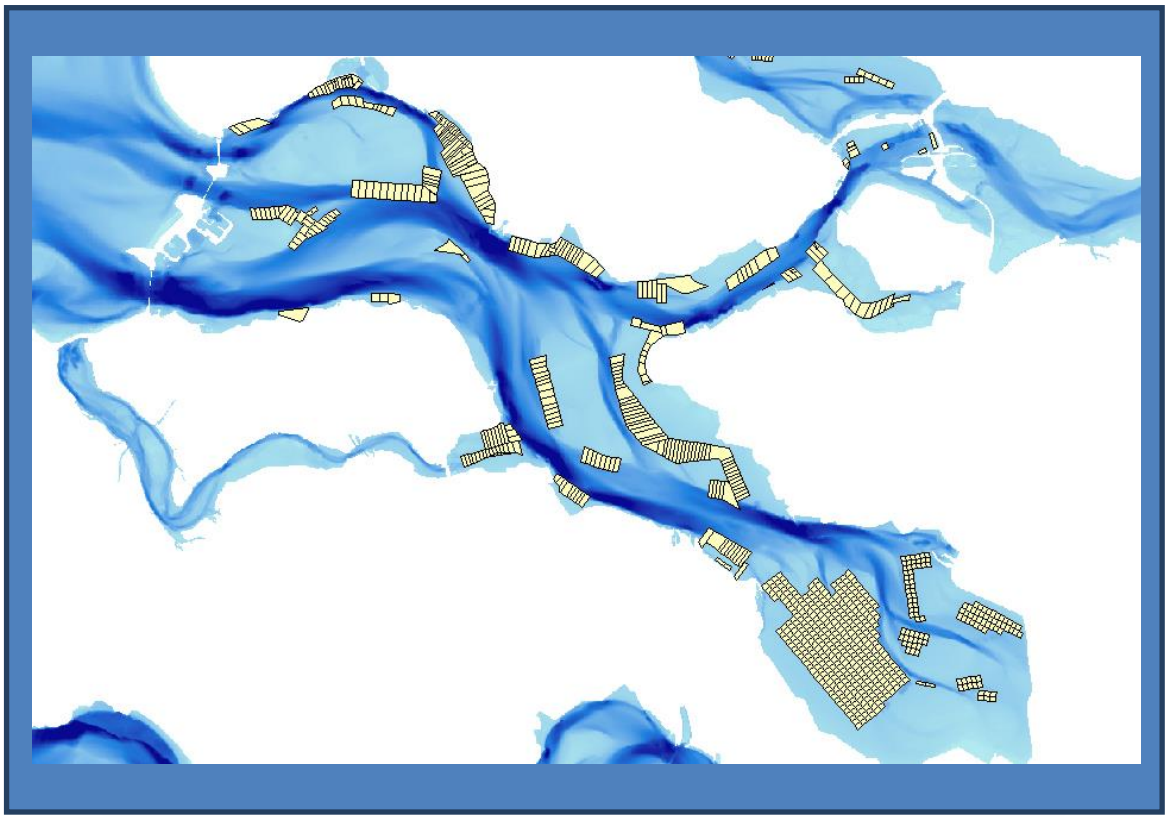
GIS Mapping on Mussel Culture

ProFMos: Data Management, GIS Mapping and
Spatial Analysis of Mussel Growth in the Eastern Scheldt



Ingrid Wong

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DELTA ACADEMY

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1.0 INTRODUCTION

Aquaculture is the farming of aquatic organisms such as fish, molluscs, crustaceans and aquatic plants being practiced all around the world (FAO, 2014). Similar with agriculture and grazing, the purpose of aquaculture is to use different forms of intervention in stocking, feeding, predation and disease control, etc. to enhance production mainly for consumption (FAO, 2014). In Europe, marine aquaculture is a fast growing economic sector especially in coastal Atlantic countries such as Norway, Spain, France, the Netherlands, Ireland, etc. Among all the different aquatic animal species being farmed in Europe, shellfish accounts for half of the total volume of production, in which 90 percent are oysters and mussels.

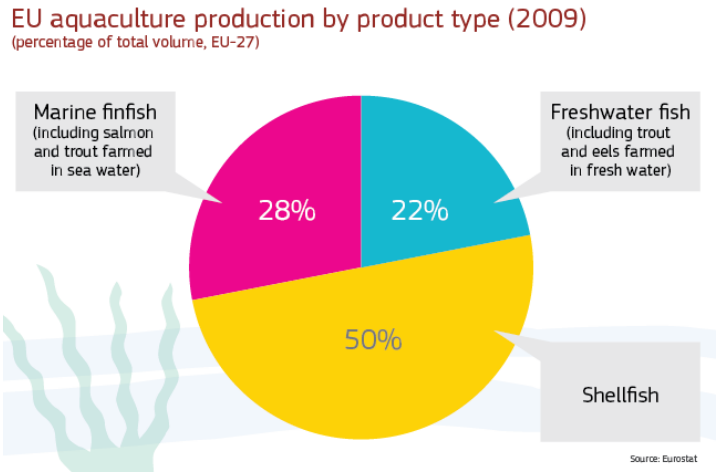


Figure 1: EU Aquaculture Production by Product Type (2009). (Eurostat, 2009).

As mentioned above, oysters and mussels contributes to the majority of shellfish production in Europe. According to the European Commission, Atlantic blue mussel (*Mytilus edulis*), Mediterranean mussel (*Mytilus galloprovincialis*), and Pacific cupped oyster (*Crassostrea gigas*) are the three common species of mussels and oysters being farmed in European coastal areas. Figure 2 displays the overall mussel culture production according to volume in European Union countries, with Spain being the top producer from producing Mediterranean mussels.

Figure 2: EU Mussel Aquaculture Production (2009). (Eurostat, 2009).

In the Netherlands, bordered by the North Sea in the north and west, the cultivation of blue mussels is widely practiced in the Wadden Sea and the Eastern Scheldt estuary. With an annual production of around 80 x 10^6 kg, the Netherlands is one of the

European countries that produces the largest amount of blue mussels. However, recent studies showed that over the past fifteen years, the total production of mussels in Europe has decreased by 50% (Smaal, Schellekens, van Stralen, & Kromkamp, 2013). Therefore, researchers are trying to understand the factors that affect growth patterns of mussels, such as farming methods, food availability, predation, other specific environmental conditions, etc.

This project, named "Data Management, GIS Mapping and Spatial Analysis in the Eastern Scheldt" is part of the "Production Factors of Mussel Culture in the Eastern Scheldt Project" (ProFMos) hosted by the Aquaculture Research Group, part of the Delta Academy of the HZ University of Applied Sciences. The objective of the ProFMos project is to determine the production factors of mussel culture in the Eastern Scheldt as to optimize production yield. Relying on the mussel growth data provided by a group of mussel farmer representatives at different culture plots, the research group seeks to use GIS as an aid to visualize and analyze mussel growth in the Eastern Scheldt.

1.1 RESEARCH LOCATION

The Eastern Scheldt is an estuary located Zeeland, Netherlands. With a size of 350 km^2, it is a hub for aquaculture, especially for shellfish bottom culture, in which 22.5 km^2 consists of mussel culture plots (Wijsman, Smaal, & Brummelhuis, 2007).

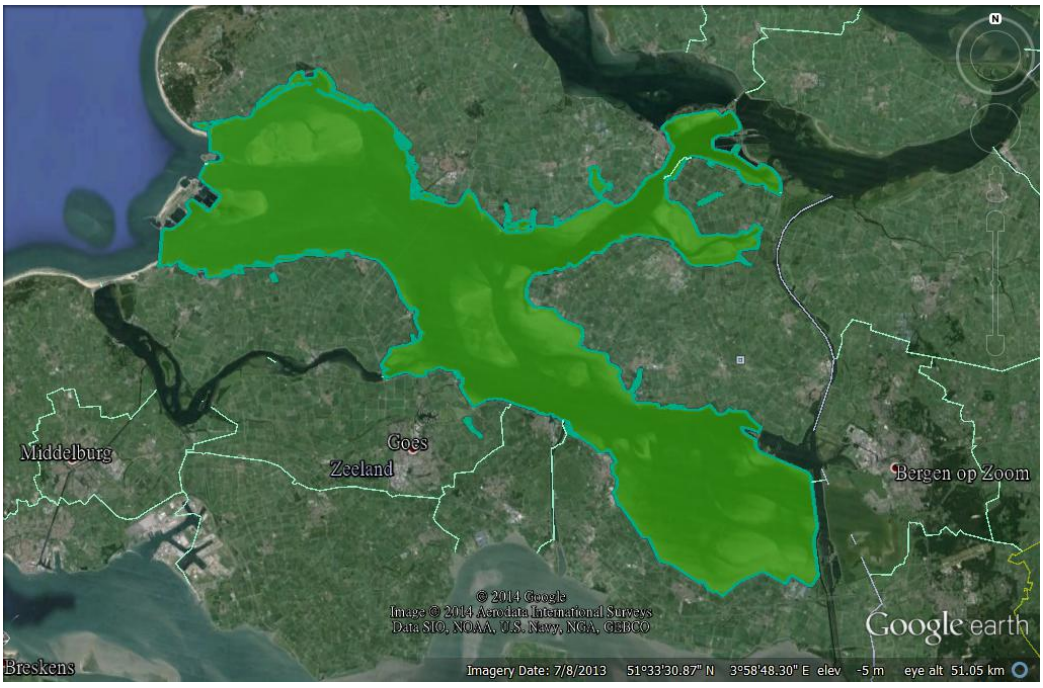


Figure 3 : Google Earth Map of the Eastern Scheldt. (Google Earth, 2014)

1.2 RESEARCH OBJECTIVES AND QUESTIONS

The ProFMos project aims to optimize the yield within the carrying capacity of the Eastern Scheldt through improving the efficiency of the culture cycle. As to achieve the main objective, nine specific research questions were set up, and this GIS project is set up to focus on one of the nine questions:

> What is the spatial distribution of growth and loss in the Eastern Scheldt?

It is expected that the ultimate product of this project is to have at least one GIS map created that will be able to provide spatial information on the overall mussel growth and loss in the Eastern Scheldt or the average growth rates of mussels on individual mussel plots for the ProFMos research group. Using different layers of colours, symbols or wordings, this project also aims to explore the following sub-question:

> What is the best way to effectively display spatial information of mussel growth and loss?

