Elkhorn Slough (ELK) NERR Nutrient Metadata
(January - December 2005)
Latest Update: July 14, 2025

I. Data Set and Research Descriptors

1) **Principal investigator(s) and contact persons**

a) Reserve Contact

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b) **Laboratory Contact**

Same as above

c) **Other Contacts and Programs**

None

2) **Research Objectives**

Elkhorn Slough (ESNERR) is a unique estuary along the central Californian coast. There are fresh water inputs during the wet season (October through May) causing a brackish environment, while during the dry season (June through September) there is very little freshwater input resulting in a much more saline environment. The surrounding area is mostly farmlands, which causes concern, as they may be a source of significant amounts of nutrients entering the slough possibly causing eutrophication. With the base monitoring program we are able to quantify the variability of these nutrients in different areas of the slough and possibly correlate any changes in land use with changes in nutrient concentrations.

a) **Monthly Grab**

Monthly grab samples are collected to quantify the spatial variability of important nutrients in the water column at sites representing the estuarine endpoints of the Elkhorn Slough estuary.

b) **Diel Sampling Program**

Once per month, samples are collected every hour through a 24-hour tidal cycle to quantify the temporal variability of important nutrients in the water column as a function of tidal forcing.

3) **Research Methods**

a) **Monthly Grab Sampling Program**

Monthly grab samples were taken at four stations within the Elkhorn Slough estuary. Samples were taken at the four principle ESNERR data sonde stations (Azevedo Pond, North Marsh, South Marsh and Vierra Mouth). All grab samples were taken on the same day between +3 hrs before slack low-water and low-water. No distinction was made between neap and spring tide conditions. Efforts were made to allow for an antecedent dry period of 72 hours prior to sampling. Replicate (N=2) samples were collected by hand at an approximate depth of 10 cm. At the time of sample collection, water temperature, salinity, and dissolved oxygen was measured with a YSI Model 650 meter. All samples were collected in amber, narrow-mouth, nalgene sample bottles that were previously acid washed (10%), rinsed (3x) with distilled-deionized water, dried, and followed by rinsing (3x) with ambient water prior to collection of the sample. Samples were immediately placed on ice in the dark and returned to the laboratory. Once in the laboratory, samples were shaken and processed for nutrient and Chl-a analysis.

b) **Diel Sampling Program**

Within the same 24-hour period of grab sample collection, we deploy an ISCO water sampler from the bank of the marsh at South Marsh at a depth of 30cm from the bottom. This device automatically samples 500 ml of water on a lunar day every 1 hrs 2min. All samples are pumped into polyethylene sample bottles that were previously acid washed (10% HCL), rinsed (3x) with distilled-deionized water and dried. Samples are kept cold with ice until the end of the 24 hr period; the 24 samples are kept in the dark and returned to the laboratory for immediate processing.

4) **Site Location and Character**

Elkhorn Slough is located on the West Coast of the United States in Central California. It connects with the Pacific Ocean in central Monterey Bay near Moss Landing, California. There are four sampling sites.

Azevedo Pond (AP) (36°50’44.64”N, 121°45’13.24”W) receives fertilizer and pesticide runoff from a strawberry field in year-round production. The YSI is located about 10m from a culvert connecting the pond to the slough. Tide ranges from 0 to 1.3 meters while salinity ranges from 8.8 during heavy runoff to 41 ppt during strong evaporation. The sonde is located approximately 30 cm off the bottom, which is composed of silty mud. Freshwater input to this site is comprised of runoff from nearby farms during the winter and agricultural runoff in the summer. Depth of water at this station is about 2 – 4 ft.

North Marsh (NM) (36°50’04.75”N, 121°44’18. 33”W) is located in between South Marsh and Azevedo Pond. This site is impacted by both agricultural and urban runoff. The tidal range is approximately 0.4 meters while salinity ranges between 20 and 40 parts per thousand. There is freshwater runoff from upland and agricultural sites. The sonde is approximately 30 cm off the bottom, which is composed of silty mud. Depth at this site is 1 – 3 ft.

South Marsh (SM) (36°49'05.00"N, 121°44'21.83"W), located about 3 km south of NM, is in a side channel of the slough and is relatively free from impact by anthropogenic influences as it is surrounded by mostly reserve land. The YSI is located on the side of a bank in one of the secondary slough channels. This site receives runoff mostly from uplands and some from cattle ranches, receiving the least amount of pollution. Tidal ranges from 0 to 3 meters while the salinity range is from 22 to 36 parts per thousand. The depth is 6 – 8 ft and has a bottom habitat of compacted silty mud. Freshwater input is from rain runoff only during the winter months.

