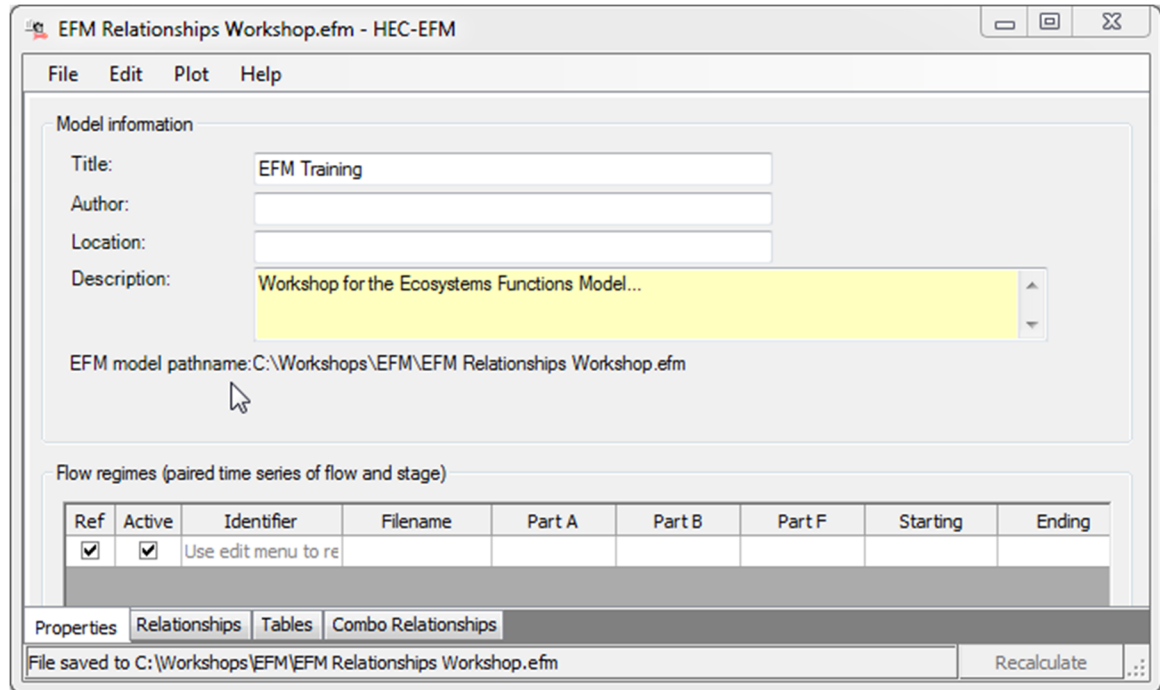


## 2.7 - Workshop: Using Statistical Features of HEC-EFM to assess Eco-change

- 1) Ok, let's use HEC-EFM to test the eco-hydro relationships you just developed. Open EFM and use the "File – New" menu option to create a new application. Enter title, author, location, and description on the Properties tab. Save application to a directory on your computer.



- 2) The hydrologic data for this workshop is stored in a file called "Data for EFM Relationships.dss". This DSS file contains gaged and natural flows and stages for the Savannah and San Joaquin Rivers.

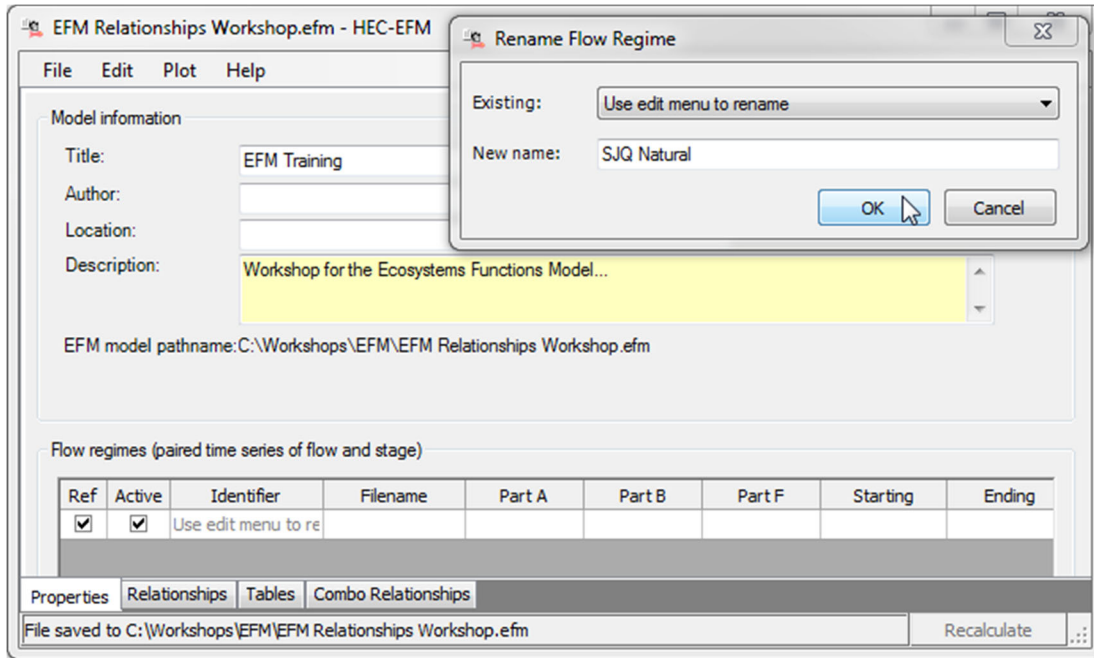
DSS stands for Data Storage System. It is the HEC database for all of our software tools. DSSVue is a tool for performing math functions, tabulating, and viewing DSS records, which are usually time series. DSS records are named with different "parts", "a" through "f". The basic naming convention is:

*/a/b/c/d/e/f/*

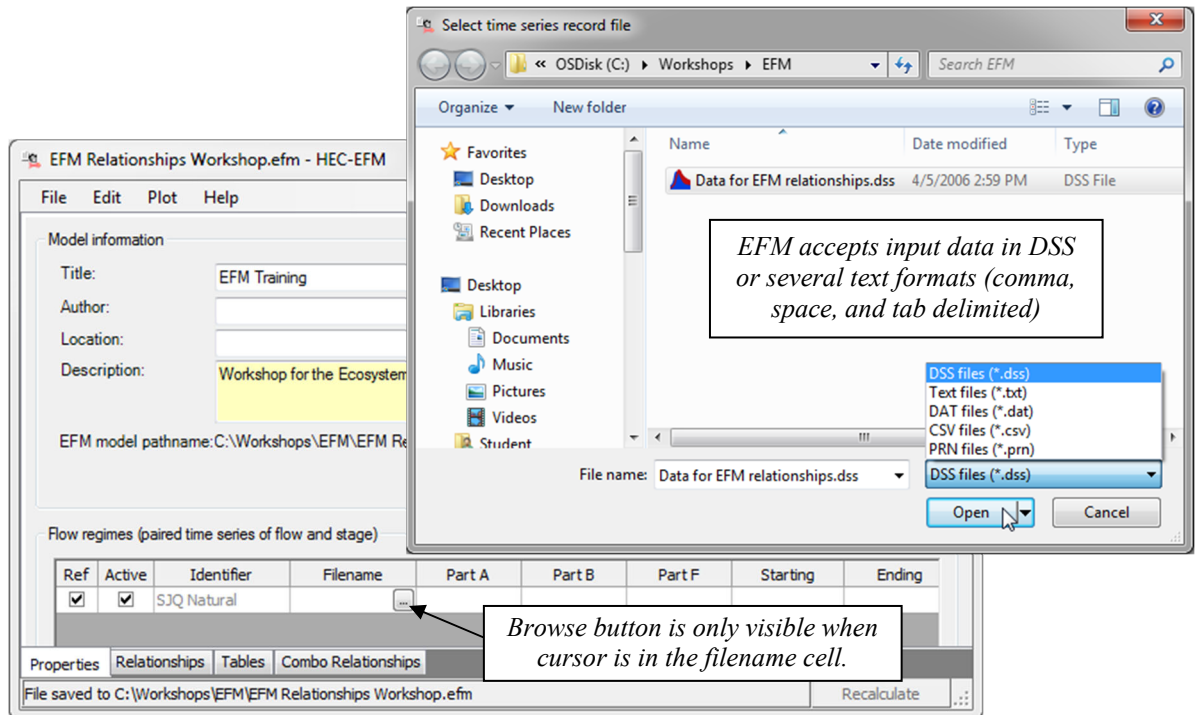
*/river name/location/data type/time range/time step/user specified name/*

Note...When moving EFM data input files on your computer or to another computer, remember to update the data input locations in the EFM application - EFM will not compute until the updates are made.