Before achieving the final product of this project, management of the data provided by mussel farmers is required. To collect mussel measurements at different culture plots operated by different farmers, each farmer is distributed with an electronic Excel data spreadsheet, and they are required to fill out the spreadsheet according to the growth stages, culture plot locations, seed origins, dates of measurements, amount in standardized can, gross amount in tons, and treatments practiced. Below is an example:

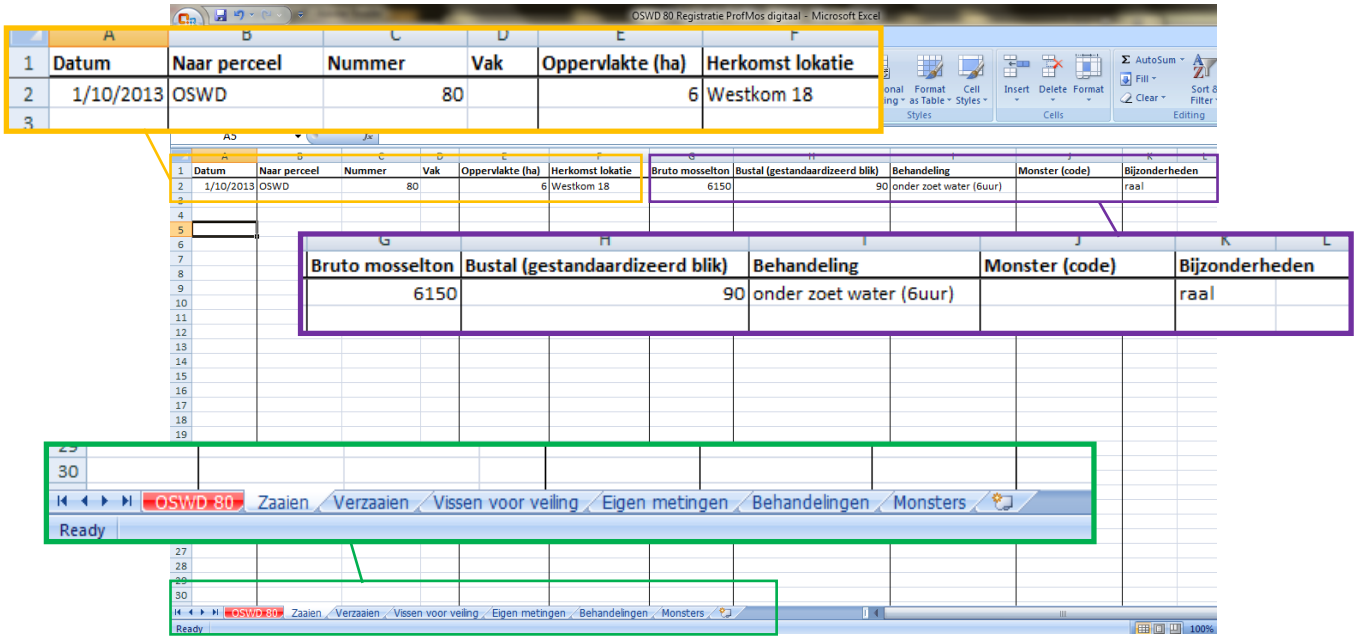


Figure 4: Excel spreadsheet of the data record sheet for mussel farmers.

The data collected has to be sorted onto a database, then the database has to be imported to GIS in order to produce spatial maps. Below are screenshots of the GIS map of culture plots in the Eastern Scheldt provided by the ProFMos research group:

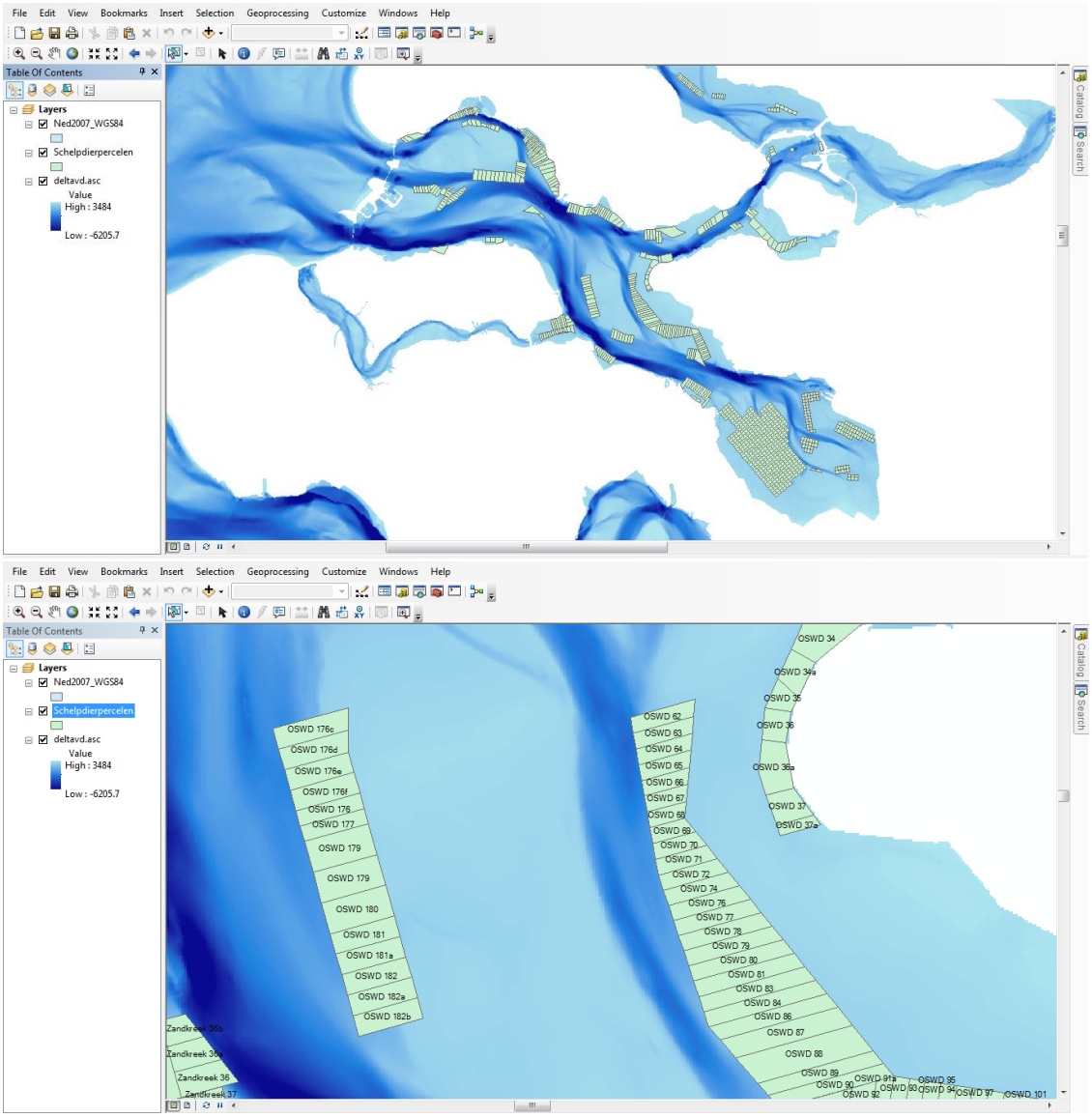


Figure 5: ArcGIS map view of the Eastern Scheldt with culture plots.

Furthermore, due to the reason that there is a lack of standardized data recording formats on the spreadsheets, inputting the records into the research database becomes more labour intensive and complicated. Therefore, this project also attempts to rearrange the set-up and standardize the data recording system for the farmers. So that it can be more user-friendly for both researchers and farmers in the future.

2.0 APPROACHES

This project was divided into three main parts of approaches according to the software to be used – Microsoft Excel, Microsoft Access, and ESRI ArcGIS stages. The following are all the activities that were conducted according to chronological order, which also meant that part 2 started when part 1 was completed, vice versa. As the methods used in this project are fairly specific and exclusive, a detailed user guide for Access and ArcGIS were written in the appendix for future users that require similar actions that was conducted in this project.

2.1.1 EXCEL DATA MANAGEMENT

This is the first sub-part of part 1, software involved: Microsoft Excel 2007-2013. The work that was done was data check of the Excel spreadsheets the mussel farmers submitted to the research group. In this section, all the data has to be modified into a unified format and without any errors because it was mandatory to prevent data duplication for database creation in part 2. Below are some screenshots of some of the errors that needed to be fixed.

1	Datum	Perceel	Nummer	Vak
2				
3	Jan/feb 2014	ISWD	81	

Figure 6: Excel datasheet from farmers - plot name spelling error.

3	25-7 2013	OSWD	1	geul
4	3/12/2013	OSWD	1	geul
5	4/3/2014	OSWD	1	geul

Figure 7 (above): Excel datasheet from farmers - incorrect date format.

1	Datum	Naar perceel	Nummer	va
110	10/12/2013	zandkreek	21	
111	10/12/2013	hammen	29	
112	11/12/2013	OSWD	180	
113	12/12/2013	Hammen	180A	
114	13/12/2013	OSWD	180	
115	17/12/2013	zandkreek	21	
116	19/12/2013	OSWD	180	
117	7/1/2014	zandkreek	21	
118	9/1/2014	oswd	239-242	
119	9/1/2014	OSWD	180	
120	9/1/2014	OSWD	180	
121	9/1/2014	OSWD	180	
122	16/1/2014	OSWD	239-242	
123	16/1/2014	OSWD	180	
124	16/1/2014	OSWD	180	
125	16/1/2014	hammen	109	
126	16/1/2014	hammen	109	
127	16/1/2014	OSWD	180	
128	16/1/2014	OSWD	180	
129	17/1/2014	zandkreek	21	
130	21/1/2014	Hammen	180A	
131	22/1/2014	hammen	109	
132	23/1/2014	zandkreek	21	

Figure 8 (right) : Excel datasheet from farmers - inconsistent plot name letter cases.

Due to the reason that the amount of data was not large, most of the modifications were done manually instead of using built-in functions.

Methods:

1. Sort: Group and sort the plot locations according to plot numbers so that data at the same location is grouped together as to spot errors easier

2. Format check: Make sure all dates are of format “dd/mm/yyyy”, manually modify discovered errors
3. Spell check: Spot spelling errors of location names, manually modify discovered errors
4. Letter case check: Check location names and plot/section numbers, the same location has to have the same case, manual modifications included:
    - 'OSWD' cannot be 'oswd'
    - Beginning of full location names should be capitalized, e.g. ‘Hammen’ cannot be ‘hammen’
    - Sub-sections should be in lower cases, e.g. 'OSWD 180b' not ‘OSWD 180B’

The completion of the above steps indicated the completion of this part, no difficulties or errors were encountered.

2.1.2 EXCEL DATA SORTING INTO INDIVIDUAL SPREADSHEETS

This is the second sub-part of part 1, software involved: Microsoft Excel 2007-2013. This part consists of creation of new Excel documents for each plot mainly to create a better documentation system for future use. Each document consists of data for one plot only. The data in each document should be sorted in chronological order as to better organize the data as well as to display a timeline of mussel transfer and amount in each plot.

Methods:

1. Extract list of unique plot names: After sorting of mussel measurement data according to individual plot names and numbers where they were transported to in the previous part, the following are the steps done to extract all the plots appeared in the spreadsheets:
    - Some farmers might already have a list of the plots they registered in the spreadsheets, check if a tab named 'perceelgegevens' is available, if not, proceed to the next step
    - Advanced filter: To determine number and name of individual plots that exist on each spreadsheet – Highlight 'Van Perceel' and 'Nummer' together. Then click [Data] > [Advanced filter] > [unique records only]. It is possible to either replace the filter results in place or copy the filter results to another location.