The fourth site Vierra Mouth (VM) (36°48'39.95"N, 121°44'45.40"W) is located at the mouth of the slough and is used to identify oceanic influence. The tidal range is from 0 to 3.2 meters while salinity ranges from 26 to 34 parts per thousand. The sonde is located approximately 30 cm off the bottom which is composed of compacted mud and sand due to strong tidal currents. This site receives drainage from the entire watershed due to its location at the mouth. There are several auto wreaking yards located approximately 2 km east of this site. Depth of water at this station in about 10 – 15 ft and freshwater input is mainly from rain runoff during the winter months.

5) **Code Variable Definitions**

elkapnut = Elkhorn Slough Reserve Azevedo Pond Site nutrient data
elknmnut = Elkhorn Slough Reserve North Marsh Site nutrient data
elksmnut = Elkhorn Slough Reserve South Marsh Site nutrient data
elkvmnut = Elkhorn Slough Reserve Vierra Mouth Site nutrient data
Monthly grab sample program= 1
Diel grab sample program= 2

6) **Data Collection Period**

Sampling occurred between January 6 02:34 and December 7 13:21

Diel Sampling

Site	Start Date	Start Time	End Date	End Time
SM	01/04/05	11:41	01/05/05	11:27
SM	02/08/05	03:04	02/09/05	02:50
SM	03/08/05	02:14	03/09/05	02:00
SM	04/05/05	02:24	04/06/05	02:10
SM	05/03/05	01:28	05/04/05	01:14
SM	06/07/05	06:01	06/08/05	05:47
SM	07/05/05	04:07	07/06/05	03.53
SM	08/01/05	02:39	08/02/05	02:25
SM	09/06/05	05:27	09/07/05	05:13
SM	10/04/05	04:15	10/05/05	04:01
SM	11/01/05	04:00	11/02/05	03:46
SM	12/06/05	07:30	12/07/05	07:16

Grab Sampling

Site	Start Date	Start Time	End Date	End Time
AP	01/05/05	11:30	01/05/05	11:31
AP	02/08/05	14:30	02/08/05	14:31
AP	03/08/05	14:25	03/08/05	14:26
AP	04/05/05	12:55	04/05/05	12:56
AP	05/03/05	12:00	05/03/05	12:01
AP	06/07/05	15:20	06/07/05	15:21

AP	07/05/05	14:40	07/05/05	14:41
AP	08/01/05	12:48	08/01/05	12:49
AP	09/06/05	18:10	09/06/05	18:11
AP	10/04/05	15:07	10/04/05	15:08
AP	11/01/05	14:55	11/01/05	14:56
AP	12/07/05	08:10	12/07/05	08:11

Site	Start Date	Start Time	End Date	End Time
NM	01/05/05	11:05	01/05/05	11:06
NM	02/08/05	15:40	02/08/05	15:41
NM	03/08/05	14:40	03/08/05	14:41
NM	04/05/05	12:30	04/05/05	12:31
NM	05/03/05	11:30	05/03/05	11:31
NM	06/07/05	14:18	06/07/05	14:19
NM	07/05/05	14:05	07/05/05	14:06
NM	08/01/05	12:25	08/01/05	12:26
NM	09/06/05	17:40	09/06/05	17:41
NM	10/04/05	14:42	10/04/05	14:43
NM	11/01/05	14:30	11/01/05	14:31
NM	12/07/05	07:35	12/07/05	07:36

Site	Start Date	Start Time	End Date	End Time
SM	01/05/05	12:30	01/05/05	12:31
SM	02/08/05	15:00	02/08/05	15:01
SM	03/08/05	13:35	03/08/05	13:36
SM	04/05/05	11:30	04/05/05	11:31
SM	05/03/05	10:55	05/03/05	10:56
SM	06/07/05	13:50	06/07/05	13:51
SM	07/05/05	13:35	07/05/05	13:36
SM	08/01/05	11:55	08/01/05	11:56
SM	09/06/05	17:15	09:06/05	17:16
SM	10/04/05	14:20	10/04/05	14:21
SM	11/01/05	14:10	11/01/05	14:11
SM	12/07/05	08:40	12/07/05	08:41

Site	Start Date	Start Time	End Date	End Time
VM	02/08/05	16:00	02/08/05	16:01
VM	03/08/05	14:15	03/08/05	14:16
VM	04/05/05	13:46	04/05/05	13:47
VM	05/03/05	12:40	05/03/05	12:41
VM	06/07/05	15:54	06/07/05	15:55
VM	07/05/05	15:20	07/05/05	15:21
VM	08/01/05	13:30	08/01/05	13:31
VM	09/06/05	16:25	09/06/05	16:26
VM	10/04/05	16:00	10/04/05	16:01
VM	11/01/05	15:30	11/01/05	15:31
VM	12/07/05	07:35	12/07/05	07:36

