4.4 HEC-GeoEFM Workshop
Using HEC-EFM and HEC-RAS Data for Ecosystem Analyses

Objective

In this workshop, you will use GeoEFM to investigate spatial aspects of habitat provided by different flow regimes. Specific tasks involve identifying which aspects of the ecosystem are predicted to be most affected (both enhanced and impacted) by a change in flow regime and proposing a location for a boat access/recreation area based on simulated fish habitat.

In this workshop, the student will perform four tasks using GeoEFM: 1) Manage spatial layers, 2) Compute habitat areas using the Tabulate tool, 3) Analyze habitat connectivity using the Patch Analysis tool, and 4) Mapping of Spatial Statistics.

To save time, much of the initial setup of the GeoEFM project has already been done. It is detailed in the next section, which is entitled "Part 1: Background and GeoEFM Project Management". **You will not need to actually use the software until Part 2.**

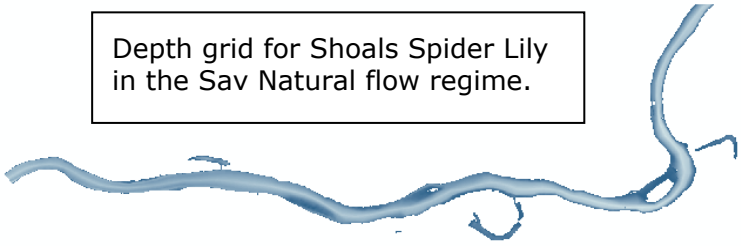
This workshop is designed to introduce GeoEFM and show how it can be used for ecosystem analyses through a series of spatial investigations. Feel free to save your work as you go, but do not perform a Save As. This would complicate connections between the GeoEFM project and its associated geodatabases.

Part 1: Background and GeoEFM Project Management

The EFM process involves statistical analyses of flow regimes and ecological relationships, hydraulic modeling, and spatial analyses of layers generated by hydraulics models. This workshop focuses on the third and final step in that process. Results from the statistical analyses are provided in the table below.

		Sav Natural		Sav Gaged		
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

All of these statistical results (flow values for the Sav Natural and Sav Gaged flow regimes for all relationships) have been simulated with a river hydraulics model to generate depth grids for use in this workshop. For example, for Shoals Spider Lily in the Sav Natural flow regime there is a depth grid that shows inundated areas and associated depths at a flow rate of 1,964-cfs.



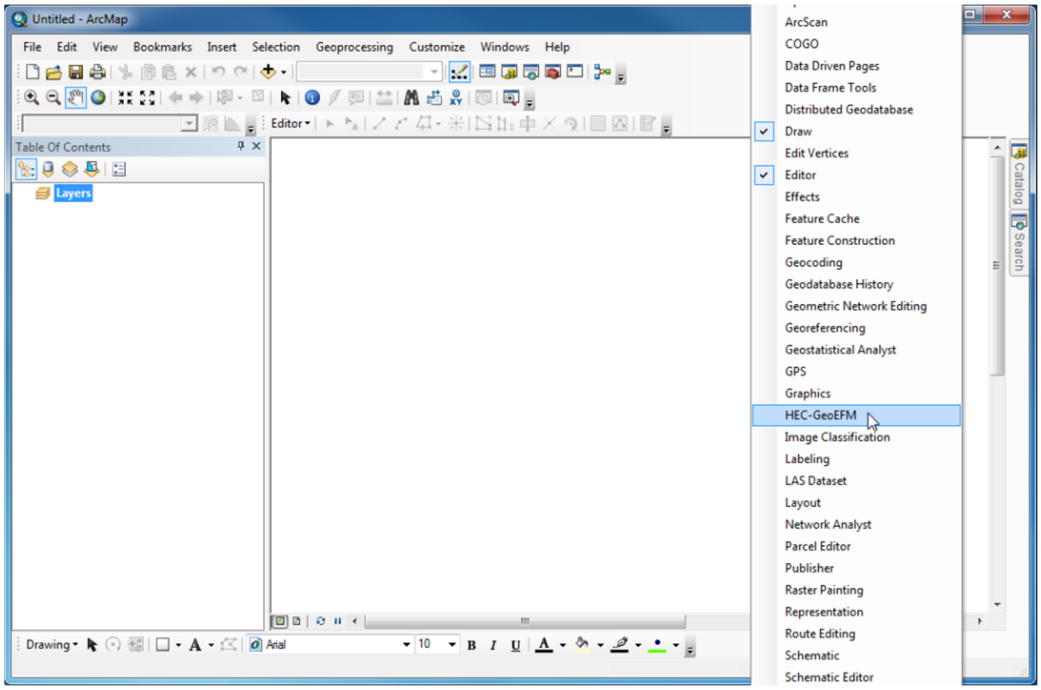
Depth grid for Shoals Spider Lily in the Sav Natural flow regime.

In this part of the workshop, the steps to set up a HEC-GeoEFM project will be demonstrated. Again, these steps have been done for you and are detailed herein only for your information.

Getting Started

To access GeoEFM, open ArcMap and load the GeoEFM toolbar.

- ☑ Open **ArcMap**.
- ☑ Load toolbar by right clicking on the toolbar area of the ArcMap interface and select **HEC-GeoEFM**.



- ☑ The GeoEFM toolbar will appear and look like this.

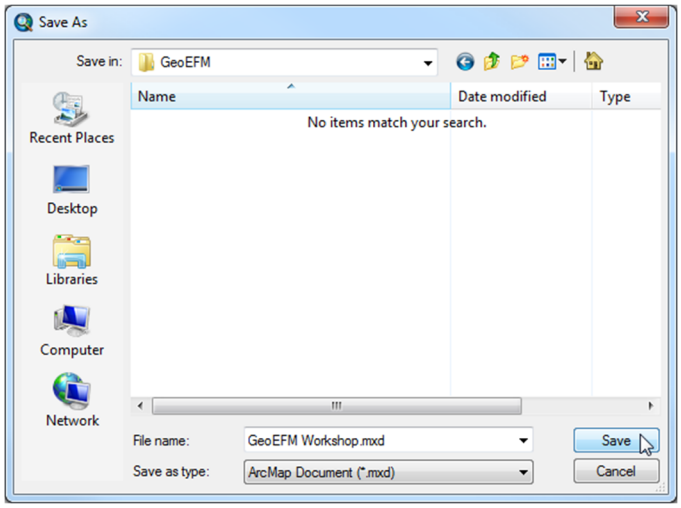
HEC-GeoEFM Project Setup

A GeoEFM project is simply an ArcMap document and geodatabase associated with an EFM project, such that ArcMap can access, interpret, and store information from EFM for use in GIS.

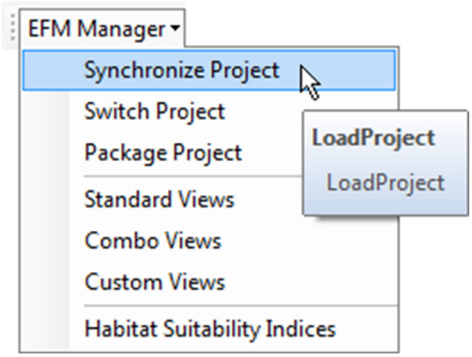
Creating a GeoEFM project

To create a GeoEFM project, save the ArcMap document and then synchronize it with an EFM project.

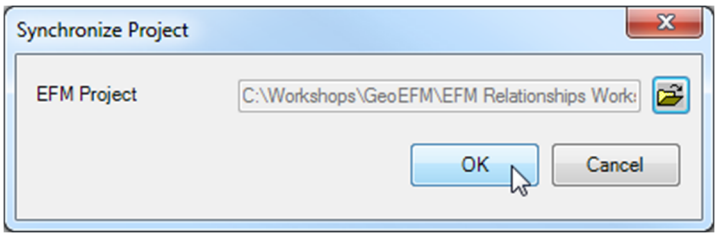
☑ Save the ArcMap document using the **File | Save As** menu option.



☑ Then select **EFM Manager | Synchronize Project** from the GeoEFM toolbar.



☑ The first time the **Synchronize Project** menu option is selected for a new GeoEFM project, the user will be prompted to load an EFM project. We will be using an EFM project entitled "**EFM Relationships Workshop.efm"**.



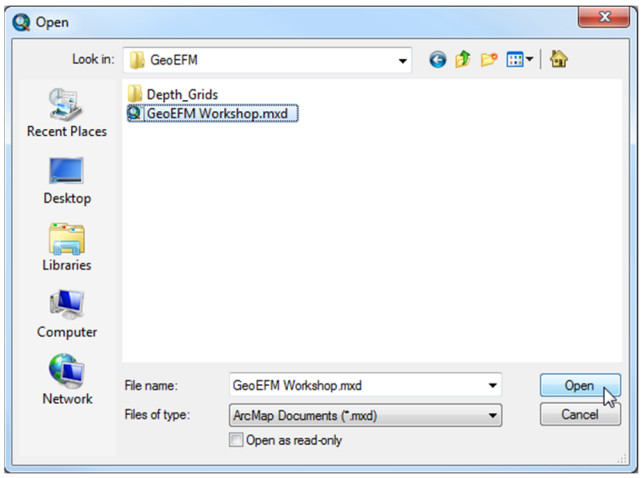
! When the EFM project is loaded, the file and path names of the EFM project are saved as part of the GeoEFM project. With each subsequent **Synchronize Project** command, GeoEFM retrieves the latest saved version of the data from its parent EFM project. Any changes, including adding, renaming, or deleting flow regimes and relationships, must be performed and saved in EFM and then updated in GeoEFM through a **Synchronize Project** command.

Part 2: Manage Spatial Layers

In this part of the workshop, spatial layers generated from the hydraulic modeling phase of the EFM process and other relevant spatial data will be added to the GeoEFM project. You will start with an existing GeoEFM project and then create Standard Views for the Splittail Spawning relationship; one for the Sav Natural flow regime and one for the Sav Gaged flow regime. The other Standard Views required for this workshop have been already been created.

So, let's get started with the exercise. Open the ArcMap file provided for you. It is entitled "GeoEFM Workshop.mxd" and located at "C:\Workshops\GeoEFM" or at the location specified by the workshop facilitator.

