

Integrated Analysis Tools for the NERRS System-Wide Monitoring Program Data

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May 5, 2016





Overview

- Background of National Estuarine Research Reserves (NERRS) System-wide Monitoring Program (SWMP)
- Genesis of “SWMPrats.net” community of practice
- Features of SWMPrats.net
 - ▶ SWMPr
 - ▶ widgets
 - ▶ forum
- Continuing work, training, and engagement

What is NERRS/SWMP?

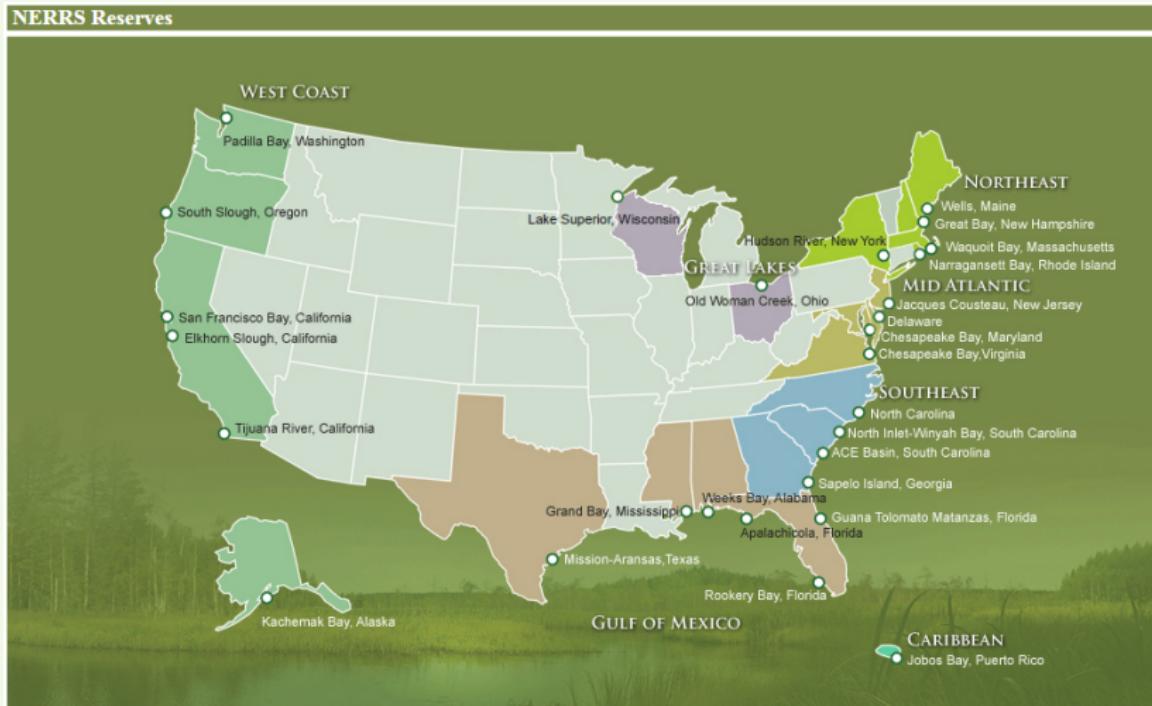
NERRS

National Estuarine Research Reserve System, established by Coastal Zone Management Act of 1972. Focus on *long-term research, monitoring, education, and stewardship* for more effective coastal management.

SWMP

System Wide Monitoring Program, initiated in 1995 to provide *continuous monitoring* data at over 300 stations in each of the 28 NERRS reserves

What is NERRS/SWMP?



<http://nerrs.noaa.gov/ReservesMap.aspx>

What is NERRS/SWMP?

Each reserve has fixed, continuous monitoring stations for ***water quality*** (15 min), ***meteorology*** (15 min), and ***nutrients*** (monthly)

The parameters for a station are specific to the parameter type

Water quality

temp, spcond, sal,
do_pct, do_mgl,
depth, cdepth, level,
clevel, ph, turb,
chlfluor

Meteorology

atemp, rh, bp, wspd,
maxwspd, wdir,
sdwdir, totpar,
totprcp, cumprcp,
totsorad

Nutrients

po4f, chla_n, no3f,
no2f, nh4f, no23f,
ke_n, urea

What is NERRS/SWMP?