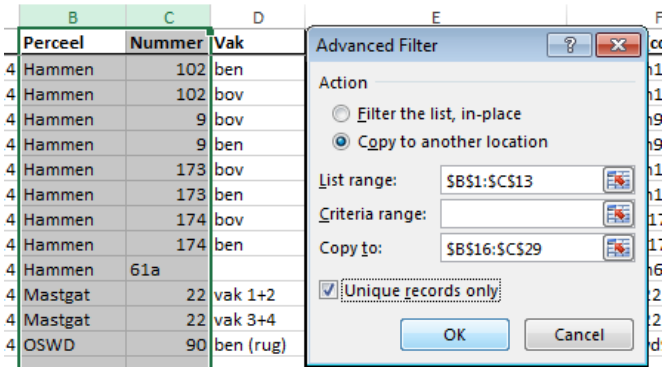


Figure 9: Excel spreadsheet advanced filtering unique plot values.

2. After filtering, the results would be displayed like in Figure 10. Copy the unique values and create a checklist of the plots like in Figure 11.

Perceel	Nummer
Hammen	102
Hammen	9
Hammen	173
Hammen	174
Hammen	61a
Mastgat	22
OSWD	90

Figure 10 (left): Excel spreadsheet advanced filtered unique plot values.

	Location	Number	Section
	Padmos		
	Hammen	9	bov+ben
	Hammen	61a	
	Hammen	102	bov+ben
	Hammen	173	bov+ben
	Hammen	174	bov+ben
	Mastgat	22	1+2+3+4
	OSWD	90	ben (rug)
	Barbe		
	Hammen	29	
	Hammen	30	
	Hammen	55	1+2+halfwas+zaad
	Hammen	109	
	Hammen	180a	
	OSWD	62-63	
	OSWD	71-72, 74	stated doesn't own 73
	OSWD	83	
	OSWD	91a	
	OSWD	93	
	OSWD	94	
	OSWD	98	
	OSWD	105-108	
	OSWD	112	
	OSWD	119	
	OSWD	180	
	OSWD	182b	
	OSWD	188	
	OSWD	201-202	
	OSWD	239-242	
	Zandkreek	20	
	Zandkreek	21	
	Vette		
	Oosterom	27	
	OSWD	1	
	OSWD	97	geul
	Zakboekje		
	Hammen	110	geheel
	Hammen	181-182	ben
	OSWD	176c	bov

Figure 11 (right): Excel spreadsheet list of unique plot values.

3. Create new Excel documents manually according to the plot names and numbers. Copy and paste sorted information corresponding to the new Excel documents.
4. Sort measurement dates of data on the new Excel documents from oldest to newest.

As it was anticipated that a large number of documents would be created, during the making of the individual documents, a new method came out that all the data is to be grouped to one single Excel document. The following are the descriptions of the newly designed Excel document:

- Each tab represents a registered plot.
- The design of the plot spreadsheets are almost the same as the individual documents, except that growth stages are grouped together instead of in separate tabs.
- Data validation: a drop down list was created on the growth stages as to prevent spelling errors. This method has inspired the of the next sub-part of the Excel data management which will be introduced later.

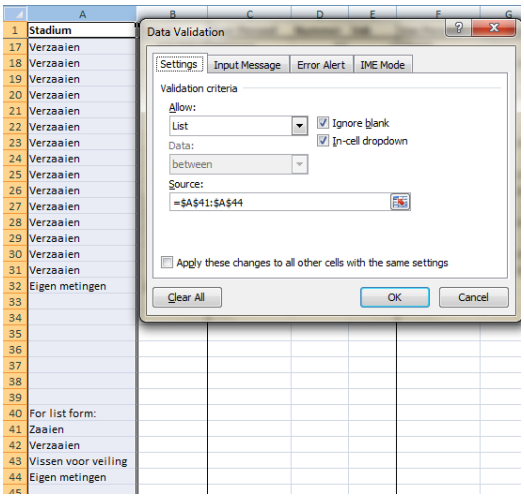


Figure 12: Creation of data validation drop down list.

2.1.3 EXCEL SPREADSHEET SET-UP REARRANGEMENT

This part is the third sub-part of part 1 and an optional sub-project to prevent complication and labour-intensive sorting work for data recording in the future, such as the data management work done in part 2.1.1. Software involved: Microsoft Excel 2007-2013. This part is to test if a better set-up of the Excel spreadsheet can be established.

Methods explored:

1. A new document is created with validations added to restrict data input into certain formats
   - "=EXACT(A1,UPPER(A1))" to create error to type in all caps
   - "=AND(CODE(LEFT(J2,1))>=65,CODE(LEFT(J2,1))<=90)" to create error to type first letter in capital letter
   - Limit to a list of locations and sections to choose from, just like how it was done in Figure 12

Although a new design is drafted, due to time limitations and the possibility of making the design of the set-up even more complicated, this part is considered to be incomplete. More exploration on how to secure and prevent validation settings from being unintentionally modified by users. Furthermore, confirmation from the research group on the design is required.

2.2 ACCESS DATABASE CREATION

After the Excel records are fixed with a unified format and each mussel plot has its own Excel spreadsheet created, a database can be formed using Access. The database is used to organize the data in a more systematic and convenient way for future references as well as importing onto ArcGIS. Software involved: Microsoft Access 2010-2013.

The following are the data that were extracted from Excel to form the Access database, with an English translation of the Dutch section names, and a brief explanation on why the information was needed:

Name on Document	**English Translation**	**Description**
Stadium: Zaaien Verzaaien Vissen voor veiling Eigen metingen	Stages: Sow Outgrow Fishing for sale Own measurements	Indicate the growth stages of the mussels were in when measurements were made, used to compare growth among different stages at the same plot as well as to track mussel party movements

Datum	Date	Dates measurements were made, important for comparing mussel growth
Naar perceel Nummer Vak	To plot Plot number Plot section	The most important data needed as measurements were conducted in those plots
Van Perceel Van nummer Van vak	Of Plot / Origin location Of plot number Of plot section	Important for mussel party tracking
Bruto mosselton Tarra (%)	Gross musseltons Tare (%)	Indicate gross amount of mussels placed in plots, another crucial data for displaying spatial patterns
Bustal (gestandaardizeerd blik)	Can amount (standardized can)	Indicate sizes the mussels measured by counting the amount of mussels that was able to fill up a standard-sized can
Behandeling	Treatment	Might have useful information regarding growth differences of various plots
Bijzonderheden	Remarks	Might have useful information for mussel party tracking

Table 13: Information from mussel farmers that formed the Access database.

Summarization of methods (detailed steps refer to section 7.1 and 7.2):

1. Create a new Access table (main table) that stores all the information needed for the database through importing data from Excel.
   - Unique primary keys were assigned to each existing data
   - Link tables through relationships
2. Based on the main table, make simple queries to calculate the average, maximum and minimum of the amount of mussels in each registered plot according to individual plots, growth stages, and dates.
3. Make parameter queries using the main table as well to provide search boxes for specific mussel parties and track their movements. A new field was created: "Tracking ID" to indicate possible mussel parties through using queries to track their movement. The ID is set according to the mussel party's original location and the stage the data represents. The length of the ID has a minimum of seven digits to maximum nine digits, an example of a tracking ID is "HAM055AcV". Below are detailed descriptions of the composition of the tracking ID:
   - The first three digits are the first three letters of the plot location (e.g. HAM for Hammen).
   - The next three digits (digits four to six) are the plot number (e.g. 055 for 55).

- The seventh digit refers to the zaaien (sow) stage using capital letters to identify different parties, if the same party is divided and transported into two different locations in their zaaien stage, add a number after the alphabet (e.g. A to identify first party, and 2 to identify second group within the first party). The number is removed in the ID for the same party in the next stage.
- The eighth digit refers to the verzaaien (outgrow) stage using lower-case letters. (e.g. c to identify that it is the third sub-group of the original party).
- The ninth digit refers to the vissen voor veiling stage by adding a capital "V" to the end of the ID.

4. Convert the tables and queries created into forms. Then put all the forms together to create a navigation form with main tabs on top and sub-tabs on the left. The sections in the navigation form with their sub-sections are listed as follow:
    - Main page: Welcome picture, List of locations, List of plot names
    - Complete data: All data, Hammen, Mastgat, Meep, Oosterom, OSWD, Zandkreek, Specific plot search
    - Calculated-Plots: All data
    - Calculated-Stages: All stages, Zaaien (Sow), Verzaaien (Outgrow), Vissen voor veiling (Fishing for sale), Eigen metingen (Own measurements)
    - Calculated-Dates: All dates, 2012, 2013, 2014
    - Tracking: Instructions, One plot tracking, Specific pair tracking, Tracking ID

To this point, the Access database is completed and can be imported onto ArcGIS.

2.3 GIS MAP PRODUCTION

When the Access database is established with the data necessary for map production, it can be imported onto ArcGIS to produce spatial information. Software involved: ESRI ArcGIS Version 10.2.1, specifically ArcCatalog and ArcMap. As not all mussel plots contain mussel data, the plots with registered data will provide additional attributes on the amount of mussel produced when imported into GIS. Through adding mussel data into GIS, it is believed that trends of growth and loss can be displayed, thus provide visualization of which areas in the Eastern Scheldt has the most and least amount of mussels grown as well as spatial patterns on tracking and estimating effects of translocations of mussel parties that are common during culture cycles.

Summarization of methods (detailed steps refer to section 7.3):

1. Access database input using ArcCatalog: This step is crucial to using Access databases in ArcGIS. It is impossible to connect to an Access database on ArcMap

if it is not linked through OLE DB Connection on ArcCatalog first.

2. Once connection is made on ArcCatalog, the Access database can be opened on ArcMap through the in-application ArcCatalog on ArcMap.
3. Merge blocks using editing tools as some plots are registered as combined numbers: (Hammen 181-182, OSWD 62-63, OSWD 71-74, OSWD 105-108, OSWD 201-202, OSWD 239-242). Rename the merged plots the same way as how they are named in the database.
4. Input table with registered average, minimum and maximum amount and sizes of mussels in plots to map layer.
5. Join attributes: Join the Access table with the plot shape file using the "NAAM" fields. Validate Join. Double check if all the fields in the Access table is successfully joined with the GIS shape file, if not, there might be spelling differences of the plot names that cause the data unable to join with each other. Validate until all data entries are successfully joined, then the shape file should have extra attribute fields added.
6. Save new shape file with joined attributes so that the joined data will be permanent. This step also allows multiple layering of the same shape file for different symbology displays in the next step.
7. Start spatial analysis using symbologies and test which spatial display provides the best and clearest results. Below is a list of different symbologies attempted:
    - Categories - displaying unique values: As the number of plots with registered data is not large, it is possible to display and sort unique values from smallest to largest, then use colours to display intensities of amount (e.g. green for smallest average amount and red for largest amount)
    - Quantities - graduated colours: Divide data into six classes according to natural breaks (jenks) for mussel amount. Each class is represented with a colour. As the intensity (amount of mussels in plot) increases, the darker the colour gets.
    - Quantities - graduated symbols: Divide data into six classes according to natural breaks (jenks) for mussel sizes. Each class is represented with a circle symbol. As the intensity (size of mussel) increases, the bigger the symbol gets.
    - Quantities - proportional symbols: Based on area of the plots, the average amount is compared proportionally through dividing average amount by area of the plots. Results are displayed as circular symbols, the more closer to 1 the proportion of amount/area is, the larger the symbol is.

