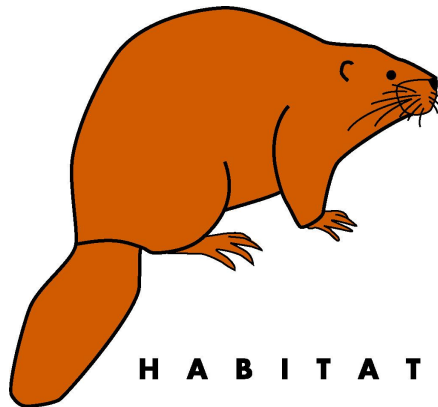


## Tutorial HABITAT 2.0



**H A B I T A T**



# Tutorial HABITAT 2.0



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# I Introduction

## HABITAT spatial analysis tool

This tutorial contains 6 exercises to get acquainted with the HABITAT tool<sup>1</sup>. HABITAT is a spatial analysis tool to support the development of river basin management plans. It is especially designed for ecological assessments to analyse the availability and quality of habitats for individual or groups of species. Its applicability is not restricted to ecological purposes, it can be used for any spatial analyses where grid operations are needed such as flood risk maps or damages to agriculture or urban areas in case of floods and droughts. The tool has been built around PCRaster<sup>2</sup>, a software package for map-calculations, and is developed by Deltares | Delft Hydraulics and Ministry of Transport, Public works and Water management, The Netherlands. The main characteristic of HABITAT is that it provides a platform for grid operations without highly advanced programming skills from the user via the user interface, which makes it usable for a broad audience. The spatial representation allows for a quick recognition of suitable areas. HABITAT helps the user to systematically follow cause-effect chains and simulate each step in knowledge rules, which may be based on monitoring results and/or expert knowledge. By making the knowledge explicit the impact assessment method becomes transparent and re-usable. Combined relations and effects can be analysed by using knowledge rules for different environmental factors and measures. Basic statistical functions can be used to summarise the results. The systematic approach allows for an easy comparison of different strategies and a better understanding the ecosystem and its relevant steering variables. The tool applies knowledge rules to maps (grid cells) (figure 1), using data in different data layers and/or a number of adjoining cells. As the analysis is performed on maps, the heterogeneity of areas and consequently the diversity of the environment can be taken into account.

Within HABITAT knowledge rules developed for specific studies can be stored in a knowledge database, re-used and adapted for other studies possibly in other areas. In the Netherlands already a start was made to set up such a database with knowledge rules and documentation for all species and species groups defined in the European Directives that occur in The Netherlands. A database could easily be expanded with knowledge rules for other purposes such as costs and risk assessments. Delft Hydraulics has adopted the principle 'Dare to Share'<sup>3</sup> in order to enhance knowledge exchange through a wiki page<sup>4</sup> and thereby improve the quality of studies done with HABITAT. HABITAT is freely available for users which are willing to share their developed knowledge rules as part of the 'Dare to Share' principle. The use of a common framework, knowledge base and tool can promote the sharing of knowledge and experiences on a level that transcends country boundaries and disciplines.

- 
1. Haasnoot M., K. van de Wolfshaar (in press). Combining a conceptual framework and a spatial analysis tool, HABITAT, to support the implementation of river basin management plans. *Journal of River Basin Management*. Haasnoot, M., J.S. Verkade, K.M. Bruijn. (2009) HABITAT a spatial analysis tool for environmental impact and damage assessment. *Hydroinformatics Conference*. Chili 12-16 January 2009
  2. <http://www.pcraster.nl>
  3. Soekijad, M. (2005). "Dare to share - Knowledge sharing professionals in co-operative networks". PhD thesis. Technical University Delft. ISBN:90-9019565-3
  4. <http://habitat.deltares.nl>

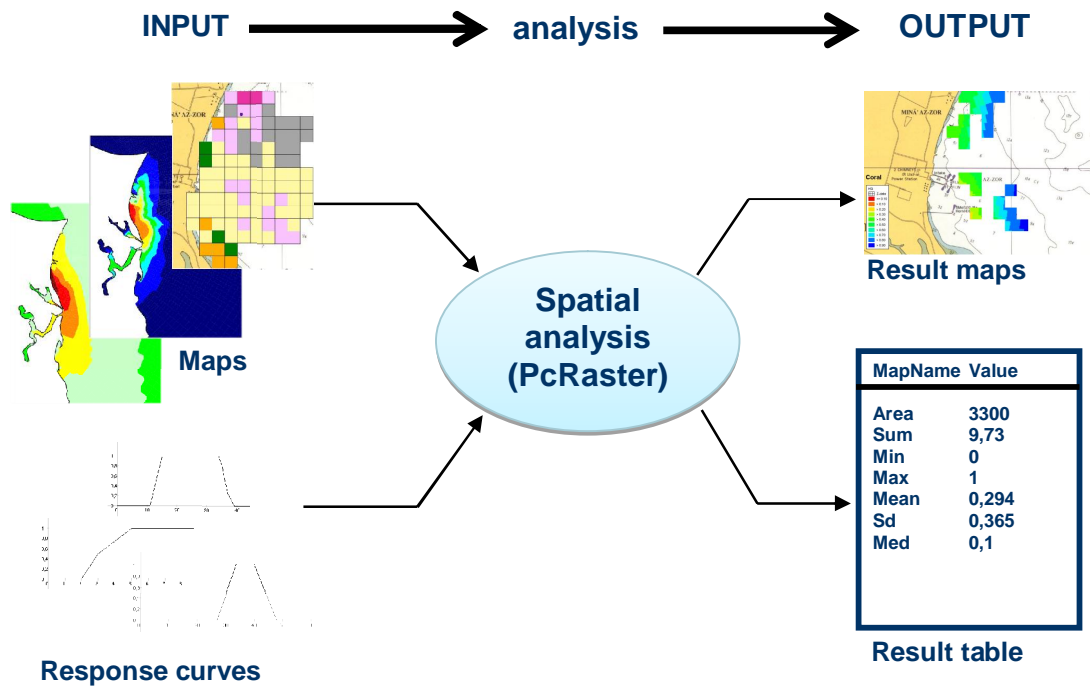


Figure 1. Working of HABITAT tool.

The manual of HABITAT can be found at the habitat wiki: <http://habitat.deltares.nl>

### Outline of the tutorial

In the first exercise you implement two habitat suitability models and save them in the ecological toolbox. In the second exercise these models are reused to run two scenarios. The results are analysed by looking at the result maps and calculation statistics. The third exercise shows how to develop an ecotope classification, analyse the results of this and calculate the statistics of a map. The fourth exercise explains how to calculate the effects of sea level rise on the occurrence of these ecotopes. The fifth exercise follows upon the 1<sup>st</sup> and 2<sup>nd</sup> and is a more complex model. It shows the possibilities of the habitat tool. The sixth exercise shows how to convert ArcGIS files to HABITAT input files and vice versa.



## 2 Exercise I: Habitat Suitability Index model

A habitat is an area in which a specific species lives. The suitability of a habitat is determined by the biotic and abiotic environmental conditions and land use.

In this exercise we will make a habitat suitability index model (HSI) for the habitat type 3140 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp.*' of the Habitat Directive and for herbivorous water birds. These kind of models describe the suitability based on environmental conditions (abiotic, biotic and management). Models can have different formats. Most of them exist of response curves between the environmental condition and the suitability for the (group of) species, indicated with a value between 0 (not suitable) and 1 (high suitable area). The total suitability is the minimum of the results of the relations of the used environmental conditions, which means that the most limiting factor is determining the final suitability. Another frequently used format is a statistic relation of environmental conditions and the occurrence of a (group of) species. A description of the models used in this exercise can be found in the knowledge base with habitat models at <http://habitat.deltares.nl>.

In this exercise a HABITAT model will be run for Lake Markermeer in the Netherlands, for the current situation and for a future situation, in which an island is constructed. The purpose of this exercise is to learn how to set up a suitability model, run different scenarios and to save the models in the toolbox of HABITAT.

### 2.1 Implement habitat suitability model for Habitat type *Chara spp.*

#### Preparation

1. **Start HABITAT** from the windows start menu. Program > Delft Hydraulics > Habitat Spatial Analysis Tool and select Habitat Spatial Analysis Tool.
2. **Save the project.** A project is the basis of the HABITAT tool. It is like a word-document from the Word program of Microsoft or the mxd file from ArcGIS. HABITAT starts with an empty project. From the menu you can save a project by selecting 'File, Save Project as'. Use the name 'Course Habitat'

The hierarchy within a Project is: Folders, Scenarios, Models. Within a project you have different folders and scenarios. Folders can be used to structure your scenarios. A folder can contain other folders or a group of scenarios. For example you can use a folder to structure you scenarios for different areas. This could be a folder including scenarios and models for the lake IJsselmeer and one for the Waddensea. A scenario exists of a group of models. Models are the actual grid processing tools. They are used to define response curves.