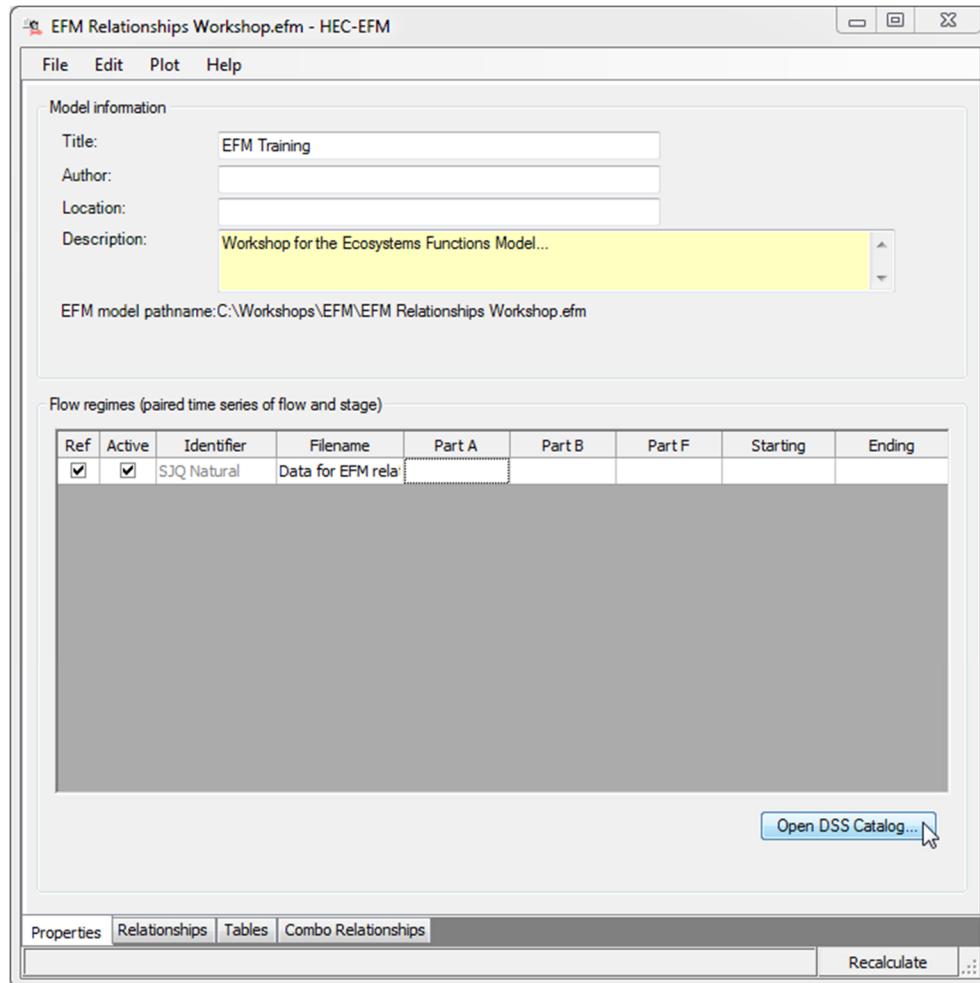
- The next step is to add the flow regimes. The first flow regime acts as a placeholder and must be renamed. Use the “Edit – Flow Regimes – Rename...” menu option. Enter the new name and click OK.



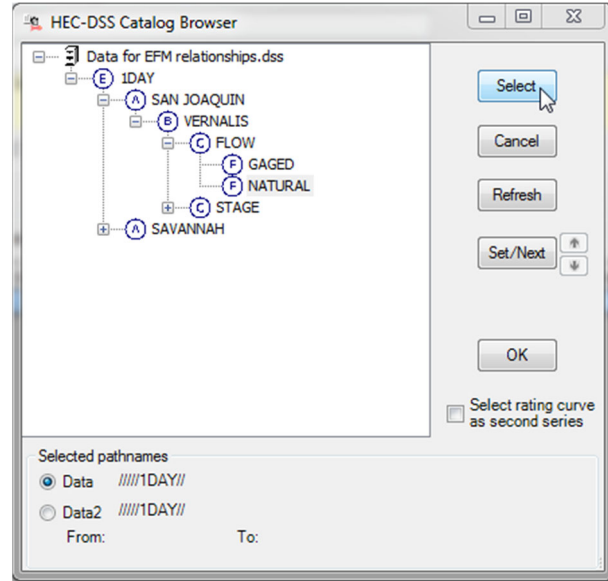
When OK is clicked, the interface moves to the Filename cell and a browse button appears. Click on the browse button and select “Data for EFM relationships.dss”.



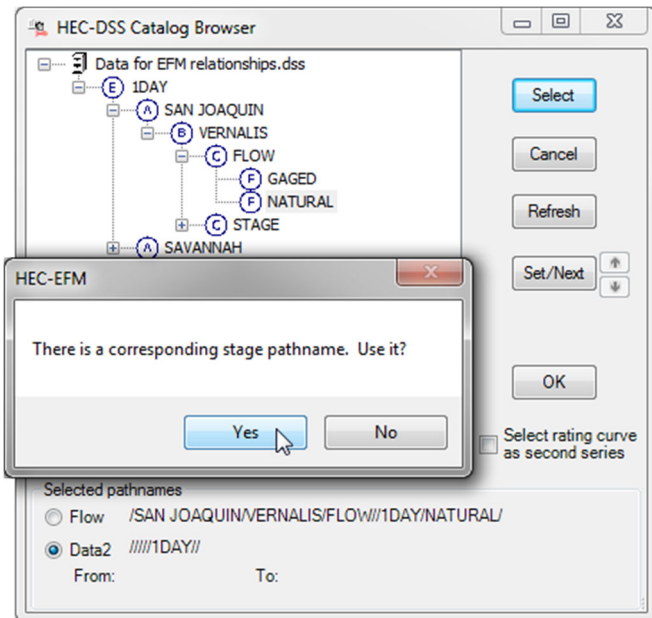
Click on the “Open DSS Catalog” button for that row.



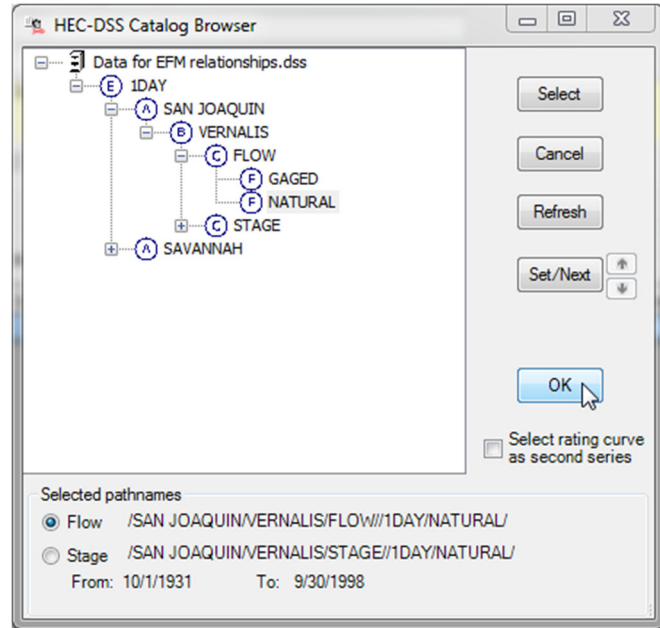
Browse through the DSS catalog, highlight the *f-part* of the flow you would like to analyze, and click Select.



EFM has an automapping feature that looks for stage time series whose *a-*, *b-*, and *f-* parts match the selected flow record. If EFM finds a match, it asks whether it should be used. Click yes.