Steps 4 to 7 were repeated using data on growth stages for more precise comparisons.

3.0 PRODUCTS AND RESULTS

Although the aim of this project is to produce at least one GIS map and analyze the spatial distribution of mussel growth and loss, there are a number of other products that were created throughout different parts of the project, and they are being divided into intermediate products and final products.

3.1 INTERMEDIATE PRODUCTS

1. Well sorted mussel measurement data: product of part 2.1.1.
2. Excel documents for individual plots: product of part 2.1.2.

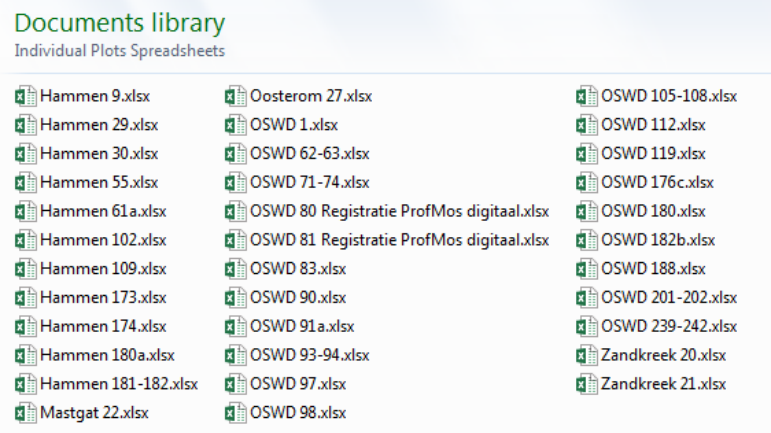
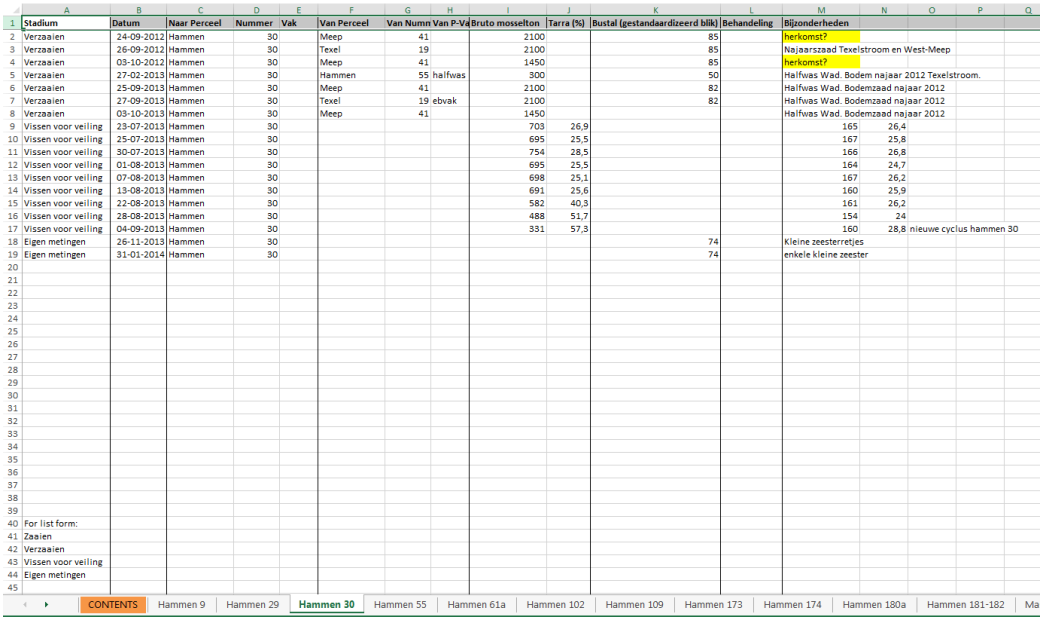


Figure 14: All the new Excel documents created.

3. New Excel document created with each plot as a tab: product of part 2.1.2.



Stadium	Datum	Naar Perceel	Nummer	Vak	Van Perceel	Van Numn	Van P-Va	Bruto mosselton	Tarra (%)	Bustal (gestandaardizeerd blik)	Behandeling	Bijzonderheden
Verzaaien	24-09-2012	Hammen	30		Meep	41		2100		85		herkomst?
Verzaaien	26-09-2012	Hammen	30		Texel	19		2100		85		Najaarszaad Texelstroom en West-Meep
Verzaaien	03-10-2012	Hammen	30		Meep	41		1450		85		herkomst?
Verzaaien	27-02-2013	Hammen	30		Hammen	55	halfwas	300		50		Halfwas Wad. Bodem najaar 2012 Texelstroom.
Verzaaien	25-09-2013	Hammen	30		Meep	41		2100		82		Halfwas Wad. Bodemzaad najaar 2012
Verzaaien	27-09-2013	Hammen	30		Texel	19	ebvak	2100		82		Halfwas Wad. Bodemzaad najaar 2012
Verzaaien	03-10-2013	Hammen	30		Meep	41		1450				Halfwas Wad. Bodemzaad najaar 2012
Vissen voor veiling	23-07-2013	Hammen	30					703	26,9			165 26,4
Vissen voor veiling	25-07-2013	Hammen	30					695	25,5			167 25,8
Vissen voor veiling	30-07-2013	Hammen	30					754	28,5			166 26,8
Vissen voor veiling	01-08-2013	Hammen	30					695	25,5			164 24,7
Vissen voor veiling	07-08-2013	Hammen	30					698	25,1			167 26,2
Vissen voor veiling	13-08-2013	Hammen	30					691	25,6			160 25,9
Vissen voor veiling	22-08-2013	Hammen	30					582	40,3			161 26,2
Vissen voor veiling	28-08-2013	Hammen	30					488	51,7			154 24
Vissen voor veiling	04-09-2013	Hammen	30					331	57,3			160 28,8 nieuwe cyclus hammen 30
Eigen metingen	26-11-2013	Hammen	30							74		Kleine zeesterretjes
Eigen metingen	31-01-2014	Hammen	30							74		enkele kleine zeester

For list form:
Zaaien
Verzaaien
Vissen voor veiling
Eigen metingen

CONTENTS | Hammen 9 | Hammen 29 | Hammen 30 | Hammen 55 | Hammen 61a | Hammen 102 | Hammen 109 | Hammen 173 | Hammen 174 | Hammen 180a | Hammen 181-182

Figure 15: Screenshot of one of the tabs of the newly designed Excel document.

4. Tentative new design of data record spreadsheet for farmers: product of part 2.1.3.

3.2 FINAL PRODUCTS AND RESULTS

1. An Access database: product of part 2.2

   There is a total of 310 specific data collected from 37 different plot locations documented in the Access database. The database is open to editing and adding of more data in the future.

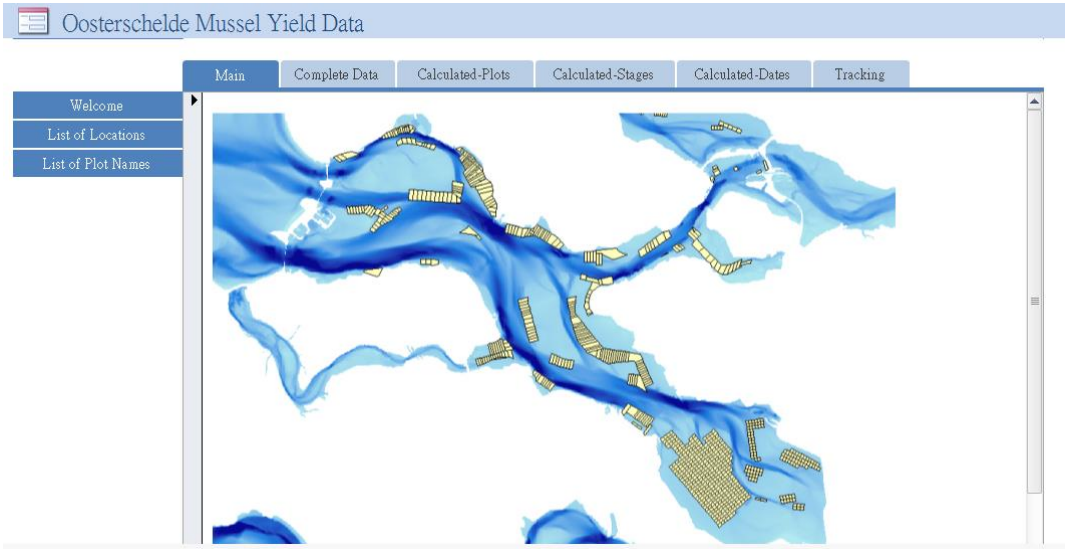


Figure 16: Main page of the Access database.

2. GIS maps produced that were chosen as the best in effectively showing mussel data at different culture plots in the Eastern Scheldt: product of part 2.3.

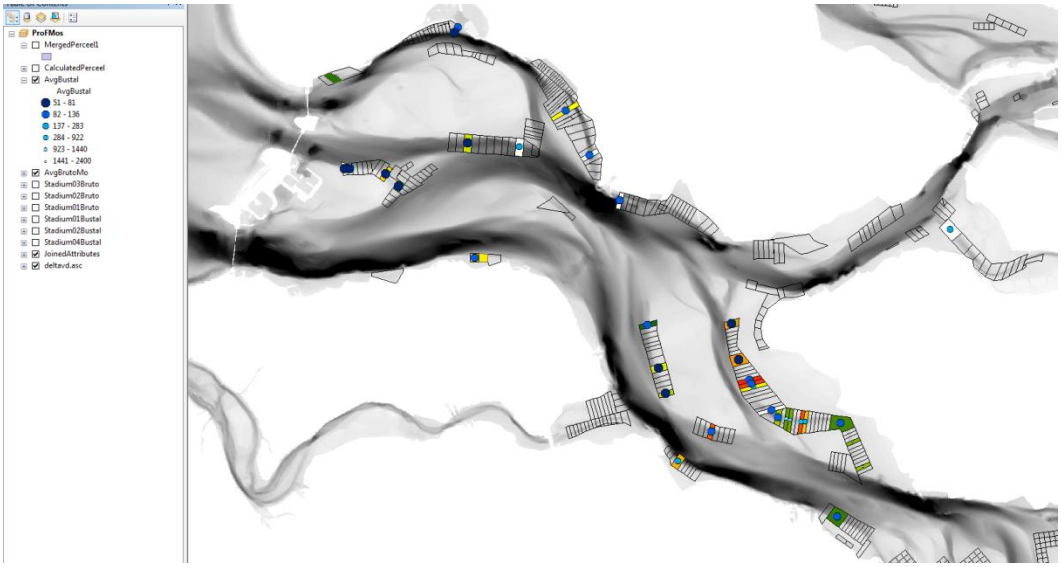


Figure 17: Overall average amount (range from green to red) and overall average sizes of mussels (in blue circular symbols, the darker the circle is, the bigger the sizes are) measured in standardized cans in 2012-2014.