Next step is to implement HSI-models in HABITAT.

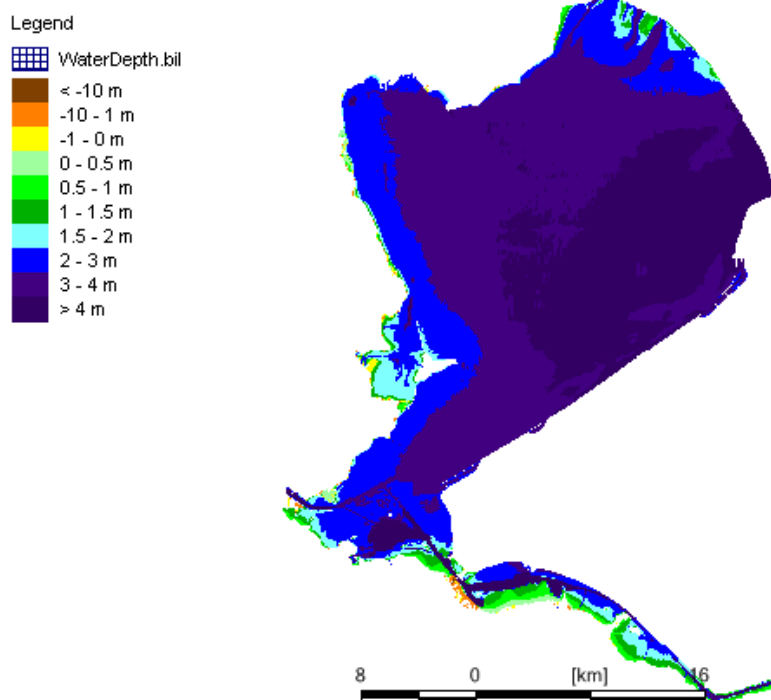
The HSI-model for the *Chara spp.* consists of two response curves: one for the transparency in terms of the percentage of light reaching the soil and one for the water depth. The total suitability of an area suitable for *Chara spp.* is determined by calculating the minimum of the suitability index for both environmental factors. In total this HSI-model includes thus three formulas:

- 1) dose-effect relation % light at soil to suitability,
- 2) dose-effect relation for water depth to suitability,
- 3) total habitat suitability is the minimum of the suitability for water depth and % of light at soil.

The input files can be found in the folder: **Data\_Exercise1**

3. **Make a new folder.** Select from the menu 'File', 'New Folder' or right click with mouse in the Project Explorer at 'new project' and select 'Add New Folder'.
4. **Rename the folder** in the properties window (right screen) to 'Lake Markermeer Current'.
5. **Add a scenario** to the folder of 'Lake Markermeer Current'. This will be the structure under which we will make the HSI-model for the habitat type *Chara spp.* Right click with mouse in the Project Explorer at the Folder 'Lake Markermeer Current' and select 'Add New Scenario'. Change the name into 'habitat type Chara spp' in the properties window.
6. **Add a model** beneath the scenario for the habitat type. Right-click the scenario and add a new model. Select a Broken Linear Reclassification model from the pop-up window. This kind of model is needed for both of the dose-effect relations for light at soil and water depth.
7. **Rename the model** 'Light' in de properties window. We start with the function for the percentage of light at the soil.

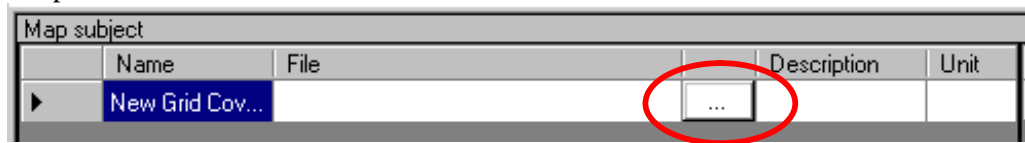
Use the input map: percentage of light at soil: LightAtSoil.bil (%)  
water depth: WaterDepth.bil (cm). Be aware that depth is represented in positive values.





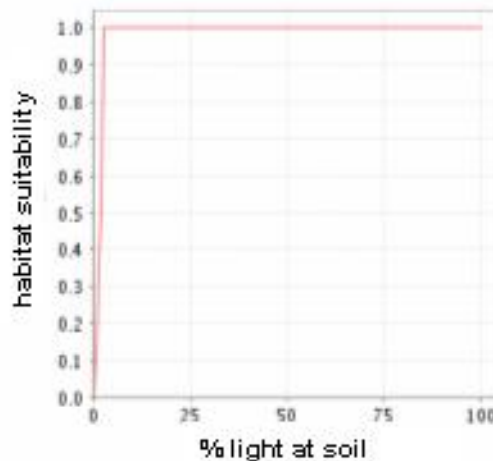
Water depth Lake Markermeer in summer, current situation.

8. **Define input:** Open the model for light by double clicking at it. Define the name of the input variable, by entering it in the field 'Name' in the first row (type 'Light'). Add the needed map from the directory and a description and unit. To insert a map in this working screen, we can easily browse to maps by clicking at browse button of the input variable:



A pop-up window for variable selection appears and then we can browse the file we want to insert. In this case LightAtSoil.bil.

9. **Enter dose-effect relation:** add x and y values of the broken linear function in the broken linear table.



%licht op de bodem	HGI
0	0
1	0.2
2	0.5
3	1.0
100	1

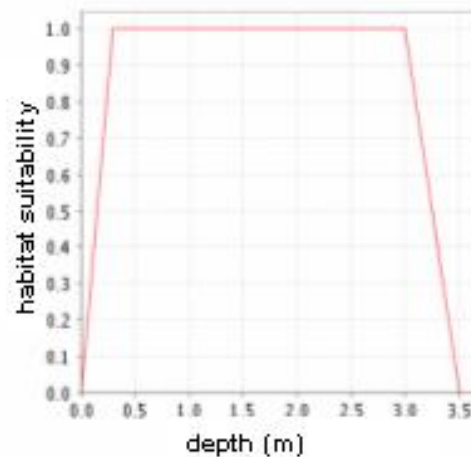
10. **Define output:** enter a variable name, HSI\_Light, and description 'habitat suitability for chara spp. regarding light at the soil'. The output maps location can be defined by typing the location of the file. This is not necessary; if no location is given the file is written in the directory of the project. This is useful when you give the project to other colleagues with the function export. In that case it is not necessary to have the same directory structure on your pc. An advantage in specifying a path and name is that you can easily locate the output maps. But you can also do that by viewing the path of the map (there it is a specified number in the chain).

11. **Add another response curve for water depth.** This is also a broken linear function. Enter also the input and the variable names (WaterDepth as input and HSI\_Depth as

output). Rename the model in the properties window 'Depth'. Enter the dose-effect relation. Use the input map WaterDepth.bil

**i** Notice that the water depth map is in cm. The maximum depth is 25 m.

**i** The result map gets only values for the range of the broken linear function. For example if the function stops at 40% then grid cells with a value higher than 40 will get 'no data' as a result.



diepte (m)	HGI
0	0
0.3	1
3.0	1
3.5	0
> 3.5	0

12. **Add a formula based model** to calculate the total habitat suitability, which is the minimum from the suitabilities for water depth and the percentage of light at the soil. Right click at the scenario in the Project Explorer and select "add model". Select from the drop down list the formula based model.

13. **Rename the model** to 'HSI\_totalChara'.

**i** The calculation order of the models is the same as the order of the models in the Project Explorer tree.

14. **Define input by linking maps:** the input for this model is the result from the above models. By linking maps of models, all information on the map (variable name, location, description and unit) is copied and now only has to be changed in place. It also gives insight in the effect chain and it avoids inconsistency in the modelling, by ensuring that all results will be deleted if one of the input maps is changed. Link the maps by dragging the output map to the input map and drop the map there. Click at the HSI\_Depth variable in the Project Explorer, drag it to the standard input variable of the Chara model. You can see from the arrow that you can drop the map. To link



another map, add first a variable name in the working screen (can be just one letter because it will be overwritten by information from the linked file). It is also possible



to link a map by clicking at the browse button and select maps from the list of maps used in previous models. Now link the map of HSI\_Light to the new model.

**i** In the model window the linked maps have a gray colour. If the results of the input model(s) (in this exercise HSI\_Depth and HSI\_Light) become(s) invalid through a change in the input files or a change in the function or classification table, than the results of the model that uses the output will also become invalid. The result maps of the models will be deleted. This is indicated in the Project Explorer with a red cross in front of the map name.

**15. Enter formula:** After the input variables are defined, it is possible to enter the formula to calculate the total habitat suitability. Enter the name of the variable (HSI\_Chara\_Current). Enter the formula in the equation row. Enter:  $\min(\text{HSI\_Light}, \text{HSI\_Depth})$ . For each grid cell the minimum value is calculated and written in the output file.