- ☑ Open **ArcMap**.
- ☑ Open the GeoEFM ArcMap document using the **File | Open** menu option.
  Browse to **C:\Workshops\GeoEFM\GeoEFM Workshop.mxd** and click **Open**.



- ☑ Synchronize the GeoEFM project with the EFM project by selecting **EFM Manager | Synchronize Project** from the GeoEFM toolbar. The EFM project is named "**EFM Relationships Workshop.efm"** and is located at **"C:\Workshops\GeoEFM\"**.

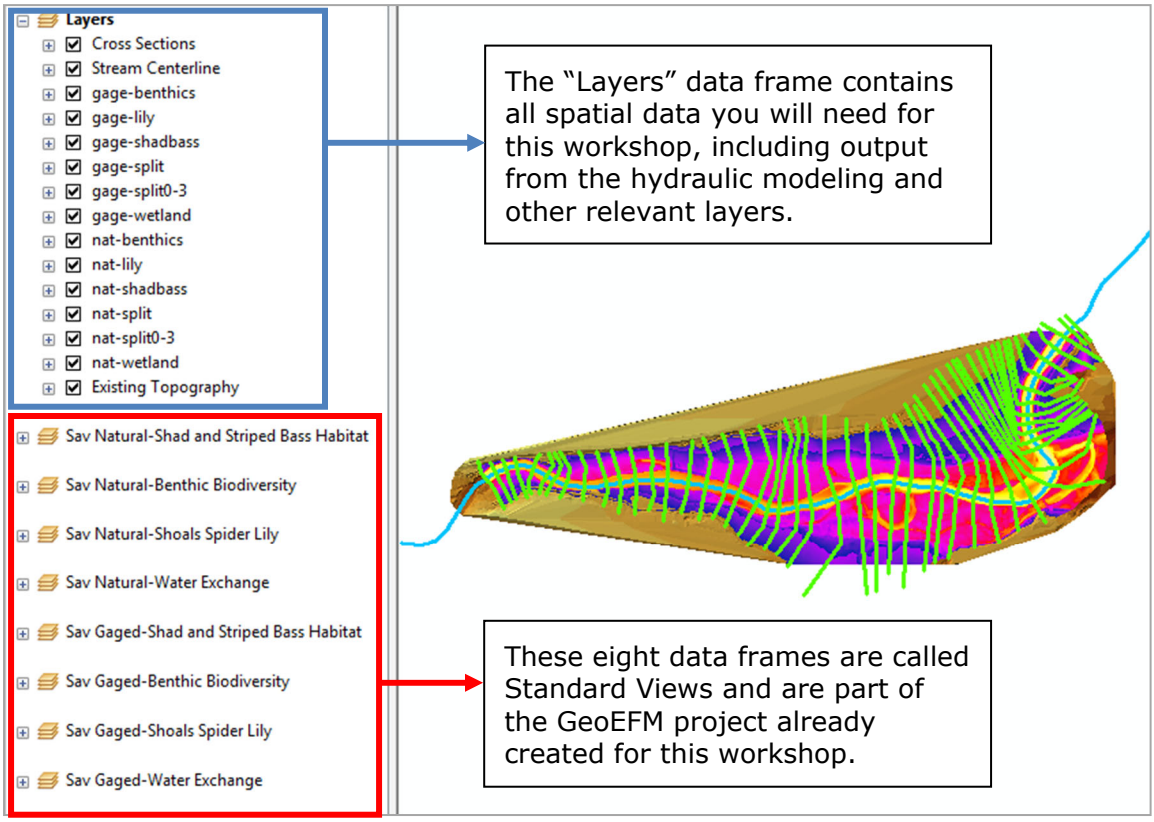
  Note that if layers are not displaying and/or if the View Finder on the GeoEFM toolbar is empty, you need to synchronize the project again.

2.1 Add Relevant Data and Statistical Results from EFM

In addition to the data and structure obtained from the EFM project, GeoEFM applications typically begin with layers generated during the hydraulic modeling phase of the EFM process as well as other relevant data such as maps of land use, soils, and vegetation.

- ☑ The default "Layers" data frame contains **cross sections**, **stream centerline**, **Existing Topography**, and the **depth grids** for each of the flow regime – relationship pairings in the EFM project.

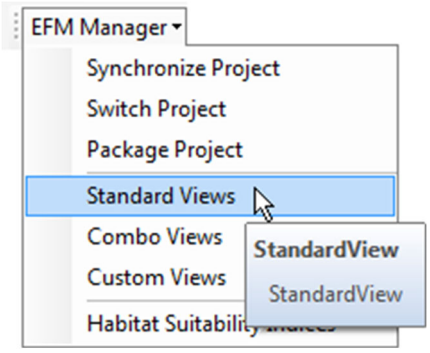
☑ In GeoEFM, sets of "views" are built per the structure obtained from the EFM project. Each "view" is a data frame. Standard Views are used as workspace for pairings of flow regimes and relationships. Use the Standard Views manager to create standard views for the Splittail Spawning relationship. Eight Standard Views have been created using the following steps.



2.2 Create Standard Views

Now, you will create two Standard Views for the Splittail. Let's start with the **gaged** flow regime.

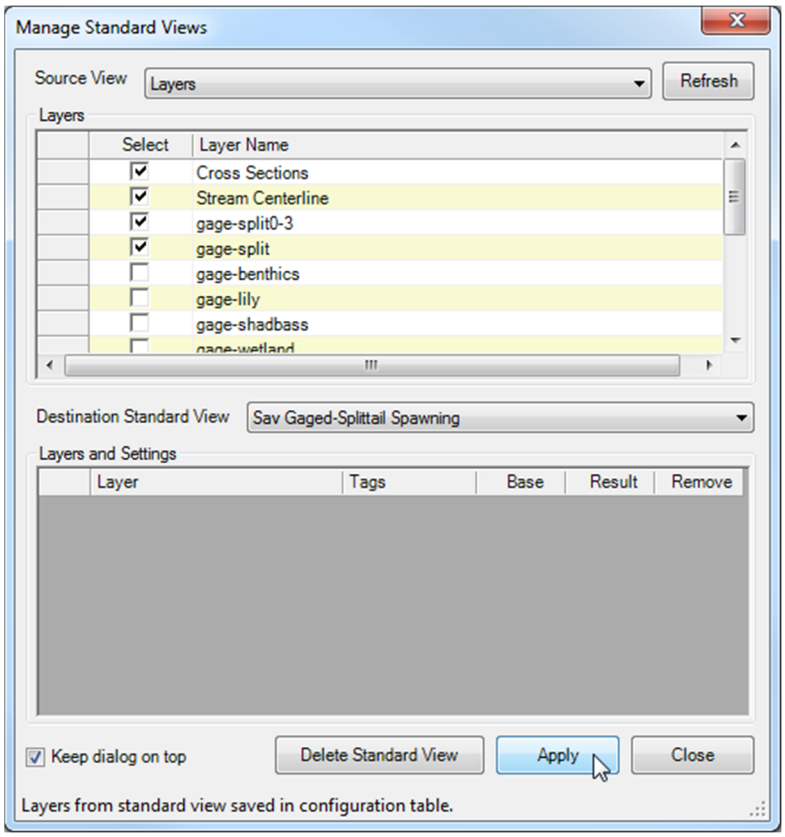
☑ To create a Standard View, use the HEC-GeoEFM toolbar to navigate to the **EFM Manager | Standard Views** menu option.



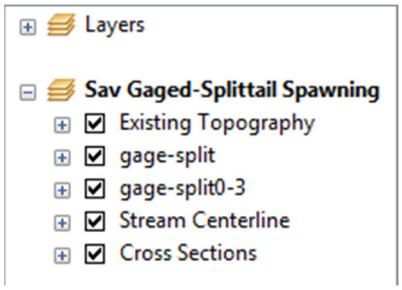
☑ This will activate the **Manage Standard Views** interface which allows you to assign layers from the Source View (in this case "Layers") to the Destination Standard View.

☑ Next, select the layers associated with the **Sav Gaged-Splittail Spawning** view **(Cross Sections, Stream Centerline, gage-split, gage-split0-3,** and **Existing Topography)** from the **Source View**.

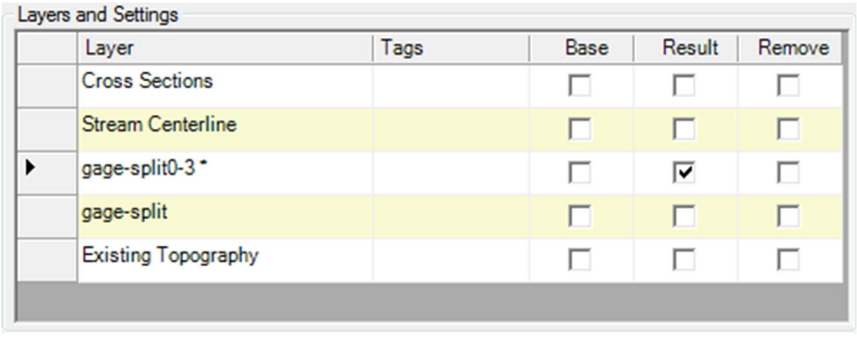
☑ In the **Destination Standard View** dropdown menu, find the **Sav Gaged-Splittail Spawning** option and select it, then click **Apply**.



☑ This will create the new Standard View/data frame with the selected layers. This data frame will also become the active data frame (shown in bold).



☑ Splittail require shallow habitat for spawning. Scientists proposed that depths of less than or equal to 3 ft for Splittail spawning would be suitable. The portion of the depth grid that met this depth criterion has been saved as a new layer called "**gage-split0-3".** As this is the layer that meets all criteria (statistical and spatial) for the relationship and flow regime being considered, identify it as the Result layer by checking the box for **gage-split0-3** under the **Result** column and click **Apply**.



☑ Repeat these steps for the **natural** flow regime of the Splittail. Be sure to select the layers that are relevant to **Savannah Natural-Splittail Spawning (Cross Sections, Stream Centerline, nat-split, nat-split0-3,** and **Existing Topography)** and deselect layers associated with the **gaged** flow regime.