Data maintained by the Centralized Data Management Office (CDMO)



The screenshot shows a website interface for the Centralized Data Management Office (CDMO). At the top, there is a navigation bar with links: Home, About CDMO, About Data, Get Data, Web Services, and Contact CDMO. Below the navigation bar is a large photograph of a white heron standing in a wetland area, with a river and green fields in the background.

View / Download Data



A large map of the United States with data collection points marked across the states. The text "View / Download Data" is overlaid on the map.

[Requested Citation Format](#)

Real Time Monitoring Data

Choose Reserve... GTMPCMET 10/08/14 09:45 AM
GTMPCWQ 10/08/14 09:45 AM



[Connect to Reserves](#)

Air Temperature: 27.8 °C (82 °F)
Wind Speed: 1.1 m/Sec (02 mph)
Water Temperature: 22.7 °C (73 °F)
Salinity: 7.1 PPT
Dissolved Oxygen: 4.7 mg/L

CDMO News

The CDMO is excited to announce the launch of our new **SWMP Mobile application**. Near real-time SWMP data is now available on your smartphone or tablet at: www.nerrsdata.org/mobile

Our **Data Export System** has been updated and now has enhanced graphing capabilities! Want to easily export or graph data? If so, check out our [Data Export System!](#)

What is NERRS/SWMP?

Hallmarks of SWMP - Standardized instruments and protocols,
rigorous QAQC, very large dataset

- All 28 reserves use identical instruments and standardized protocols
- All data are managed by the NERRS Centralized Data Management Office
- Database meets the definition of “big data”

What is NERRS/SWMP?

As of April 30th, > 63 million SWMP data records available from CDMO

Raw data will look like this...

	A	B	C	D	E	F	G	H	I	J	K	L
1	StationCode	isSWMP	DateTimeStamp	Historical	Provisional	CollMethod	REP	F_Record	PO4F	F_PO4F	NH4F	F_NH4F
2	apacpnut	P	1/10/2012 10:20	0	1	1	1		0.003 <-4> [SBL]		0.03 <0>	
3	apacpnut	P	2/7/2012 11:41	0	1	1	1		0.005 <0>		0.019 <0>	
4	apacpnut	P	3/5/2012 11:51	0	1	1	1		0.003 <-4> [SBL]		0.041 <0>	
5	apacpnut	P	4/4/2012 10:30	0	1	1	1		0.003 <-4> [SBL]		0.043 <0>	
6	apacpnut	P	5/9/2012 10:12	0	1	1	1		0.003 <0>		0.053 <0>	
7	apacpnut	P	5/9/2012 10:15	0	1	1	2		0.003 <-4> [SBL]		0.022 <0>	
8	apacpnut	P	5/9/2012 10:20	0	1	1	3		0.003 <0>		0.016 <0>	
9	apacpnut	P	6/5/2012 8:30	0	1	1	1		0.003 <-4> [SBL]		0.04 <0>	
10	apacpnut	P	7/3/2012 9:58	0	1	1	1 {CSM}		0.004 <0>		0.094 <0>	
11	apacpnut	P	7/3/2012 9:59	0	1	1	2 {CSM}		0.004 <0>		0.066 <0>	
12	apacpnut	P	7/3/2012 10:01	0	1	1	3 {CSM}		0.005 <0>		0.069 <0>	
13	apacpnut	P	8/7/2012 9:53	0	1	1	1 {CSM}		0.003 <-4> [SBL]		0.05 <0>	
14	apacpnut	P	9/5/2012 10:56	0	1	1	1		0.003 <-4> [SBL]		0.026 <0>	
15	apacpnut	P	10/2/2012 9:22	0	1	1	1		0.003 <-4> [SBL]		0.042 <0>	
16	apacpnut	P	10/2/2012 9:27	0	1	1	2		0.003 <-4> [SBL]		0.024 <0>	
17	apacpnut	P	10/2/2012 9:32	0	1	1	3		0.003 <0>		0.042 <0>	
18	apacpnut	P	11/6/2012 10:30	0	1	1	1		0.003 <-4> [SBL]		0.07 <0>	
19	apacpnut	P	11/26/2012 11:39	0	1	1	1		0.003 <-4> [SBL]		0.041 <0>	

What are the problems?