**i** HABITAT is case sensitive. It is possible to copy the variable names from the input variable list and paste them in the equation row to avoid errors. If the formula is incorrect it turns red, like in the picture below:

Input variable				
	Name	File	Description	Unit
▶	HSI_light	D:\HabitatMarjolijn\Course\Exercise1.prj_d...	...	
	HSI_Depth	D:\HabitatMarjolijn\Course\Exercise1.prj_d...	...	
*			...	

Function equation	
Name	Equation
HSI_h3140_Char	$\min(\text{HSI\_light}, \text{HSI\_DEPTH})$

**✓** To learn more about the formulas, explore the manual of HABITAT. Open the manual through 'Help', 'User Manual'. Or go to windows, 'Start', 'Programs', 'Delft Hydraulics', 'Habitat Spatial Analysis Tool', 'User Manual'. Go to chapter 5 and select from the grid processing tools the formula based function. The formulas correspond with the PCRaster functions. A link to an extended list of these functions can be found there as well.

**Useful Information**

The following PCRaster functions are often used:

'\*'

Multiplies the values of two expressions and sends this product to the result, on a cell-by-cell basis.

'\*\*'

Calculates the n-th power of a first expression, where n is the value on a second expression, and sends it to the result, on a cell-by-cell basis.

'-'

Subtracts the value of the second expression from the value of the first expression and assigns this difference to the result, on a cell-by-cell basis.

'+'

Adds the values of two expressions and assigns this sum to the result, on a cell-by-cell basis.

'/'

Divides the value of a first expression by the value of a second expression and assigns this quotient to the result, on a cell-by-cell basis.

Exp()

calculates the exponent of a value or map

max()

For each cell, determines the maximum value of multiple expressions and assigns it to the corresponding cell for the result.

min()

For each cell, determines the minimum value of multiple expressions and assigns it to the corresponding cell for the result.

If then function:

if(Map1 == 1 then Map2 else 0) is

means if map1 is equal to 1 then take the values from map2 else the value will be 0). HABITAT will change the 'then' and 'else' into a comma, so the function will look like:

if(Map1 == 1, Map2, 0)

A double == means equal to

> means greater than

< means smaller than


For more information, see the [PCRaster Manual](#).


16. **Define the output** at the lower part of the window. In this case it is useful to enter a variable name, description and unit as we are going to use this map to compare scenarios in exercise 3. Enter the variable name HSI\_Chara\_current.

With the implemented model, we can calculate the habitat suitability for habitattyp 3140 'Hard oligo-mesotrophic waters with benthic vegetation of *Chara spp.*' in Lake Markermeer.

17. **Run the scenario:** Right click at the scenario 'Habitattyp Chara' in the Project Explorer and select 'Run Scenario'.


**i** Notice that the scenario and models become darker blue in the Project Explorer while running. Notice also that the icon of the output maps changes.

18. **Analyse results:** open the output map HSI\_Chara\_current and have a closer look at the results by zooming in. Zoom back to full extent with this  button:

19. **Import legend:** Open the legend with the edit legend button . Import a legend for the habitat suitability (this is a \*.leg file). Press 'import' and select HSI.leg, press 'ok'. Note that you can also make your own legend by specifying the number of classes, maximum values of the classes, colours and labels. You can also export your legend and to re-use it in other projects.

20. **Look at values** of the result and check if they correspond with what you expect from the dose-effect relations and the input maps. Open also the result maps for the response curves. It is possible to arrange the windows next to each other to see all




maps in once. Grab the window at the title and drag it to the centre of the window and choose drop left, right, above or below. Zoom again to the centre of the map .

21. You can see the values below in the main working area next to the coordinates when you move your mouse over the map

## 2.2 Implement habitat suitability model for herbivorous waterbirds

**Do the same for the HSI model for herbivorous water birds. The input maps are the water depth and the Habitat Suitability of the Chara spp.**

22. **Add a scenario** to the folder of Lake Markermeer Current'. Change the name into 'water birds' in the properties window.
23. **Add a model** for the response curve. Click right at the scenario and add a new model. Select a Table reclassification model (multiple grid) from the pop-up window.
24. **Rename the model** in the properties window to 'herbivorous water birds'
25. **Define input:** Open the model and define the name of the input variables. First, link the output map of the model for the habitat type Chara spp. to the input map of this model. Click at the HSI\_Chara\_current variable in the Project Explorer, drag it to the standard input variable of the water birds model. The second input map is the water

depth. Click at the browse button  and select the water depth. It is possible to sort the list.





26. **Enter the response curve:** This is a classification table. The output value indicate different habitats for different birds.

Classification table				
	Output Value	Description	HSI_Chara_Current	WaterDepth
▶	0	land	<.>	<.0>
	10	geese, swimming ducks,	[0.5,1]	[0,20>
	20	swimming ducks, geese, s...	[0.5,1]	[20,50>
	30	swans	[0.5,1]	[50,100>
	40	diving ducks	[0.5,1]	[100,200>
	0	not available for ducks an...	[0.5,1]	[200,>
	0	no macrophytes	<.0.5>	[0,>
*				

Pay attention to the notation format given below:

"[" means the value belongs to the range, ">" means it does not. For example:


<1, 3]	All grid cells with a value from 1 to 3 (without 1 and including 3)
[5,>	All grid cells with a value equal or larger than 5
4	All grid cells with exact the value 4
<,>	All values

output value	herbivorous waterbirds in this habitat		waterdepth
10		geese, swimming ducks	<20 cm
20		swimming ducks, geese, swans	20-50 cm
30		swans	50 -100 cm
40		diving ducks	100 – 200 cm

27. **Define the output** at the lower part of the window. Enter 'HSI\_WBirds\_Cur' in the field for the output variable name.

28. **Run the model:** Right click at the model 'herbivorous water birds' in the Project Explorer and select 'Run Model'

29. **Open output map:** HSI\_WBirds\_Cur map

30. **Import legend:** Open the legend with the edit legend button . Import a legend for the habitat suitability from d:\Habitat\course\Data\_exercise1\. Press 'import' and select waterbirds.leg, press 'ok'.


31. **Analyse results:** HSI\_WBirds\_Cur map. What do you see? Are there places on the map where the birds cluster? How come?

## 2.3 Use Toolbox

32. **Save models in Toolbox:** if you are satisfied about the results, you can store the models in the Toolbox. Add a folder to the Toolbox and change the name in the properties window. Take the scenario for both the Chara and water birds from the Project Explorer and drop it into the new folder in the Toolbox.





 The toolbox is a storage area with tools (HSI models). The Toolbox can be used to store your models and scenarios as a template, in order to use them in other projects or other areas. Once the scenarios or models are loaded into the Project Explorer (by dragging and dropping) you can adjust them if needed for your new project or study area. Tools can be either empty models, or completely filled in for a specific species.


### **33. Save the project**

## 3 Exercise 2: Calculating scenarios, compare results and use of toolbox

In this exercise we are going to use the HSI models of exercise 1 to calculate two scenarios and compare the results.

### 3.1 Copy models and use Toolbox

1. **Make a new folder.** Select from the menu 'File', 'New Folder' or right click with mouse in the Project Explorer at 'new project' and select 'Add New Folder'.
2. **Rename the folder** to 'Lake Markermeer Water and Land use'. Change the name of the folder by typing the new name in the properties window.
3. **Copy the habitat type scenario from exercise 1.** Right click at the scenario for the habitat type and select 'Copy scenario'. Right click at the new folder for exercise two and select 'Paste Scenario'.
4. **Use toolbox to re-use a scenario.** Another possibility to re-use the scenarios is by using the Toolbox. Take the scenario for the water birds and drag and drop it to the folder of exercise 'Lake Markermeer Water and Land use'. Make sure you copy this scenario beneath the Habitat type scenario, as the output of this model is used as input for the water birds.
5. **Rename output variables:** Rename the output variables of the total habitat suitability to HSI\_Chara\_Scen and HSI\_WBirds\_Scen.

 It is also possible to copy a folder. Select the folder in the Project Explorer. Press 'ctrl' and drag the folder to the preferred location. This can only be beneath another folder (indicated with a plus sign under the pointer of the mouse).

### 3.2 Define and Run a scenario

To calculate a scenario you now only have to change the input files for the models in the folder 'Lake Markermeer Water and Land use'. For this purpose another water depth map and a map with the percentage of light at the soil is given in the folder: **Data\_Exercise2**

In the scenario an island is constructed in the South-west part of the Lake. In addition, embankments are created to reduce the influence of the wind. Furthermore, the water level is changed from a mean summer water level of -20 cm NAP to -33 cm NAP, which is the lowest possible water level considering the boundary conditions given by shipping and water supply for this lake.