☑ When you are finished, click the **Close** button.

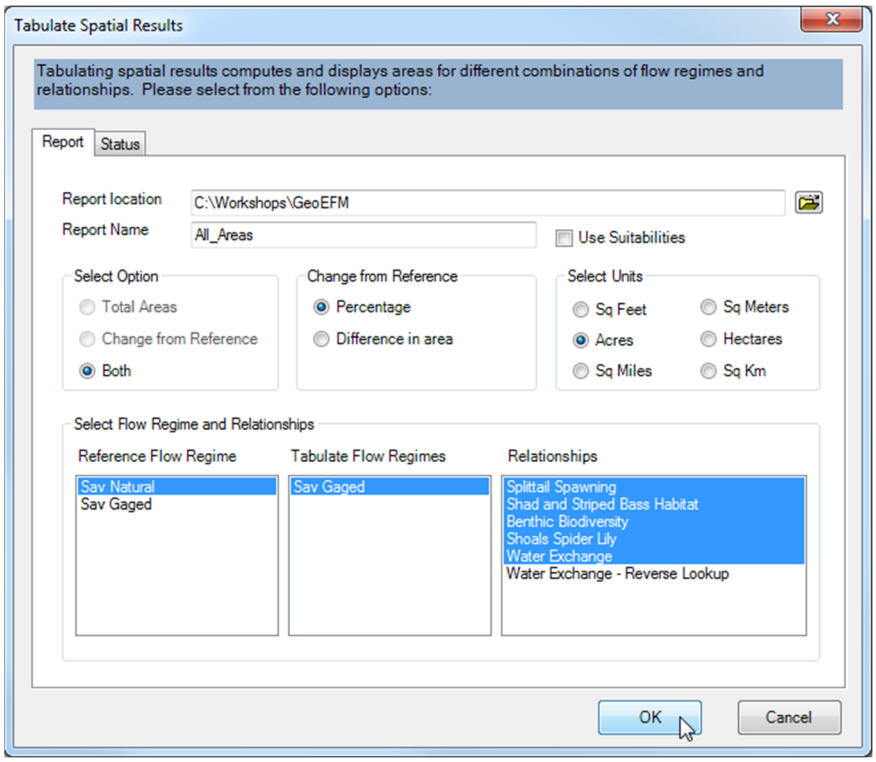
! There can only be one "Result" layer per Standard View. The Tabulate feature, discussed in the next section, queries Result layers when computing and reporting total habitat areas for different flow regime – relationship pairings.

Part 3: Compute Habitat Areas

In this part of the workshop, total habitat areas for each pairing of flow regime and relationship will be computed and compared.

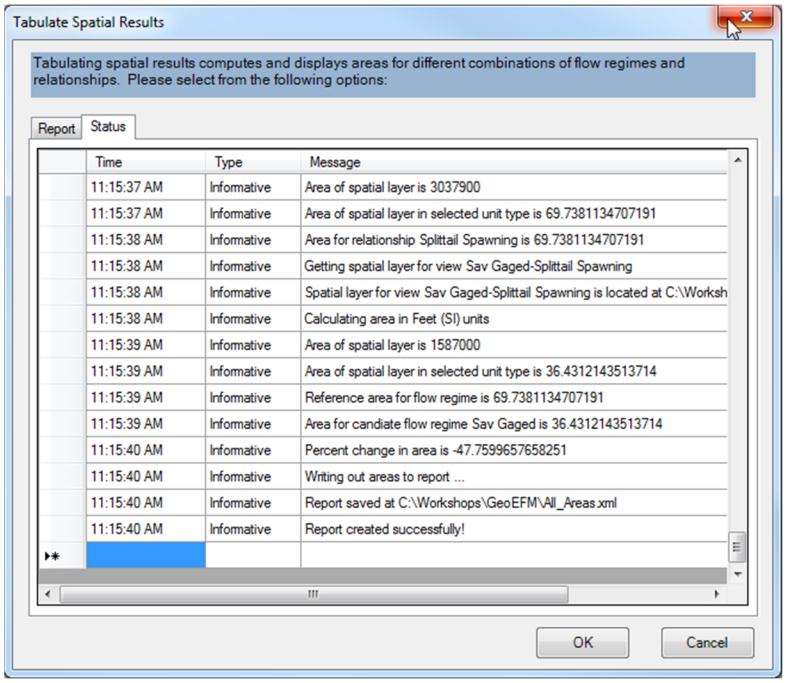
☑ To begin, click the **Tabulate Results**  button on the HEC-GeoEFM toolbar.

☑ Fill in/select the following information:
Report Location: C:\Workshops\GeoEFM\
Report Name: All_Areas
Change from Reference: Percentage
Select Units: Acres
Reference Flow Regime: Sav Natural
Tabulate Flow Regimes: Sav Gaged
Relationships: Select All except Water Exchange – Reverse Lookup



☑ Press the **OK** button.

☑ The Status tab details progress as output is generated and provides warning messages if any problems are encountered.



! Note that GeoEFM will not compute and report habitat areas unless all required results layers are identified and have defined spatial references. Use the **ArcToolbox | Data Management Tools | Projections and Transformations | Define Projection** feature to assign the appropriate projection.

☑ **All_Areas.xml** is generated that shows a summary of the data. Use the summary file to fill in the table below.

☑ **Tabulate** the areas again by going from the Results tab to the Reports tab, but this time use **difference in area** for the **Change from Reference** option and fill in the last column of the table.

Habitat Areas for All Relationships				
	Natural	Gaged		
Relationship	Area, Acres	Area, Acres	Change, %	Change, Acres
Sacramento Splittail				
Shad & Striped Bass				
Benthic Biodiversity				
Shoals Spider Lily				
Water Exchange for Wetland Health				

Based on change in area, which ecological communities or processes gained and lost the most habitat area?

Based on percent change, which ecological community or process is predicted to be the most enhanced under the gaged flow regime (as compared to the reference flow regime - Sav Natural)? Which is predicted to be the most impacted?

Part 4: Analyze Habitat Connectivity

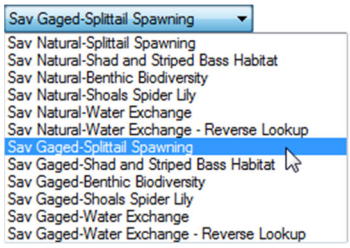
Congratulations! You are now a recognized habitat expert for this river system. As such, you have just been asked to identify a location for a proposed community recreation area and boat access site. Community planners have specified that the ideal site would:

- *Minimize disturbance to Splittail Spawning, which is a threatened species*
- *Provide boat access to deeper areas and proximity to open water*
- *For safety purposes, have a gentle slope in the land to water transition zone*
- *Be located on the North bank of the river to minimize travel time for visitors*
- *Avoid the North/South reach due to other development plans*

Community planners also said that to mitigate for any impacts of the recreation area and to maintain balance between recreation and environmental values, one third of the study area is to be set aside as a conservation zone for Splittail Spawning.

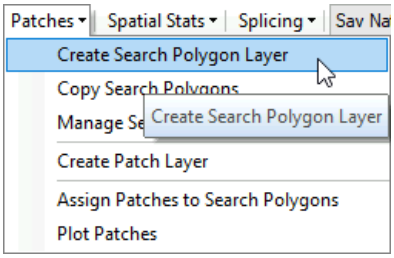
For this task, you will use GeoEFM to analyze connectivity of Splittail Spawning habitat.

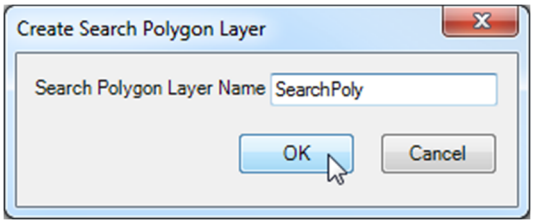
☑ Since the Sav Gaged flow regime represents the existing conditions in the river, make sure that the **Sav Gaged-Splittail Spawning** data frame is active. The active data frame is shown in bold font. If it is not the active data frame, go to the GeoEFM toolbar and select it from the View Finder dropdown menu and click the Show View  button to the right of the dropdown menu.



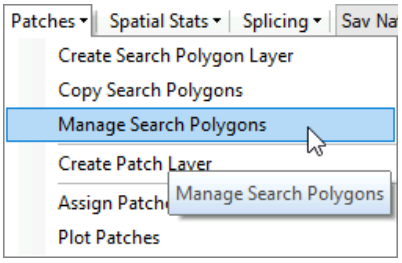
☑ The next step is to define our areas of interest with **Search Polygons**.

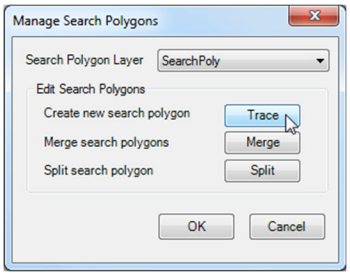
☑ On the HEC-GeoEFM toolbar, navigate to and select the **Patches | Create Search Polygon Layer** menu option. Name the Search Polygon Layer **SearchPoly** and click **OK**.





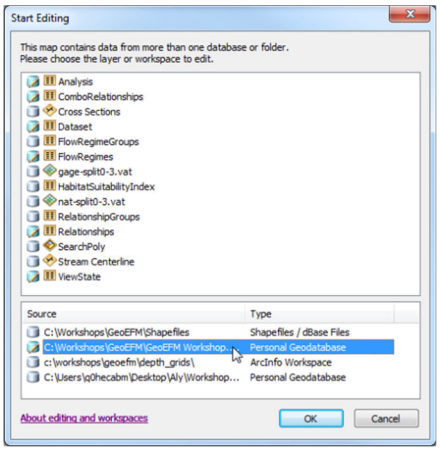
☑ Next, select the **Patches | Manage Search Polygons** menu option. In the **Manage Search Polygons** window, click the **Trace** button.