An invaluable data source but no recent comparative analyses between systems

NERRS researchers, managers, and technicians need more tools for trend analysis

Some specific issues:

- Knowing what data to use and how to obtain
- Dealing with QAQC columns or removing ‘bad’ observations
- Combining data for comparison
- Issues inherent with time series, e.g., signal vs. noise, data quantity

What are the needs?

Several needs were identified given the challenges:

- Understand regional and national trends while retaining the ability to determine local trends
- Train users
- Maintain a versatile and evolving data analysis approach
- Create a community of practice



NERRS / SWMP

Data Analysis Workshop: *Time Series*

November 17, 2014

One-day training workshop at 2014 annual meeting

- Attended by over 70 NERRS staff, representing 19 of 28 reserves
- General focus on time series analysis, simple applications with SWMP data
- Pre/post workshop materials, including an R package for SWMP



Genesis of SWMPrats



A working group was formed from this meeting

*S*ystem- *W*ide *M*onitoring *P*rogram *R*esources for the
*A*nalysis of *T*ime *S*eries

SWMPrats.net is our base of operations...



A website with information and tools for SWMP data analysis

SWMPrats.net

The SWMPrats.net web pages serve as a time series and data analysis information and tool resource for the National Estuarine Research Reserve System (NERRS) System-wide Monitoring Program (SWMP).

Trends in SWMP parameters

Created by Marcus W. Beck, beck.marcus@noaa.gov, Todd O'Brien, todd.o'brien@noaa.gov

This widget is an interactive tool to evaluate trends in SWMP data. Trends are described by an increase or decrease in values over time using a simple linear regression of summarized data. The significance of the trend is indicated by the p-value, where lower values indicate a more significant trend. The direction of the trend is indicated by the sign of the slope and color shading where larger points with darker colors indicate a strong trend. Original data are available from [NOAA/NERRS](http://nerrs.noaa.gov).

Select parameter:

air Temperature (C)

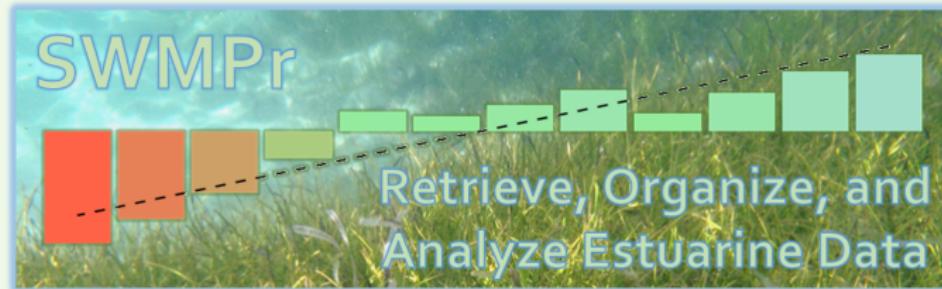
Select data range:

1980-2013

oceanic, Temperature (C), NEQ (p=0.81)



SWMPrats.net: The SWMPr package



SWMPr is an open-source R package described on the website, v2.1.5 is now available

```
> # install/load from R  
> install.packages('SWMPr')  
> library(SWMPr)
```



SWMPrats.net: The SWMPPr package

The software addresses the unglamorous but necessary challenges of analyzing time series, specific to SWMP

What are some challenges?