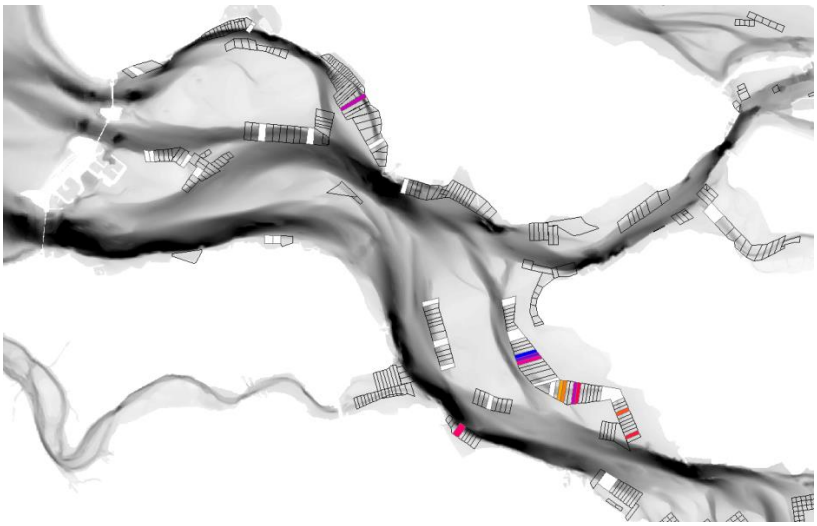


Figure 18: Mussel amount on plots in growth stage – zaaien (sow) (range from yellow to dark purple).

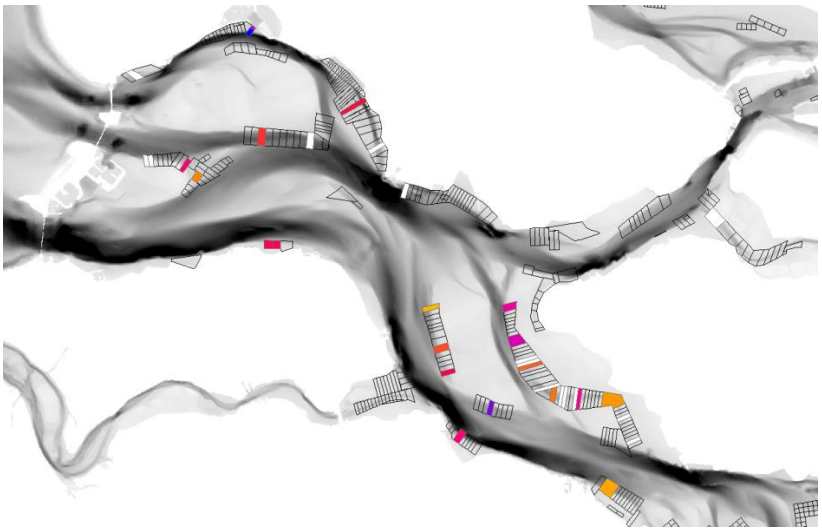


Figure 19: Mussel amount on plots in growth stage – verzaaien (outgrow) (range from yellow to dark purple).

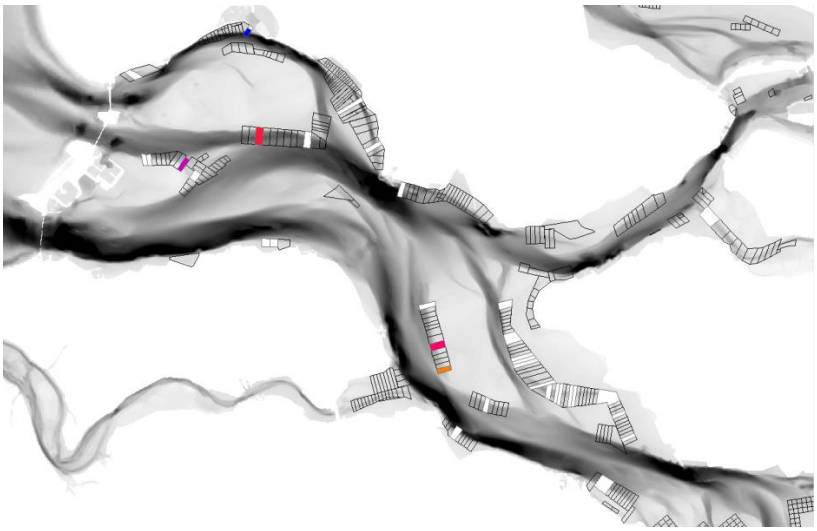


Figure 20: Mussel amount on plots in growth stage – vissen voor veiling (fishing for sale) (range from yellow to dark purple).

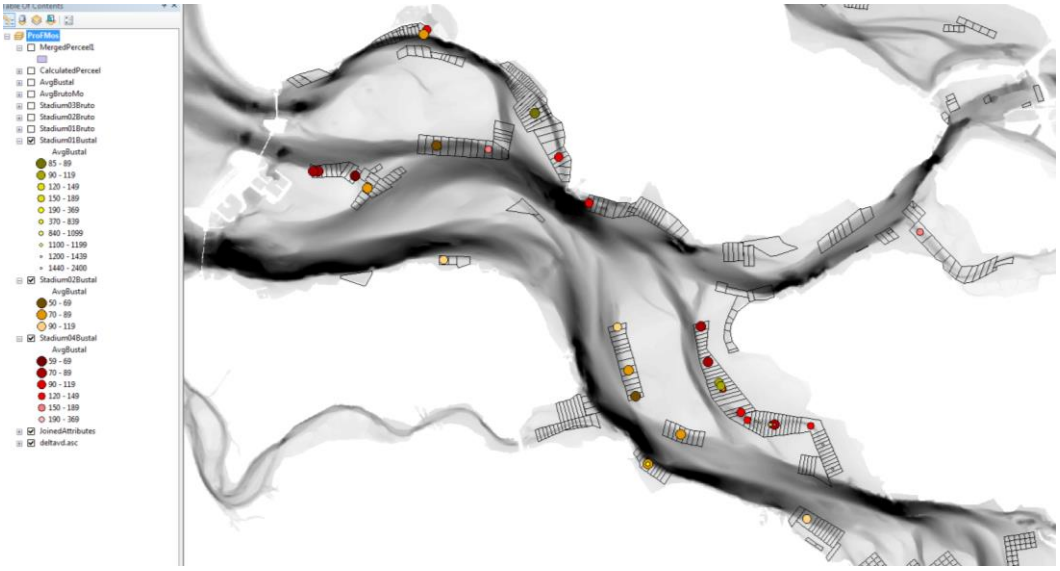


Figure 21: Mussel sizes in standardized cans comparison in three different stages (stages in colours: zaaien - yellow tones, verzaaien - orange tones, eigen metingen - red tones; sizes range from small to large circles).

4.0 DISCUSSION

The discussion session is divided into three main sections: methods used, results displayed from maps, and an analysis of some additional data provided by the ProFMos research group to seek answers for the research question of this project.

4.1 METHODS USED

Regarding part 2.1.1, as mentioned within the section, due to the reason that the amount of data to be managed was small, therefore allows user to manually check and fix errors. However, when working with a larger size of data, the use of built-in functions might be necessary to save time and effort.

Regarding part 2.1.2, creating new Excel documents for each mussel plot might be the best way to sort, store, search and modify data in Excel. The other method which is the creation of the one big document with tabs of different plots can only apply to this project, because in the future with more data recorded and plots registered, the chance of Excel crashing or loss of data would increase. As in the future, where there will only be more data being added, making separate documents of individual plots is a safer way to document large amounts of data. Furthermore, for Access database creation that base on importing Excel data, it is not required unifying all plots into separate spreadsheet tabs in one Excel document.

In part 2.1.3, the listed ways of data validation was brainstormed and tested, and a tentative new design is created. The reasons for stating that more considerations and testing need to be put into actually establishing a new set-up is that: First, the validation designs, especially for creating a drop-down list for farmers to choose from instead of typing in, requires large amount of untouchable space on the same spreadsheet to store the validation list options. With this limitation, a certain part of the spreadsheet needs to be locked to ensure the validation list options are secure, if not, the whole set-up of the spreadsheet might be disturbed unintentionally by users who are inputting data. Secondly, regarding the quality of information received from farmers, it needs to be accessed whether the current set-up, such as the type of information requested to be measured and recorded, is helpful enough. It would be very informative if farmers can provide feedback on the setup of the record spreadsheets. It is also encouraged to discuss with farmers whether adding a tracking column of mussel parties on the spreadsheet is feasible because it is the farmers that know where the mussels they grow are being transported.

Both parts 2.2 and 2.3 required an extensive time doing online searches on instructions and tutorials on how to use specific functions of the programs. Therefore, as to make the work of future users more convenient, user guidelines were written on all the steps and procedures conducted in these two parts to get the desired results. The guidelines may not consist of the best methods, but it is believed that it can save a lot of time trying to figure out how to obtain certain results from the two programs.

In part 2.2, it is very useful for the ProFMos research group because not only a database was created to store all the data provided by farmers, searching and tracking of specific group of mussel was made possible using queries. As mussel farmers transport mussels to different locations when growing them in different stages, movement tracking of mussel parties allow researchers to better observe growth or loss of mussels at different locations. Nevertheless, without GPS tracking or specifically labelled parties, it is inaccurate to only rely on educated guesses through determining possible parties using Access queries. Furthermore, a better tracking system needs to be established, the tracking ID being used in the database now is not compatible to more complicated dividing and transporting of mussel parties, because it is a better idea to use the origin location name or farmers' name as a base for the tracking ID, so that the base that is used in the database now (e.g. HAM055) can be shorter and only be in alphabets. It is strongly suggested to start tracking mussel parties the time they are seeded, and it would be best if farmers can directly involve in tracking and identifying mussel parties.

For the last part of the project, part 2.3, there are four types of symbologies explored. It is believed that the use of colours and symbols is effective in providing spatial information for the mussel data collected from the farmers. For displaying mussel average amount of mussels, using graded colour symbology is efficient in showing intensities. Different symbol sizes is a simple and clear way to show mussel sizes measured in standardized cans. The bigger the circular symbols, the larger the mussels are. Combining colours and symbol layer displays, two kinds of information can be displayed all at once - colours can refer to growth stage or average amount, and symbol sizes refer to average mussel sizes. Stacking of symbol layers is a great method to display changes of mussel sizes over different stages.

4.2 RESULTS DISPLAYED ON MAPS

Before discussing in depth on the results shown on the maps produced (Figures 17-21), as to give a clearer background on the general locations of the plots that will be

discussed, below is a map (Figure 22) showing four main plot locations in the Eastern Scheldt.