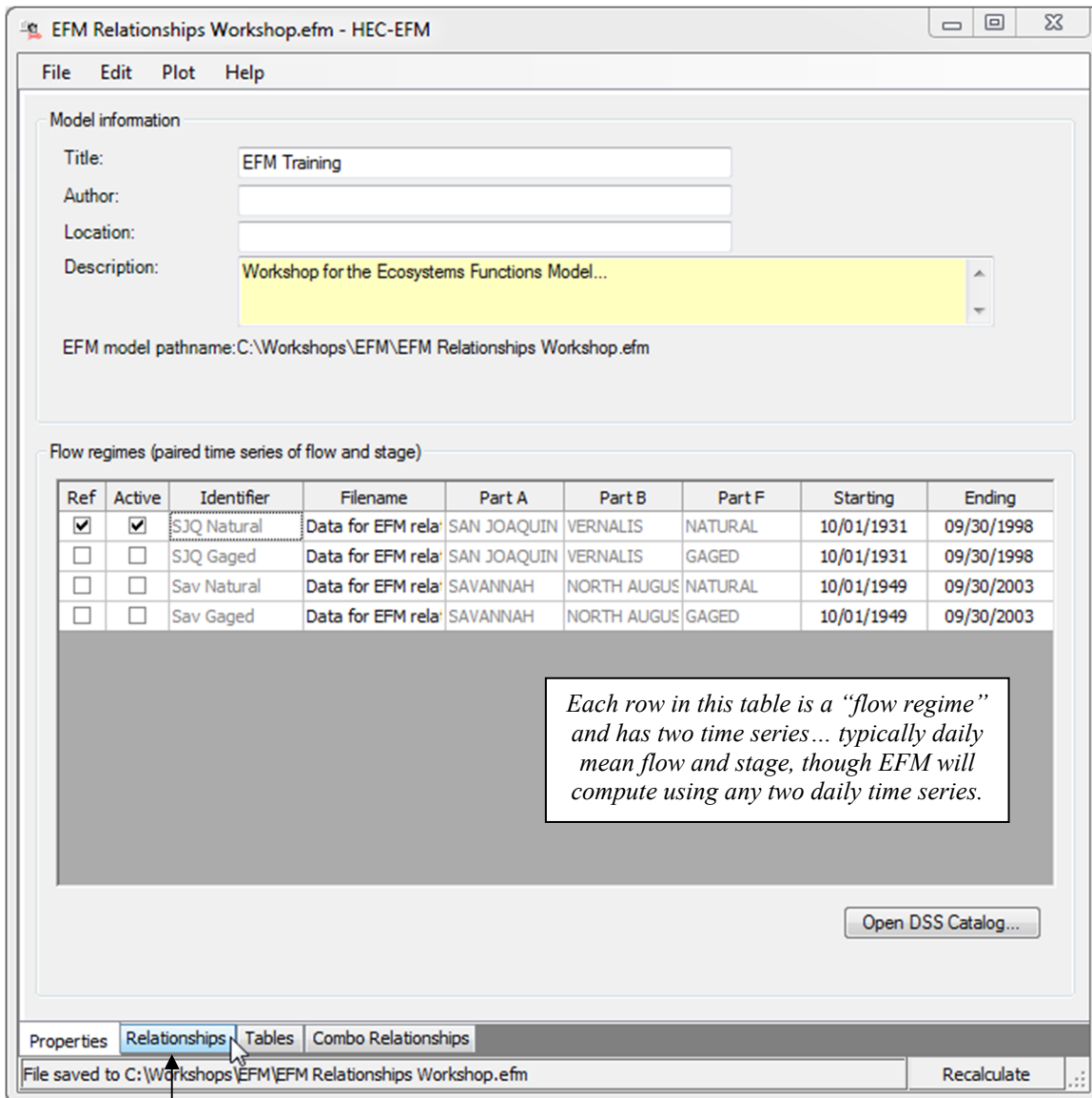


When both time series are selected (look at bottom of interface under “Selected pathnames”), click OK.

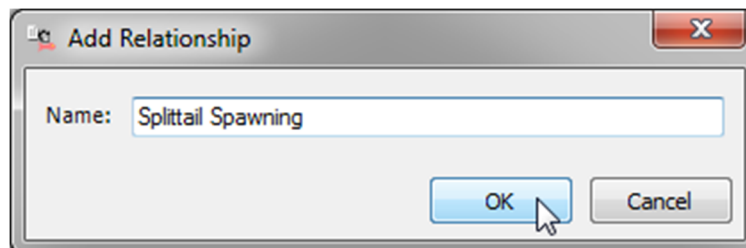


Use the “Edit – Flow Regimes – Add...” menu to repeat this process for three other flow regimes (SJQ Gaged, Sav Natural, and Sav Gaged). When complete, save your application.

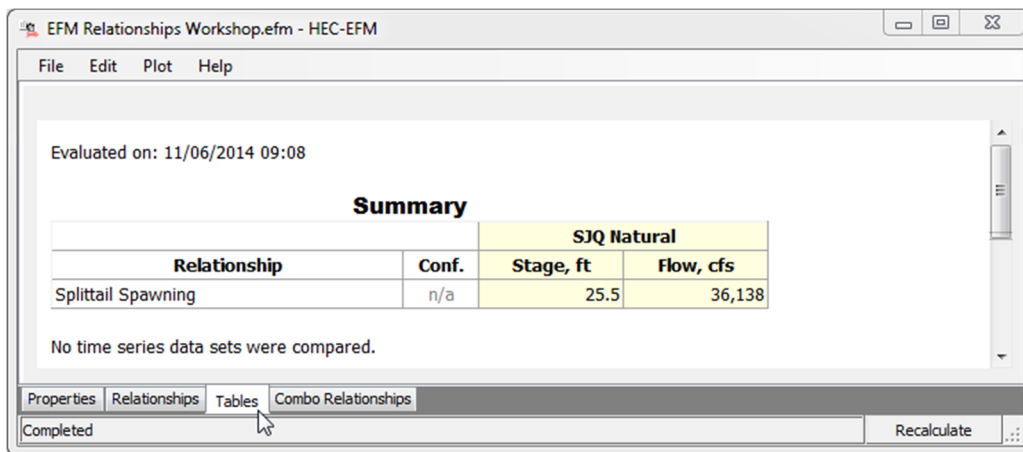
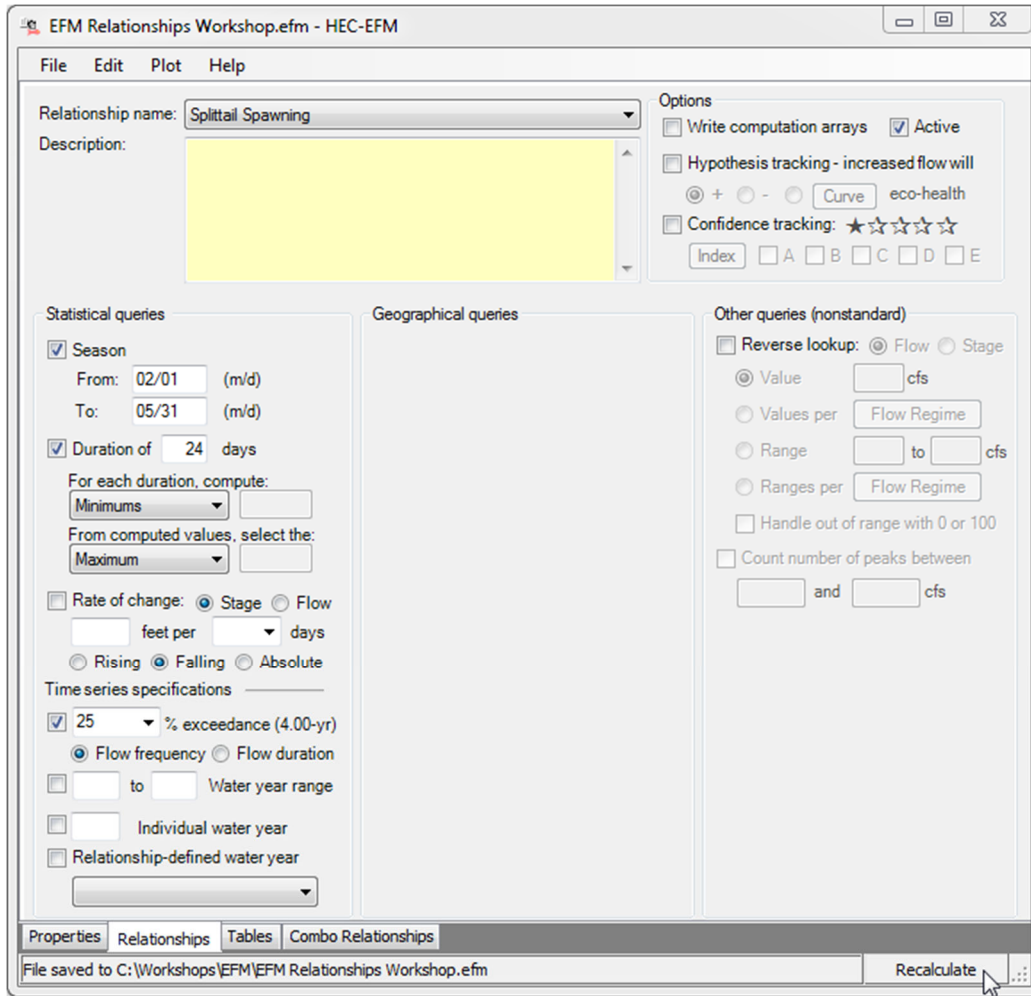
The Properties tab should look something like...



- 4) The next step is to add the relationships. Go to the **Relationships** tab and add a new relationship via the "Edit – Relationships – Add..." menu. Click OK.



- 5) Add the Statistical Queries for the relationship and hit the Recalculate button in the lower right corner of the EFM interface. EFM should compute statistical results.



- 6) Repeat this process for your other relationships. Save your project.
- 7) Go to the properties tab and activate the SJQ Gaged flow regime...