- Dealing with ‘bad’ data
- Subsetting by date ranges, parameters
- Combining data from different sites
- Standardizing time steps
- ...and analysis

A	B	C	D	E	F	G	H	I	J	K	L
1	StationCo_idSWMP	Date/Time/Stamp	Historical	Provisional	Correlation	REP	F_Record	PDR	F_PDR	NHDF	F_NHDF
2	apeprin P	1/10/2012 10:30	0	1	1	1	3	0.003 <-4 [SWL]	0.03 <0	0.003 <-4 [SWL]	0.03 <0
3	apeprin P	1/10/2012 10:30	0	1	1	1	3	0.003 <-4 [SWL]	0.03 <0	0.003 <-4 [SWL]	0.03 <0
4	apeprin P	3/5/2012 11:51	0	1	1	1	3	0.003 <-4 [SWL]	0.041 <0	0.003 <-4 [SWL]	0.041 <0
5	apeprin P	4/4/2012 10:30	0	1	1	1	3	0.003 <-4 [SWL]	0.043 <0	0.003 <-4 [SWL]	0.043 <0
6	apeprin P	5/9/2012 10:12	0	1	1	1	3	0.003 <0	0.053 <0	0.003 <0	0.053 <0
7	apeprin P	5/9/2012 10:12	0	1	1	2	2	0.003 <-4 [SWL]	0.032 <0	0.003 <-4 [SWL]	0.032 <0
8	apeprin P	5/9/2012 10:30	0	1	1	3	3	0.003 <-4 [SWL]	0.055 <0	0.003 <-4 [SWL]	0.055 <0
9	apeprin P	5/9/2012 10:30	0	1	1	3	3	0.003 <-4 [SWL]	0.044 <0	0.003 <-4 [SWL]	0.044 <0
10	apeprin P	7/3/2012 9:58	0	1	1	3	3 [SWL]	0.004 <0	0.004 <0	0.004 <0	0.004 <0
11	apeprin P	7/3/2012 9:58	0	1	1	2	2 [SWL]	0.004 <0	0.006 <0	0.004 <0	0.006 <0
12	apeprin P	7/3/2012 10:59	0	1	1	3	3 [SWL]	0.005 <0	0.005 <0	0.005 <0	0.005 <0
13	apeprin P	8/7/2012 10:59	0	1	1	2	2 [SWL]	0.005 <0	0.005 <0	0.005 <0	0.005 <0
14	apeprin P	9/5/2012 9:56	0	1	1	2	2	0.003 <-4 [SWL]	0.030 <0	0.003 <-4 [SWL]	0.030 <0
15	apeprin P	10/2/2012 9:22	0	1	1	3	3	0.003 <-4 [SWL]	0.042 <0	0.003 <-4 [SWL]	0.042 <0
16	apeprin P	10/2/2012 9:27	0	1	1	2	2	0.003 <-4 [SWL]	0.034 <0	0.003 <-4 [SWL]	0.034 <0
17	apeprin P	10/2/2012 9:32	0	1	1	3	3	0.003 <0	0.042 <0	0.003 <0	0.042 <0
18	apeprin P	11/6/2012 10:40	0	1	1	3	3	0.003 <-4 [SWL]	0.07 <0	0.003 <-4 [SWL]	0.07 <0
19	apeprin P	11/6/2012 11:39	0	1	1	2	2	0.003 <-4 [SWL]	0.041 <0	0.003 <-4 [SWL]	0.041 <0



Package description published in The R Journal this year

SWMPr: An R Package for Retrieving, Organizing, and Analyzing Environmental Data for Estuaries

by Marcus W Beck

Abstract The System-Wide Monitoring Program (SWMP) was implemented in 1995 by the US National Estuarine Research Reserve System. This program has provided two decades of continuous monitoring data at over 140 fixed stations in 28 estuaries. However, the increasing quantity of data provided by the monitoring network has complicated broad-scale comparisons between systems and, in some cases, prevented simple trend analysis of water quality parameters at individual sites. This article describes the **SWMPr** package that provides several functions to facilitate data retrieval, organization, and analysis of time series data in the reserve estuaries. Previously unavailable functions for estuaries are also provided to estimate rates of ecosystem metabolism using the open-water method. The **SWMPr** package has facilitated a cross-reserve comparison of water quality trends and links quantitative information with analysis tools that has use for more generic applications to environmental time series.

What can SWMPr do?