7) **Associated Researchers and Projects**

Ken Johnson *et al.* are looking at nutrient budgets in the slough with real time nitrate loggers in the main channel of the slough. Adina Paytan, Scott Wankle *et al* are looking at nitrogen isotopes to assess the contributions of nitrogen through ground water. Nicholas Welshmier *et al* are looking at nutrients and phytoplankton populations in the main channel of the slough on a weekly basis. Marc Los Huertos *et al* are investigating nutrient budgets in the Elkhorn Slough watershed and identifying "hot spots" of nutrients in the slough while working with local farmers to attempt to decrease high nutrient loads. Gage Daton *et al* from Moss Landing Marine Laboratories are investigating the functionality of wetlands as nitrate source reduction.

8) **Distribution**

NOAA/ERD retains the right to analyze, synthesize and publish summaries of the NERRS System-wide Monitoring Program data. The PI retains the right to be fully credited for having collected and processed the data. Following academic courtesy standards, the PI and NERR site where the data were collected will be contacted and fully acknowledged in any subsequent publications in which any part of the data are used. Manuscripts resulting from this NOAA/OCRM supported research that are produced for publication in open literature, including refereed scientific journals, will acknowledge that the research was conducted under an award from the Estuarine Reserves Division, Office of Ocean and Coastal Resource Management, National Ocean Service, National Oceanic and Atmospheric Administration. The data set enclosed within this package/transmission is only as good as the quality assurance and quality control procedures outlined by the enclosed metadata reporting statement. The user bears all responsibility for its subsequent use/misuse in any further analyses or comparisons. The Federal government does not assume liability to the Recipient or third persons, nor will the Federal government reimburse or indemnify the Recipient for its liability due to any losses resulting in any way from the use of this data.

NERR water quality data and metadata can be obtained from the Research Coordinator at the individual NERR site (please see Section 1. Principal investigators and contact persons), from the Data Manager at the Centralized Data Management Office (please see personnel directory under the general information link on the CDMO home page) and online at the CDMO home page http://cdmo.baruch.sc.edu/. Data are available in text tab-delimited format, Microsoft Excel spreadsheet format and comma-delimited format.

II. Physical Structure Descriptors

9) **Entry Verification**

Monthly nutrient data is measured and entered into an excel file consisting of sampling station ID, date and time, and parameter values expressed in unit concentrations. John Haskins and Rhea Sanders verify all parameter values in the excel file by cross comparison with laboratory data sheets and by graphing the data and identifying anomalous data points or other problems. Monthly excel files were compiled into a yearly excel file. Missing data are verified through inspection of field logs and flagged by an "M" in the compiled excel file. Values flagged with a "K" are further explained in the metadata. Calculated values are flagged by a "C" in the compiled excel file.

10) **Parameter Titles and Variable Names by Data Category**

Required NOAA/NERRS System-wide Monitoring Program water quality parameters are denoted by an asterisks "*".

Data Category	Parameter	Variable Name	Units of Measure
i) Phosphorus:	*Orthophosphate	PO4F	mg/L as P
ii) Nitrogen:	*Nitrite + Nitrate, Filtered	NO23F	mg/L as N
	*Nitrite, Filtered	NO2F	mg/L as N
	*Nitrate, Filtered	NO3F	mg/L as N
	*Ammonium, Filtered	NH4F	mg/L as N
iii) Plant pigments:			
	Chlorophyll a, Fluorometric	CHLA_N	µg/L

Notes:
1. Time is coded based on a 2400 hour clock and is referenced to Pacific Standard Time (PST).
2. Reserves have the option of measuring either NO23 or NO2 or NO3.

11) **Measured and Calculated Laboratory Parameters**

a) Variables Measured Directly

Nitrogen species:	NO2F, NO23F, NH4F
Phosphorus species:	PO4F
Other:	CHLA

b) Computed Variables

NO3:	NO23F-NO2F

12) **Limits of Detection**

Method Detection Limits (MDL), the lowest concentration of a parameter that an analytical procedure can reliably detect, has been established by the Moss Landing Marine Lab (MLML) Nutrient Analytical Laboratory. The MDL is determined as 3 times the standard deviation of a minimum of 7 replicates of a single low concentration sample. The following chart presents the current MDL's; these values are periodically reviewed and revised.

