cover for that winter period | days | - | Integer | NA |
| LONGITUDE | Date of ice-on date | YYYY-MM-DD | - | Date format | NA |
| ELEVATION | Date of ice-breakup date | YYYY-MM-DD | - | Date format | NA |
| DATE | Date of ice-on date | Day of the year | - | Integer | NA |
| AWND | Average daily wind speed | Meter per second | - | Integer | NA |
| PGTM | Peak gust time | Hours and minutes |  | Time in HHMM | NA |
| PRCP | Precipitation | Millimeter | - | Integer | NA |
| SNOW | Snowfall | Millimeter | - | Integer | NA |
| SNWD | Snow depth | Millimeter | - | Integer | NA |
| TAVG | Average air temperature | Degree Celsius | - | Integer | NA |
| TMAX | Maximum air temperature | Degree Celsius | - | Integer | NA |
| TMIN | Minimum air temperature | Degree Celsius | - | Integer | NA |
| WDF2 | Direction of fastest 2-minute wind | Degrees | - | Double | NA |
| WDF5 | Direction of fastest 5-minute wind | Degrees | - | Double | NA |
| WSF2 | Fastest 2-minute wind speed | Meter per second | - | Integer | NA |
| WSF5 | Fastest 5-minute wind speed | Meter per second | - | Integer | NA |

Dataset filename: /fieldmonitoring/[lake\_id]\_[layer]\_[time].csv

Dataset description: Bathymetry data (area over depth data); here ME refers to Mendota, MO to Monona; and EPI to epilimnion, HYPO to hypolimnion

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| # | Number of sequence | - | - | Integer | NA |
| Date | Date | MM-DD-YYYY hh:mm:ss | - | Date-time format | NA |
| Low Range | Electrical conductivity measured on low range (low salinity) | microSiemens per centimer | - | Double | NA |
| Full Range | Electrical conductivity measured on high range (high salinity) | microSiemens per centimer | - | Double | NA |
| Temp | Water temperature | Degree Celsius | - | Double | NA |

Dataset filename: /output/[variable]\_[model].csv

Dataset description: Modeled output; variable can be density for water density, ice for ice thickness, lakenumber for Lake Number, salt for salinity, ssi for Schmidt Stability Index, wtemp for water temperature; model refers either to GLM, GOTM, Simstrat, or – if not existent – to the average ensemble output

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| datetime | Number of sequence | YYYY-MM-DD | - | Date-time format | NA |
| null | Modeled output for null salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 01 | Modeled output for 0.1 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 05 | Modeled output for 0.5 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 1 | Modeled output for 1.0 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 15 | Modeled output for 1.5 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 2 | Modeled output for 2.0 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 25 | Modeled output for 2.5 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 3 | Modeled output for 3.0 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 35 | Modeled output for 3.5 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 4 | Modeled output for 4.0 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 45 | Modeled output for 4.5 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 5 | Modeled output for 5.0 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| 10 | Modeled output for 10 salt load scenario | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |
| id | Lake identification | dens in kilogram per cubic meter, ice in meter, ln is dimensionless, salt in gram per kilogram, ssi in Joule per meter squared, temp in degree Celsius | Dens for density, ice for ice thickness, ln for Lake Number, salt for salinity, ssi for Schmidt Stability Index, temp for water temperature | Double | NA |

Dataset filename: /output\_modelruns/[scenario]/[lake\_id]\_[model]\_[variable].csv

Dataset description: Bathymetry data (area over depth data); here ME refers to Mendota, MO to Monona; and EPI to epilimnion, HYPO to hypolimnion

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Column name** | **Description** | **Units** | **Code explanation** | **Data format** | **Missing data code** |
| datetime | Date | MM-DD-YYYY hh:mm:ss | - | Date-time format | NA |
| ice\_height | Height of ice layer | meter | - | Double | NA |
| wtr | Depth-specific water temperature | Degree Celsius | - | Double | NA |
| sal | Depth-specific salinity | gram per kilogram | - | Double | NA |
| dens | Depth-specific density | kilogram per cubic meter | - | Double | NA |

**Table 3. Data provenance**

If you used data derived from other sources, provide the information here so future users know where the data came from.

|  |  |  |  |
| --- | --- | --- | --- |
| **Dataset title** | **Dataset DOI or URL** | **Creator (name & email)** | **Contact (name & email)** |
| /data/USWOOO14837\_DaneCountyAirport.csv | <https://www.ncdc.noaa.gov/cdo-web/> | NOAA | ncei.orders@noaa.gov |
| /data/ntl\_icedatescombo.csv | https://doi.org/10.6073/pasta/ab31f2489ee436beb73fc8f1d0213d97 | NTL-LTER | Emily Stanley [ehstanley@wisc.edu](mailto:ehstanley@wisc.edu) |
| /fieldmonitoring/[lake\_id]\_[layer]\_[time].csv | https://doi.org/10.6073/pasta/1bef2de0650bdc9e90a422b61aaa59e5 | Linnea Rock | Linnea Rock lrock@wisc.edu |
| /NTL\_data/Lake[lake\_id]\_Dane\_WI\_VIII.csv | https://portal.edirepository.org/nis/mapbrowse?packageid=knb-lter-ntl.319.17 | City of Madison, DNR | Dick Lathrop  rlathrop@wisc.edu |

**Scripts/code (software) –** OPTIONAL

It is recommended that you also provide your scripts along with your data, although it is not required at this time in our journal.

|  |  |  |
| --- | --- | --- |
| **File name** | **Description** | **Scripting language** |
| 1\_readData.R | Reads model outputs and converts them to CSV | R |
| 2\_createFigures\_HD.R | Produces high-quality plots for publications | R |
| 3\_plotModel\_functions.R | Reads model outputs for visualization | R |
| 3\_plotModelOutputs\_plots.R | Produces high-quality plots for model output comparisons | R |
| /numerical/…/1\_calibration/calibrate\_LER.R | Calibration script for model ensemble using LHC | R |
| /numerical/…/2\_validation/validate\_LER.R | Validation script for model ensemble | R |
| /numerical/…/3\_scenarios/analyse\_scenarios.R | Initial postprocessing of scenario results | R |
| /numerical/…/1\_calibration/…/scenario\_LER.R | Runs scenario simulation | R |

**Notes and Comments:**

1. *This document liberally borrows from a similar document provided by the Environmental Data Initiative* [↑](#footnote-ref-1)