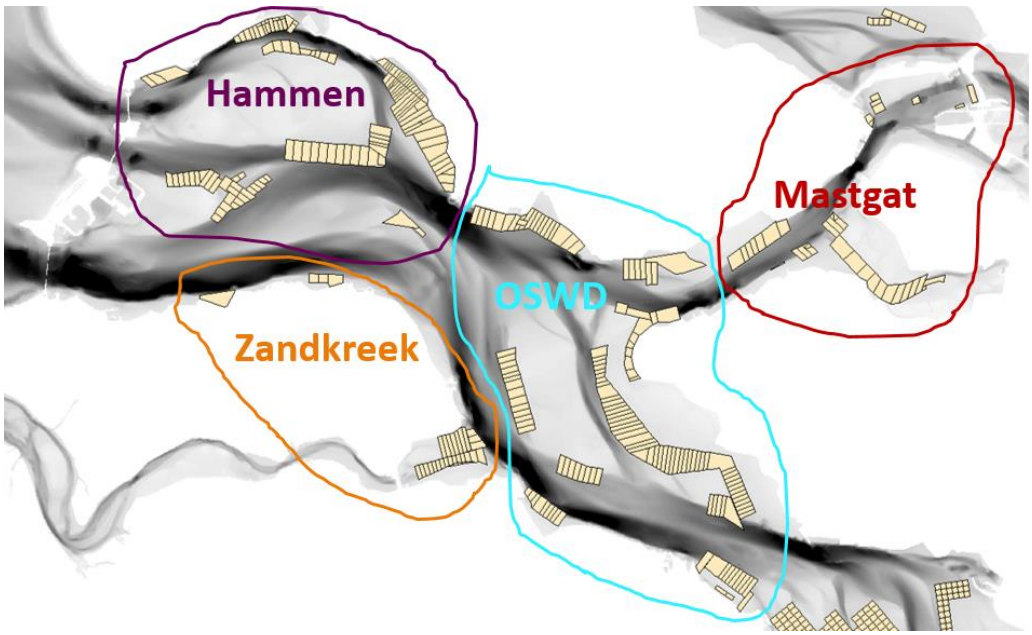


Figure 22: Mussel plot locations. Each block on the map is a plot, assigned with numbers.

Referring to Figure 17, which shows the average amount and sizes of mussels on the registered culture plots, indicated that the area with the most average amount of mussels placed in plot is the OSWD plots area. However, for average sizes of mussels, the OSWD area consists of smaller average sizes, where the biggest sizes are mainly grouped in the Hammen area. This map has shown a general picture that the OSWD area is crowded with smaller mussels, and larger mussels are grown in the Hammen area. However, more data is required to display a more accurate and clear result.

In Figure 21 which showed mussel sizes measured in different plots at different stages using three layers of symbols stacked together, it effectively displayed size differences of the mussels at different stages. Same as the analysis of Figure 17, the OSWD area grows mostly smaller and younger mussels and the further towards west in the Eastern Scheldt, the larger and later in stage the mussels tend to be. However, the amount of data collected is still insufficient to determine which culture plots grew the biggest sized mussels or mussels with the largest growth. Furthermore, the mussel sizes measured at the plot might not represent the same group of mussels since farmers rotate and transport mussels among several plots throughout the growing period. It is inaccurate to conclude that a certain plot has the most growth or loss using this map due to the high possibility of inconsistency by comparing different groups of mussels that were grown under different conditions.

By comparing Figures 18 to 20 which show the average amount of mussels on culture plots at three different stages, it explains and supports the results and claims on Figures 17 and 21. The amount of mussels placed in plots during sow period is the highest in the OSWD area, the mussels are then transported to the Hammen area in their outgrow stage. From the maps produced in this project, it allows visualization of the translocation of mussels within the Eastern Scheldt.

4.3 ADDITIONAL DATA PROVIDED TO ANALYZE MUSSEL GROWTH

From the data provided, the average, minimum and maximum yield of mussels in tons could be calculated. However, it is not really sufficient enough to determine growth or loss in specific areas. As the maps produced are not able to analyze mussel growth at different locations in the Eastern Scheldt, the ProFMos project research group provided data on nine groups of mussels in three stages (seed, half grown and consumption) at various locations in the Eastern Scheldt that have been monitored by the research group since March 2014. Below and on the next page, there are three graphs (Figures 23, 24 and 25) produced according to the lengths measured from March 2014 to July 2014.

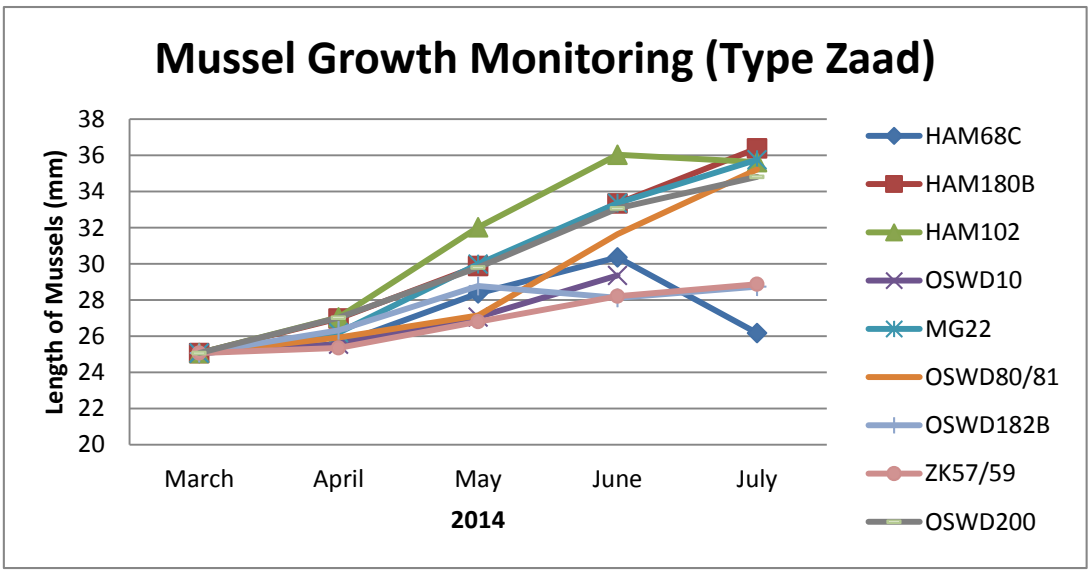


Figure 23: Mussel growth monitoring in seed stage.

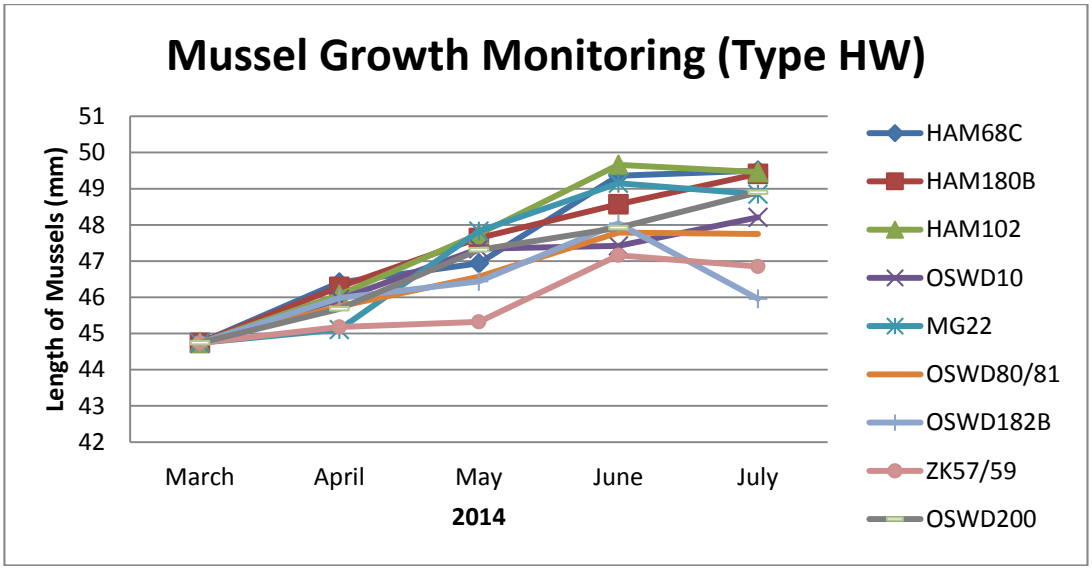


Figure 24: Mussel growth monitoring in half grown stage.

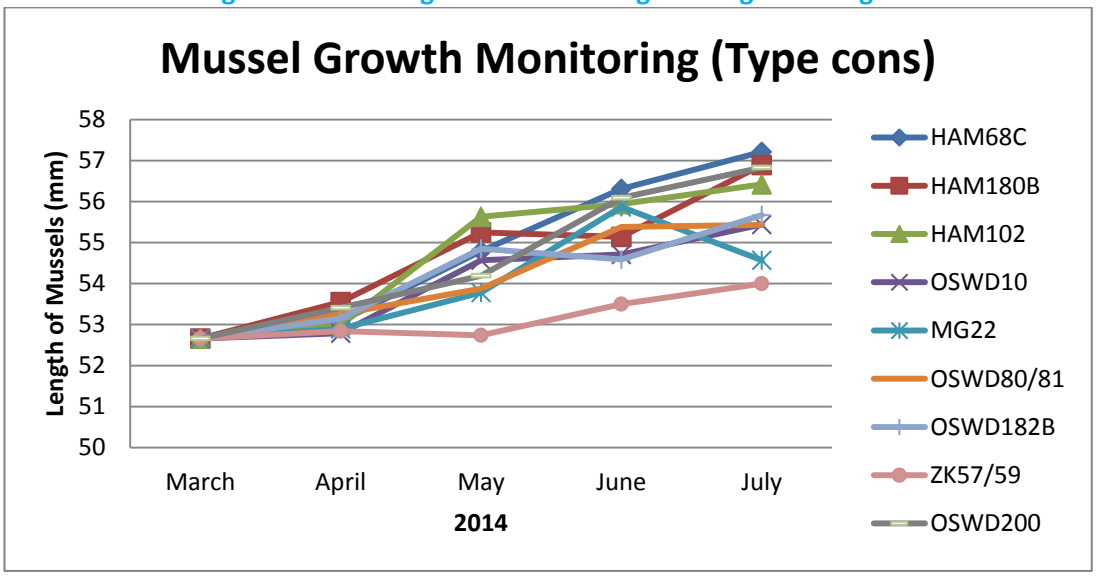


Figure 25: Mussel growth monitoring in consumption stage.

According to the overall trend displayed on all three graphs, all the locations are able to sustain growth over a period of four months, even though loss occurred at some locations, especially between the month of June to July. It appears that mussel length is systematically higher at the Hammen area comparing with other areas, especially for Hammen 102 and 180b, that area is on the west side of the Eastern Scheldt, where it is the closest to the opening of the storm surge barriers to the North Sea. Sufficient food source is likely a factor to the higher growths occur in the Hammen area.