SWMPr functions are grouped into three categories that describe their use in the ‘data workflow’

Retrieve

all_params
all_params_dtrng
import_local
import_remote
single_param
site_codes
site_codes_ind

Organize

comb
qaqc
qaqcchk
rem_reps
setstep
subset

Analyze

aggreswmp
aggremetab
ecometab
decomp
decomp_cj
hist
lines
na.approx
plot
plot_metab
plot_summary
smoother



SWMPrats.net: The SWMPr package

Proof of concept, import and combine wq and weather data from Apalachicola Bay

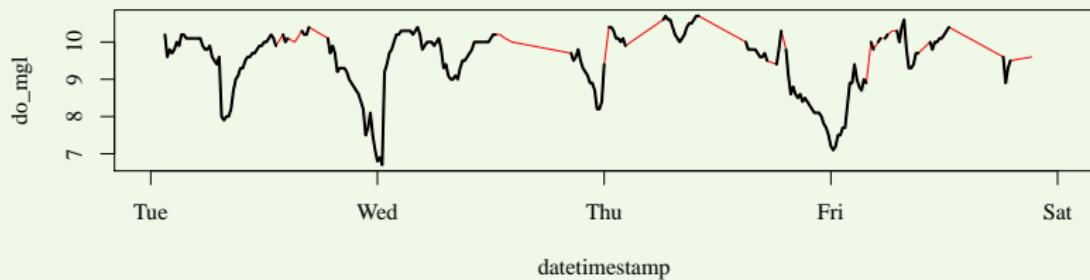
```
> # import data
> data(apaebmet)
> data(apacpwq)
> met <- apaebmet
> wq <- apacpwq
>
> # combine, two hours time step
> # only overlapping date ranges
> dat <- comb(met, wq, timestep = 120,
+   method = 'intersect')
```

Try doing the same by hand...