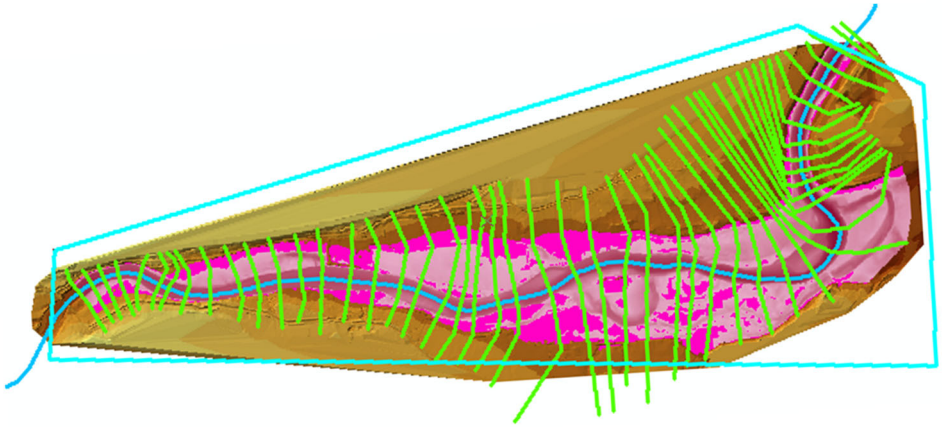


☑ This will open a **Start Editing** window that asks which database you would like to edit. Select **C:\Workshops\GeoEFM\GeoEFM Workshop.mdb** (you should see the SearchPoly layer listed in that database) and click **OK**.

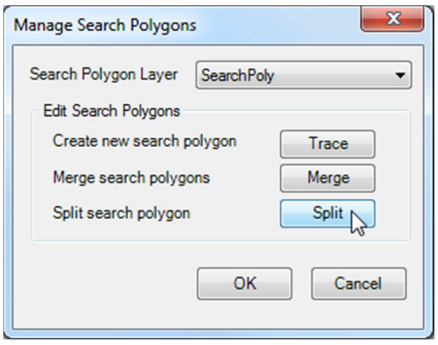
*Note: For the purposes of this workshop, you may disregard any warnings about spatial references not matching the data frame.

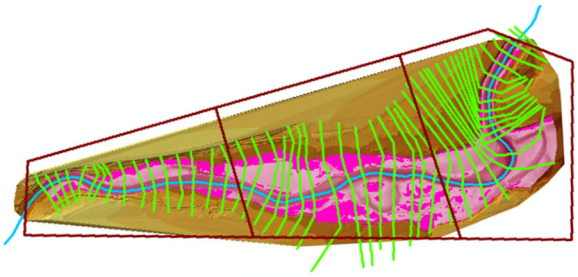


☑ The cursor's appearance will change to look like this +. If the cursor does not look like this, click the **Trace** button again. Make a polygon around the area by clicking to create each vertex. Double-click the last vertex to finish the polygon.

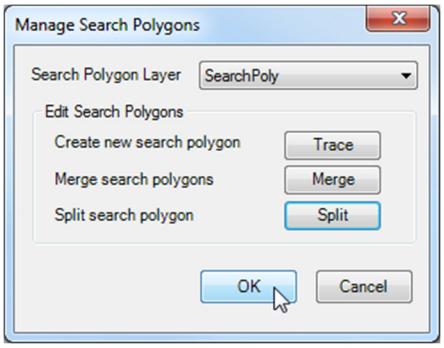


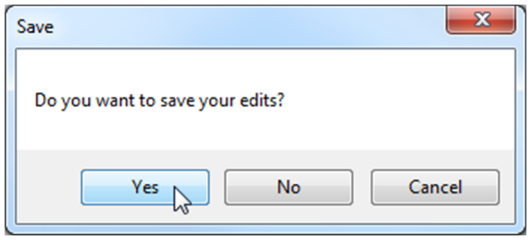
☑ Now, split the polygon into three approximately equal areas. To do this, click the **Split** button in the **Manage Search Polygons** window. Create split lines by clicking once at the starting point and then double-clicking at the end point.





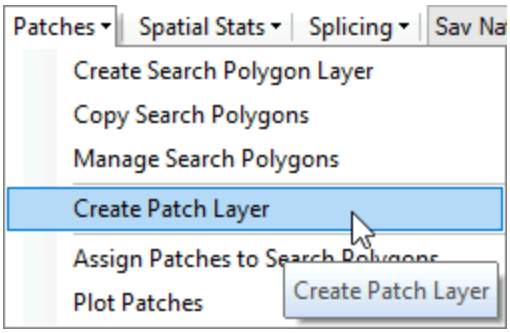
☑ When finished, close the **Manage Search Polygons** window by clicking the **OK** button. This will pop up a prompt asking if you want to save your edits, select **Yes**.



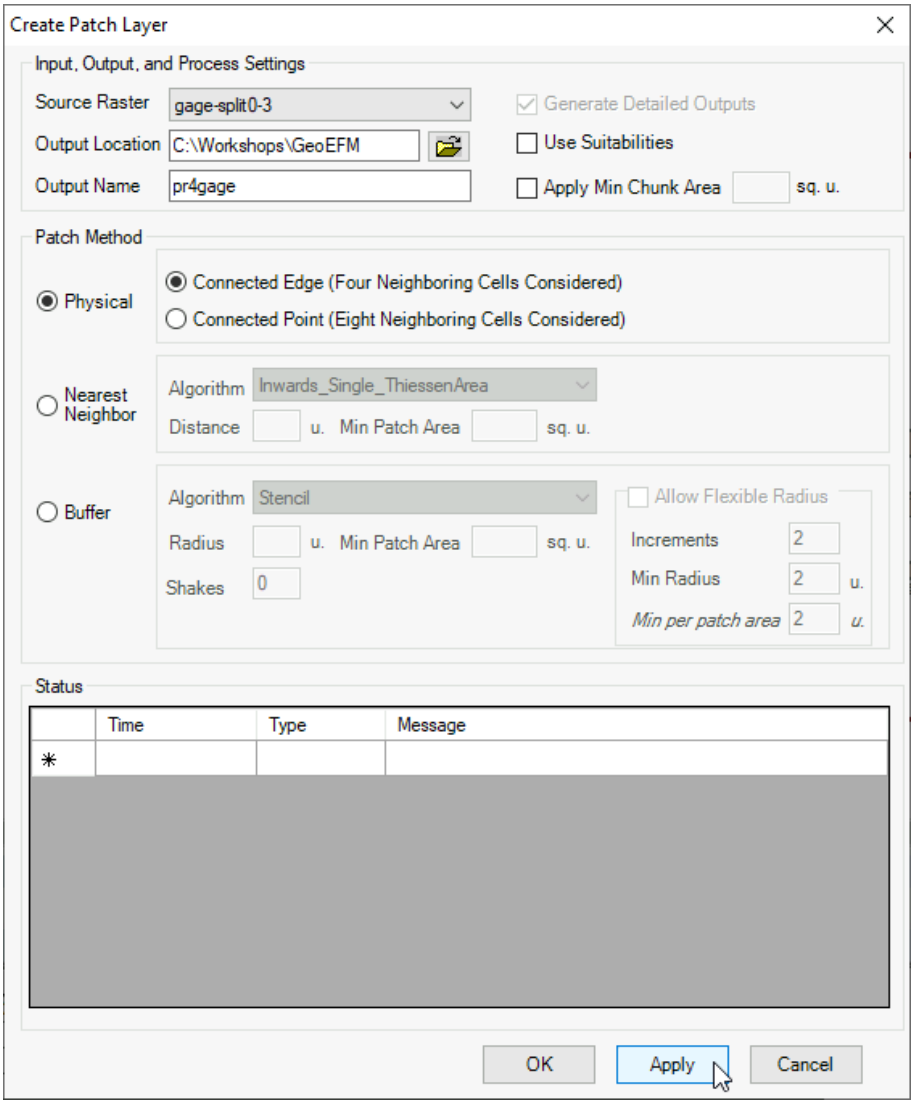


☑ The next step is to create a **patch raster**, which is simply a raster data set whose data has been split into separate habitat areas or patches. **Patches** are defined as areas that share either a connected edge or a connected point.

☑ To create a patch raster, select the **Patches | Create Patch Layer** menu option.

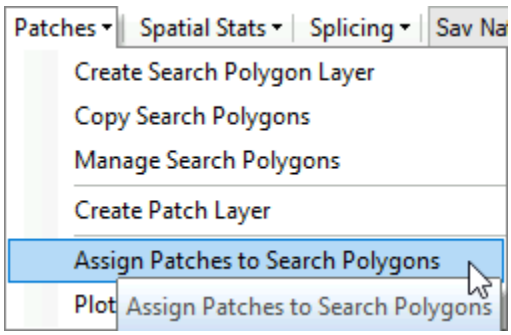


☑ In the **Create Patch Raster** window, use **gage-split0-3** as the **Source Raster Layer**. Keep the default **Area included in patch based on** option as **Connected Edge**. The **Output Location** should be **C:\Workshops\GeoEFM**. The **Patch Raster Name** should be **pr4gage**. Then click **OK**.

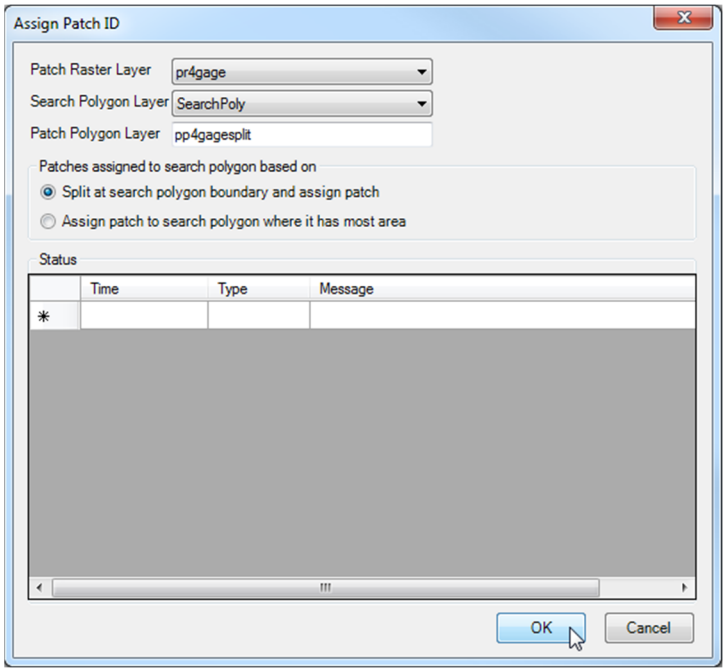


☑ When the calculations are done, click the **Cancel** button.

