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

 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.

| Model information         Title:       EFM Training         Author:   | ile l           | Edit F   | Plot H                                   | -<br>Help   |  |                  |                    |        |          |        |
|---|-----------------|--|--|---|--|------------------|--------------------|--------|----------|--------|
| Title:       EFM Training         Author:   | Model i         | informatio   | n  |   |  |                  |                    |        |          |        |
| Author:       Location:         Description:       Workshop for the Ecosystems Functions Model         EFM model pathname: C:\Workshops\EFM\EFM Relationships Workshop.efm         Image: Composition of the series of flow and stage)         Ref       Active         Identifier       Filename         Part B       Part F         Starting       Ending         Image: Composition of the series of flow and stage)         Ref       Active         Identifier       Filename         Image: Part B       Part F         Starting       Ending         Image: Part B       Part F         Image: Part B       Part B  | Title:          | :  |  | EFM Traini  | ing  |                  |                    |        |          |        |
| Location:       Description:       Workshop for the Ecosystems Functions Model         EFM model pathname: C:\Workshops\EFM\EFM Relationships Workshop.efm       Image: Compose the series of flow and stage)         Flow regimes (paired time series of flow and stage)       Image: Compose time series of flow and stage)         Ref       Active       Identifier         Filename       Part A       Part B       Part F         Starting       Ending         operties       Relationships       Compo Relationships  | Autho           | or:  |  |   |  |                  |                    |        |          |        |
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| Flow regimes (paired time series of flow and stage)           Ref         Active         Identifier         Filename         Part A         Part B         Part F         Starting         Ending           Image: Im |                 |  |  |   |  |                  |                    |        |          | Ŧ      |
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| Use edit menu to re   | EFM<br>Flow re  | model p  | athname<br>Do<br>aired time              | :C:\Worksh  | ops\EFM\EFM Rei                              | lationships Work | shop.efm           |        |          | T      |
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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.

3) 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.

| 😫 EFM R    | elations             | hips Wo                | orkshop.e | im - HEC-EFM                    | 📲 Rename Fl       | ow Regime    |             |          | ß          |
|------------|----------------------|------------------------|-----------|---------------------------------|-------------------|--------------|-------------|----------|------------|
| File E     | idit P               | Plot H                 | lelp      |                                 |                   |              |             |          |            |
| Model in   | nformatio            | n                      |           |                                 | Existing:         | Use edit men | u to rename |          | •          |
| Title:     |                      |                        | EFM Train | ning                            | New name:         | SJQ Natural  |             |          |            |
| Autho      | r:                   |                        |           |                                 |                   |              |             | OK N     | Cancel     |
| Locat      | ion:                 |                        |           |                                 |                   |              |             |          |            |
| EFM (      | model p<br>gimes (pa | athname:<br>aired time | C:\Worksh | nops\EFM\EFM R<br>ow and stage) | elationships Work | shop.efm     |             |          | Ŧ          |
| Ref        | Active               | Ide                    | ntifier   | Filename                        | Part A            | Part B       | Part F      | Starting | Ending     |
|            |                      | Use edit               | menu to r |                                 |                   |              |             |          | , <u> </u> |
|            |                      | 1                      |           |                                 |                   |              |             | L.       |            |
| Properties | Relat                | ionships               | Tables    | Combo Relationshi               | ips               |              |             |          |            |

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".

|                   |                     | ſ                       | Select time s                     | eries record      | file           |                |                             |                         |   |                              |                  | × |
|-------------------|---------------------|-------------------------|-----------------------------------|-------------------|----------------|----------------|-----------------------------|-------------------------|---|------------------------------|------------------|---|
|                   |                     |                         | 00-1                              | « OSDisk (        | (C:) 🕨         | Worksho        | ops 🕨 EFM                   | <b>- ↓</b>              | Search E  | FM                           |                  | Q |
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| 📲 EFM Relat       | ionships Worksho    | op.efm - HEC-EFM        | 쑦 Favorites<br>💻 Deskto           | p                 | Â              | Name           | ta for EFM relation         | nships.dss              | Date modifie<br>4/5/2006 2:5                      | ed<br>9 PM                   | Type<br>DSS File |   |
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| Ref Act           | tive Identifier     | Filename                | Part A                            | Part B            |                | Part F         | Starting                    | Endin                   | g   |                              |                  |   |
| Properties R      | elationships Table  | es Combo Relationship   | B                                 | rowse b<br>cursor | utton<br>is in | is or<br>the f | nly visible v<br>ilename ce | vhen<br>ll.             |   |                              |                  |   |
| File saved to C   | :\Workshops\EFM\E   | EFM Relationships Works | hop.efm                           |                   |                |                |                             | Recalculate             | e .::   |                              |                  |   |

