

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

Marcus W. Beck¹ Todd D. O'Brien² Marie H. Bundy²

¹USEPA NHEERL Gulf Ecology Division

Email: beck.marcus@epa.gov

²NERRS/NMFS/NOAA

Emails: todd.obrien@noaa.gov, marie.bundy@noaa.gov

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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

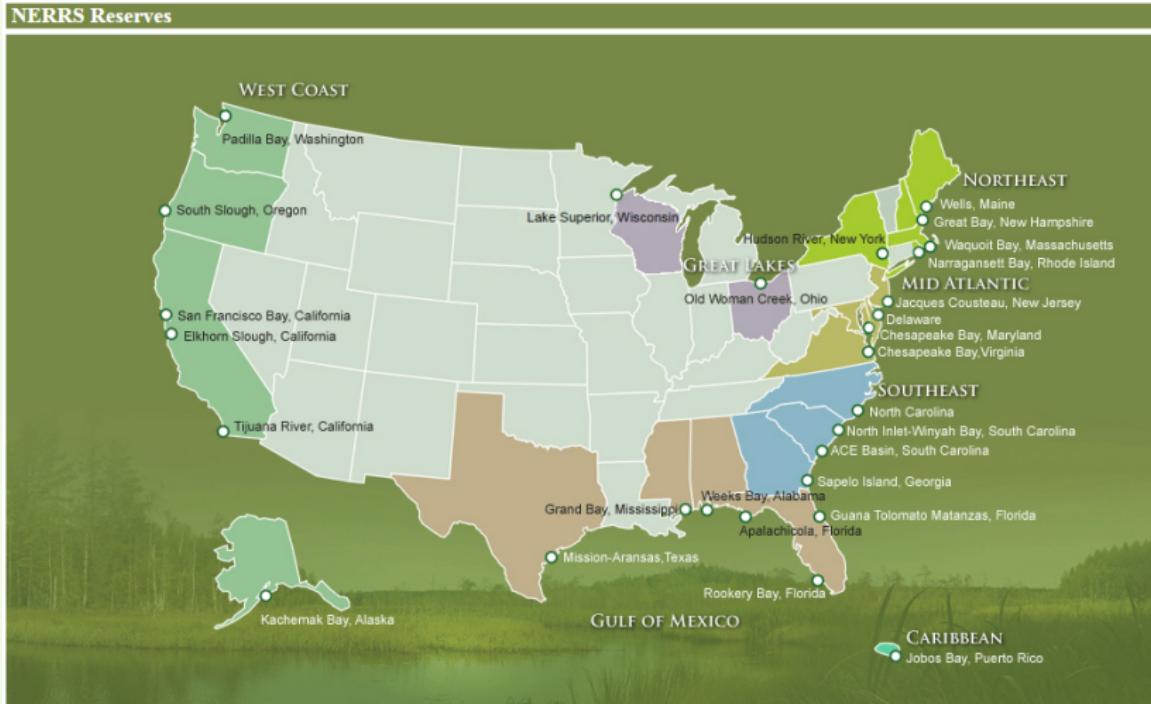
National Estuarine Research Reserve System, established by Coastal Zone Management Act of 1972. Focus on *long-term research, monitoring, education, and stewardship* for more effective coastal management.

SWMP

System Wide Monitoring Program, initiated in 1995 to provide *continuous monitoring* data at over 140 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)

Water quality

temperature,
conductivity, salinity,
dissolved oxygen,
depth, pH, turbidity,
fluorescence

Meteorology

air temperature,
humidity, pressure,
wind speed, wind
direction, PAR,
precipitation

Nutrients

phosphate,
chlorophyll, nitrate,
nitrite, ammonium,
Kjeldahl nitrogen,
urea



What is NERRS/SWMP?

Data maintained by the Centralized Data Management Office (CDMO)



What is NERRS/SWMP?

As of last month, > 63 million SWMP data records available

Raw data will look like this...

A	B	C	D	E	F	G	H	I	J	K	L	
1	StationCode	isSWMP	DateTimeStamp	Historical	Provisional	CollMeth	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 needs?