☑ Now, we will assign patches to search polygons. Navigate to the **Patch Analysis | Assign Patches to Search Polygons** menu option.

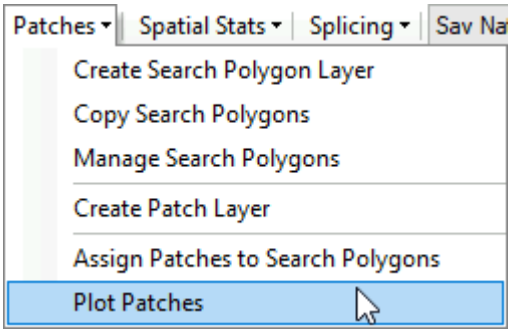


☑ In the Assign Patch ID window, select **pr4gage** as the **Patch Raster Layer**, **SearchPoly** as the **Search Polygon Layer**, and name the **Patch Polygon Layer** **pp4gagesplit**. Keep the default **Patches assigned to search polygon based on** option as **Split at search polygon boundary and assign patch**. Click **OK**.



☑ When the calculations are finished, click the **Close** button.

☑ To see a graphical representation of the patches and their sizes, use the **Patch Analysis | Plot Patches** menu option.



☑ Use the shapefile output (**pp4gagesplit**) and plot patches to answer the following questions.

You have analyzed three areas of interest. Which area would you recommend as a conservation zone for Splittail Spawning and why?

Which area would you recommend for the recreation area and boat access and why?

Remember, an ideal site would:

- *Minimize disturbance to Splittail Spawning, which is a threatened species*
- *Provide boat access to deeper areas and proximity to open water*
- *For safety purposes, have a gentle slope in the land to water transition zone*
- *Be located on the North bank of the river to minimize travel time for visitors*
- *Avoid the North/South reach due to other development plans*

As you are writing about your findings, a colleague walking by your work station compliments you on the impressiveness of your GeoEFM project. During the conversation, you learn that a restoration project has just been approved that will implement the Sav Natural flow regime. Follow the process below and use the Patch Analysis tool to analyze the Splittail natural flow regime.

☑ A new Search Polygon layer could be created, but it is easier to simply copy the existing one. To do this, right click on the **SearchPoly** layer and choose **Copy**. Activate the **Sav Natural-Splittail Spawning** data frame by choosing it from the dropdown menu and click the Show View  button. Now, right-click on the **Sav Natural-Splittail Spawning** data frame and select **Paste Layer(s)**.

☑ Next, create a Patch Raster using the **nat-split0-3** raster.

☑ Then, Assign Patches to Search Polygons.

Has the natural flow regime analysis changed your suggestion about locating the conservation zone? Why?

What about the recreation area and boat access? Why?

Part 5: Incorporating Fisheries Monitoring Data

A year later, construction on the recreation area is about to begin and pre-project fish monitoring results have just become available. The fisheries biologist was able to refine criteria for splittail spawning, and questions have been raised about how many shad and bass can overwinter in the study area.

The new splittail information shows that spawning did not occur in less than 0.25 feet of depth, began to taper in depths above 1.5 feet, and was absent in areas deeper than 3 feet.

The resulting "Splittail spawning" habitat suitability index (HSI) is:

Variable (depth, ft)	Suitability (0 to 1; 0 is wholly unsuitable and 1 is ideal)
0	0
0.25	0
1	1
1.5	1
2	0.5
3	0
20	0

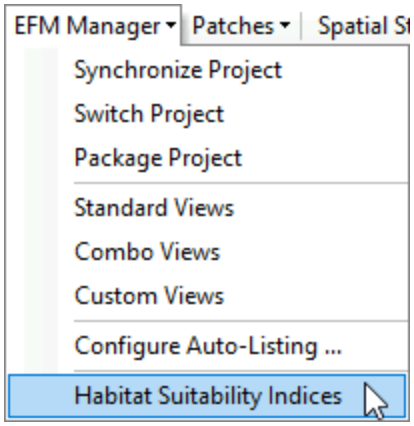
Additionally, splittail spawners are territorial, defending nest sites as far away as 50 feet. Splittail pairs require 2,000 square feet of habitat for nest creation and local forage.

Let's apply this new information to verify the choice of conservation area and location of recreation center and boat access.

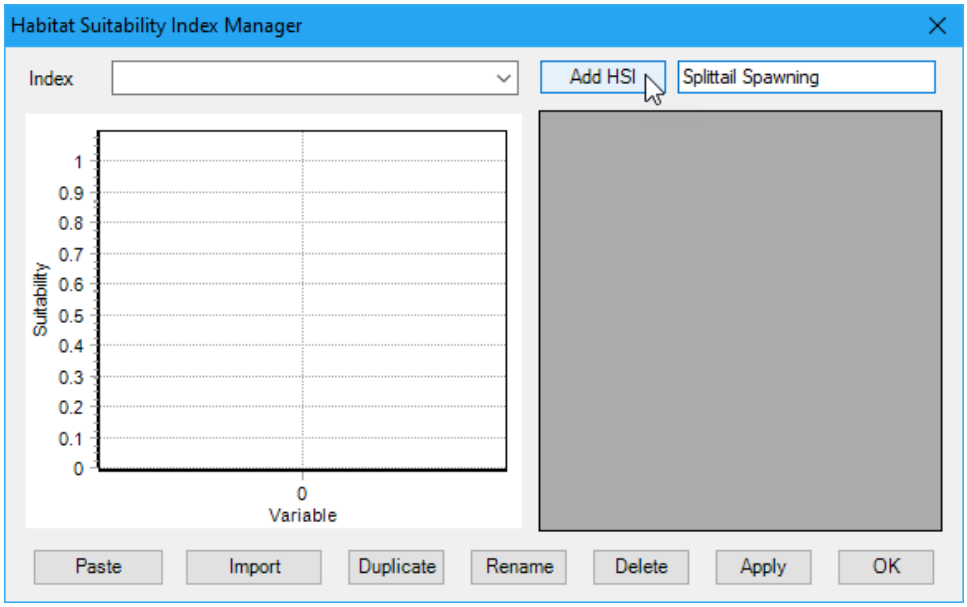
5.1 Create a Habitat Suitability Index (HSI) for Splittail

☑ If it's not active, activate the **Sav Natural-Splittail Spawning** data frame by choosing it from the dropdown menu and click the Show View button 

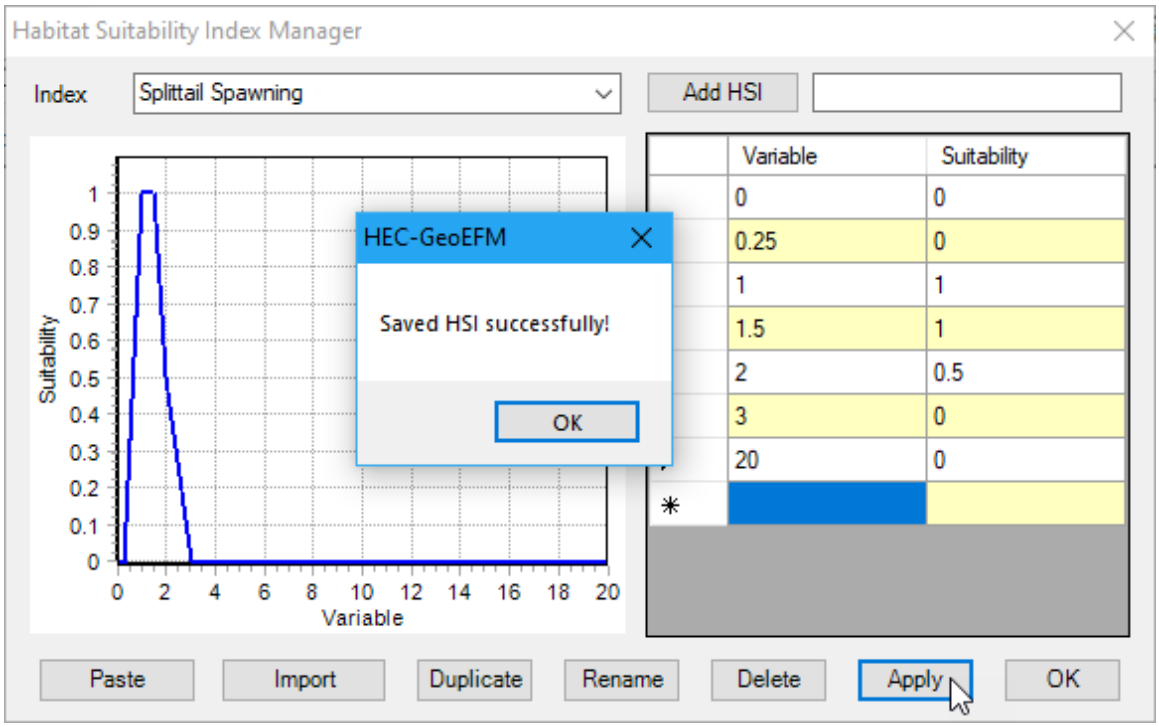
☑ Select the **EFM Manager – Habitat Suitability Indices** menu option.



☑ Enter name ("Splittail Spawning") for the new HSI and click the **Add HSI** button.

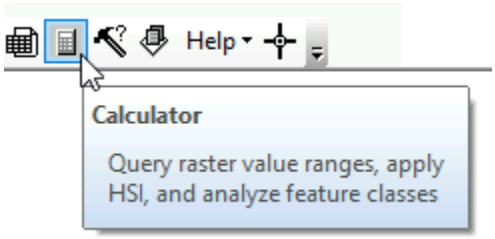


☑ Enter HSI data and click **Apply**. Close interface by clicking x button or OK.