6. **Change input file** for the scenario. Double click at the folder of 'Lake Markermeer Water and Land use' in the Project Explorer. This gives an overview of the input and output maps within the scenario. Change the input map of the water depth map of both HSI models and the map with the percentage of light at the soil for the Chara HSI



model. Re-establish the link between the HSI\_Chara\_Scen as input to the water birds model. (Be aware that you use the input files from the correct folder!)

7. **Open input map:** Double click at each of the input maps and explore the difference between the new input maps and those of the current situation regarding the water depth and the percentage of light at the soil. Notice the island and the embankments (zoom in). The island influences water depth and the embankments influence the habitat by reduction of wind influence on the growth of macrophytes and the erosion of sediment. The impact of the wind is not an environmental factor included in this model.

### 3.3 Compare results of two calculations

In the next part of the exercise you will calculate the difference between two scenarios. You will analyse the spatial differences with the formula based model and the total differences with the spatial statistics model.


8. **Calculate all models.** Select 'Task', 'Start all scenarios' from the menu. All scenarios in the project will be calculated. Look at the progress in the Project Explorer tree.
9. **Analyse the results:** Open the output maps. Arrange the windows to easily compare the results by dragging one of the tabs of the output maps into the map viewer.
10. **Add a scenario** to the folder. This scenario will be used to calculate the differences between the two calculations. Rename the scenario to 'Difference' in the properties window.
11. **Add a formula based model** in the scenario 'Difference'.
12. **Link maps:** link the output maps of chara and water birds of the scenarios in exercise 1 and 2 to this formula by using the Project Explorer tree.
13. **Enter formulas:** add two equations to calculate the difference between both suitability maps for the scenarios. For Chara this could be for example:  

$$\text{Dif\_Chara} = \text{HSI\_Chara\_scen} - \text{HSI\_Chara\_current}$$

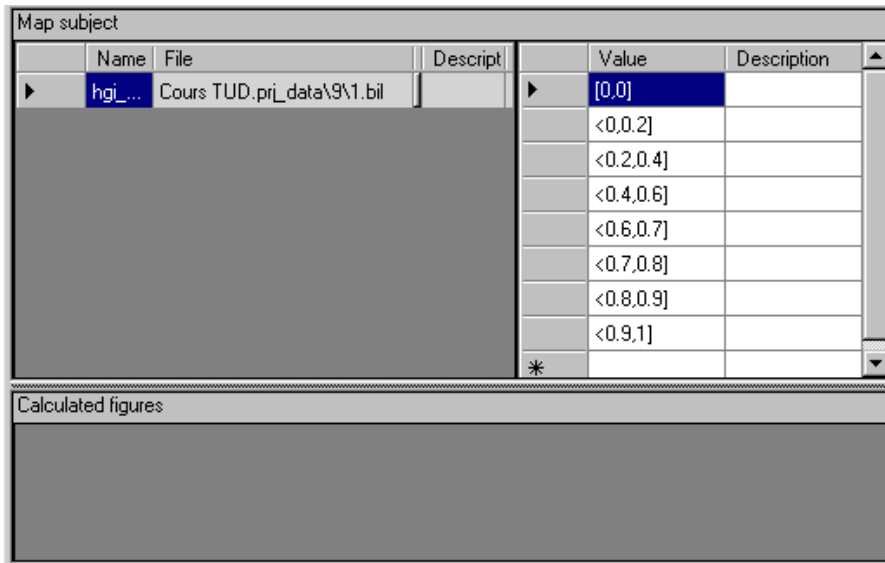
The values in the waterbirds maps are codes for habitats and can therefore not be subtracted. To get an indication of the differences we will enter the following formula:  

$$\text{Dif\_wbirds} = \text{if}(\text{HSI\_WBirds\_Cur} \neq \text{HSI\_WBirds\_Scen}, \text{scalar}(1), 0)$$
This will result in a map which has a value of 1 in areas where two maps differ and a value of 0 where the maps are the same.

14. **Add a spatial statistics model:** right click at the scenario 'Difference' and select 'add model'. Choose from the pull down menu 'Spatial statistics'. Change the name of the model in the properties window to 'Stat Chara Current' and add meta-data.

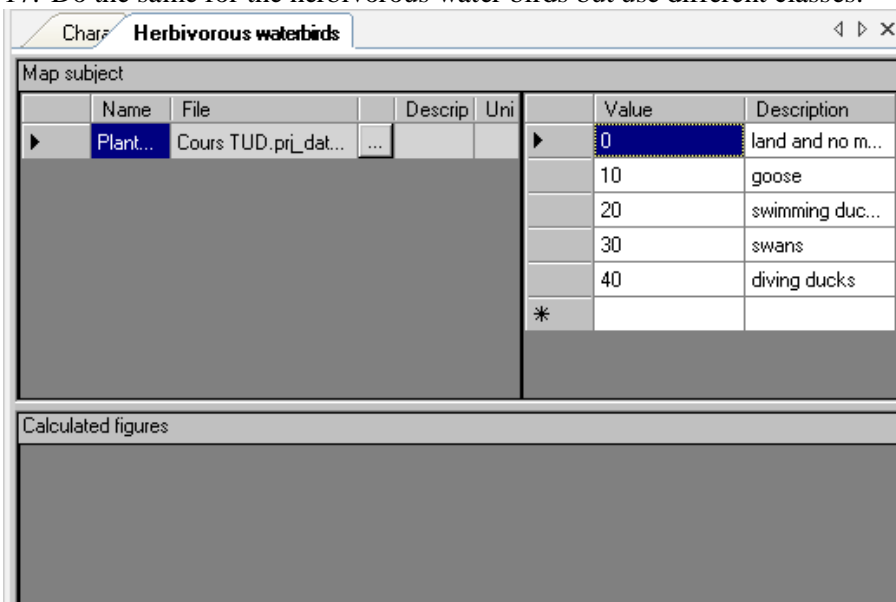
 The Spatial Statistics model type can be used to calculate the minimum, maximum, average, median, standard deviation of the whole map, for the whole map, a part of the map or for subareas defined by another map. Furthermore, it is possible to calculate the area of different classes of values, e.g. the habitat suitability between 0 - 0.7 and 0.7 and 1.

15. **Link the input file** of the map with the habitat suitability for the current situation. Add classes for the habitat suitability like in the picture below:




16. Do the same for the other habitat suitability map of HSI\_Chara\_Scen.

17. Do the same for the herbivorous water birds but use different classes:



18. **Run the scenario** 'Difference' to calculate the difference between the current situation and the possible future situation with the construction of an island and the embankments.

 It is possible to copy the results of statistics to Excel to make figures of the results. Select the data and click 'ctrl+c', open Excel and paste with 'ctrl+v' in Excel .

 Pay attention to the fact that HABITAT uses a comma as delimitator.




Fill in the table below based on the results:

	current situation	island and lower water level
HSI	area (ha)	area (ha)
0		
<0,0.2]		
<0.2,0.4]		
<0.4,0.6]		
<0.6,0.7]		
<0.7,0.8]		
<0.8,0.9]		
<0.9,1]		

	current situation	island and lower water level
HSI	area (ha)	area (ha)
0		
10		
20		
30		
40		

Which water depth results in the best suitable areas for the habitat type of Chara spp.?  
 Why is the effect of the island less than you would expect? What is the most limiting environmental factor?

 Look at the results of the models with dose-effect relations for the different environmental factors.

**Optional:**

19. **Run another calculation with a change in water level.** Try to create an input map of the water depth that has a different water level than the maps used in these scenarios.
20. **Save your project and close your project (choose ‘file’ and ‘close project’)**

## 4 Exercise 3: Ecotope classification


An ecotope classification is a functional classification of an area based on abiotic and biotic environmental conditions. In this exercise you will make an ecotope classification and run this for an imaginary case and for the Westerschelde. The purpose of this exercise is to get acquainted with HABITAT by defining a simple model and statistics.

An estuary can be characterised into ecotopes based on water depth and salt content:

Table 1 Simple ecotope classification

Ecotope Number	Ecotope	Salt content (ppt)	Depth (cm NAP)
1	Intertidal area, brackish	0 t/m 20	-200 t/m 200
2	Intertidal area, salt	20 t/m 35	-200 t/m 200
3	Shallow water, brackish	0 t/m 20	-500 t/m -200
4	Shallow water, salt	20 t/m 35	-500 t/m -200
5	Channel, brackish	0 t/m 20	< -500
6	Channel, salt	20 t/m 35	< -500

In this exercise we will make an ecotope classification with HABITAT based on the criteria in table 1. We will use two input maps from two different areas: an imaginary case and the 'Westerschelde', which is an estuary in the South of the Netherlands.

 HABITAT uses so-called \*.bil format maps as input, which is accompanied with a \*.hdr file. This is a binary form of an ascii-grid file. An ascii-grid file exists of a header with the first two lines indicating the amount of columns and rows (ncols en nrows), subsequently the coordinates of the lower left corner of the grid (xllcorner en yllcorner), the cellsize (cellsize, grids are in a square) and the value used for missing data (nodata value). After the header a matrix of values of the grid is given. The header of the bil file is given in the \*.hdr file (useful to check grid size and coordinates).