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

- 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

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 color of the bars. A dashed line indicates the mean value. The background color of the bars indicates the direction of the trend: green for increasing and red for decreasing. 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 NOAA's National Centers for Environmental Information.

Select parameter:

swmp Temperature (C)

Select summary by:

Years anomalies

Select date range:

1980-2014

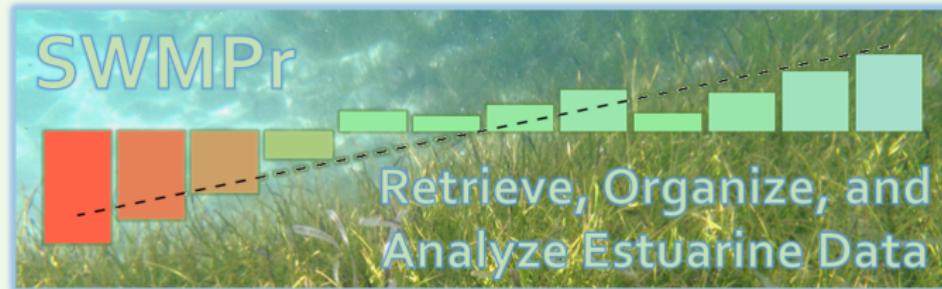
oceanus, Temperature (C), NED (p=0.81)

Temperature (C) vs. Year

Year	Temperature (C)
1980	15.0
1981	15.5
1982	15.2
1983	15.8
1984	15.4
1985	15.6
1986	15.3
1987	15.7
1988	15.2
1989	15.9
1990	15.5
1991	15.4
1992	15.6
1993	15.3
1994	15.8
1995	15.2
1996	15.7
1997	15.4
1998	15.6
1999	15.3
2000	15.9
2001	15.5
2002	15.4
2003	15.6
2004	15.3
2005	15.8
2006	15.2
2007	15.7
2008	15.4
2009	15.6
2010	15.3
2011	15.9
2012	15.5
2013	15.4
2014	15.6
2015	15.3
2016	15.8
2017	15.2
2018	15.7
2019	15.4
2020	15.6
2021	15.3
2022	15.9
2023	15.5
2024	15.4
2025	15.6
2026	15.3
2027	15.8
2028	15.2
2029	15.7
2030	15.4
2031	15.6
2032	15.3
2033	15.9
2034	15.5
2035	15.4
2036	15.6
2037	15.3
2038	15.8
2039	15.2
2040	15.7
2041	15.4
2042	15.6
2043	15.3
2044	15.9
2045	15.5
2046	15.4
2047	15.6
2048	15.3
2049	15.8
2050	15.2
2051	15.7
2052	15.4
2053	15.6
2054	15.3
2055	15.9
2056	15.5
2057	15.4
2058	15.6
2059	15.3
2060	15.8
2061	15.2
2062	15.7
2063	15.4
2064	15.6
2065	15.3
2066	15.9
2067	15.5
2068	15.4
2069	15.6
2070	15.3
2071	15.8
2072	15.2
2073	15.7
2074	15.4
2075	15.6
2076	15.3
2077	15.9
2078	15.5
2079	15.4
2080	15.6
2081	15.3
2082	15.8
2083	15.2
2084	15.7
2085	15.4
2086	15.6
2087	15.3
2088	15.9
2089	15.5
2090	15.4
2091	15.6
2092	15.3
2093	15.8
2094	15.2
2095	15.7
2096	15.4
2097	15.6
2098	15.3
2099	15.9
2000	15.0
2001	15.5
2002	15.2
2003	15.8
2004	15.4
2005	15.6
2006	15.3
2007	15.9
2008	15.5
2009	15.4
2010	15.6
2011	15.3
2012	15.8
2013	15.2
2014	15.7
2015	15.4
2016	15.6
2017	15.3
2018	15.9
2019	15.5
2020	15.4
2021	15.6
2022	15.3
2023	15.8
2024	15.2
2025	15.7
2026	15.4
2027	15.6
2028	15.3
2029	15.9
2030	15.5
2031	15.4
2032	15.6
2033	15.3
2034	15.8
2035	15.2
2036	15.7
2037	15.4
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2042	15.4
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2051	15.9
2052	15.5
2053	15.4
2054	15.6
2055	15.3
2056	15.8
2057	15.2
2058	15.7
2059	15.4
2060	15.6
2061	15.3
2062	15.9
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2066	15.3
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2070	15.4
2071	15.6
2072	15.3
2073	15.9
2074	15.5
2075	15.4
2076	15.6
2077	15.3
2078	15.8
2079	15.2
2080	15.7
2081	15.4
2082	15.6
2083	15.3
2084	15.9
2085	15.5
2086	15.4
2087	15.6
2088	15.3
2089	15.8
2090	15.2
2091	15.7
2092	15.4
2093	15.6
2094	15.3
2095	15.9
2096	15.5
2097	15.4
2098	15.6
2099	15.3