5.2 Create a suitable habitat map based on the HSI (Splittail)

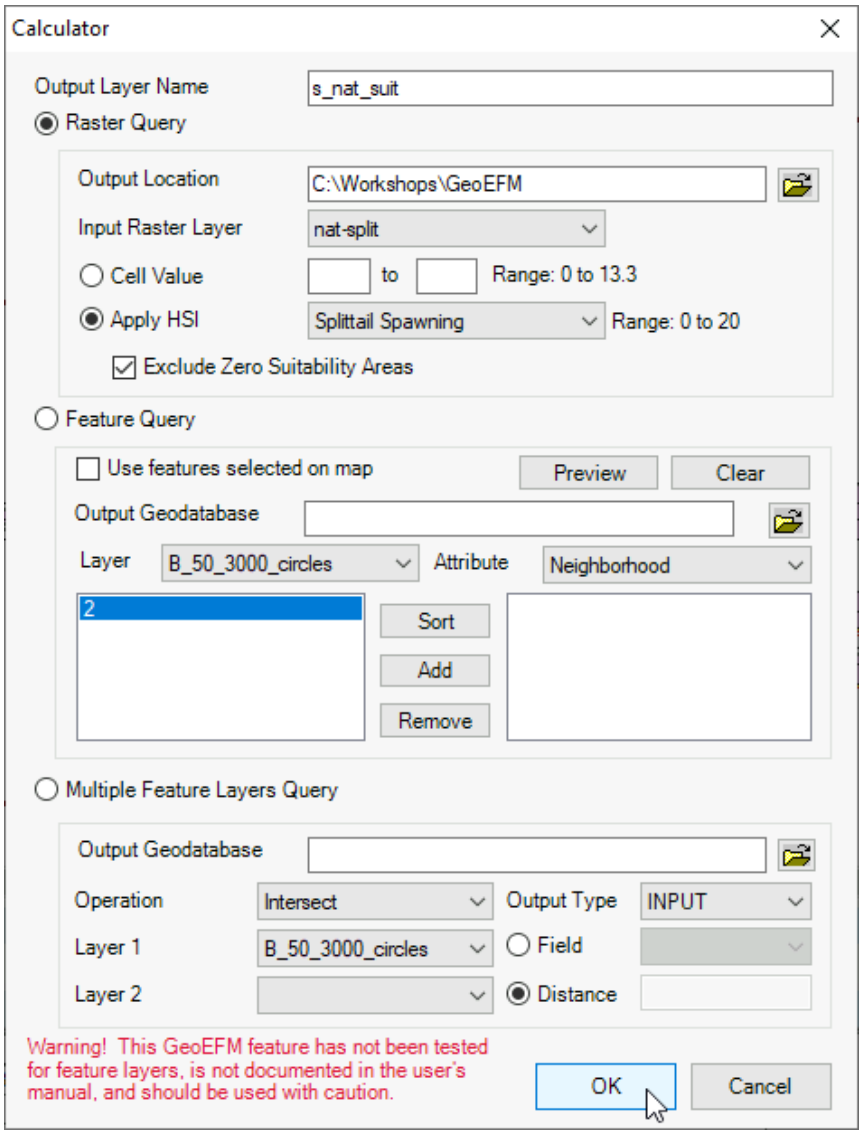
☑ Open the GeoEFM **Calculator** tool



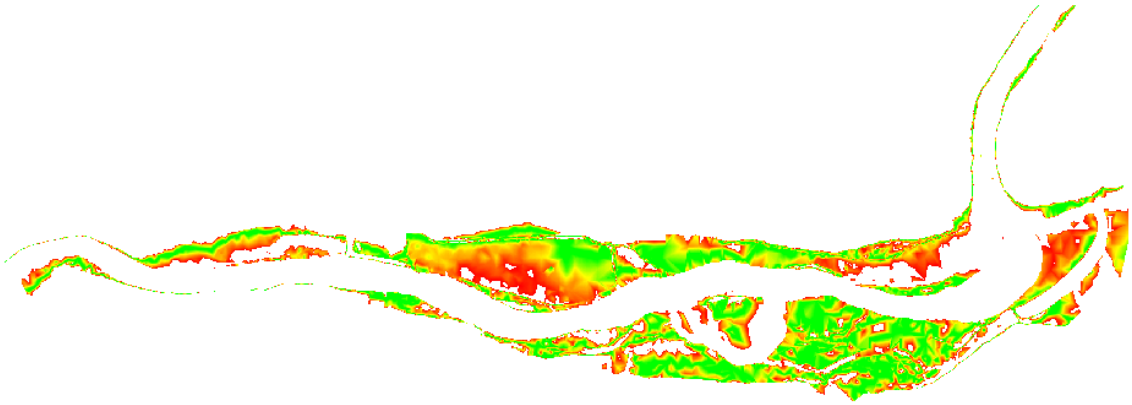
☑ Enter the following information:

Output Layer Name: s_nat_suit
Use the **Raster Query**
Output Location: C:\Workshops\GeoEFM
Input Raster Layer: nat-split
Exclude Zero Suitability Areas

…then click OK

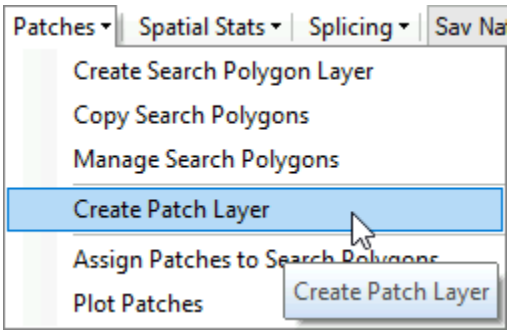


☑ The resulting suitable habitat map should look like…



5.3 Create Patches of Suitable Habitat (nest sites) based on Splittail needs

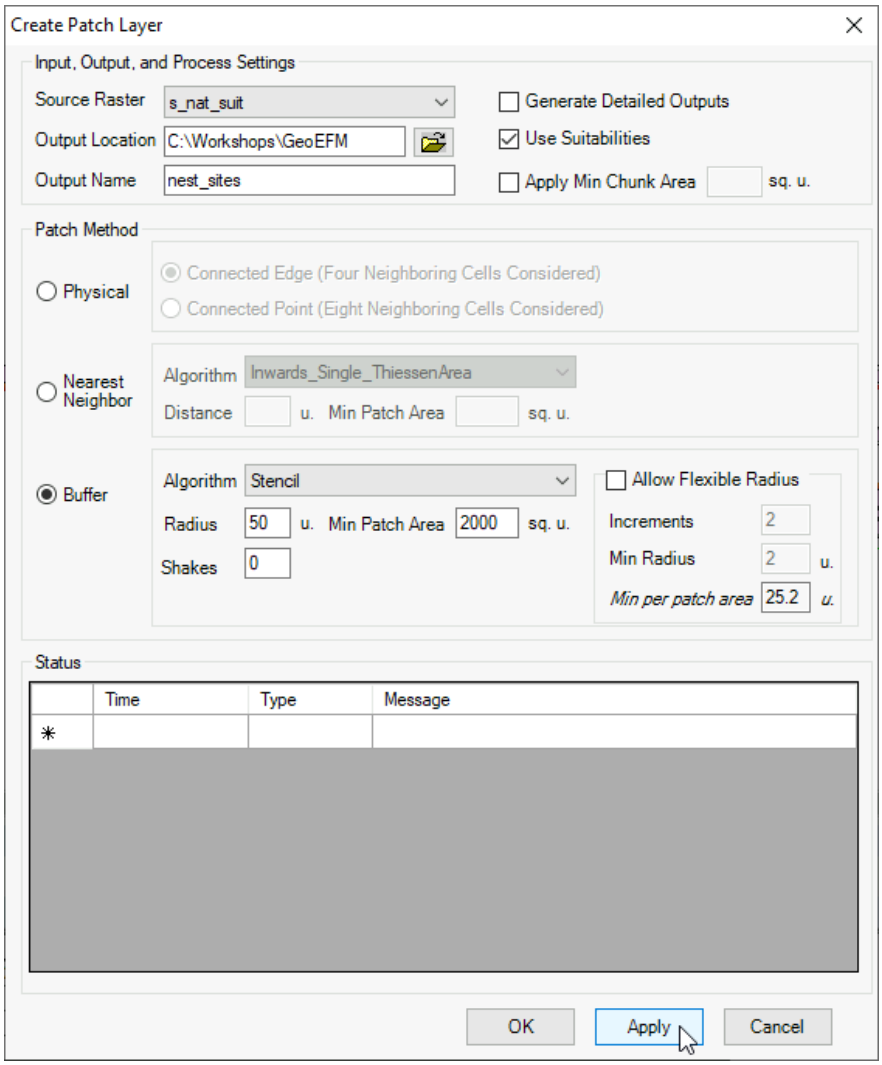
☑ Select the Patches – Create Patch Layer menu option.



☑ Enter the following information:

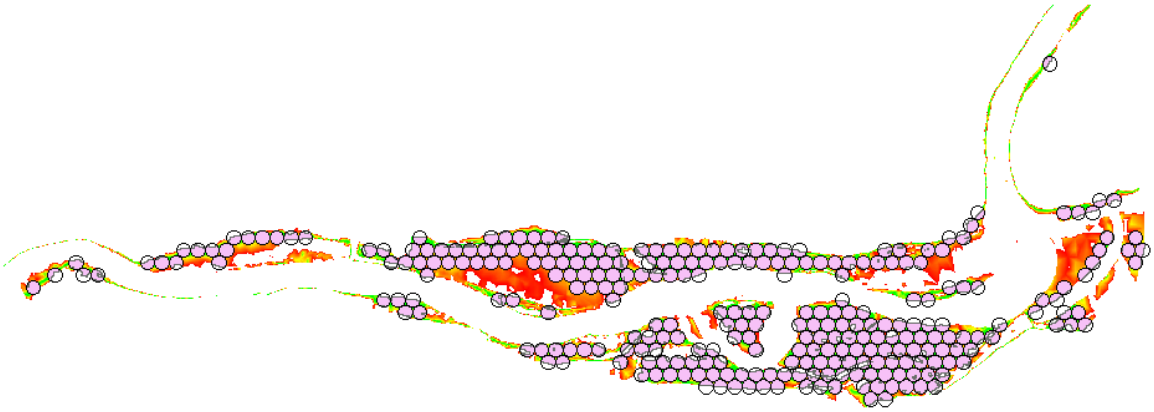
Source Raster: s_nat_suit
Output Location: C:\Workshops\GeoEFM
Output Name: nest_sites
Use Suitabilities
Select the Patch Method: Buffer
Radius =50; Min Patch Area = 2000

…then click Apply



☑ Processing time should take about one minute. GeoEFM is positioning a stencil of circles (radius = 50 feet) over the habitat layer and identifying circles that encompass enough suitable habitat (2,000 square feet) to support spawning.