Ref	Active	Identifier	Filename	Part A	Part B	Part F	Starting	Ending
<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	SJQ Natural	Data for EFM rela	SAN JOAQUIN	VERNALIS	NATURAL	10/01/1931	09/30/1998
<input type="checkbox"/>	<input checked="" type="checkbox"/>	SJQ Gaged	Data for EFM rela	SAN JOAQUIN	VERNALIS	GAGED	10/01/1931	09/30/1998
<input type="checkbox"/>	<input type="checkbox"/>	Sav Natural	Data for EFM rela	SAVANNAH	NORTH AUGUS	NATURAL	10/01/1949	09/30/2003
<input type="checkbox"/>	<input type="checkbox"/>	Sav Gaged	Data for EFM rela	SAVANNAH	NORTH AUGUS	GAGED	10/01/1949	09/30/2003

Click the Recalculate button. Now there should be results for both flow regimes...

Evaluated on: 11/06/2014 09:19

		SJQ Natural		SJQ Gaged		
Relationship	Conf.	Stage, ft	Flow, cfs	Chg.	Stage, ft	Flow, cfs
Splittail Spawning	n/a	25.5	36,138	n/a	17.6	18,300
Shad and Striped Bass Habitat	n/a	5.1	3,186	n/a	3.0	1,713
Benthic Biodiversity	n/a	28.5	44,274	n/a	14.2	12,500
Shoals Spider Lily	n/a	3.6	2,122	n/a	0.8	330
Water Exchange	n/a	18.2	19,427	n/a	4.5	2,780

Completed Recalculate

8) Enter your hypothesis for each relationship (look at the next page in this handout for a screen capture). Recalculate. Check out the output column entitled “Chg.” (short for change). This is output for direction of change in ecosystem health.

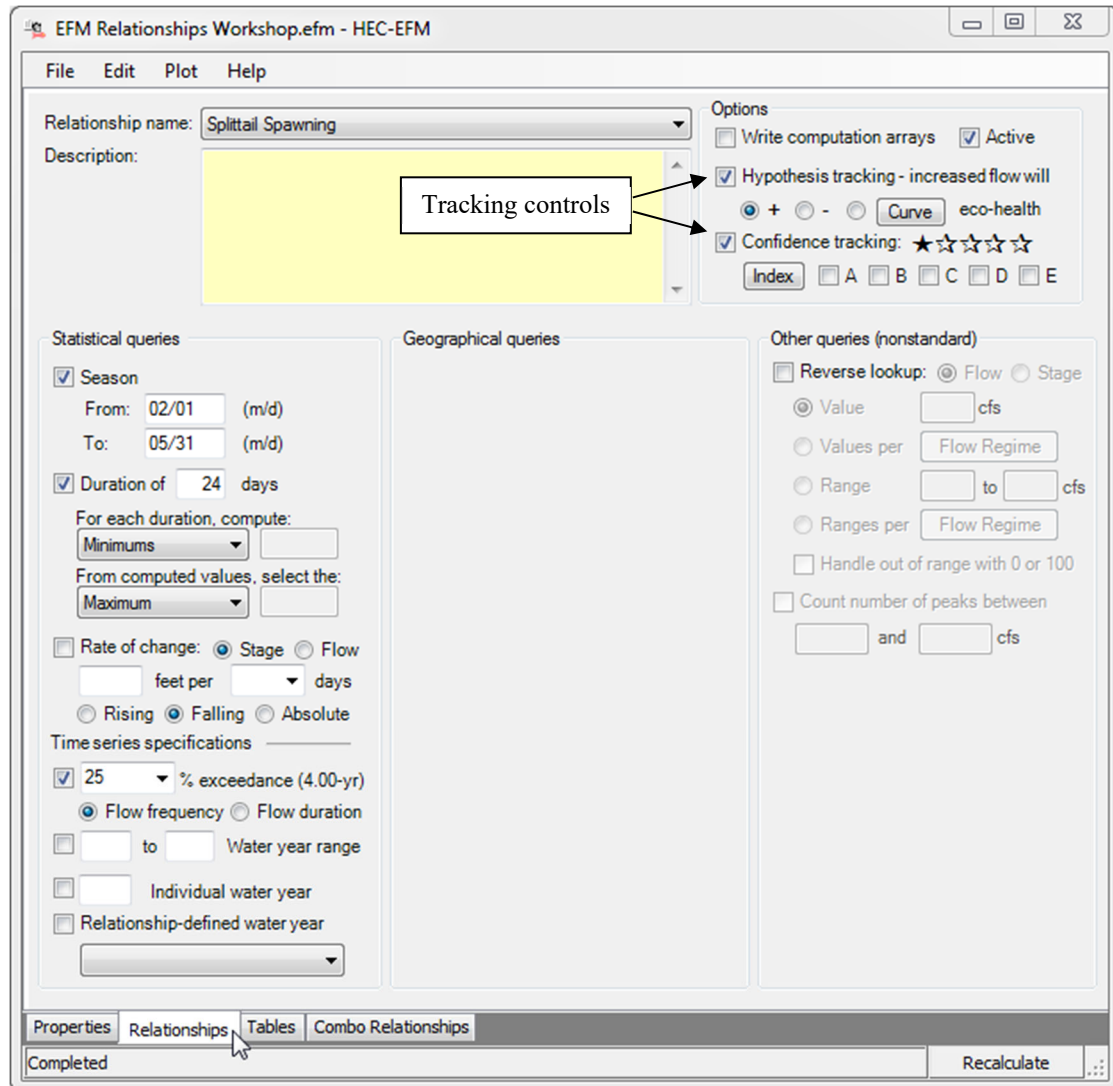
Evaluated on: 11/06/2014 09:27

		SJQ Natural		SJQ Gaged		
Relationship	Conf.	Stage, ft	Flow, cfs	Chg.	Stage, ft	Flow, cfs
Splittail Spawning	n/a	25.5	36,138	Neg	17.6	18,300
Shad and Striped Bass Habitat	n/a	5.1	3,186	Neg	3.0	1,713
Benthic Biodiversity	n/a	28.5	44,274	Neg	14.2	12,500
Shoals Spider Lily	n/a	3.6	2,122	Neg	0.8	330
Water Exchange	n/a	18.2	19,427	Neg	4.5	2,780

Completed Recalculate



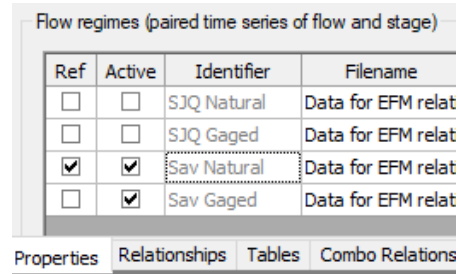
Hypothesis tracking allows users to compare the direction of change of eco-health for different flow regimes. The question that hypothesis tracking asks is: “Increased flow *will do what to* eco-health?” for this relationship. Users have the option of saying that increased flow will help (+), hurt (-), or have a non-linear response (via the curve button) to eco-health.



- 9) Turn on Confidence tracking too. For now, leave all of the relationships at one star.

Confidence tracking provides a way to track the relative certainty of EFM relationships. The default is one star. This starting point implies that there is the same amount of scientific understanding for each of the relationships. As confidence in a particular relationship grows, its number of stars can be increased. This usually occurs at the discretion of the study team, perhaps when the relationship is verified with field data, backed with scientific literature, or approved by a group of scientists or agencies.

- 10) What do the statistical results indicate for your relationships? Test the other river. Any thoughts about the extra credit question for the “water exchange” scenario?



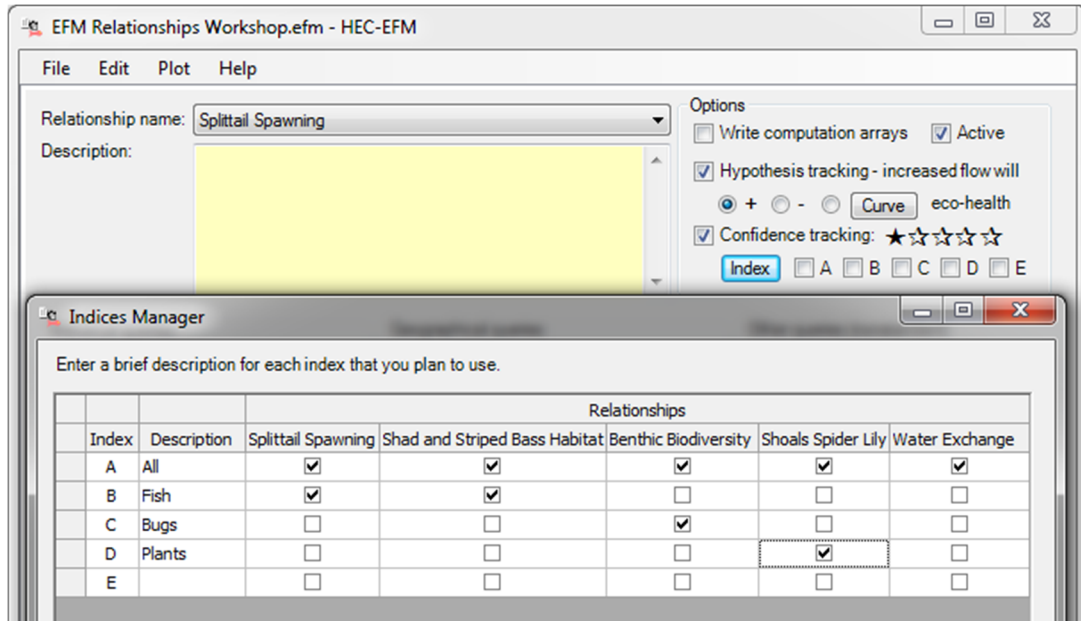
To test the other river, switch flow regimes to:

### Reverse Look-ups - Flow Duration

Relationship	Conf.	Sav Natural	Sav Gaged	
		% X, of time	Chg.	% X, of time
Water Exchange - Reverse Lookup	n/a	32.8	Pos	63.8

- 11) A common result when analyzing multiple relationships is that for a certain flow regime, some are helped and some are hurt. Indices are a tool that can help users look at the net effect of different flow regimes. Indices are controlled through Confidence tracking. Hypothesis tracking must be in use if you want to include a particular relationship in an index.