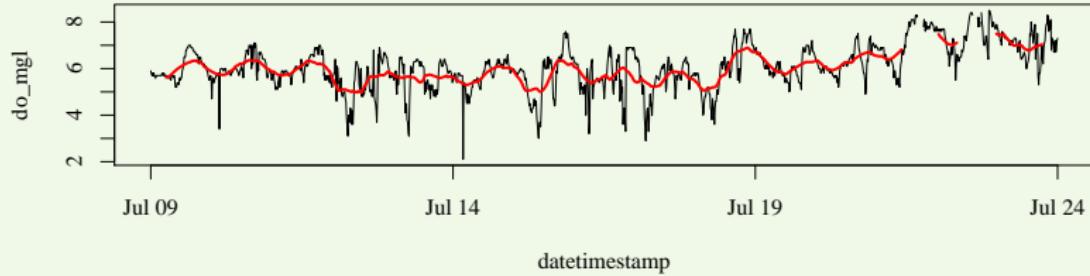


SWMPrats.net: The SWMPr package

Example: fill missing data with `na.approx`



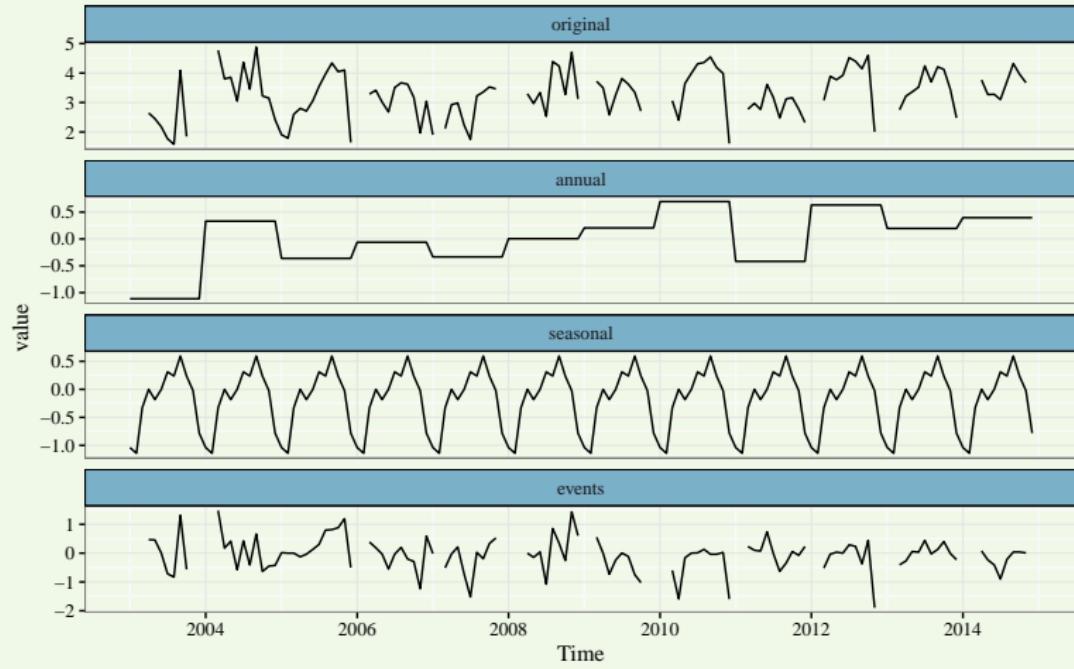
Example: smooth data with `smoother`





SWMPrats.net: The SWMPr package

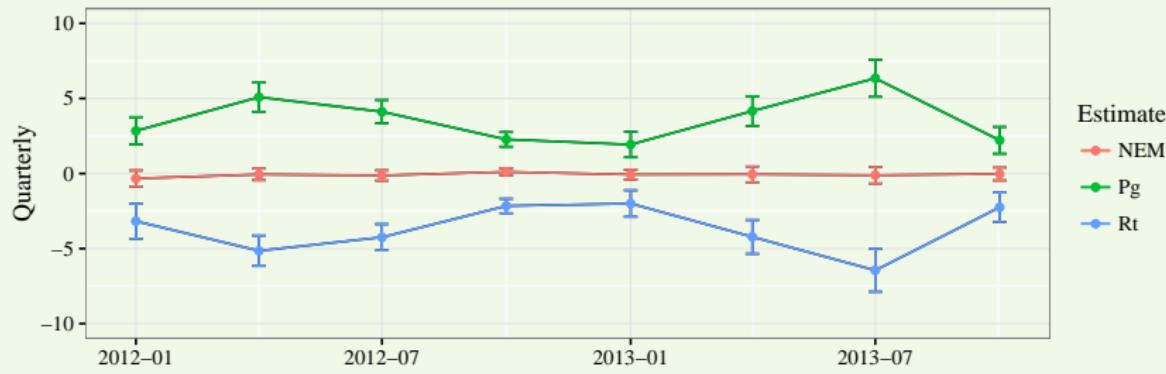
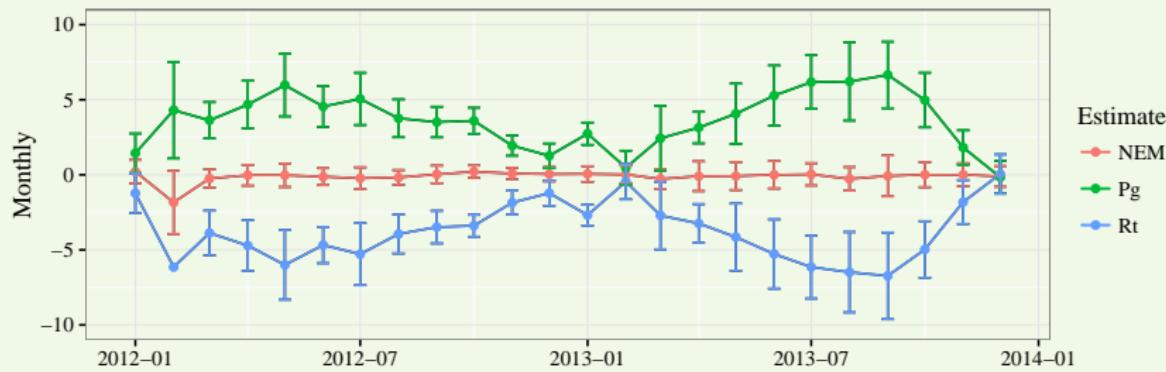
Example: time series decomposition with `decomp_cj` (chl-a at cbmocnut)





SWMPrats.net: The SWMPr package

Example: estimate ecosystem metabolism with `ecometab` (`apadbwq`)





The most common question - has there been a change over time at my site?