| · ·     | Edit P    | lot H      | elp       |                       |                |             |        |          |              |
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| Aodel i | nformatio | n          |           |                       |                |             |        |          |              |
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| Autho   | or:       |            |           |                       |                |             | _      |          |              |
| Loca    | ion:      |            |           |                       |                |             |        |          |              |
| Desc    | ription:  |            | Worksh    | nop for the Ecosystem | is Functions M | odel        |        |          | *            |
|         |           |            |           |                       |                |             |        |          | Ŧ            |
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| low re  | gimes (pa | aired time | series of | f flow and stage)     |                |             |        |          |              |
| Ref     | Active    | Ident      | ifier     | Filename              | Part A         | Part B      | Part F | Starting | Ending       |
|         | ✓         | SJQ Nati   | ıral      | Data for EFM rela     |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
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|         |           |            |           |                       |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
|         |           |            |           |                       |                |             |        |          |              |
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|         |           |            |           |                       |                |             |        | Open D   | SS Catalog   |
|         |           |            |           |                       |                |             |        | Open D   | SS Catalog N |

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 *fparts* 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...

| e      | Edit     | Plot Help         |                       |                  |              |                        |  |            |
|--------|----------|-------------------|-----------------------|------------------|--------------|------------------------|--|------------|
| odel i | nformati | on                |                       |                  |              |                        |  |            |
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| ow re  | gimes (p | aired time series | s of flow and stage)  |                  |              |                        |  |            |
| Ref    | Active   | Identifier        | Filename              | Part A           | Part B       | Part F                 | Starting                                 | Ending     |
| ✓      | ✓        | SJQ Natural       | Data for EFM rela     | SAN JOAQUIN      | VERNALIS     | NATURAL                | 10/01/1931                               | 09/30/1998 |
|        |          | SJQ Gaged         | Data for EFM rela     | SAN JOAQUIN      | VERNALIS     | GAGED                  | 10/01/1931                               | 09/30/1998 |
|        |          | Sav Natural       | Data for EFM rela     | SAVANNAH         | NORTH AUGUS  | NATURAL                | 10/01/1949                               | 09/30/2003 |
|        |          | Sav Gaged         | Data for EFM rela     | SAVANNAH         | NORTH AUGUS  | GAGED                  | 10/01/1949                               | 09/30/2003 |
|        |          |                   |                       | _                |              |                        |  |            |
|        |          |                   |                       |                  | Each row in  | n this table           | is a "flow re                            | gime"      |
|        |          |                   |                       |                  | and has tw   | o time seri            | es typically                             | daily      |
|        |          |                   |                       |                  | mean flow    | <sup>,</sup> and stage | , though EFM                             | l will     |
|        |          |                   |                       |                  | comments and | sing any tu            | o dailv time s                           |            |
|        |          |                   |                       |                  | compute us   | ing any in             | <i>c call</i> , <i>j call</i> , <i>c</i> | eries.     |
|        |          |                   |                       | L                | compute us   |                        |  | series.    |
|        |          |                   |                       | L                |              |                        |  | series.    |
|        |          |                   |                       | L                | compute us   |                        | Open D                                   | series.    |
|        |          |                   |                       |                  |              | ing uny tw             | Open D                                   | series.    |
|        |          |                   |                       |                  | compute us   | ing uny tw             | Open D                                   | series.    |
|        |          |                   |                       |                  | compute us   |                        | Open D                                   | SS Catalog |

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.

| <b>X</b>  |
|-----------|
|           |
| OK Cancel |
|           |

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.