Example of an ascii-gridfile:

```
ncols      3
nrows      3
xllcorner  0.0
yllcorner  0.0
cellsize   100.00
nodata_value -999
100  -310  0
-400  -200  -1050
-999  -310  -3000
```

The input maps for the water depth and salt content for the imaginary case, called 'Bak', are given in the folder: **Data\_Exercise3**. 'Bak' exists of 9 raster cells of 100 m × 100 m.

**Salt content: Data\_Exercise\_3\bak \Zout\_Bak.bil**

10.3	18	25.3
12	25.9	19
14	30	30

**Waterdepth: Data\_Exercise\_3\bak Diepte\_Bak.bil**

100	-310	0
-400	-200	-1050
-999	-310	-3000

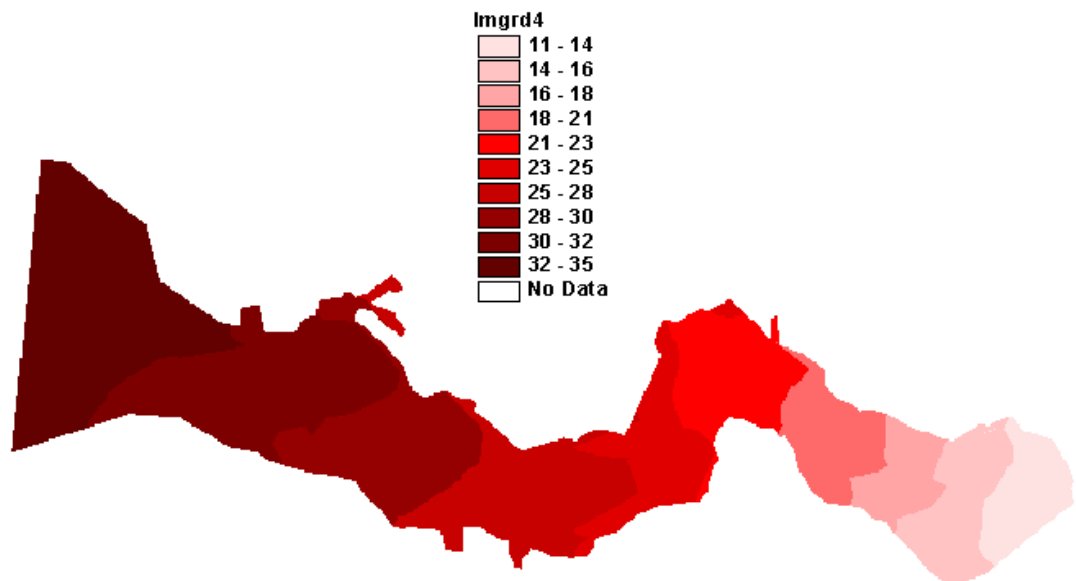
NB: -999 is a missing value.

For the Westerschelde the two input maps can be found at:

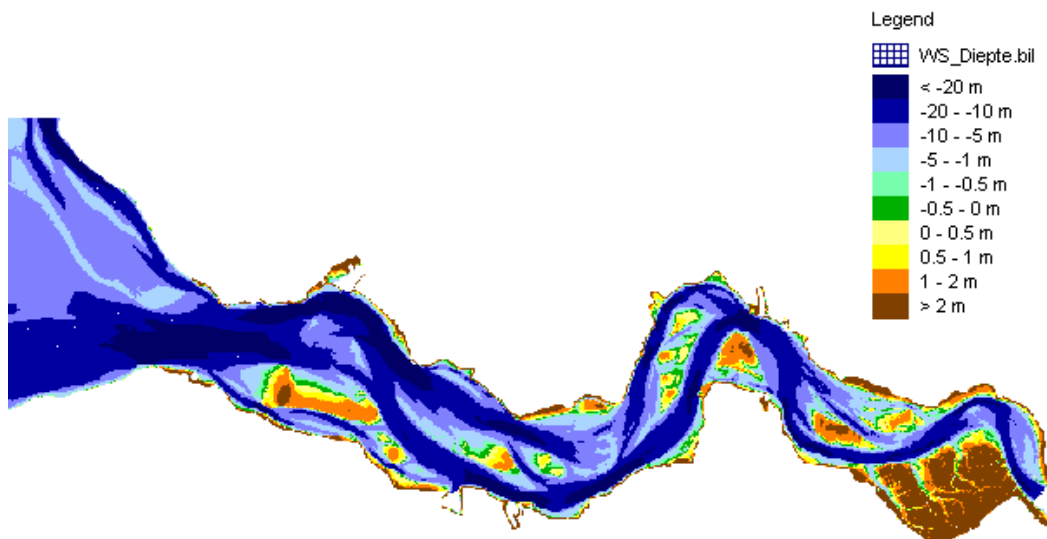
**Salt content:** Data\_Exercise3\Westerschelde\WS\_Zout.bil

**Water depth:** Data\_Exercise3\Westerschelde\WS\_Diepte.bil

The maps of the Westerschelde have a grid size of 25 x 25 m.



Salt content map for the Westerschelde



Water depth map for the Westerschelde

In this exercise we will save our project in the user directory first, then we will make a structure and describe the meta-data and after that we will link the input maps (depth and salt content) and visualize them. We start with the imaginary case.

## 4.1 Imaginary case 'Bakje'

### Preparation

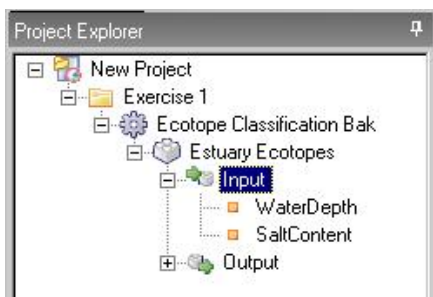
1. **Make a new folder.** Select from the menu 'File', 'New Folder' or right click with mouse in the Project Explorer at 'new project' and select 'Add New Folder'.
2. **Save your project** (e.g. Habitat Exercise3)
3. **Rename the folder.** Change the name of the folder by typing a new name in the properties window. For example: Exercise 3.
4. **Add a scenario** with right click at the folder and select 'Add New Scenario'.
5. **Rename the scenario** in the properties window to Ecotope Classification Bak.
6. **Add a model** to make the ecotope classification. Right click at the scenario and select 'Add model'. Select from the drop down menu in pop-up window the 'Table Reclassification (multiple grids)'.
7. **Add meta data** of the model in the properties window.
8. **Rename** the model 'Estuary ecotopes'. Enter the creator of the model (your name) and the documentation (habitat course) and the purpose of the model (ecotope classification of Dutch estuary).
9. **Define input:** Double click at the model in the Project Explorer to open the work screen. Select the inputmap from Data\_Exercise3\Bak\Diepte\_Bak.bil. Name the map 'Waterdepth'. Add a description and also the unit (m NAP, positive value is below water level).
10. **Add another variable for salt:** Data\_Exercise3\Bak\Zout\_Bak.bil and name it 'SaltContent'.




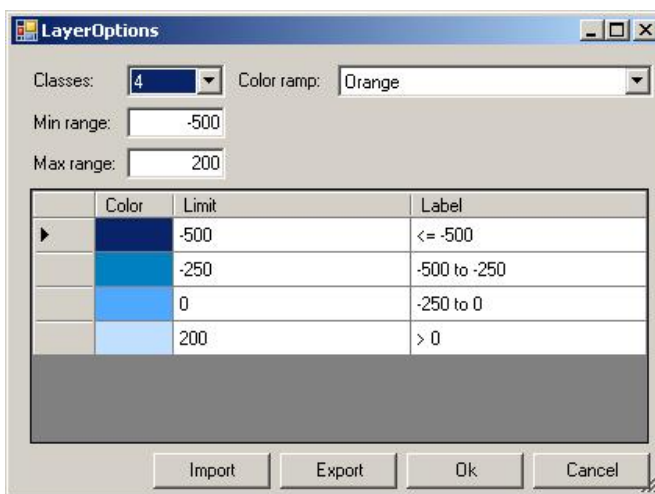


- ❗ HABITAT is case sensitive
- ❗ It is not possible to use a '-' sign in a variable name (map name). 'map-name' will be read as: calculate variable 'map' minus variable 'name'. Use underscore ('\_') in stead of '-'. The same accounts for other mathematic signs like:
  - '\*' or 'x' which mean multiply
  - '^' which indicates square
  - 'exp' indicates exponent
- ❗ Pay attention that there will be no empty space behind a variable name. It may lead to an unrecognisable variable name in a formula-based function.