Create four indices: one for all relationships, one for fish, one for bugs, and one for plants. Associate each relationship (except Water Exchange – Reverse Lookup, which cannot be included in the indices) with at least one index. Click OK and then Recalculate.



- 12) Check out the results. A positive value suggests that the positive changes outweigh the negatives for the relationships in the index. But this should really be used only as a screening tool. Lumping multiple, and pseudo-independent, relationships into one numeric index is an approach to be used with caution.

Confidence (0-5) is one of the variables used in computing indices. Test the sensitivity of the indices output by switching the confidence of one of the relationships from one star to five. If your index result is positive, switch one of the relationships that showed a negative change, or vice versa. Go to the Tables tab and then hit Recalculate. Did the index result reverse the conclusion it had suggested? *Hint... Try switching the Benthic Biodiversity relationship for the Savannah to five stars and compare results for the "All" index.*

The screenshot shows the 'EFM Relationships Workshop.efm - HEC-EFM' application window. The main content area displays a 'Summary' table and 'Index Values'.

Evaluated on: 11/06/2014 09:51

Relationship	Conf.	Sav Natural		Chg.	Sav Gaged	
		Stage, ft	Flow, cfs		Stage, ft	Flow, cfs
Splittail Spawning	*	10.5	12,105	Pos	14.4	17,025
Shad and Striped Bass Habitat	*	3.2	5,063	Pos	4.2	5,878
Benthic Biodiversity	*	24.0	62,935	Neg	20.9	32,050
Shoals Spider Lily	*	0.0	1,964	Pos	1.9	4,100
Water Exchange	*	4.7	6,263	Pos	6.2	7,620

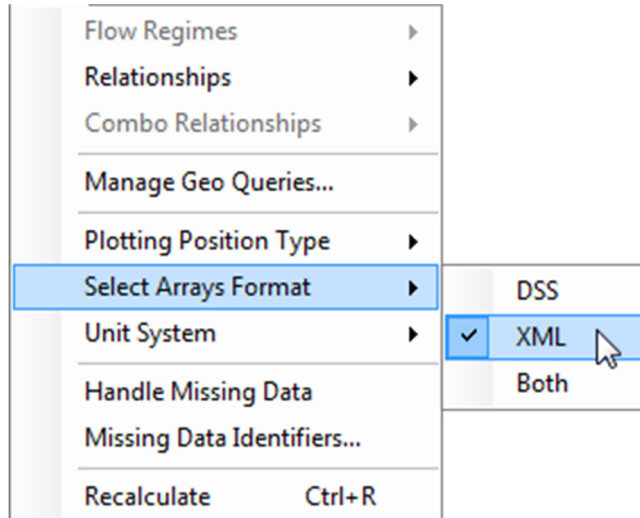
Index	Sav Gaged
A - All	13.4
B - Fish	28.4
C - Bugs	-49.1
D - Plants	37.5

The bottom of the window features a tabbed interface with 'Properties', 'Relationships', 'Tables', and 'Combo Relationships'. The 'Tables' tab is active, and a 'Recalculate' button is visible in the bottom right corner.

13) The last thing to do is experiment with output. Go to the Relationships tab and activate the “Write computation arrays” option (upper right corner) for the Splittail relationship. Write arrays tells the EFM to output the computations being done while analyzing a relationship.

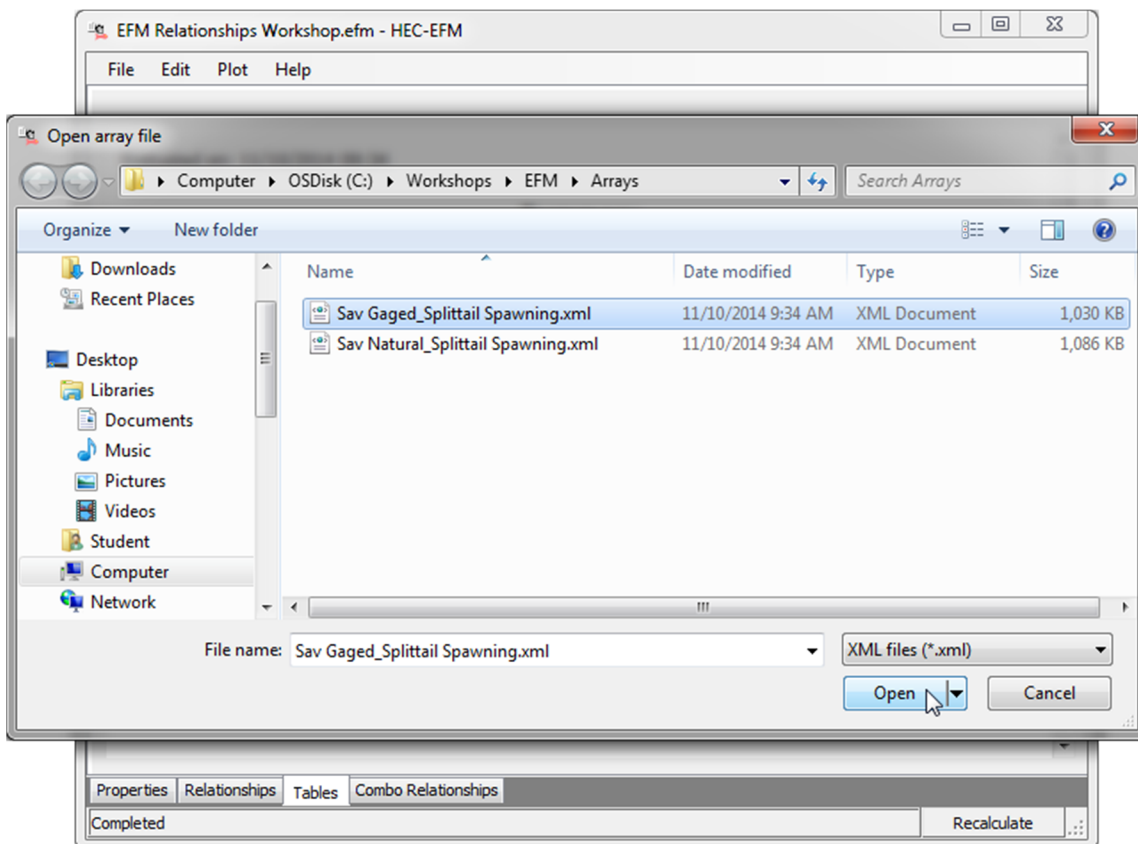


EFM computations are output to different formats according to settings controlled by the user. Available formats are .xml, DSS, or both. For now, use the “Edit – Select Arrays Format – XML” setting



Click the Recalculate button.

A folder named “Arrays” is automatically generated in the same directory as the project file (.efm) and stores DSS and .xml output. Array files can be opened by browsing to that folder and double-clicking on an output file or via the “File – View Array File...” menu option.



*Quick tip:* If EFM says “The specified style sheet arrays.xml could not be found”, please re-add that style sheet via the “File - Select Style Sheets - Arrays - Add Custom Style Sheet” menu option. arrays.xml is located in the EFM install directory. And then repeat the “File – View Array File...” step.

Array files contain results for each computational step performed while analyzing a relationship.

.XML arrays are organized such that the final results are located at the top of file followed by each computational step in reverse order.

The file to the right is for the Splittail Spawning relationship, which used a flow frequency of 25% exceedance.

The result was 17,025-cfs. The final computation step, also shown in the file, was to select or interpolate the 25% event from a ranked table of annual values, in this case between seasonal values for 1976 and 1996.

Array files contain a lot of information, which can provide more ecological insights than the EFM output summary report.

**HEC-EFM computational arrays**

This page shows intermediate computational arrays from the following analyses. Choose the *go* link to jump to a particular analysis.