☑ The resulting map of nesting sites should look like…



- *How many nest sites were identified in the study area?*

- *Does the distribution of nesting sites change your suggestions about locating the conservation zone or the recreation area and boat access? Why?*

- *How many nests are likely to be disturbed and likely lost due to construction?*

Overwintering Shad and Bass

Let's investigate how many shad and bass can overwinter in the study area. Monitoring has shown:

Adults are not territorial during the overwinter period
Adult individuals require 15,000 square feet of suitable habitat to overwinter
Isolated chunks of habitat with 5,000 square feet of habitat or less are not utilized
Pieces of habitat separated by 100 feet should be considered separately
Adults prefer depths between 3 to 5 feet
Adults avoid areas of depth less than 1 ft and more than 10.

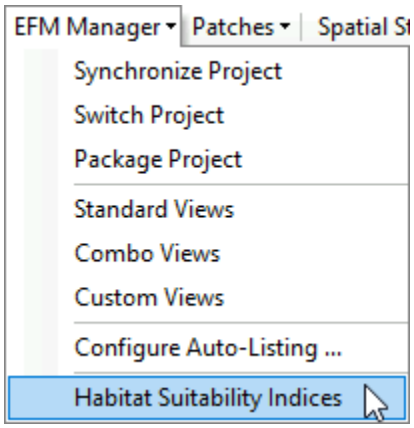
The resulting "Shad and Bass" habitat suitability index (HSI) is:

Variable (depth, ft)	Suitability (0 to 1; 0 is wholly unsuitable and 1 is ideal)
0	0
1	0
3	1
5	1
10	0

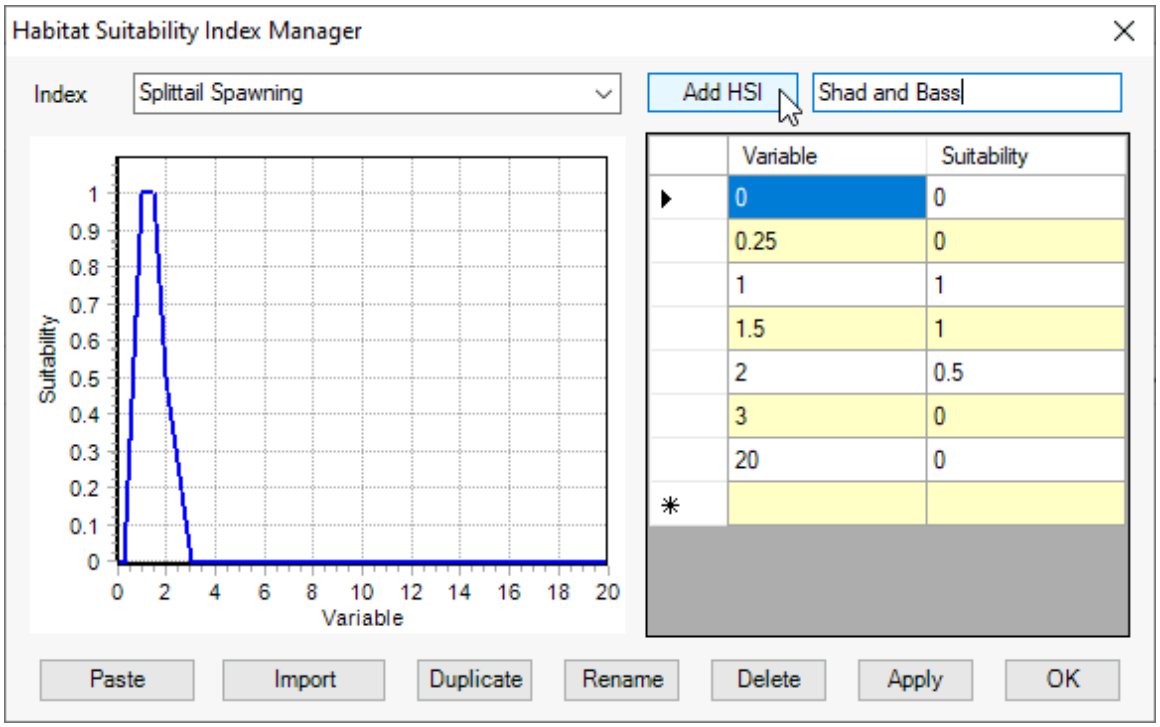
5.4 Create a Habitat Suitability Index (HSI) for Shad & Striped Bass

☑ Activate the **Sav Natural-Shad and Striped Bass Habitat** data frame by choosing it from the dropdown and clicking the Show View button.

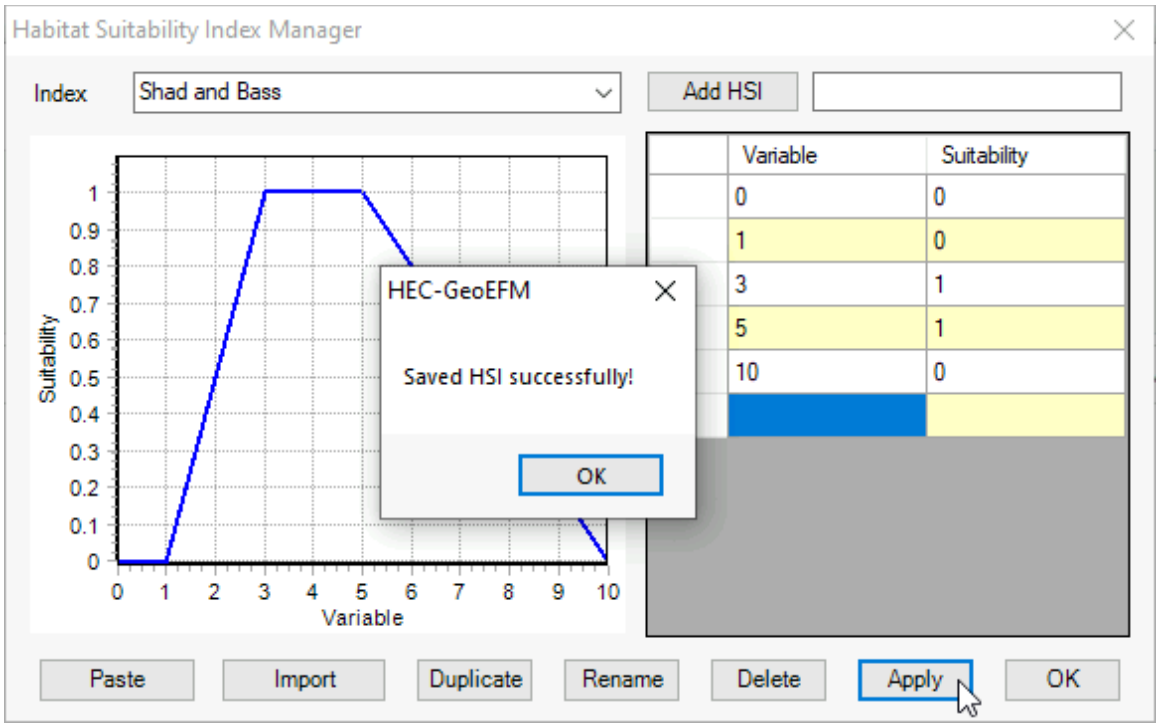
☑ Select the **EFM Manager – Habitat Suitability Indices** menu option.



☑ Enter name ("Shad and Bass") for the new HSI and click the **Add HSI** button.

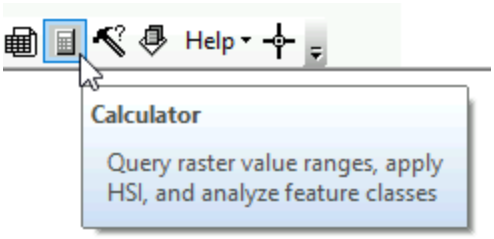


☑ Enter HSI data and click **Apply**. Close interface by clicking x button or OK.