**11. Visualise input maps:** double click in the Project Explorer at the input maps. A window with the map appears.



**12. Change legend:** Click at the icon for editing the legend  above the map. Change the legend for the salt content. Choose two classes and change the first limit to 20 and the second to 35. Select two different colours. The first colour presents the values smaller than or equal to the first limit ( $\leq 20$ ). The second colour presents the values larger than 20 than or equal to 35 (the second limit). Change the labels to '< 20 ppt' and '> 20 ppt'. Change the legend of the water depth map to four classes with limits -1000, -500,-250 and larger than 0, like in the picture below.



Now it is time to really define the ecotope classification, based on the description of the ecotopes in table 1.

 Notice that output map has still a red cross in the Project Explorer

### Define ecotope classification

13. **Open the ecotope classification:** Double click the Project Explorer at the model called Estuary Ecotopes.
14. **Fill in classification table:** use table 1 to fill in the classification table. In the first column the value for the ecotope to be calculated is given. In the second column it is possible to give a description, like for example the name of the ecotope. The third and fourth columns give the ranges of the values of the input maps. For example: if in a grid cell the salt content is 24 and the depth is 1 than the ecotope should be 'Intertidal area, salt' (table 1).

It is possible to copy and paste cells or rows, with right click at a cell or row and select copy or paste from the menu.

15. **Define the output map:** Add a variable name for the output in the field 'Name' beneath the output variables. Use here: Ecotope.
16. **Save the project**

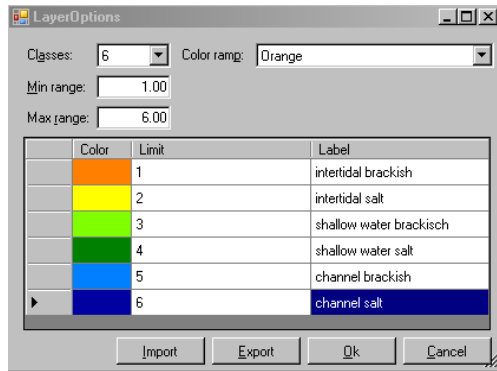
### Run the ecotope classification

17. **Run the ecotope classification:** To make a calculation, you have the following possibilities:
  - a) Run a model
  - b) Run a scenario (group of models)
  - c) Run all the scenarios in the project.

To do this right click at a model or scenario or select from the menu Task, Start all scenarios, Start current scenario, Start current model. As mentioned before: during the calculation the scenario or model lights up darker blue. In the message window the text "Scenario Exercise 3 has finished successfully" or if you run the model: "Model Ecotope Classification Bak finished successfully" will appear when the calculation is finished. Be careful, because this message does not mean that all the calculations are finished successfully. Therefore, keep an eye on the message field while running your models or scenarios, if something is wrong you will see a red circle passing by with a warning text.

Now, that we have done the calculation we can analyse the results:

18. **Open the output map:** Double click at 'Ecotope'. A map with the ecotope classification appears. Change the legend: choose 6 classes and type 0 at 'min range' and 6 at 'max range'. Choose also a colour range you prefer. For example like below (choose a colour ramp or double click at a given colour):



19. **Save the legend:** export the legend as ecotope.leg in order to use the same legend for the Westerschelde case.

**i** Think about a place where it easy for you to store the legends (as in the future you want to import them).

20. **Analyse values** and add them in the grid below.

**i** Notice that you can see the values and coordinates when you move the mouse over the map.

### EcoRes


## 4.2 Westerschelde case


**Do the same ecotope classification for the case of the Westerschelde.**

21. **Make a copy of the ecotope classification:** right click at the model 'Estuary ecotopes' and select 'copy'. Go to the scenario of exercise 3, right click and select 'paste' .

22. **Change the name:** Select the second model and go to the properties window. Change the name to 'Estuary Ecotopes Westerschelde'. If necessary change the rest of the meta-data.

**✓** Make a habit of filling in the Meta information of models, scenarios and folders in the Properties window

**23. Change the input:** Double click at the model to open the work screen. Double click at file path for the input maps and browse to go to the maps of the Westerschelde case. Data\_Exercise3\Westerschelde

 To prevent confusion about the maps you are using, use unique names only.

**24. Name the output:** Eco\_Res

**25. Run the model:** right click at the model and choose 'Run model'.

### 4.3 Analyse results and calculate statistics

**Next step is to analyse the results of the Westerschelde case.** We will do this by looking at the map and by calculating the area of the different ecotopes in the Westerschelde. For this purpose we will add a new model to calculate the statistics of the ecotope map.

**26. Analyse results:** open the output map.


**27. Import legend:** Open the legend with the edit legend button. Import the legend made for the imaginary case by selecting 'import', select the correct legend and press 'ok'.

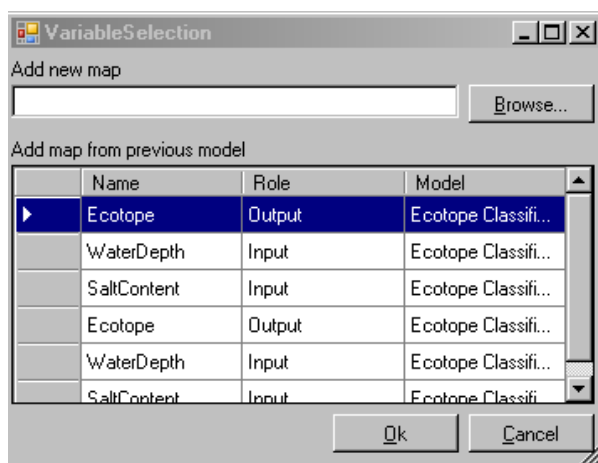
**28. Add a spatial statistics model:** right click at the scenario of exercise 3 and select 'add model'. Choose from the pull down menu 'Spatial statistics'. Change the name of the model in the properties window to 'Stat Ecotope WS' and add meta-data.

In the next part you will calculate the area of the ecotopes you defined before for the whole of the Westerschelde

**29. Open the model:** double click the model 'Stat Ecotope WS'.

**30. Define the statistics:** To calculate the statistics we have to define the input map and define the classes for which we want to calculate the area (in this exercise this corresponds with the ecotopes). Browse to the map output map of the ecotope classification of the Westerschelde.

 It is possible to sort the list at name, role or model.





**31. Run spatial statistics:** first run the spatial statistics without adding the classes for the ecotopes. Right click at the model and select 'Run Model'. The output is presented in the same window as the definition of the statistics and not in the output map.

**i** Where does HABITAT save the output of the statistics? Look in the properties window. This is also the location where you can determine your own location.

What is the total area of the Westerschelde? What is the minimum and maximum value of the ecotope map?

Let's calculate the area of the intertidal ecotopes.

**32. Copy the spatial statistics model**

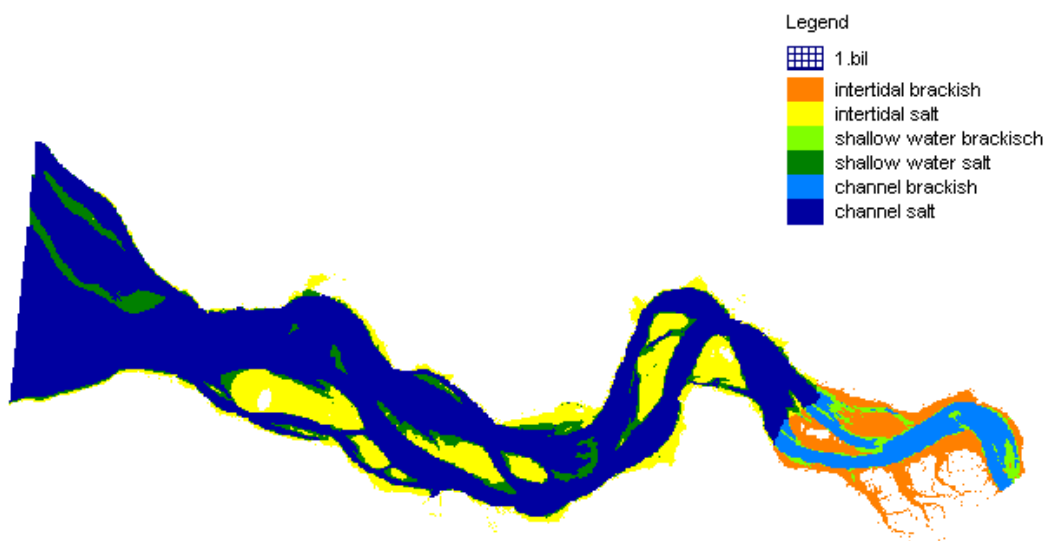
**33. Add classes for the ecotopes,** like in the figure below:

Map subject				
	Name	File	Descriptio	Unit
▶	Ecotope	D:\HabitatMarjolijn\Co...	...	
▶	1			Intertidal area, ...
	2			Intertidal area, ...
	3			Shallow water,...
	4			Shallow water,...
	5			Channel, brac...
	6			Channel, salt
	*			

**34. Run the model**

**35. Analyse the results.** How large is the area of the intertidal ecotopes? (The results are given in m2)

**36. Save the project and close HABITAT:** Select 'File', 'Save project' and close HABITAT.



Ecotope map for the Westerschelde



**From here you can choose to expand on the Westerschelde exercise that will continue in exercise 4**



## 5 Exercise 4: Sea level rise and ecotopes

In this exercise you will expand on exercise 3. As is known by almost everyone, sea level rise in the near future is to be expected. This rise in sea level also effects the composition of ecotopes. As such, this exercise is about sea level rise and the consequences it has for ecotopes in the Westerschelde. Maps and legends you can find in the folders “Westerschelde” and “legends”.