1. Time series record: Sav Gaged, relationship: Splittail Spawning [go](#)

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**Sav Gaged, Splittail Spawning**

Computations made: 11/6/2014 10:03:32 AM, EFM Relationships Workshop.efm

Result: Flow = 17,025.0 , Stage = 14.4, Closest water year = 1996

Eco-value = 17,025.0

Water years omitted due to missing data: None

**Frequency analysis**

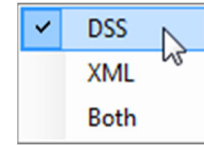
Plotting position: Weibull

Rank	Frequency	WY	Flow	Stage
1	.0182	1975	33,300.0	21.200
2	.0364	1964	32,800.0	21.075
3	.0546	1960	26,300.0	19.100
4	.0727	1993	24,000.0	18.200
5	.0909	1980	23,900.0	18.167
6	.1091	1952	23,100.0	17.800
7	.1273	1979	22,700.0	17.600
8	.1455	1990	22,600.0	17.550
9	.1636	1998	20,800.0	16.650
10	.1818	1995	18,600.0	15.450
11	.2000	1973	18,500.0	15.400
12	.2182	1974	18,400.0	15.300
13	.2364	1976	17,400.0	14.650
14	.2546	1996	16,900.0	14.300
15	.2727	1966	16,300.0	13.850
16	.2909	1977	15,400.0	13.150
17	.3091	1983	14,700.0	12.600
18	.3273	1984	14,500.0	12.450
19	.3455	1965	13,300.0	11.500
20	.3636	2003	12,400.0	10.750
21	.3818	1972	12,200.0	10.600
22	.4000	1969	12,000.0	10.400

Properties Relationships **Tables** Combo Relationships

Completed Recalculate

Results can also be output to DSS. In the “Arrays” folder, a DSS file named “Arrays.dss” is generated. Computational steps, statistical results, and frequency/duration curves are output to this file for each combination of flow regime (a-part) and relationship (b-part), for which the user has activated the “Write computation arrays” option.



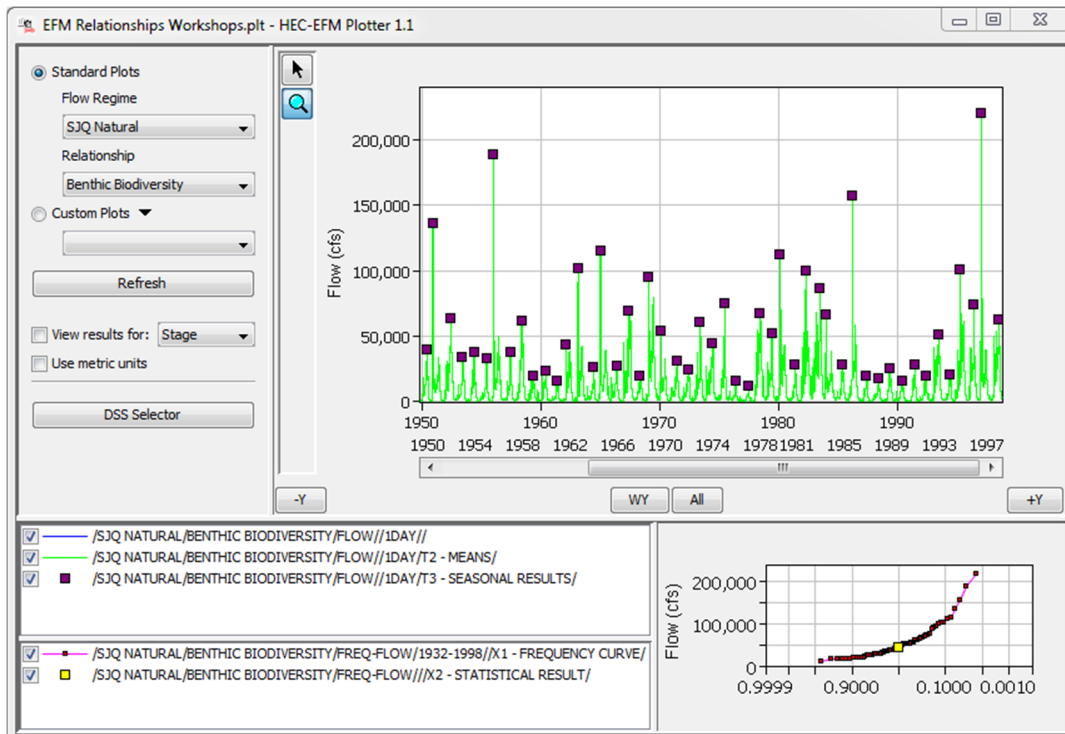
Use the “Edit – Select Arrays Format – DSS” to switch the output format to DSS.

Follow these steps to generate output:

- ✓ Activate the “Write computation arrays” option for all relationships
- ✓ On the Properties tab, make sure the Savannah River flow regimes are selected with “Sav Natural” as the reference flow regime
- ✓ Recalculate
- ✓ Return to the Properties tab, deselect the Savannah flow regimes, and select the San Joaquin flow regimes with “SJQ Natural” as the reference flow regime
- ✓ Recalculate
- ✓ Save your project

Notice EFM takes longer to finish a compute. It takes time to generate all that output.

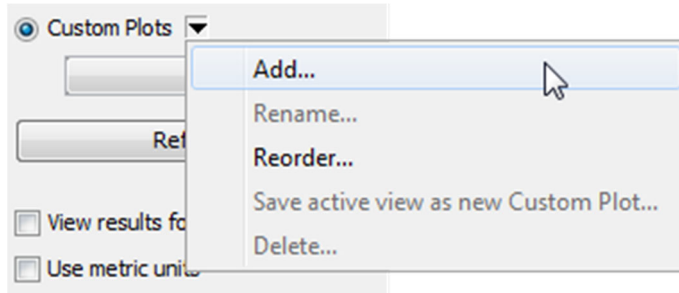
When complete, use the “Plot – Activate HEC-EFM Plotter” menu option to start Plotter.



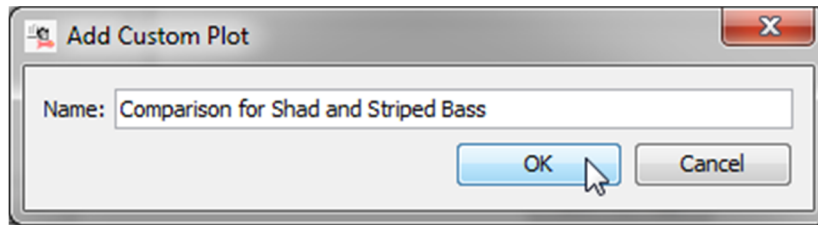
Standard plots are created for each flow regime - relationship pairing. These are selected by the dropdown lists in the upper left hand portion of the interface. Time series data are shown in the upper right plot window; frequency data in the lower right plot window. The position of these windows can be switched by pressing “Ctrl-T”.

Data can be turned on and off using the check boxes in the legend and time series data can be navigated using the zoom tool and the +/-Y, WY, and All buttons.

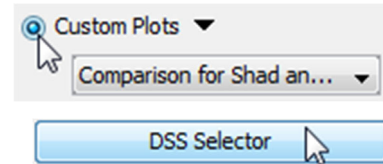
Custom plots display data selected by the user. Create a custom plot for one of your relationships by right clicking on the “Custom Plots” label and selecting “Add...”



Enter a name and click “Ok”.