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
Station	Co-idsWMP	Date/Time/Stamp	Historical	Provisional	Correlation	REP	F_Records	PDA	F_PDA	NHAF	F_NHAF
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>
2	apeprin P	2/10/2012 10:30	0	1	1	1	3	0.003 <-4> [SWL]	0.03 <-0>	0.003 <-4> [SWL]	0.03 <-0>
2	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	3	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 <-0>	0.053 <-0>	0.003 <-0>	0.053 <-0>
9	apeprin P	5/9/2012 10:30	0	1	1	2	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	[CSW]	0.004 <-0>	0.004 <-0>	0.004 <-0>
11	apeprin P	7/3/2012 9:58	0	1	1	2	2	[CSW]	0.004 <-0>	0.066 <-0>	0.004 <-0>
12	apeprin P	7/3/2012 10:51	0	1	1	3	3	[CSW]	0.005 <-0>	0.069 <-0>	0.005 <-0>
13	apeprin P	8/7/2012 9:58	0	1	1	2	2	[CSW]	0.003 <-4> [SWL]	0.031 <-0>	0.003 <-4> [SWL]
14	apeprin P	9/5/2012 9:58	0	1	1	2	2	[CSW]	0.003 <-4> [SWL]	0.033 <-0>	0.003 <-4> [SWL]
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	3	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> [SWL]	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 11:49	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

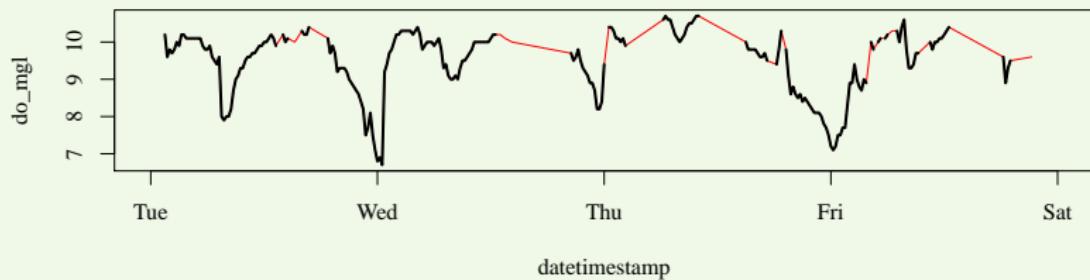
by Marcus W Beck

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.