Firstly, you will make a scenario for the current situation, followed by a scenario of 50 cm sea level rise and a scenario of 150 cm sea level rise. In this exercise, changes in ecotopes are dependent on water depth, water dynamics, salt content of the water and the amount of time per year shores fall dry.

1. **Open** a new HABITAT file.
2. **Create a folder, a scenario and a classification (single-grid) model** and give them names you find appropriate for the current situation.
3. **For the model browse to the map: WS\_Zout.bil.** Fill out the table according to the information below:  
Water with a salt content of 0.54 ppt or less is fresh water, between 0.54 and 5.4 ppt is slightly brackish, between 5.4 and 18 ppt is brackish, between 18 and 30 ppt is salt water and euhalien waters have salt content above the 30 ppt.  
Give the input and output maps names and make a suitable legend
4. **Add a new classification (single-grid) model** and use the input map WS\_Diepte.bil. This map represents the amount of time per year shores fall dry. Now, fill out the table with the information find below (be aware that depth is in given in negative figures):  
85-100% dry fall a year occurs in areas where the elevation is 202 cm. 75-85% dry fall a year happens between 148 and 202 cm and between -120 and 148 cm dry fall occurs for 25-75% a year. Dry fall between 1-25% occurs between -237 and -120 cm and  $\leq 1\%$  dry fall occurs in places where the elevation is beneath -237 cm.  
Check the names of the input and output maps and consider whether the legend is appropriate.
5. **Add yet another classification (single-grid) model** and use also the input map WS\_Diepte.bil. This time the map represents depth. Fill out the table according to: Very deep water occurs by depths of -1500 cm and lower (class 1), deep water between -1500 and -737 cm (class 2), shallow water between -737 and -237 cm (class 3) and littoral waters can be found by depths of -237 cm and up (class 4).  
Check again the names of the input and output maps. Is the legend clear?
6. **Insert a new model**, this time a classification (**multiple-grid**) model. Browse for the following input map: v<sub>max</sub>\_2004\_def\_2.bil. This map represents the hydrodynamics of the area. Then link the output map of the depth model to this model. Then fill out the table as follows:

Output value	Description	V <sub>max</sub> 2004	Depth
1	Sub-littoral low dynamic	<,80]	[1,3]
2	Sub-littoral high dynamic	<80,>	[1,3]
3	Littoral low dynamic	<,50]	4
4	Littoral high dynamic	<50,>	4

What does the output map represents?





7. **Define the ecotopes.** Add another classification (**multiple-grid**) model and link the 4 output maps of the previous models to this model. Then insert the following classification table (if this handout is digital: copy paste will do):

Output value	Description	Salt	Dry fall	Depth	Dynamics
1	Brackish_vdeep_LD	3	<, >	1	1
2	Brackish_vdeep_HD	3	<, >	1	2
3	Brackish_deep_LD	3	<, >	2	1
4	Brackish_deep_HD	3	<, >	2	2
5	Brackish_Shallow_LD	3	<, >	3	1
6	Brackish_Shallow_HD	3	<, >	3	2
7	Brackish_Lit_LD_low	3	2	4	3
8	Brackish_Lit_LD_middle	3	3	4	3
9	Brackish_Lit_LD_High	3	4	4	3
10	Brackish_Supralitoraal_LD	3	5	4	3
11	Brackish_Lit_HD_low	3	2	4	4
12	Brackish_Lit_HD_middle	3	3	4	4
13	Brackish_Lit_HD_High	3	4	4	4
14	Brackish_Supralitoraal_HD	3	5	4	4
15	Zout_vdeep_LD	[4,5]	<, >	1	1
16	Zout_vdeep_HD	[4,5]	<, >	1	2
17	Zout_deep_LD	[4,5]	<, >	2	1
18	Zout_deep_HD	[4,5]	<, >	2	2
19	Zout_Shallow_LD	[4,5]	<, >	3	1
20	Zout_Shallow_HD	[4,5]	<, >	3	2
21	Zout_Lit_LD_low	[4,5]	2	4	3
22	Zout_Lit_LD_middle	[4,5]	3	4	3
23	Zout_Lit_LD_High	[4,5]	4	4	3
24	Zout_Supralitoraal_LD	[4,5]	5	4	3
25	Zout_Lit_HD_low	[4,5]	2	4	4
26	Zout_Lit_HD_middle	[4,5]	3	4	4
27	Zout_Lit_HD_High	[4,5]	4	4	4
28	Zout_Supralitoraal_HD	[4,5]	5	4	4

Check the legend. Is it workable? If not, adapt it.

8. **Add a statistical model** for easy comparison with the other scenario's. Use as input the ecotopes output map.
9. Now, for the other two scenario's you can copy the newly build scenario and adapt it, so it will fit changes in sea level rise. Make one scenario for +50 cm sea level rise and one scenario for +150 cm sea level rise. Hint: which maps are influenced by changes in water level?
10. **Describe** some differences between the scenario's.

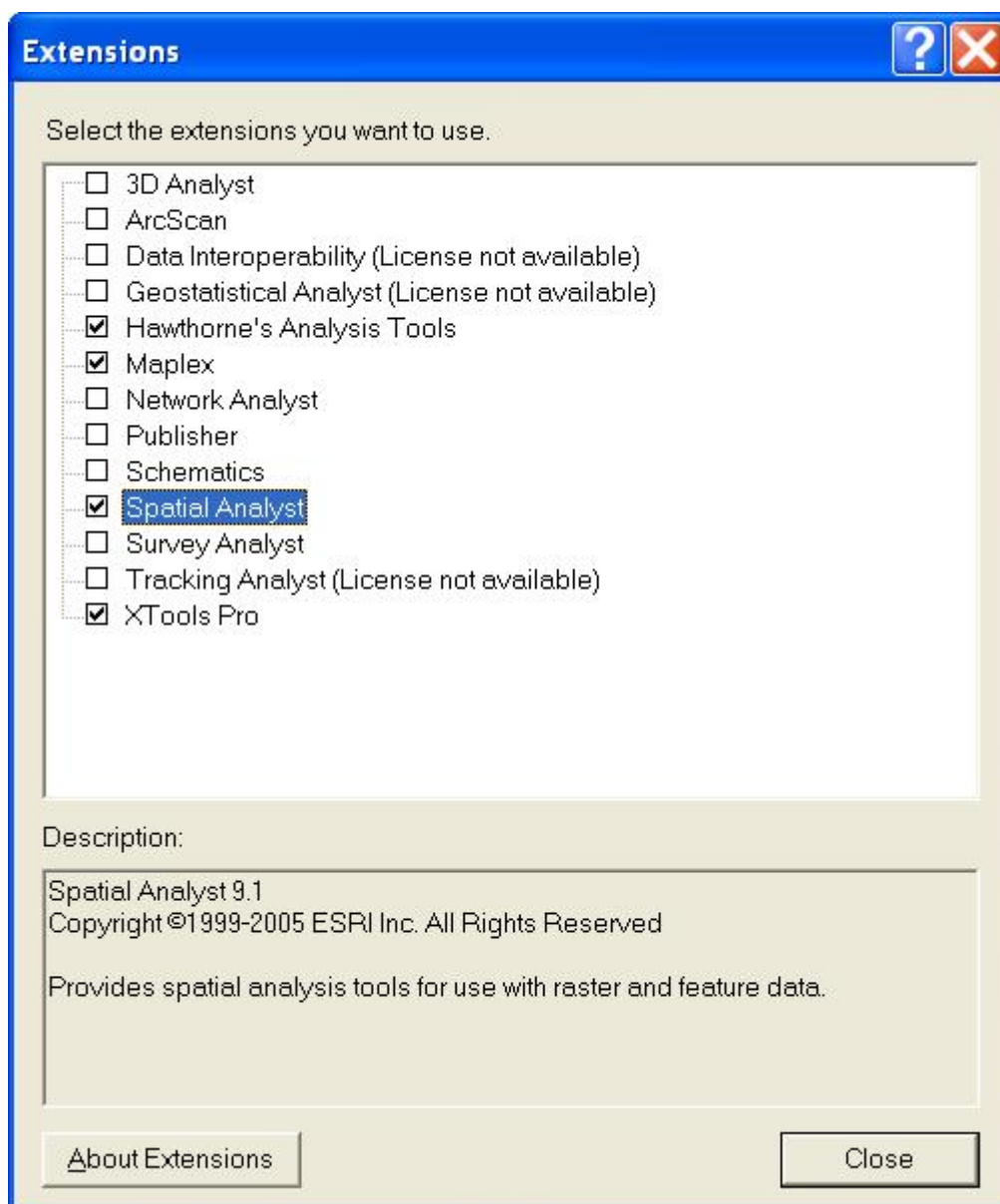
## 6 Exercise 5: Import results from and to ArcGIS