5.0 CONCLUSION AND RECOMMENDATION

Although the project was conducted smoothly, the results were unable to fully answer the research question: What is the spatial distribution of growth and loss in the Eastern Scheldt? Instead, it provided spatial information on which areas have the most average, maximum and minimum amounts and sizes of mussels. However, the results shown on the visualization might be affected by the difference in the amount of data collected from farmers as there is a possibility that a higher average amount or size is displayed in the areas which data was sufficiently received (OSWD areas). Therefore, more data is required to make accurate observations and conclusions.

The problem with being unable to answer the research question is also due to the reason that it is difficult and almost impossible to determine growth and loss of mussels without tracking of specific mussel parties, it is also difficult to set up an effective tracking system with the large amount of plots and farmers involved. The ProFMos research group started monitoring nine groups of mussels within the Eastern Scheldt in March 2014 monthly, it is believed that trends of growth and loss can be mapped out with the information collected. Due to time constraints, maps of the monitored mussel data were not able to be produced within the time period of this project.

As for the sub-question: What is the best way to effectively display spatial information of mussel growth and loss? It is concluded that using colour and symbol layering symbologies can effectively show which areas in the Eastern Scheldt generated the most average yield and produced the largest mussels in size. These two types of symbologies are easy and straightforward to use and clear to make spatial analysis.

Apart from achieving parts of the research question by generating maps, a database on mussel data provided by farmers is created and a user manual is drafted for future references in the appendix.

There are several recommendations for future continuation of developing the Access mussel database and GIS maps for spatial analysis.
First of all, the spatial information shown on GIS would be more accurate if more mussel data is collected. This would mean that would be better if it is possible to cooperate with more farmers, so that more information on more different plots can be received.
Secondly, create a better mussel party tracking system, the tracking system

established in this project is only a start. A great way to establish a good tracking system is through farmers because they know where they transport and rotate mussel parties among their culture plots. A new column can be added on the Excel record spreadsheet for farmers to fill in tracking ID according to their name or the mussel seed origin + a number code.

Thirdly, access whether the current set-up of the Excel spreadsheet for farmers is helpful enough to make spatial analysis for mussel culture patterns. It might be more helpful to collect more different types of data from the farmers, and more options and analysis can be made. A new design of the Excel spreadsheets would be required to prevent as much error during data input as possible, but more exploration is needed to make the spreadsheet validation settings secure.

Lastly, this project requires long-term continuation as there will be more data collected from farmers and the spatial information produced are useful for both researchers and farmers. Even though a guideline was written for future users, it is desirable to assign the tasks in this project to people with more experience or knowledge with using Microsoft Access and ArcGIS.

6.0 REFERENCES

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7.0 APPENDIX

7.1 DETAILED STEPS: ACCESS DATABASE CREATION (SECTION 2.2)

Why is an Access database required even though data is already on Excel? There are four advantages on creating an Access database: 1. More organized and safer to make large data modifications; 2. Prevents data duplication and inputting errors; 3. Specific look up functions and relational queries; 4. ArcGIS compatible.

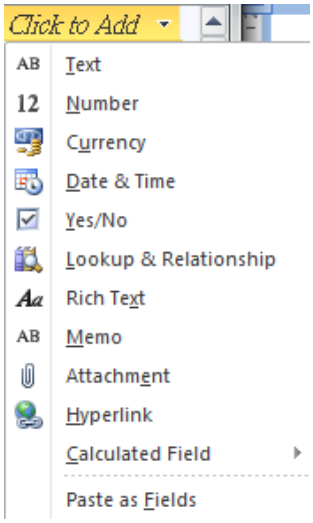
This manual is written based on Microsoft Access 2010-2013 .accdb formatted databases. The set ups and tools used might vary from other versions of the software.

Part 1: Tables

What are tables? Tables are what form an Access database, they store all the information that exists in the database. Tables must be created and fully organized to further build a database with relationships and queries.

Building a new table. A new table can be created through [Create] > [Table] or [Table Design]. Both ways are fairly straightforward to use. Access tables are almost like tables in Excel, only that there are more settings and restrictions involved.

Fields. In a table, each column represents a data field, and on Access, each field must have a field data type. When creating a new table, a column can only be used when a field type is set in it. The most common types of fields are text and number, other types are shown on the screenshot on the right. Furthermore, there are field sizes to choose from within a type of data (such as integer, long integer, double, etc. for numbers) depending on how much data that the field has to store.

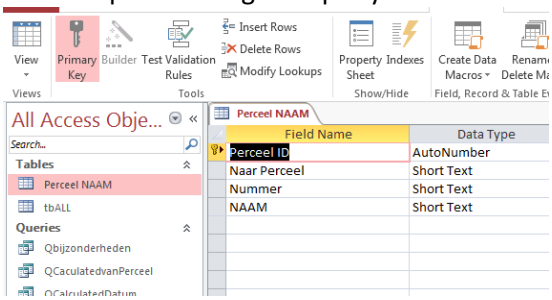


To add a field, in the datasheet view, click on [Click to Add] for a new column, and a popup list would be shown and select the desired field type. In the design view, type in field name, and select the desired data type from the dropdown list.

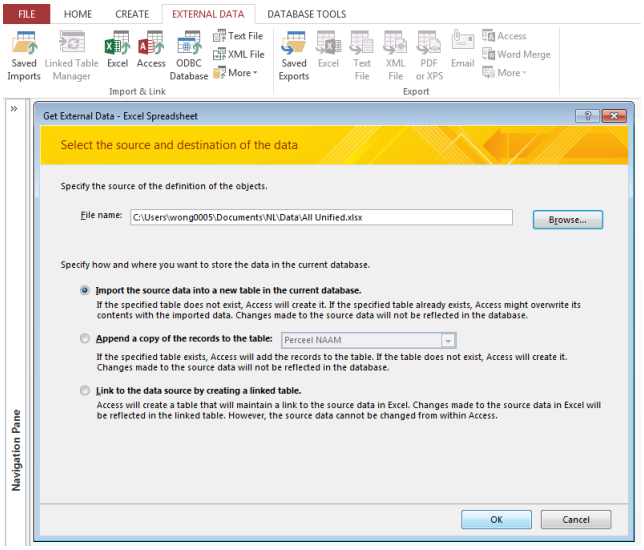
For more detailed descriptions of field types go to:
http://office.microsoft.com/en-ca/access-help/introduction-to-data-types-and-field-properties-HA010341783.aspx

Detailed descriptions of field sizes go to:
http://office.microsoft.com/en-ca/access-help/set-the-field-size-HA010341996.aspx?CTT=5&origin=HA010341783

Keys. Primary keys are what gives identification to each unique data. It is highly recommended to give an ID to each data because that would make relationship building, lookup field filling and query searches more convenient. Keys can be numbers or texts, as long as they are unique. A convenient way of setting keys is through Auto Numbering. When a new table is created, the first column is usually already set as an auto numbering key. Go to design view, like the screenshot on the left, to manually set auto numbering primary key.



Importing Excel files. Data on Excel files can be imported onto Access through [External Data] > [Excel]. There are three ways to import an Excel table as shown in the screenshot on the right: Create a new table with the Excel data, add the Excel data into an existing table, and link the Excel data with a table. The methods of the first two options will be introduced below.



First option:

- Importing an Excel file into a new table has a fairly straightforward wizard to go through.
- Browse and select the Excel document [Ok]
- Choose the worksheet/tab in the Excel document to input data to Access [Next]
- Usually, the first row contains column headings. If so, check the box so that the first row would not be considered as part of the data. Instead, the first row would automatically become the Access field column headings [Next]
- Field names and data type for each column can be modified in this step. Also fields can be chosen to be imported or not [Next]
- This step gives you three options to set primary keys: let access add an auto number primary key, choose own primary key from the data being imported, or no primary key [Next]
- Last step, where the table can be named [Finish]

Second option:

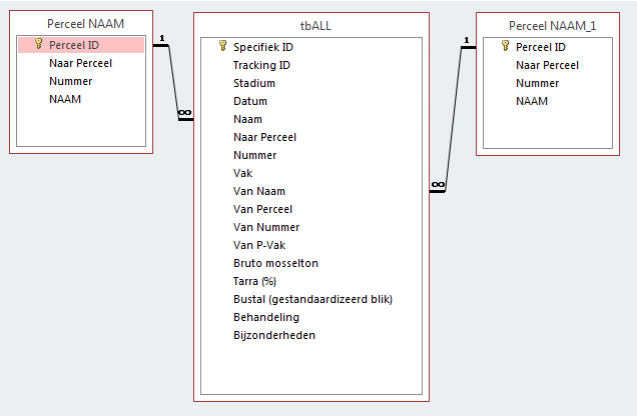
- Adding Excel data into an existing table in Access has very similar steps to the first option, with less steps but slightly more precautions to make.
- Before starting the wizard, double check whether the column names of the Excel spreadsheet and Access table match, because they must be identical to go through a successful build wizard.

- As long as the column names match, run through the wizard that is the same as the first option.

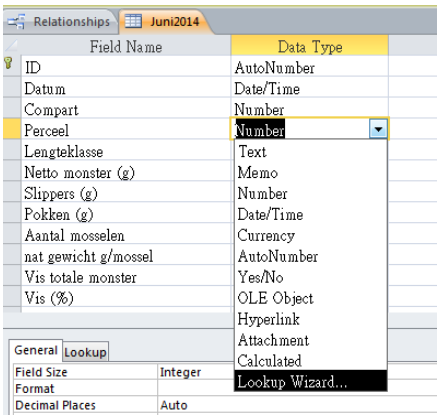
Dealing with errors when importing Excel files.

- Access only identifies identical field name and format to allow importing of Excel data, if an error pops out regarding non-identical or wrongly formatted data, double check every field name and format of data in the Excel file
- If importing Excel files to existing table and random errors pop out, try create new table instead, then copy and paste the data from the newly created table to the original table destination of the data, then delete the newly created table

Relationships. A big difference between Excel spreadsheets and Access tables is relationships. It links tables that share common fields, thus generate a relational database. One big advantage of relationships is to create lookup drop down list for a large database. It is almost like validation list on Excel, it prevents errors when inputting data by making the field data type into a lookup list that refers to data on another table in the database. To view and edit relationships, go to [Database Tools] > [Relationships].