5.5 Create a Map of Suitable Habitat based on the HSI (Shad & Striped Bass)

☑ Open the GeoEFM **Calculator** tool

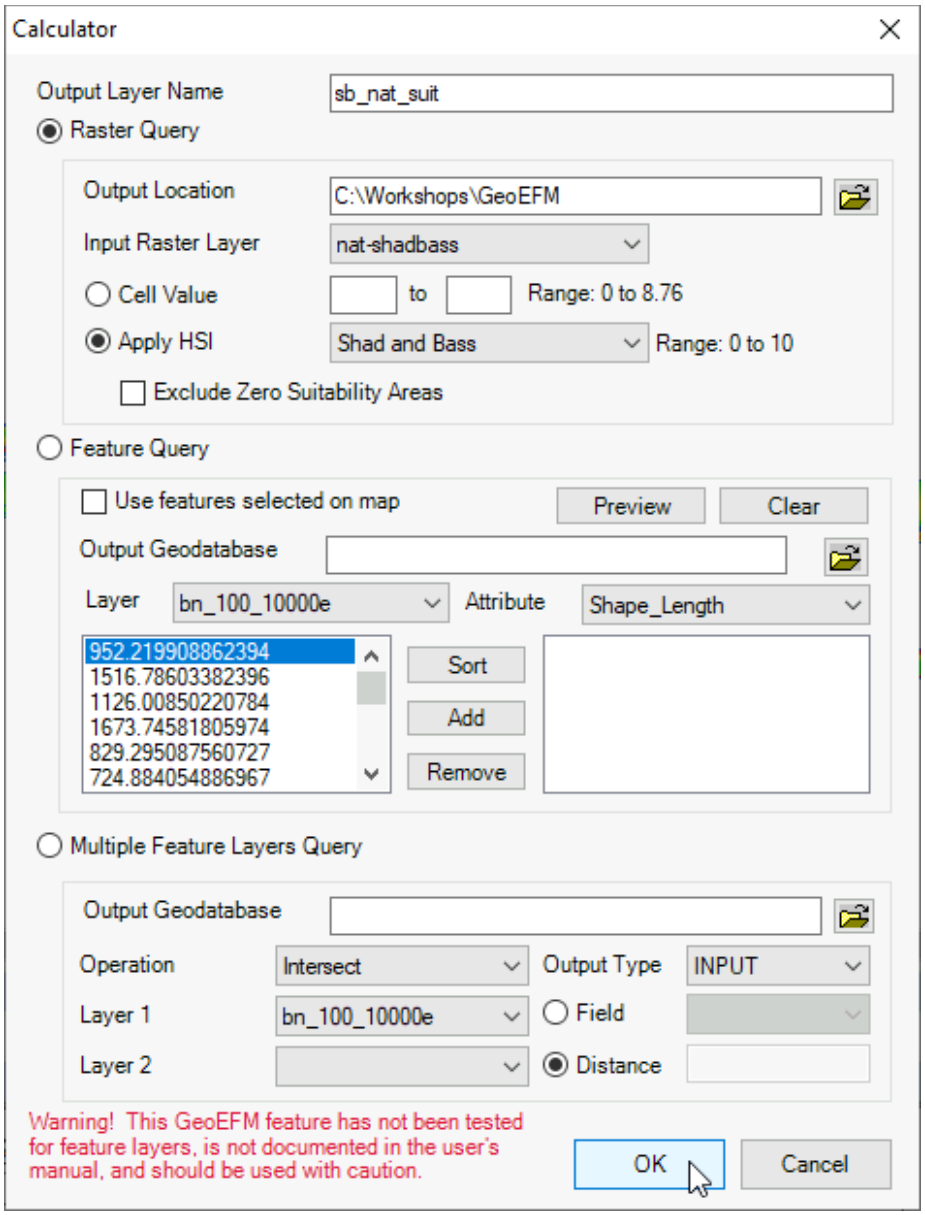


☑ Enter the following information:

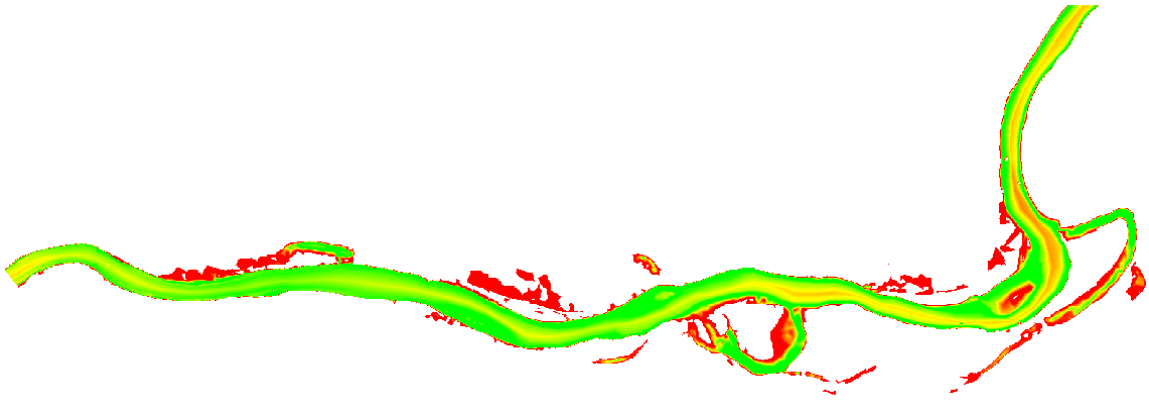
Output Layer Name: sb_nat_suit
Select Raster Query
Output Location: C:\Workshops\GeoEFM
Input Raster Layer: nat-shadbass

…then click OK

Include Zero Suitability Areas

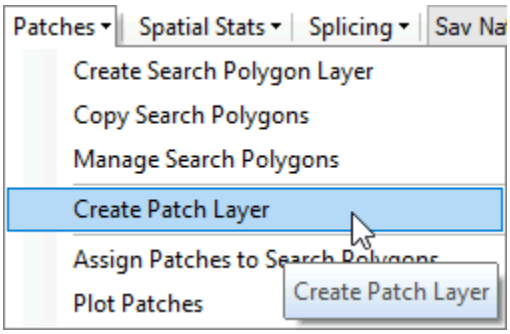


☑ The resulting suitable habitat map should look like…



5.6 Create Patches of Suitable Habitat based on overwintering needs

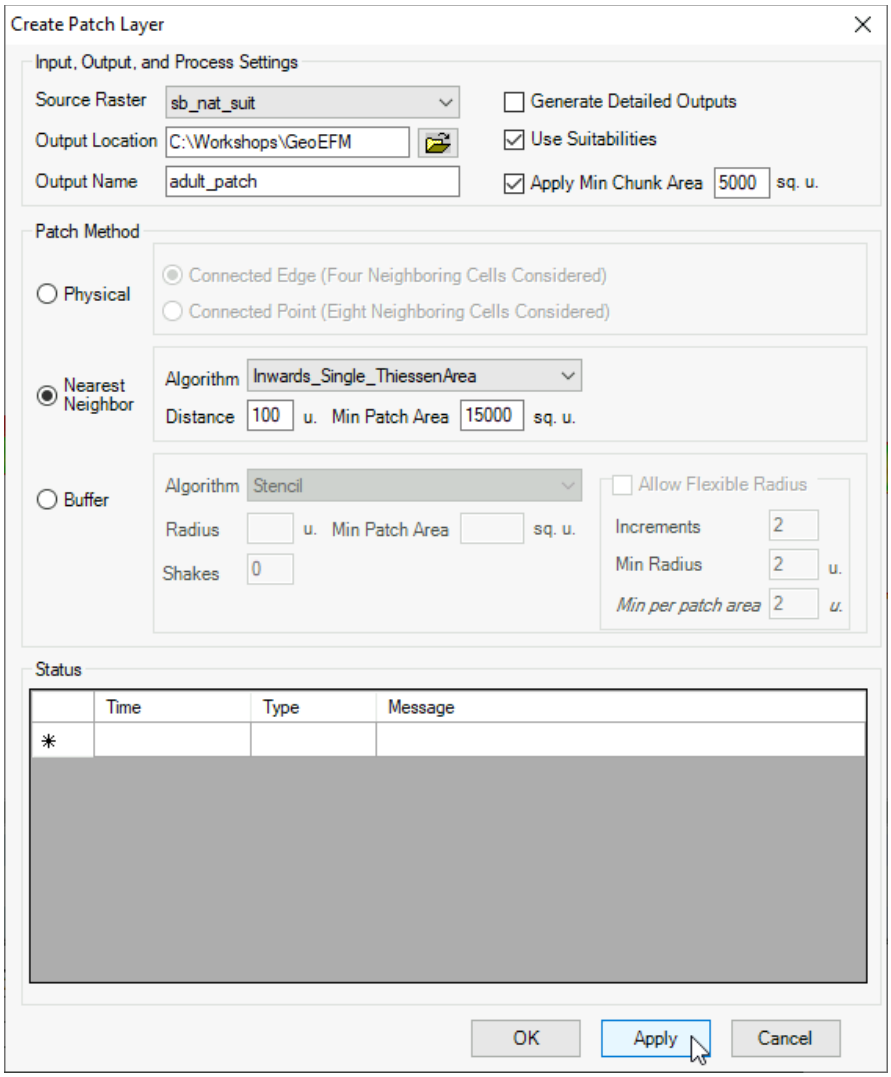
☑ Select the Patches – Create Patch Layer menu option.



☑ Enter the following information:

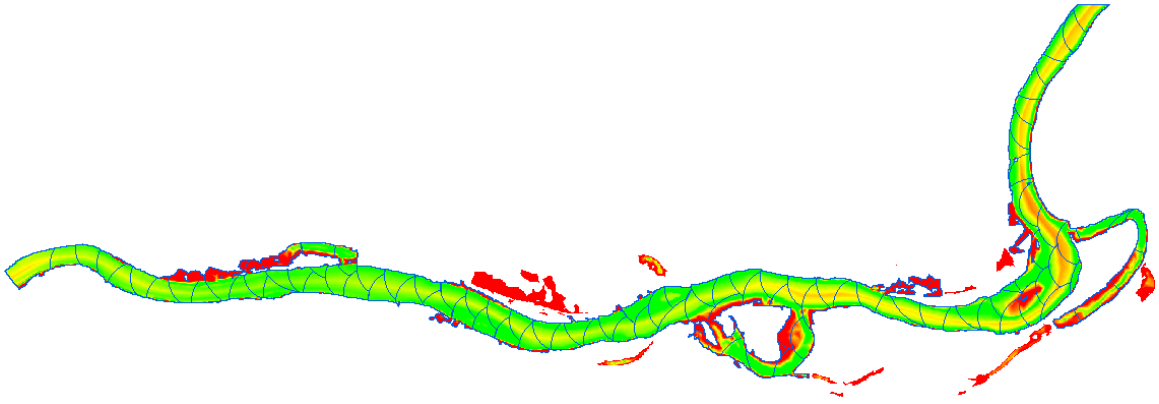
Source Raster: sb_nat_suit
Output Location: C:\Workshops\GeoEFM
Output Name: adult_patch
Uncheck: Generate Detailed Outputs
Use Suitabilities
Apply min chunk area = 5000
Use the Nearest Neighbor Patch Method
Distance = 100; min patch area = 15000

…then click Apply



☑ Processing time should take about two minutes. GeoEFM is partitioning suitable habitat into patches that contain enough habitat to support an individual adult fish during the overwinter period.

☑ After a symbology change, the resulting map of nesting sites should look like…



- *How many adults can overwinter in the study area?*

- *Does the suitable habitat map make sense based on the hydraulics and HSI?*

- *What parts of the process that you just completed (application of HSI, Nearest Neighbor patch analysis) can exclude pieces of habitat as not viable for adults?*