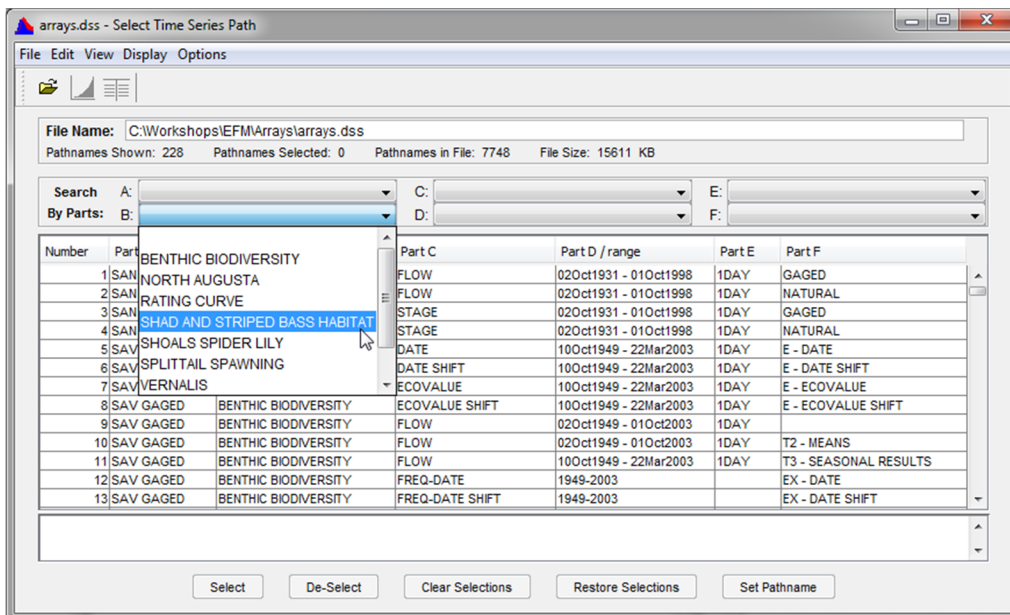


Make sure that the radio button for Custom Plots is selected

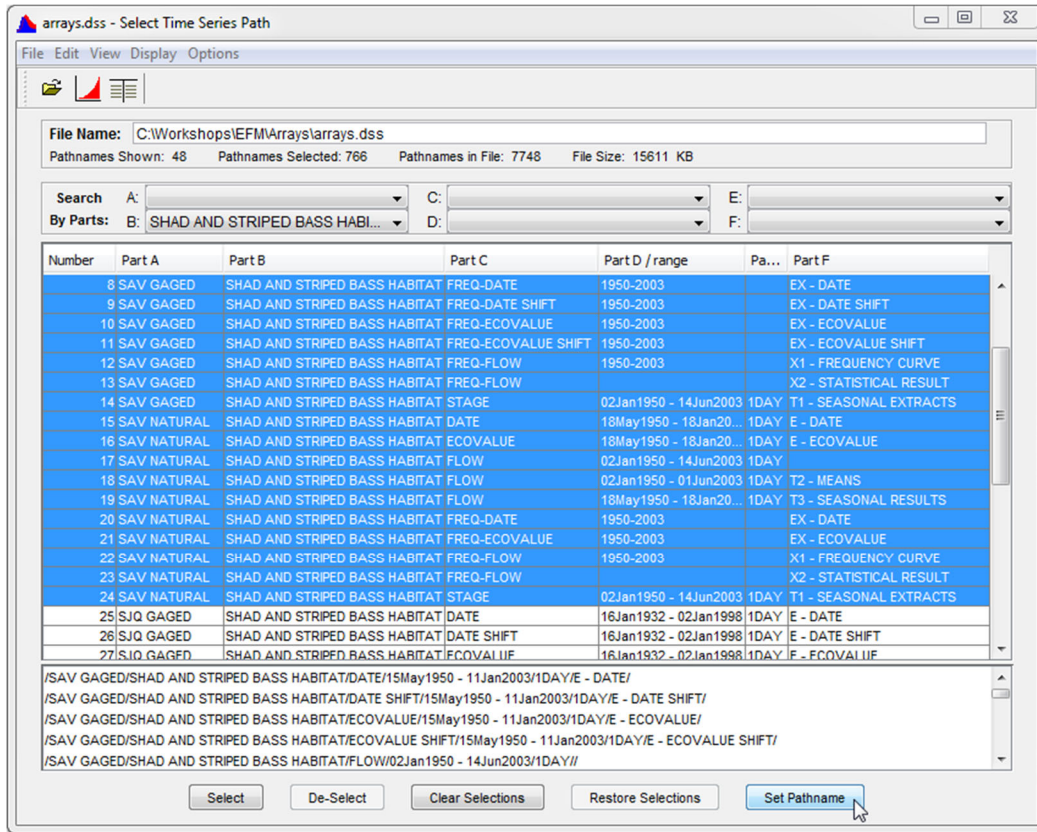


To add data, click on the “DSS Selector” button and then click the file open button.

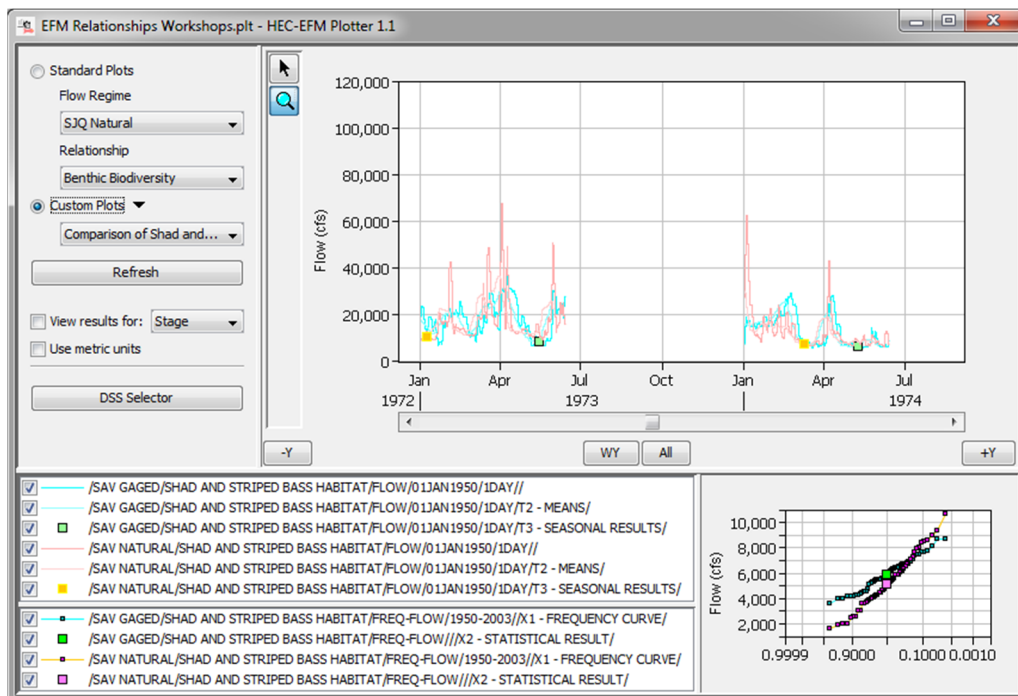
Browse to C:\Workshops\EFM\Arrays and open “Arrays.dss”. Use the “Search By Parts” drop downs to filter the data.



Select all data related to the Savannah flow regimes and the shad and striped bass relationship and click the Set Pathname button.



Plotter will display the selected data in the proper plot windows...

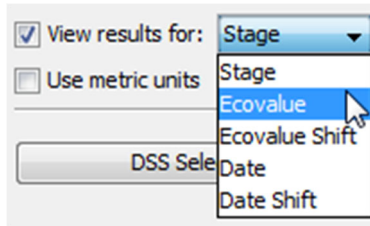




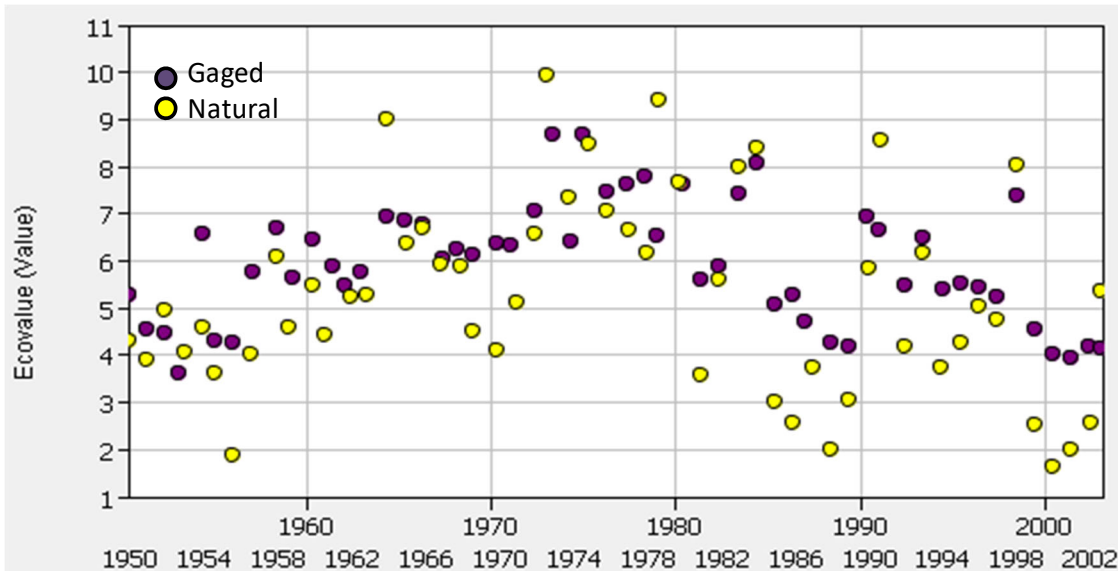
**Bonus Questions:**

New features in EFM and Plotter allow users to investigate seasonal “Ecovalues” and “Dates”.

For the existing custom view (Comparison for Shad and Striped Bass), switch the data being viewed to “Ecovalues”.



Ecovalues are a dimensionless measure of how successfully a flow regime met the criteria of a relationship. Ecovalues for shad and striped bass are presented on a scale from 0 to 10, based on the hypothesis curve entered earlier in this workshop for that relationship.