Recalculate

| EFM Relationship   | s Workshop.efm - HEC   | C-EFM  |         |  |  |
|--|--|--|---------|--|--|
| File Edit Plot   | Help   |  |         |  |  |
| Relationship name:<br>Description:   | Splittail Spawning   |  | •       | Options<br>Write computation a<br>Hypothesis tracking<br>0 + 0 - 0 0<br>Confidence tracking                    | rrays IV Active<br>- increased flow will<br>Curve eco-health<br>: 大気気気気<br>B □ C □ D □ F   |
| Statistical queries<br>V Season<br>From: 02/01<br>To: 05/31<br>V Duration of<br>For each duration<br>Minimums<br>From computed<br>Maximum<br>Rate of change:<br>feet pa<br>Rising  Fom computed<br>Maximum<br>Rate of change:<br>feet pa<br>Patient of the patient of the patient<br>Relation for the patient of the | (m/d)<br>(m/d)<br>24 days<br>n. compute:<br>values. select the:<br>values. select | Geographical qu<br>elationships<br>hips Workshop.efm | veries  | Other queries (no<br>Preverse loo<br>Value<br>Values pe<br>Range<br>Ranges p<br>Handle ou<br>Count numbe<br>an | Instandard)<br>kup:  Flow Flow Stage<br>Flow Regime<br>to cfs<br>r Flow Regime<br>to cfs<br>r Flow Regime<br>to cfs<br>r Recalculate |
| , EFM Relationships<br>File Edit Plot  | Workshop.efm - HEC-E<br>Help   | FM   |         |  |  |
| Evaluated on: 11   | /06/2014 09:08   | Summary  |         |  | E  |
|  |  |  |         |  |  |
|  | olationship  | Conf   | SJQ Nat | tural  |  |

6) Repeat this process for your other relationships. Save your project.

No time series data sets were compared.

Properties Relationships Tables Combo Relationships

Completed

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     |
|-----|--------------|-------------|--------------------|-------------|-------------|---------|------------|------------|
|     | $\checkmark$ | SJQ Natural | Data for EFM relat | SAN JOAQUIN | VERNALIS    | NATURAL | 10/01/1931 | 09/30/1998 |
|     |              | SJQ Gaged   | Data for EFM relat | SAN JOAQUIN | VERNALIS    | GAGED   | 10/01/1931 | 09/30/1998 |
|     | - W          | Sav Natural | Data for EFM relat | SAVANNAH    | NORTH AUGUS | NATURAL | 10/01/1949 | 09/30/2003 |
|     |              | Sav Gaged   | Data for EFM relat | SAVANNAH    | NORTH AUGUS | GAGED   | 10/01/1949 | 09/30/2003 |

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

| 😫 EFM Relationships Workshop.efm - HEC-EFM |                       |           |           |      |           |             |   |  |  |  |  |
|--|-----------------------|-----------|-----------|------|-----------|-------------|---|--|--|--|--|
| File Edit Plot Help                        |                       |           |           |      |           |             |   |  |  |  |  |
|  |                       |           |           |      |           |             |   |  |  |  |  |
|  |                       |           |           |      |           |             | ^ |  |  |  |  |
| Evaluated on: 11/06/2014 09:19             |                       |           |           |      |           |             |   |  |  |  |  |
|  |                       | Summa     | iry       |      |           |             | - |  |  |  |  |
|  | 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       |   |  |  |  |  |
|  |                       |           |           |      |           |             | 4 |  |  |  |  |
| Properties Relationships Tables Combo Re   | lationships           |           |           |      |           |             |   |  |  |  |  |
| 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.