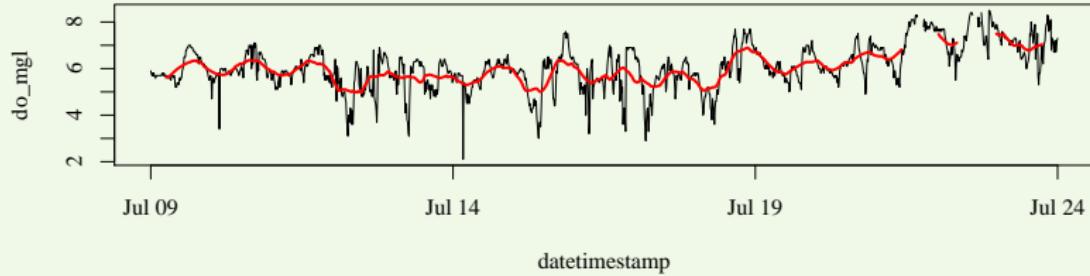


SWMPrats.net: The SWMPr package

Example: fill missing data with `na.approx`



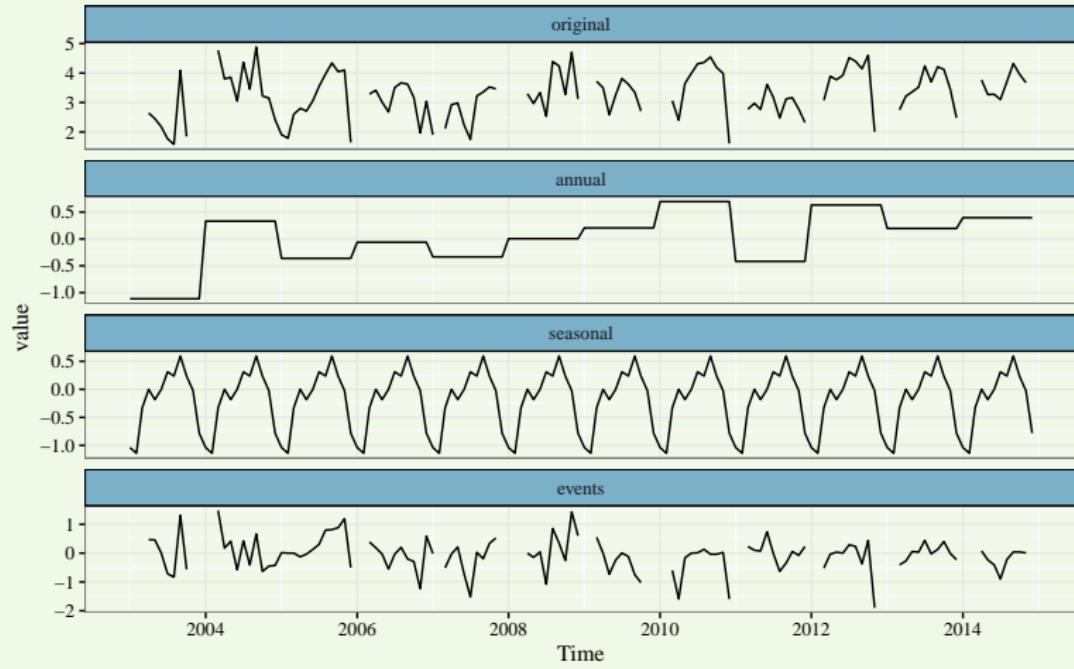
Example: smooth data with `smoother`





SWMPrats.net: The SWMPr package

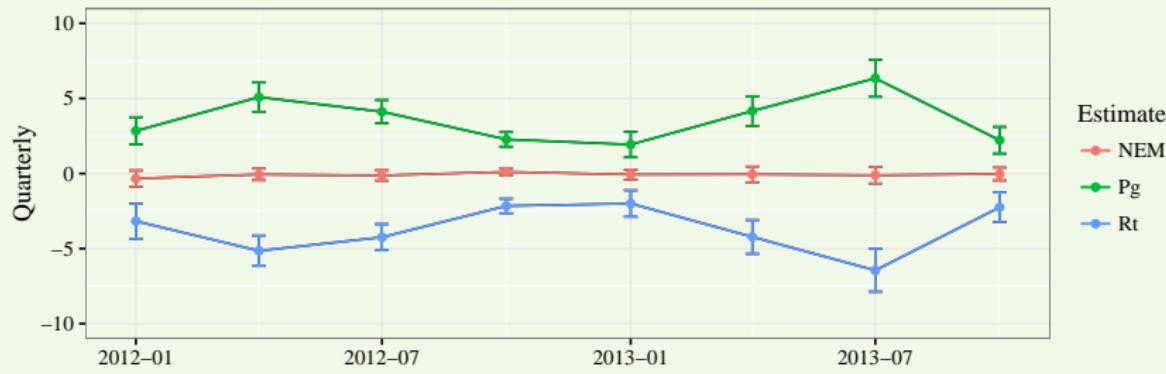
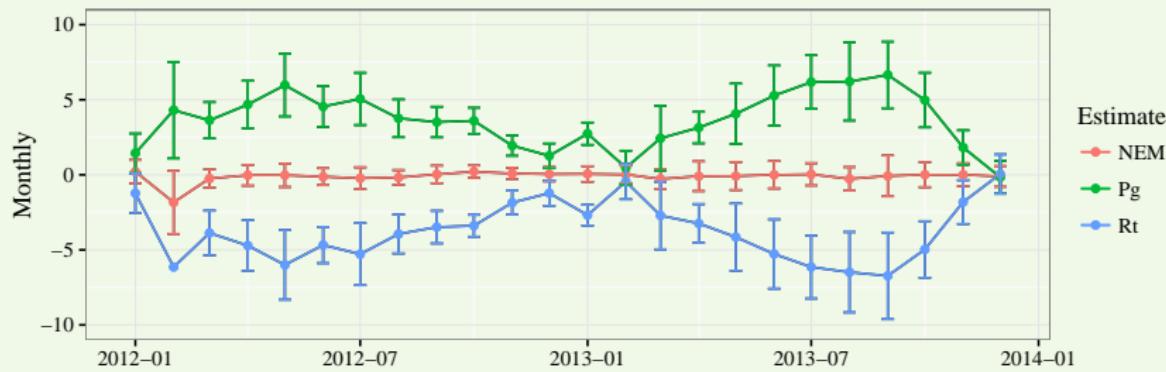
Example: time series decomposition with `decomp_cj` (chl-a at cbmocnut)