### 6.1 Prepare input in ArcGIS

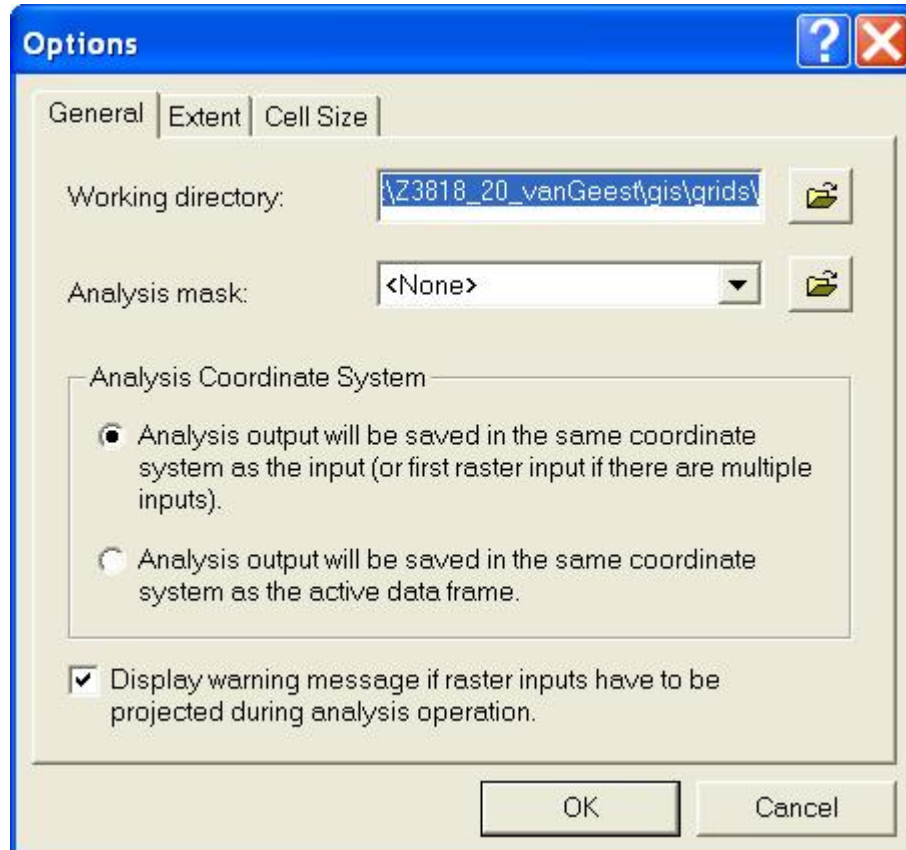
To generate a wanted grid file, there are 2 common types of files that can serve as basic input. It involves a vector or an existing grid file. A vector file example is a shapefile or an ArcInfo coverage. A grid file example is a ArcInfo grid coverage.

Procedure for converting a vector file.

1. Within Arcgis under the **Tools** menu the **Extension** for **Spatial Analyst** must be selected.



- Within the **Spatial Analyst** menu the **Options** should be set. In this environment the properties of the resulting grid will be set. In this stage it is important to think about the NODATA (use possible the **Analysis mask**) and what kind of cell size should be used. This is also the place to set the number of rows and columns and position the grid in the “real” world.



- Convert the vector file by using the menu **Spatial Analyst** → **Convert** → **Features to Raster**

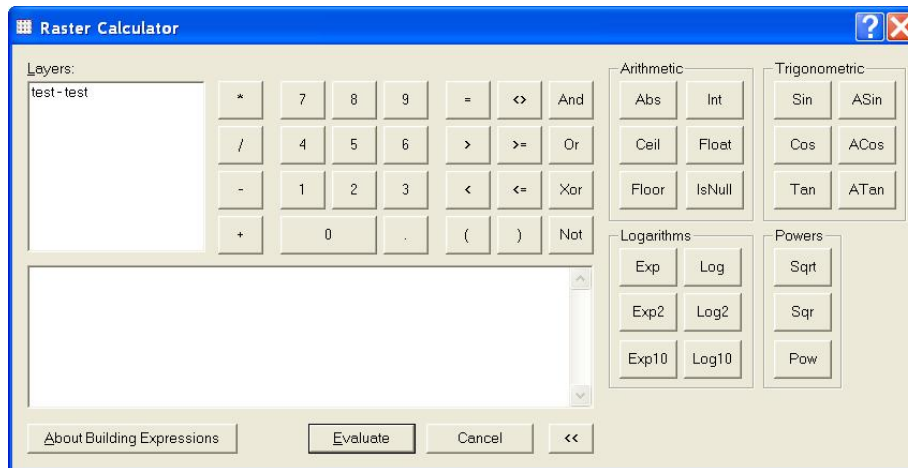


- Convert the created grid file to an .ASC or .BIL file. See Chapter 5.2

Procedure for converting a grid file.

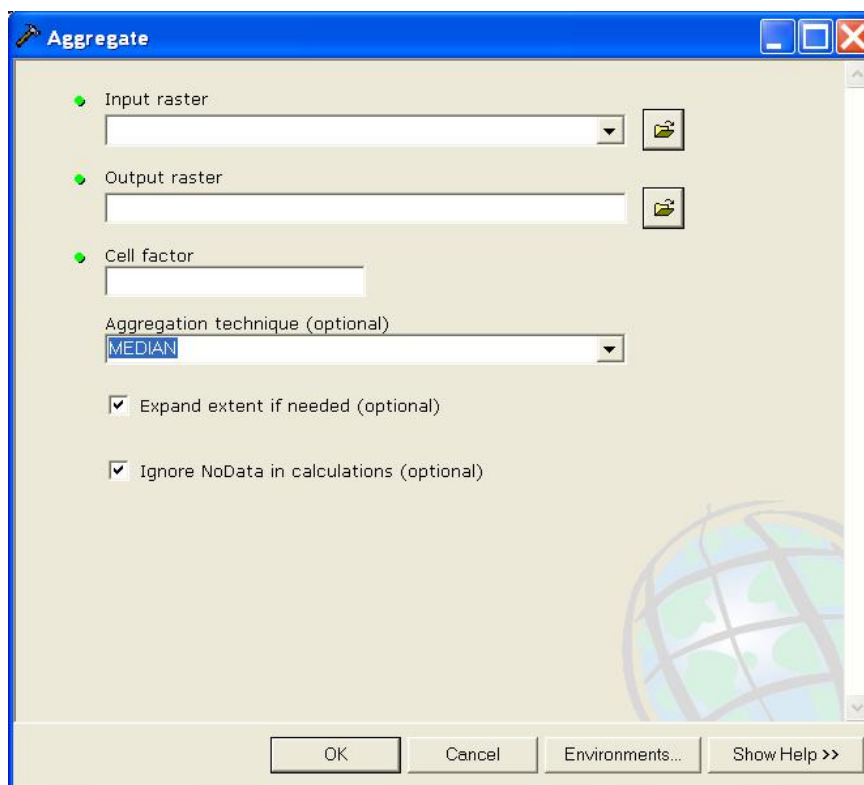
An existing grid can be refined or unrefined.

1. See step 1 in the previous approach.
2. Use the menu **Spatial Analyst** → **Raster Calculator**



To reduce the cell size, the ArcToolbox can be used.

3. **ArcToolbox** → **Spatial analyst tools** → **Generalization** → **Aggregate**



Take good care for making the right Aggregation technique choice.



The previous text is merely an example of how to work. An alternative in creating a grid might even be EXCEL. The 2007 version of EXCEL can handle about 16,000 columns and about 1,000,000 rows.

## 6.2 Convert maps to and from ArcGIS

With ArcGIS 9.2 it is possible to read the bil files. For older version of ArcGIS or ArcView it is possible to convert grids in ArcGIS to ASCII and convert them to bil format.

Select 'Tools', 'Habitat', 'Tools', 'Convert map' . A pop-up window appears. Select tabblad conversion. Type under 'filename' the name and location of the input file eg. d:\course\EcoRes.bil) and under 'destination path' the name and location of the output file d:\course\EcoRes.asc

See for more information the manual chapter 10.

## 7 More information

Visit our website: [habitat.deltares.nl](http://habitat.deltares.nl)

For questions send an email to: [habitat@deltares.nl](mailto:habitat@deltares.nl)