| 🕱 EFM Relationships Workshop.efm - HEG  | C-EFM        |           |           |      |           |             | 23 |
|---|--------------|-----------|-----------|------|-----------|-------------|----|
| File Edit Plot Help                     |              |           |           |      |           |             |    |
|   |              |           |           |      |           |             |    |
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|   |              | Summa     | ary       |      |           |             | E  |
|   |              | SJQ Na    | itural    |      | SJQ Gage  | t           |    |
| 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       |    |
|   |              |           |           |      |           |             | +  |
| Properties Relationships Tables Combo R | elationships |           |           |      |           |             |    |
| Completed                               |              |           |           |      |           | Recalculate | 1  |

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.

|   |                      | Options                                      |
|---|----------------------|--|
| Relationship name: Splittail Spawning                     |                      | Write computation arrays V Active            |
| Description:  |                      | A Whypothesis tracking - increased flow will |
|   | Tracking controls    |  |
|   | Theking controls     |  |
|   |                      |  |
|   |                      |  |
| Statistical queries                                       | Geographical queries | Other queries (nonstandard)                  |
| Season  |                      | Reverse lookup:  Flow  Stag                  |
| From: 02/01 (m/d)   |                      | Value cfs                                    |
| To: 05/31 (m/d)   |                      | Values per                                   |
| Duration of 24 days                                       |                      |  |
| For each duration compute:                                |                      |  |
| Minimums  |                      | Ranges per Flow Regime                       |
| From computed values, select the:                         |                      | Handle out of range with 0 or 100            |
| Maximum 👻   |                      | Count number of peaks between                |
| Rate of change:  Stage  Elow                              |                      | and cfs                                      |
| feet per  |                      |  |
| Rising      Ealling      Absolute                         |                      |  |
| Time series specifications                                |                      |  |
| ✓ 25 ▼ % exceedance (4 00-vr)                             |                      |  |
| <ul> <li>Flow frequency          Flow duration</li> </ul> |                      |  |
| Water year range  |                      |  |
|   |                      |  |
| Individual water year                                     |                      |  |
| Relationship-defined water year                           |                      |  |
| ▼   |                      |  |

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?

| Flov | ow regimes (paired time series of flow and stage) |        |          |        |                    |  |  |  |  |  |  |
|------|---|--------|----------|--------|--------------------|--|--|--|--|--|--|
| R    | ef  | Active | Ident    | tifier | Filename           |  |  |  |  |  |  |
|      |   |        | SJQ Nat  | ural   | Data for EFM relat |  |  |  |  |  |  |
|      |   |        | SJQ Gag  | jed    | Data for EFM relat |  |  |  |  |  |  |
|      |   | ✓      | Sav Nati | ural   | Data for EFM relat |  |  |  |  |  |  |
|      |   | ✓      | Sav Gag  | ed     | Data for EFM relat |  |  |  |  |  |  |
|      |   |        |          |        |                    |  |  |  |  |  |  |
| oper | ties  | Relati | onships  | Tables | Combo Relations    |  |  |  |  |  |  |

To test the other river, switch flow regimes to:

| Reverse Lo                      | ok-ups - | Flow Duration | on   |              |
|---------------------------------|----------|---------------|------|--------------|
|                                 |          | Sav Natural   | S    | av Gaged     |
| Relationship                    | Conf.    | % 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.

| <u> 9</u> | EFM                       | Relati                       | onships Wor                                | kshop.efm - HEC-                   | EFM                           |               |  |   |
|-----------|---------------------------|------------------------------|--|------------------------------------|-------------------------------|---------------|--|---|
| F         | ile                       | Edit                         | Plot He                                    | lp                                 |                               |               |  |   |
| F         | Relatio<br>Descri<br>Ente | onship<br>iption:<br>dices N | name: Splitta<br>Manager<br>ef description | il Spawning<br>for each index that | you plan to use.              |               | ptions<br>Write computation arra<br>Hypothesis tracking - ir<br>+ - Cun<br>Confidence tracking:<br>Index A B | ys ♥ Active<br>ncreased flow will<br>ve eco-health<br>★☆☆☆☆<br>C D E<br>C D E |
| Ш.        |                           |                              |  |                                    | Re                            | elationships  |  |   |
|           |                           | Index                        | Description                                | Splittail Spawning                 | Shad and Striped Bass Habitat | Benthic Biodi | versity Shoals Spider Lily   | Water Exchange  |
| н.        |                           | Α                            | All  | $\checkmark$                       | $\checkmark$                  | $\checkmark$  | $\checkmark$   |   |
| h.        |                           | В                            | Fish                                       |                                    | $\checkmark$                  |               |  |   |
|           |                           | С                            | Bugs                                       |                                    |                               | $\checkmark$  |  |   |
|           |                           | D                            | Plants                                     |                                    |                               |               |  |   |
|           |                           | Е                            |  |                                    |                               |               |  |   |
|           |                           |                              |  |                                    |                               |               |  |   |