MDL TABLE

2005	Jan	0.0009	0.0025	0.0012	0.0023	0.045
2005	Feb	0.0004	0.0009	0.0022	0.0038	0.045
2005	Mar	0.0004	0.0015	0.0023	0.0023	0.045
2005	Apr	0.0003	0.001	0.0027	0.0022	0.045
2005	May	0.0005	0.001	0.0005	0.0024	0.045
2005	Jun	0.0001	0.0025	0.0017	0.0012	0.045
2005	Jul	0.0001	0.0032	0.0018	0.0009	0.045
2005	Aug	0.0001	0.0014	0.0039	0.0024	0.045
2005	Sep	0	0.0015	0.0015	0.0039	0.045

2005	Oct	0.0002	0.0016	0.0023	0.0032	0.045
2005	Nov	0.0002	0.0011	0.0026	0.0007	0.045
2005	Dec	0.0002	0.0009	0.0028	0.0103	0.045

13) **Laboratory Methods**

a) **Parameter: NH4F**

i) Method Reference: Stricklin and Parsons Determination of Ammonia.

ii) Method Descriptor: Samples collected and stored on ice in amber bottles prior to being filtered with a 0.45 μm GFF filter and subsequently subjected to hypochlorite-phenol in the presence of NH3. Sodium nitroprusside is then used as a catalyst in the reaction. An oxidizing solution is then added (a mixture of sodium hypochlorite and alkaline reagent). The sample is then allowed to stand at a temperature between 20 and 27 C for at least 1 hour and then placed in a 10 cm cuvette and absorbance is measured at 640 nm.

iii) Preservation Method: Samples filtered and stored at 4 °C up to 24 hours.

b) **Parameter: NO23F, NO3F, and NO2F**

i) Method Reference: Stricklin and Parsons Determination of Nitrite.

ii) Method Descriptor: The water sample is first filtered then is passed through a cadmium column where the nitrate is reduced to nitrite. When only analyzing for nitrite the sample is not exposed to cadmium and thus the nitrite in the water is quantified. The nitrite is then exposed to sulfanilamide solution and allowed to react for 2 minutes then is exposed to N-(1-naphthyl)-ethylenediamine dihydrochloride solution and allowed to react for at least 10 minutes. The sample is then placed in a 1 cm cuvette where the absorbance is measured at 543 nm. Nitrate concentration equals the NO23F (nitrate + nitrite) concentration minus the nitrite concentration. Thus NO3 is calculated by subtracting NO23F - N02F.

iii) Preservation Method: Sample is filtered through a 0.45 um filter and analyzed the same day.

c) **Parameter: PO4F**

i) Method Reference. Same as Nitrite with Alpkem analyzer.

ii) Method Descriptor: Ammonium molybdate is added to a water sample to produce phosphomolybdic acid, which is then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine (or hydrazine) sulfate. The sample is passed through a 50 mm flowcell and absorbance is measured at 820 nm.

iii) Preservation Method: Sample is filtered through a 0.45 um filter and analyzed the same day.

d) **Parameter: CHLA**

i) Method Reference. EPA method 445.0*UNESCO* (1994) Protocols for the joint global ocean flux study (JGOFS) core measurements. pp. 97-100.

ii) Method Descriptor: CHLA is extracted in 10 ml 90% acetone for 24 hrs and then fluorescence is measured and recorded (Fo). Several drops (2-3) of 10% are added to convert the CHLA to phaeopigments (PHAE). The fluorescence is again measured and recorded (Fa). The concentration (μg/L) of CHLA and PHAE are calculated using the Fo/Fa ratio.

iii) Preservation Method: A known volume of sample is filtered onto a 25 mm GF/F filter, folded in half and placed in a know volume of 90% acetone and then stored a -4ºC until analysis 24 hrs later.

14) **Reporting of Missing Data, Data with Concentrations Lower than Method Detection Limits**

Nutrient/Chla comment codes and definitions are provided in the following table. Missing data are denoted by a blank cell " " and commented coded with an "M". Laboratories in the NERRS System submit data that are censored at a lower detection rate limit, called the Method Detection Limit or MDL. MDL's for specific parameters are listed in the Laboratory Methods and Detection Limits Section (Section II, Part 14) of this document. Measured concentrations that are less than this limit are replaced with the minimum detection limit value and comment coded with a "B" in the variable code comment column. For example, the measured concentration of NO23F was 0.0005 mg/L as N (MDL=0.0008), the reported value would be 0.0008 with a "B" placed in the NO23F comment code column. Calculated parameters are comment coded with a "C" and if any of the components used in the calculation are below the MDL, the calculated value is removed and also comment coded with a "B". If a calculated value is negative, the value is removed and comment coded with an "N".