The functions in the package can help answer this very general question...

...but it's often easier to interactively evaluate the data!

Two shiny applications, hosted on shinyapps.io, allow users to visualize trends in SWMP data

These apps were created with SWMPr functions or use them 'reactively'



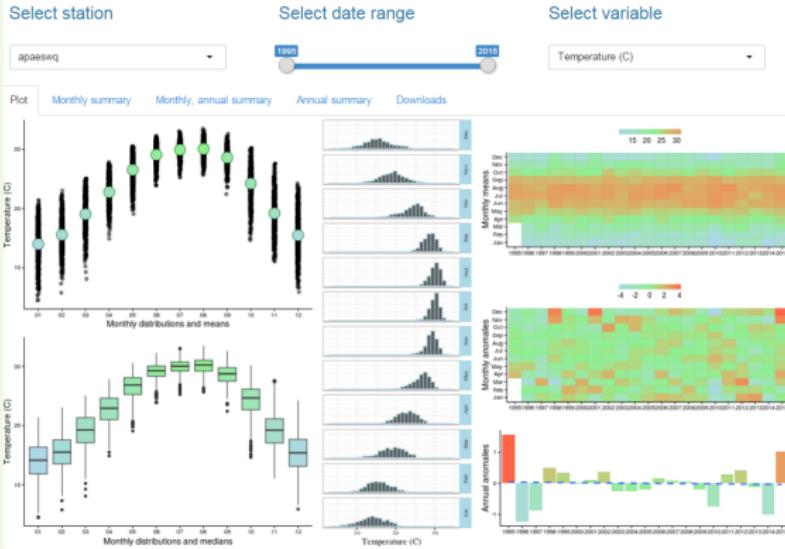
SWMPPrats.net: Widgets

SWMP summary plots: https://beckmw.shinyapps.io/swmp_summary/

Monthly and annual summary of SWMP parameters

Created by Marcus W. Beck, beck.marcus@epa.gov Todd O'Brien, todd.obrien@noaa.gov

This interactive widget provides graphical summaries of water quality, weather, and nutrient station data from the System Wide Monitoring Program of the National Estuarine Research Reserve System ([NERRS](#)). The drop down menus can be used to select the station, date range, and parameter for plotting. The raw data used for plotting include all SWMP records from the earliest date at each station after processing to remove QAQC flags. The data include observations through December 2015 and are current as of January 2016. Plots are based on daily averages for each parameter. Cumulative precipitation data are based on the daily maximum. See the [Github repository](#) for source code.





SWMP trends map: https://beckmw.shinyapps.io/swmp_comp/



Trends in SWMP parameters

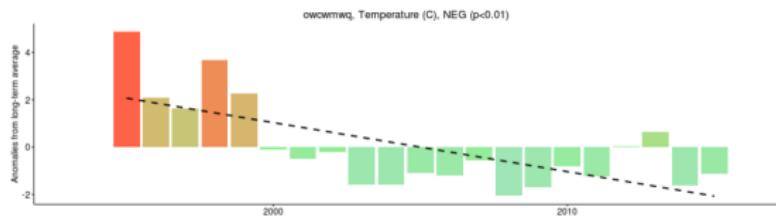
Created by Marcus W. Beck, beck.marcus@epa.gov, Todd O'Brien, todd.obrien@noaa.gov

This widget is an interactive tool to explore trends in SWMP data. Trends are described by an increase or decrease in values over time using a simple linear regression of summarized data. The regression for each station can be viewed by clicking on a map location. Trends at each station are plotted as circles that identify the direction and significance of the trend. The trend direction is blue for decreasing and red for increasing. The significance is indicated by radius of the circle and color shading where larger points with darker colors indicate a strong trend. Original data are available from <http://cdmo.baruch.sc.edu/>. See the [GitHub repository](#) for source code. The data include observations through December 2015 (if available) and are current as of January 2016. Please note that the use of simple regression to identify trends is for exploratory purposes only and may not be appropriate for all datasets. The map is centered at 40°, -94 with a zoom level of 3.