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.* 

| le Edit Plot Help              |        |           |           |      |           |           |
|--------------------------------|--------|-----------|-----------|------|-----------|-----------|
|                                |        |           |           |      |           |           |
| Evaluated on: 11/06/2014 09:51 |        |           |           |      |           |           |
|                                |        | Summa     | ary       |      |           |           |
|                                | Sav Na | atural    |           | 1    |           |           |
| Relationship                   | Conf.  | Stage, ft | Flow, cfs | Chg. | 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 Values                   |        |           |           |      |           |           |
|                                |        |           |           |      |           |           |
| B - Fish 28.4                  |        |           |           |      |           |           |
| C - Bugs -49.1                 |        |           |           |      |           |           |
| D - Plants 37.5                |        |           |           |      |           |           |
|                                |        |           |           |      |           |           |
|                                |        |           |           |      |           |           |

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 doubleclicking on an output file or via the "File – View Array File..." menu option.

| Write comput             | atio | n ar | rays |   |
|--------------------------|------|------|------|---|
| Flow Regimes             | •    | ]    |      |   |
| Relationships            | •    |      |      |   |
| Combo Relationships      | ►    |      |      |   |
| Manage Geo Queries       |      |      |      |   |
| Plotting Position Type   | ۲    |      |      |   |
| Select Arrays Format     | •    |      | DSS  |   |
| Unit System              | •    | ~    | XML  |   |
| Handle Missing Data      |      |      | Both | ~ |
| Missing Data Identifiers |      |      |      |   |
| Recalculate Ctrl+R       |      |      |      |   |

| EFM Relationshi   | psWo<br>t ⊦ | rkshop.efm - HEC-EFM<br>lelp          |                    |                   |             |
|---|-------------|---------------------------------------|--------------------|-------------------|-------------|
| Open array file   | er 🕨        | OSDisk (C) > Workshops > FEM > Arrays | - <b>f</b> a       | Search Arrays     |             |
| Organize   New fold   | ler         |                                       |                    |                   |             |
| 🚺 Downloads   | ^           | Name                                  | Date modified      | Туре              | Size        |
| 🔛 Recent Places   |             | Sav Gaged_Splittail Spawning.xml      | 11/10/2014 9:34 AM | XML Document      | 1,030 KB    |
| Desktop<br>Libraries<br>Documents<br>Music<br>Pictures<br>Videos<br>Student<br>Computer | E           | Sav Natural_Splittail Spawning.xml    | 11/10/2014 9:34 AM | XML Document      | 1,086 KB    |
| Network   | Ψ.          | •                                     |                    |                   | •           |
| File r  | iame:       | Sav Gaged_Splittail Spawning.xml      | •                  | XML files (*.xml) | ▼<br>Cancel |
| Properties Relation<br>Completed  | ships       | Tables Combo Relationships            |                    | Recalcula         | ate:        |

*Quick tip:* If EFM says "The specified style sheet arrays.xsl could not be found", please re-add that style sheet via the "File -Select Style Sheets -Arrays - Add Custom Style Sheet" menu option. arrays.xsl 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. EFM Relationships Workshop.efm - HEC-EFM

# **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

## 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 |                   |  |
|         | .2500     |       | 17,025.0 | 14.392 |                   |  |
| 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 |                   |  |
|         |           |       |          |        |                   |  |
| perties | Relation  | ships | Table    | s Co   | nbo Relationships |  |
| pleted  |           |       | -        | 2      |                   |  |
| ieu     |           |       |          | *0     |                   |  |