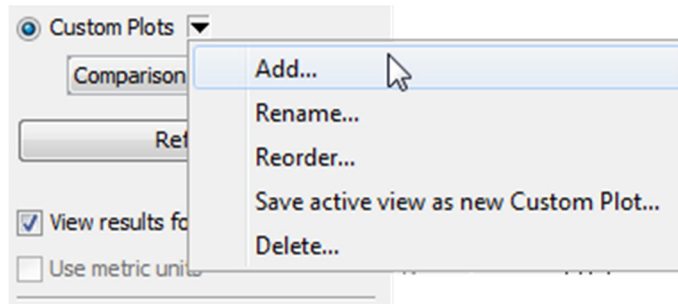


Do you recognize any noteworthy differences in the character of ecovalues when contrasting patterns for natural and gaged flow regimes?

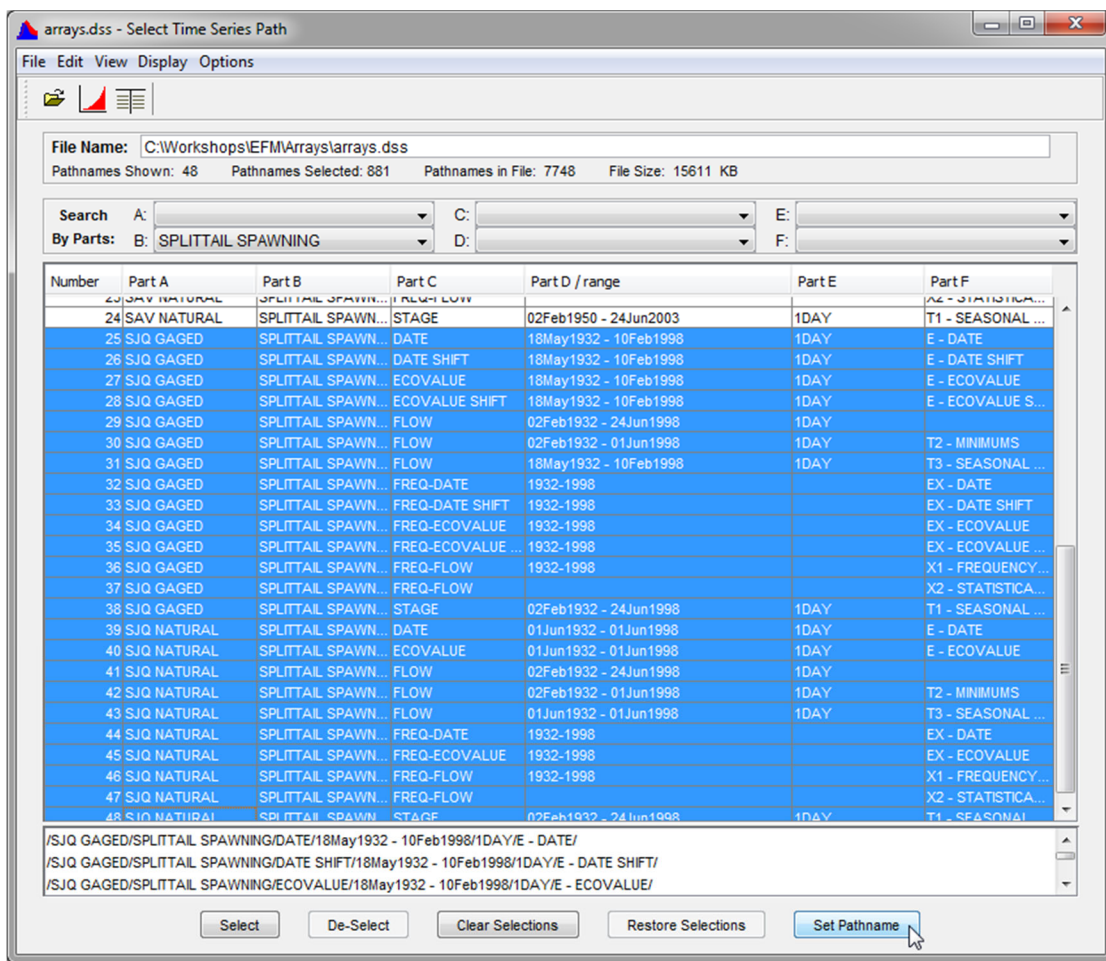
The Savannah River was in drought in the early 2000’s. This relationship was about stress caused by persistent low flow conditions in winter and spring months. Based on the ecovalues, what information could you convey to fisheries managers about drought effects on overwintering success of shad and striped bass (ie, historical severity, comparison to natural)?

Switch the data being viewed to “Ecovalue Shift”. In what percentage of years, does the Gaged flow regime provide higher ecovalues than the Natural flow regime?

Now create a new custom view entitled “Splittail Spawning Comparison – SJQ”.

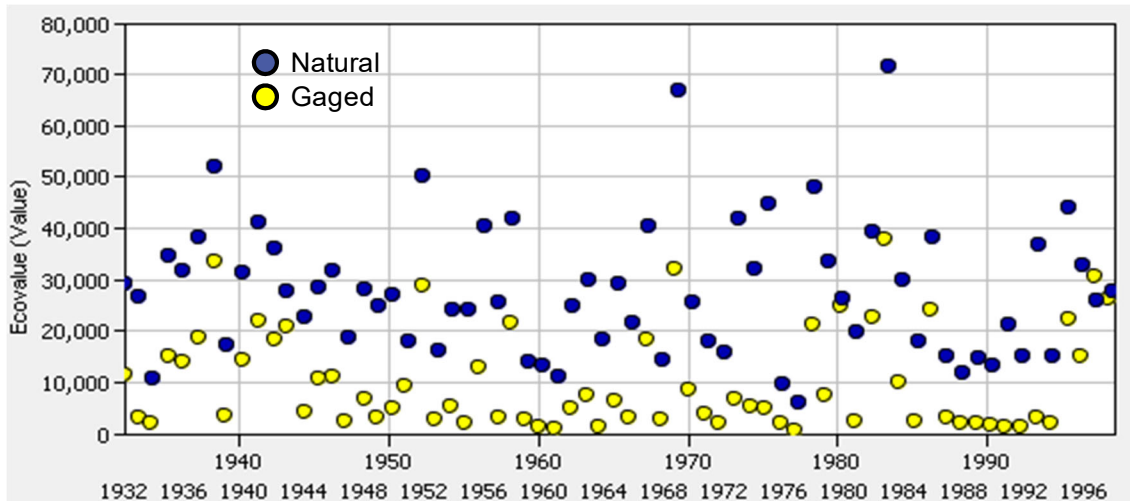


Add all data related to Splittail Spawning for the San Joaquin River flow regimes.



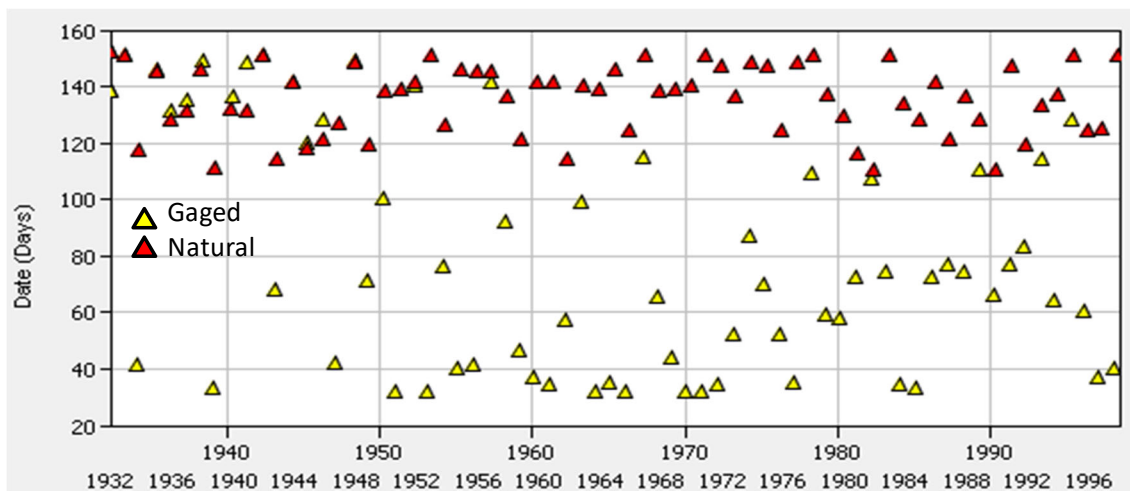
Scientists have noticed changes in the abundance and size of young-of-the-year Splittail minnows.

View the ecovalue results.



What do you see that might explain a change in abundance for hatching splittails between the natural and gaged flow regimes and how do you predict that abundance will change (ie, more or less young fish under the gaged flow regime)?

View the Date results. Numerically, a seasonal date value is equal to the number of days between 01 January and the day and month of its corresponding seasonal result (e.g., a seasonal date value of 31 would correspond to a seasonal result occurring on 31 January).



Do you recognize any noteworthy differences in date values when comparing flow regimes?

If everything else is the same (food, predation, etc), how do you predict that size of young-of-the-year recruits will change (ie, bigger or smaller young fish under the gaged flow regime)?

View the Date shift results. In what percentage of years, do spawning conditions occur earlier in the Gaged flow regime as compared to the Natural flow regime?