SWMPrats.net: The SWMPr package

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

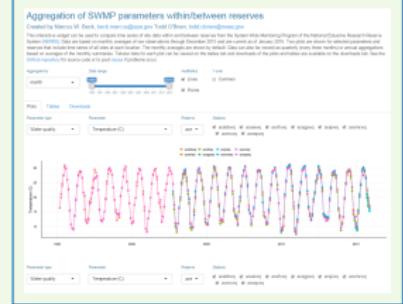
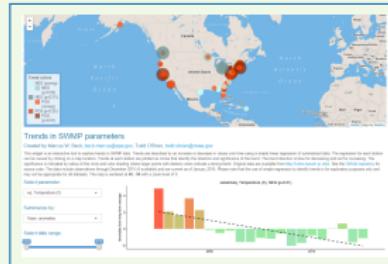
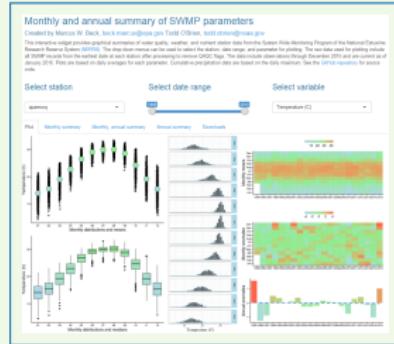




The most common question - has there been a change over time at my site (long-term trends)?

Three Shiny applications allow users to visualize trends in SWMP data

These apps allow ‘reactive’ use of SWMPr functions





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 Category: SWMPr Help/Support Topic started 2 days 6 hours ago by Marcus Beck		9 Views Last Post by Kim_Cressman 7 hours 40 minutes ago
1 Replies		POTM April 2016 - Simple Chlorophyll Graph Category: POTM: Single Variable Exploration Topic started 1 week 5 days ago by Kim_Cressman		58 Views Last Post by Marcus Beck 2 days 6 hours ago
2 Replies		Basic R resources Category: SWMPr Help/Support Topic started 1 week 5 days ago by Kim_Cressman		29 Views Last Post by Kim_Cressman 5 days 5 hours ago



Continuing work and engagement

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

- Over 4000 visits to the website this year
- 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

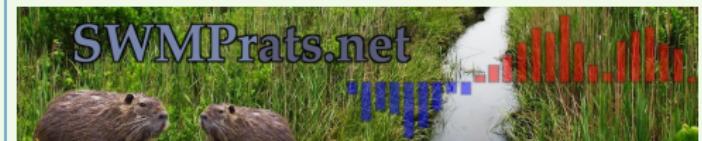


SWMPrats is an ad hoc group formed organically from the NERRS community

Success depends on:

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

Continuing work and engagement



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 SWMPrat:
<https://github.com/fawda123/SWMPrat>