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<br>by the user. Create a custom plot for<br>one of your relationships by right<br>clicking on the "Custom Plots" label<br>and selecting "Add" | <ul> <li>Custom Plots</li> <li>Ref</li> <li>View results fo</li> <li>Use metric units</li> </ul> | Add<br>Rename<br>Reorder<br>Save active view as new Custom Plot<br>Delete |
|--|--|---|
| Enter a name and click<br>"Ok".  | Custom Plot<br>Comparison for Shad and St  | triped Bass   |
| Make sure that the radio button for Cu   | stom Plots is selected   | Custom Plots  Comparison for Shad an                                      |
| To add data, click on the "DSS Selector the file open button.  | or" button and then cli  | DSS Selector  |

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

| arrays.dss - Select Time Se<br>ile Edit View Display Opti  | ries Path<br>ons<br>ps\EFM\Arrays\arrays.dss<br>Pathnames Selected: 0 Pat  | hnames in File: 7748 F   | ile Size: 15611 KB  |  |   |        |
|--|--|--|---|--|---|--------|
| Search A:<br>By Parts: B:  | <b>▼</b>   | C:<br>D:   |   | E:<br>F:   |   | •      |
| Number         Part<br>SAN         BENTHIC           1         SAN         NORTH AI           2         SAN         RATING C           3         SAN         SHAD ANI           4         SAN         SHAD ANI           5         SAV         SHOLS S           6         SAV         SPLITAIL           7         SAV GAGED         9           9         SAV GAGED         11           11         SAV GAGED         12 | BIODIVERSITY<br>UGUSTA<br>URVE<br>DISTRIPED BASS HABITAT<br>SPIDER LILY<br>SPAWNING<br>3<br>BENTHIC BIODIVERSITY<br>BENTHIC BIODIVERSITY<br>BENTHIC BIODIVERSITY<br>BENTHIC BIODIVERSITY<br>BENTHIC BIODIVERSITY | Part C           FLOW           FLOW           STAGE           DATE SHIFT           ECOVALUE           ECOVALUE SHIFT           FLOW           FLOW           FLOW           FLOW           FLOW           FREQ-DATE | Part D / range<br>020ct1931 - 010ct1998<br>020ct1931 - 010ct1998<br>020ct1931 - 010ct1998<br>100ct1949 - 2014<br>100ct1949 - 22Mar2003<br>100ct1949 - 22Mar2003<br>100ct1949 - 22Mar2003<br>020ct1949 - 010ct2003<br>020ct1949 - 010ct2003<br>100ct1949 - 22Mar2003<br>190ct1949 - 22Mar2003<br>190ct1949 - 22Mar2003 | Part E<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY<br>1DAY | Part F           GAGED           NATURAL           GAGED           NATURAL           E - DATE           E - DATE SHIFT           E - ECOVALUE           E - ECOVALUE SHIFT           T2 - MEANS           T3 - SEASONAL RESULTS           EX - DATE |        |
|  | Select De-Select   | Clear Selections   | Restore Selections  | Set P  | ex - DATE SHET  | *<br>* |