Note: The way below MDL values are handled in the NERRS SWMP dataset was changed in November of 2011. Previously, below MDL data from 2002-2006 were also coded with a B, but replaced with -9999 place holders. Any 2002-2006 nutrient/pigment data downloaded from the CDMO prior to December November of 2011 will contain -9999s representing below MDL concentrations.

Comment Code	Definition
A	Value above upper limit of method detection
B	Value below method detection limit
C	Calculated value
D	Data deleted or calculated value could not be determined due to deleted data, see metadata for details
H	Sample held beyond specified holding time
K	Check metadata for further details
M	Data missing, sample never collected or calculated value could not be determined due to missing data
P	Significant precipitation (reserve defined, see metadata for further details)
U	Lab analysis from unpreserved sample
S	Data suspect, see metadata for further details

15) **QA/QC Programs**

a. Precision

i) **Field Variability** –ELKNERR collects two successive grab samples for the determination of water mass variability within each site.

ii) **Laboratory Variability** – In determining laboratory variability, replicates are split from a single diel sample. Laboratory replicates are done for ammonium, nitrite, nitrate and phosphate standards on a semi-regular basis. Variability was found to be within 8%.

	Average percent difference
Nitrite	3.3
Ammonia	7.5
Nitrate	3.4
Phosphate	2.6

iii) **Inter-organizational splits** – None

b. Accuracy

iv) **Sample Spikes** – Sample spikes were split from a single diel sample. Sample spikes are done for nitrite and ammonium on a monthly basis. Average percent recovery was found to be 102.7% and 97.3% respectively.

v) **Standard Reference Material Analysis –** Standard reference materials are split from a single diel sample. Standard reference analysis is conducted for nitrite and ammonium on a semi-regular basis. Average percent difference was found to be 6.7% and 8.3% respectively.

vi) **Cross Calibration Exercises** – An inter-comparison study is conducted annually of a know concentration of nutrients in seawater as part of the NOAA National Estuarine Research Reserve System-Wide Monitoring Program. Our analyses of all the nutrients have been within one standard deviation of all nutrients analyzed among all labs in the program.

16) **Other Remarks**

On 7/14/2025 this dataset was updated to include embedded QAQC flags and codes for anomalous/suspect, rejected, missing, and below detection limit data. System-wide monitoring data beginning in 2007 were processed to allow for QAQC flags and codes to be embedded in the data files rather than using the original single letter codes used for the nutrient and pigment dataset along with the detailed sections in the metadata document for suspect, missing, and rejected data. Please note that prior to 2007, rejected data were deleted from the dataset so they are unavailable to be used at all. Suspect, missing, rejected and below minimum detection flags and appropriate three letter codes were embedded retroactively for dataset consistency. The QAQC flag/codes corresponding to the original letter codes are detailed below.

Flag/code	*If also C*	Historic Letter Code	Historic Code Definition
<1> [SUL]		A	Value above upper limit of method detection
<-4> [SBL]	<-4> [SCB]	B	Value below method detection limit
no need to flag/code unless combined		C	Calculated value
<-3> [GQD]	<3> [GCR]	D	Data deleted or calculated value could not be determined due to deleted data, see metadata for details
<1> (CHB)		H	Sample held beyond specified holding time
<0> (CSM) unless other flag		K	Check metadata for further details
<-2> [GDM]	<-2> [GCM]	M	Data missing, sample never collected or calculated value could not be determined due to missing data
<-3> [SNV] and <1> [SCC] for components		N	Negative calculated value
(CRE) or F_Record {CRE}		P	Significant precipitation (reserve defined, see metadata for further details)
<0> (CUS)		U	Lab analysis from unpreserved sample
<1> (CSM)		S	Data suspect, see metadata for further details

There were no significant storm events during 2005.

The following data were labeled suspect because values were very low and nitrite (NO2F) concentrations were reported higher than nitrate plus nitrite (NO23F) concentrations.

Date	Site	Monitoring Program	Parameter	Time
05/03/05	AP	Grab Sample (Rep 1,2)	NO2F, NO23F, DIN	12:00, 12:01
06/07/05	SM	Diel Sample	NO2F, DIN	08:05
07/05/05	NM	Grab Sample (Rep 1,2)	NO2F, NO23F, DIN	14:05, 14:06
07/05/05	SM	Diel Sample	NO2F, NO23F, DIN	04:07, 05:09, 06:11
08/01/05	NM	Grab Sample (Rep2)	NO2F, NO23F, DIN	12:26
08/01/05	SM	Diel Sample	NO2F, NO23F, DIN	04:43, 05:45
11/01/05	SM	Diel Sample	NO2F, NO23F, DIN	16:24, 17:26, 18:28, 19:30