Select parameter:

Summarize by:

Select date range:



SWMP aggregation: https://beckmw.shinyapps.io/swmp_agg/

Aggregation of SWMP parameters within/between reserves

Created by Marcus W. Beck, beck.marcus@epa.gov Todd O'Brien, todd.obrien@noaa.gov

This interactive widget can be used to compare time series of site data within and between reserves from the System Wide Monitoring Program of the National Estuarine Research Reserve System (NERRS). Data are based on monthly averages of raw observations through December 2015 and are current as of January 2016. Two plots are shown for selected parameters and reserves that include time series of all sites at each location. The monthly averages are shown by default. Data can also be viewed as quarterly (every three months) or annual aggregations based on averages of the monthly summaries. Tabular data for each plot can be viewed on the tables tab and downloads of the plots and tables are available on the downloads tab. See the GitHub repository for source code or to post issues if problems occur.





SWMPrats.net: Forum

Last but not least, a discussion forum for all things analytical

SWMPrats.net

Welcome, Guest

Username: Password: Remember me

Forgot your password? Forgot your username? Create an account

Forum > Recent Topics

21 Topics Year Board Categories Go Page: 1 2

Recent Discussions					
1 Replies		SWMPr manuscript available		9 Views	Last Post by Kim_Cressman 7 hours 40 minutes ago
1 Replies		POTM April 2016 - Simple Chlorophyll Graph		58 Views	Last Post by Marcus Beck 2 days 6 hours ago
2 Replies		Basic R resources		29 Views	Last Post by Kim_Cressman 5 days 5 hours ago



Last but not least, a discussion forum for all things analytical

TOPIC: POTM (Jan-2016): The Menu Command

• POTM (Jan-2016): The Menu Command 3 months 2 days ago

#57

Todd.O'Brien



OFFLINE

Moderator



Posts: 6

Karma: 3



The January "POTM" should perhaps be called a "PPOTM" (Practical Programming of the Month).

Select a file (enter ZERO to quit): |

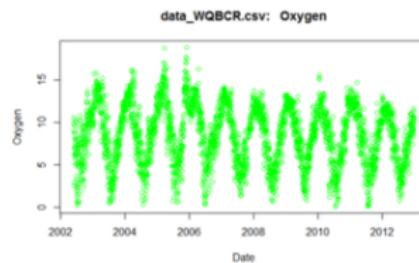
```
1: data_ACEBB.csv  
2: data_ELKNM.csv  
3: data_NOCRC.csv  
4: data_WQBCR.csv
```

Selection: 3

Pick a variable (0 to exit):

```
1: DATE.YMD  
2: Temperature  
3: Salinity  
4: Oxygen  
5: Turbidity  
6: AirTemp
```

Selection: 3



The R **menu** command will take a data structure (e.g. a list of all "*.csv" file names found in the current working directory, or a list of column headings present in a data table) and list it out as a numbered menu of choices (e.g., a list of five items would show a menu with options 1 – 5



Continuing work and engagement

SWMPrats.net is in its infancy but already seeing heavy use

- 3140 downloads of SWMPr to date
- Apps have been used 160 hours in the last three months

Additional training workshops Oct. 2015, planned for 2016





Continuing work and engagement



SWMPrats is an ad hoc group formed organically from the NERRS community

Success depends on:

- Healthy discourse between the creators and users
- In-person training workshops
- Benefits of open-source resources



Continuing work and engagement



- SWMP data are now more accessible and analyses are tractable
- Site, regional, and national comparisons provide capacity to develop understanding of climate and anthropogenic drivers of change in estuarine systems
- As the dataset expands, these tools will facilitate evaluation of long-term trends within and between locations

Continuing work and engagement



Contacts:  beck.marcus@epa.gov,  todd.obrien@noaa.gov,  marie.bundy@noaa.gov

To get this presentation: https://github.com/fawda123/NWQMC_16

Apps: <http://swmprats.net/swmp-widgets/summary-plots>,
<http://swmprats.net/swmp-widgets/trends-maps>,
<http://swmprats.net/swmp-widgets/swmp-widget-aggregation>

Visit the development site for the most recent version of SWMPr:
<https://github.com/fawda123/SWMPr>