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

| File Name<br>Pathnamer | e: C:\Workshop<br>s Shown: 48 | s\EFM\Arrays\arrays.dss<br>Pathnames Selected: 766 Pathnam | nes in File: 7748 File | Size: 15611 KB                         |      |                         |   |
|------------------------|-------------------------------|--|------------------------|--|------|-------------------------|---|
| Search<br>By Parts:    | A:<br>B: SHAD AND             |  |                        | <ul> <li>▼ E:</li> <li>▼ F:</li> </ul> |      |                         |   |
| Number                 | Part A                        | Part B   | Part C                 | Part D / range                         | Pa   | Part F                  |   |
|                        | 8 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-DATE              | 1950-2003                              |      | EX - DATE               |   |
|                        | 9 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-DATE SHIFT        | 1950-2003                              |      | EX - DATE SHIFT         |   |
|                        | 0 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-ECOVALUE          | 1950-2003                              |      | EX - ECOVALUE           |   |
|                        | 1 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-ECOVALUE SHIFT    | 1950-2003                              |      | EX - ECOVALUE SHIFT     |   |
|                        | 2 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-FLOW              | 1950-2003                              |      | X1 - FREQUENCY CURVE    |   |
|                        | 3 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-FLOW              |  |      | X2 - STATISTICAL RESULT |   |
|                        | 4 SAV GAGED                   | SHAD AND STRIPED BASS HABITAT                              |                        |  | 1DAY | T1 - SEASONAL EXTRACTS  |   |
|                        | 5 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              |                        | 18May1950 - 18Jan20                    |      | E - DATE                |   |
|                        | 6 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | ECOVALUE               | 18May1950 - 18Jan20                    | 1DAY | E - ECOVALUE            |   |
|                        | 7 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FLOW                   |  |      |                         |   |
|                        | 8 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FLOW                   |  |      | T2 - MEANS              |   |
|                        | 9 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FLOW                   | 18May1950 - 18Jan20                    |      | T3 - SEASONAL RESULTS   |   |
|                        | SAV NATURAL                   | SHAD AND STRIPED BASS HABITAT                              | FREQ-DATE              | 1950-2003                              |      |                         |   |
|                        | 1 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FREQ-ECOVALUE          | 1950-2003                              |      | EX - ECOVALUE           |   |
|                        | 2 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FREQ-FLOW              | 1950-2003                              |      |                         |   |
|                        | 3 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | FREQ-FLOW              |  |      | X2 - STATISTICAL RESULT |   |
|                        | 4 SAV NATURAL                 | SHAD AND STRIPED BASS HABITAT                              | STAGE                  |  |      | T1 - SEASONAL EXTRACTS  |   |
|                        | 5 SJQ GAGED                   | SHAD AND STRIPED BASS HABITAT                              | DATE                   | 16Jan1932 - 02Jan1998                  | 1DAY | E - DATE                |   |
| 25                     |                               | SHAD AND STRIPED BASS HABITAT                              | DATE SHIFT             | 16Jan1932 - 02Jan1998                  | 1DAY | E - DATE SHIFT          |   |
| 25                     | 6 SJQ GAGED                   |  |                        |  |      | 1                       | _ |
| 25                     |                               | SHAD AND STRIPED BASS HABITAT                              | DATE SHIFT             | 16Jan1932 - 02Jan1998                  | 1DAY | E - DATE SHIFT          |   |

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".

| View results for: | Stage 👻        |
|-------------------|----------------|
| Use metric units  | Stage          |
|                   | Ecovalue 🛛 📐   |
|                   | Ecovalue Shift |
| DSS Sele          | Date           |
|                   | Date Shift     |

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?

| Ocustom Plots   |   |
|-----------------|---|
| Comparison      | Add   |
| Ref             | Rename<br>Reorder                             |
| View results fo | Save active view as new Custom Plot<br>Delete |

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.

| File Name: C:\Workshops\EFMIArrays\arrays.dss Pathnames Shown: 48 Pathnames Selected: 881 Pathnames in File: 7748 File Size: 15611 KB                           |            |                  |                 |                        |        |                 |  |  |  |
|---|------------|------------------|-----------------|------------------------|--------|-----------------|--|--|--|
| Search         A:         •         C:         •         E:           By Parts:         B:         SPLITTAIL SPAWNING         •         D:         •         F: |            |                  |                 |                        |        |                 |  |  |  |
| Number F  | Part A     | Part B           | Part C          | Part D / range         | Part E | Part F          |  |  |  |
| 23 3  | AVINATURAL | SPLITTAL SPAVIN  | I REGHEOW       |                        |        | AZ - STATISTICA |  |  |  |
| 24 5  | AVNATURAL  | SPLITTAIL SPAWN  | STAGE           | U2Feb1950 - 24JUN2003  | 1DAY   | 11 - SEASUNAL   |  |  |  |
| 25 S  | SUC GAGED  | SPLITTAIL SPAWN  |                 | 10May1932 - 10Feb1998  | 1DAY   |                 |  |  |  |
| 26 5  | SUC GAGED  | SPLITTAIL SPAWN  | ECOVALUE        | 10May1932 - 10Feb1998  |        | E - DATE SHIFT  |  |  |  |
| 2/ 5  | SUC GAGED  | SPLITTAIL SPAWN  |                 | 19May1932 - 10Feb1998  |        |                 |  |  |  |
| 28 S  | JU GAGED   | SPLITTAIL SPAWN  | ECOVALUE SHIFT  | 10May1932 - 10Feb1998  | 1DAY   | E - ECOVALUE S  |  |  |  |
| 29 5  | SJQ GAGED  | SPLITTAIL SPAWN  | FLOW            | 02Feb1932 - 24Jun1998  | 1DAY   | 70. 10000000    |  |  |  |
| 30 S  | JQ GAGED   | SPLITTAIL SPAWN  | FLOW            | 02Feb1932 - 01Jun1998  | 1DAY   | T2 - MINIMUMS   |  |  |  |
| 31 5  | JQ GAGED   | SPLITTAIL SPAWN  | FLOW            | 18May1932 - 10Feb1998  | 1DAY   | 13 - SEASONAL   |  |  |  |
| 32 5  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-DATE       | 1932-1998              |        | EX - DATE       |  |  |  |
| 33 S  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-DATE SHIFT | 1932-1998              |        | EX - DATE SHIFT |  |  |  |
| 34 S  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-ECOVALUE   | 1932-1998              |        | EX - ECOVALUE   |  |  |  |
| 35 8  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-ECOVALUE   | . 1932-1998            |        | EX - ECOVALUE   |  |  |  |
| 36 5  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-FLOW       | 1932-1998              |        | X1 - FREQUENCY  |  |  |  |
| 37 5  | JQ GAGED   | SPLITTAIL SPAWN  | FREQ-FLOW       |                        |        | X2 - STATISTICA |  |  |  |
| 38 S  | JQ GAGED   | SPLITTAIL SPAWN  | STAGE           | 02Feb1932 - 24Jun1998  | 1DAY   | T1 - SEASONAL   |  |  |  |
| 39 S  | JQ NATURAL | SPLITTAIL SPAWN  | DATE            | 01Jun1932 - 01Jun1998  | 1DAY   | E - DATE        |  |  |  |
| 40 S  | JQ NATURAL | SPLITTAIL SPAWN  | ECOVALUE        | 01Jun1932 - 01Jun1998  | 1DAY   | E - ECOVALUE    |  |  |  |
| 41 S  | JQ NATURAL | SPLITTAIL SPAWN  | FLOW            | 02Feb1932 - 24Jun1998  | 1DAY   |                 |  |  |  |
| 42 S  | JQ NATURAL | SPLITTAIL SPAWN  | FLOW            | 02Feb1932 - 01Jun1998  | 1DAY   | T2 - MINIMUMS   |  |  |  |
| 43 S  | JQ NATURAL | SPLITTAIL SPAWN  | FLOW            | 01Jun1932 - 01Jun1998  | 1DAY   | T3 - SEASONAL   |  |  |  |
| 44 S  | JQ NATURAL | SPLITTAIL SPAWN  | FREQ-DATE       | 1932-1998              |        | EX - DATE       |  |  |  |
| 45 S  | JQ NATURAL | SPLITTAIL SPAWN  | FREQ-ECOVALUE   | 1932-1998              |        | EX - ECOVALUE   |  |  |  |
| 46 S  | JQ NATURAL | SPLITTAIL SPAWN  | FREQ-FLOW       | 1932-1998              |        | X1 - FREQUENCY  |  |  |  |
| 47 S  | JQ NATURAL | SPLITTAIL SPAWN  | FREQ-FLOW       |                        |        | X2 - STATISTICA |  |  |  |
| 12 5  |            | SPI ITTAII SPAWN | STAGE           | 02Feh1932 _ 24 lun1998 | 1DAY   | T1_SEASONAL     |  |  |  |

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-ofthe-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?