Using lookup wizard to create relationships. Go to design view, select "Lookup Wizard" from the data type dropdown menu for the field that a relationship wants to be created, like the screenshot on the left. Then follow the following steps:



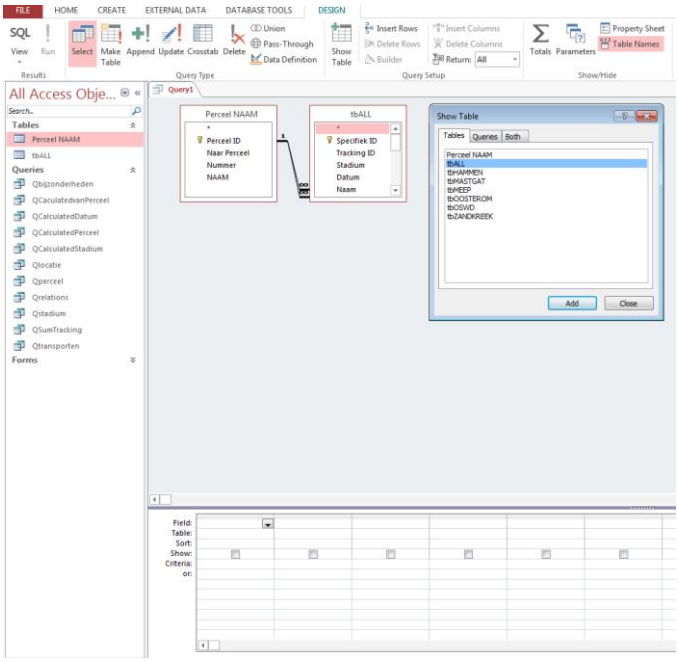
- Select "I want the lookup field to get the values from another table or query" [Next]
- Choose the table or query the lookup field want to refer to [Next]
- Add fields from the table or query that the lookup field should refer to [Next]
- Sorting of field lookup options (usually just skip it) [Next]
- Hiding or displaying key column, if the ID of the lookup is known, it is better to uncheck the "Hide key column" because it is more efficient to type in ID numbers later instead of choosing from a drop down menu manually (this setting can be modified later) [Next]
- Rename the lookup field if needed, and check "Enable Data Integrity" to create a one to multiple relationship [Finish].

Official online tutorial for more detailed introduction to tables:
http://office.microsoft.com/en-001/access-help/introduction-to-tables-HA102749616.aspx

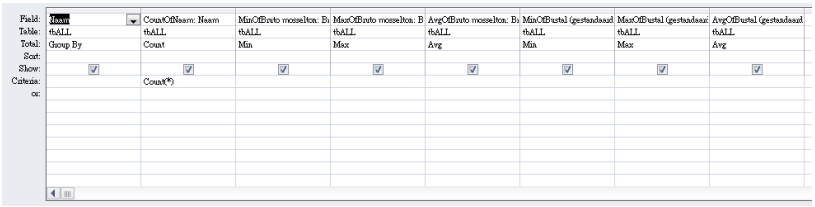
Part 2: Queries

What are queries? Queries are used for several purposes: to calculate or summarize data, to look up or filter specific criteria of the data, and to reorganize and group data in different ways. As tables are used to store every single information in the database, queries are used to take out data that are necessary for certain purposes.

Building a query. A new query can be created through [Create] > [Query Wizard] or [Query Design]. There will only be steps on using [Query Design] as it is more straightforward to use.



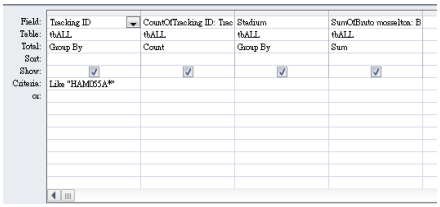
- After clicking on [Query Design], a new query table will be created and the design view will be displayed like the screenshot on the right.
- There are three view modes for queries: Datasheet, SQL, and Design views. Under the [File] button, the view modes can be switched. This tutorial will not deal with SQL codings.
- The [Show Table] window automatically pops out once a new query is created through design mode, and the tables or queries that need to be used can be chosen. Or simply drag the wanted tables or queries to use from the nagivation pane into the blank area where tables are shown as relationships in the screenshot on the right.
- Select which field to appear in the query either by double clicking the field from the table you added into the blank area or choose from the drop down list in the "Field" area in the query/expression building area. The added fields would form form into a new table when the query is run through.



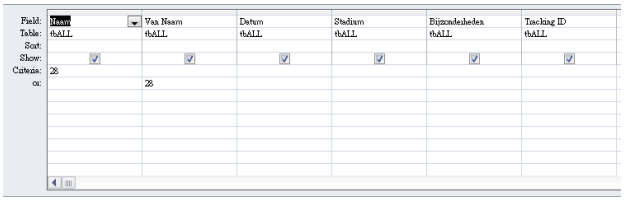
- After adding the wanted fields, a simple query is basically completed. Click [Design] > [Run] or change into datasheet view to run the query.

Using expressions and criteria. Criteria can be set to limit certain data to appear after running the query. Below is a list of expressions and criteria that were explored and how they work:

- Count(*) : Display the number of the same name repeated in a field
- Like "abc": This displays data that is exactly "abc". By adding a * after "abc", the query will display all the data that starts with "abc"; the same applies when adding a * before "abc", the query will display all the data that ends with "abc"



- Like "*2012*"
  Between #01-01-2012# And #01-01-2013#
  DatePart("yyyy";[Datum])=2012: These three expressions all apply the same effect to dates, which is to display data dated in 2012
- Simply type in a key under a field registered with keys can display all the data registered under that key



There is another function that allow data to be calculated without using functions. On the top toolbar, click on [Design] > [Totals], a new row labelled as "Total" in the query building section would be displayed. It is defaulted in the Totals section that the data is displayed by grouping same names together. Other options include: count, average, min, max, sum, stdev, etc.

For the steps used to create parameter queries for searching and tracking in the database, refer to section 7.2.

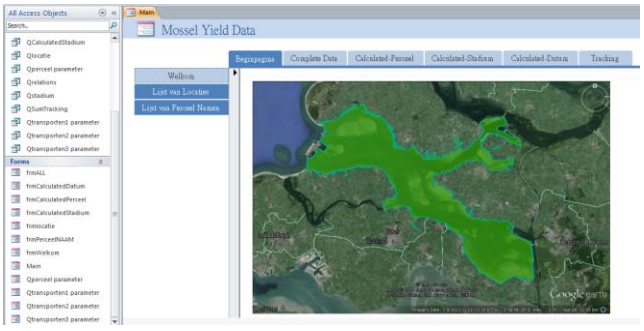
Official guide on different criteria:
http://office.microsoft.com/en-ca/access-help/apply-criteria-to-text-values-HA102809526.aspx?CTT=5&origin=HA102836326

Official guide on how to build expressions:
http://office.microsoft.com/en-ca/access-help/build-an-expression-HA102749614.aspx

More detailed introduction to different types of queries:
http://office.microsoft.com/en-001/access-help/introduction-to-queries-HA102749599.aspx?CTT=5&origin=HA104146756

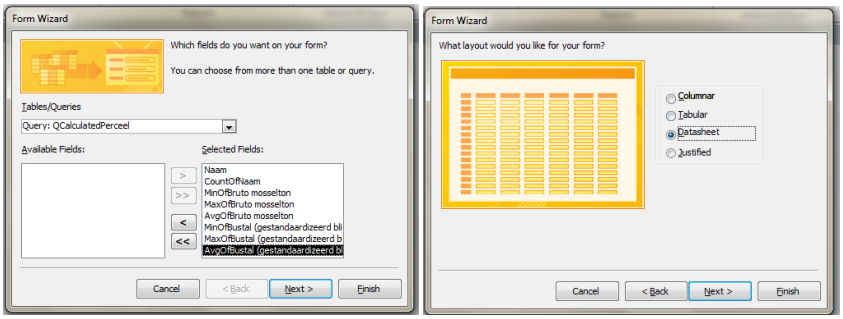
Part 3: Forms

What are forms? Forms are what groups tables and queries created together into an organized and systematic way. Ultimately, a form with navigation buttons to different pages is to be created in this tutorial.



There are two main views that would be mainly used: Form View and Layout View. Form view displays the formatting done in layout view.

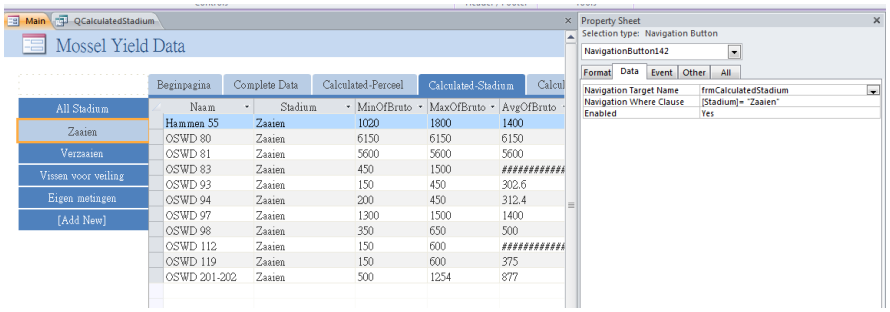
Creating new forms. It is very simple to create forms using existing tables or queries. First way is to select the table or query in the navigation pane that needs to be converted into a form, then click on [Create] > [Form]. A new form would be created immediately. If not all fields in a table or query is needed, [Create] > [Form Wizard] would be the best option as it allows more options to choose from. For the navigation form that will be created, the forms are desirably be in datasheet form.



Create navigation forms. There are templates available for navigation forms, but this guideline will not be using templates. Select [Create] > [Navigation] > choose the layout of the navigation form, in this case, it will be [Horizontal Tabs and Vertical Tabs, Left]. A new blank navigation form would be created. It is better to have the whole navigation form designed out before adding forms to it. To add forms that were created from tables and queries, simply drag the forms over to the navigation button [Add New] area, then new buttons and display tab with the form names would be created.

Reminder: Horizontal tabs must be created before adding vertical tabs. Access does not allow creation of vertical tabs first.

Navigation button filtering. There are filtering functions that can be added to navigation buttons, so there will be no need create new queries and forms of filtered data. Open the property sheet in the layout view: [Design] > [Property Sheet]. Click on the tab that a filter would like to be added, then add [field name]= ”criteria” to the [Navigation Where Clause] field under [Data] of the Property Sheet, just like the screenshot below.



Useful tips for building a database.

1. It is always helpful to name the beginning of tables as 'tb', queries as 'Q', and forms as 'frm'.

Official training course for Microsoft Access 2013:
http://office.microsoft.com/en-001/access-help/training-courses-for-access-2013-HA104030993.aspx

7.2 DETAILED STEPS: ACCESS SPECIFIC SEARCHES AND PLOT TRACKING (SECTION 2.2)

The use of queries is crucial to doing searches for specific data within the database and conduct relationship tracking among information. The use of parameter queries will be introduced in this session.

What are parameter queries? It is a type of query that provides dialogue boxes which require the user to type in parameters for the query to run and give results. It is similar with a search box.

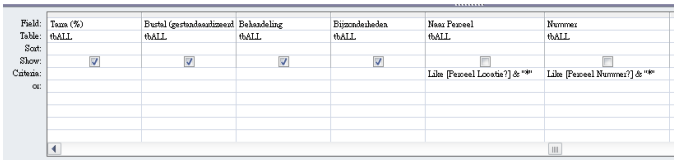
Tip: A smarter way to open parameter queries for modifications is to right click the query on the navigation pane, then go to design view.

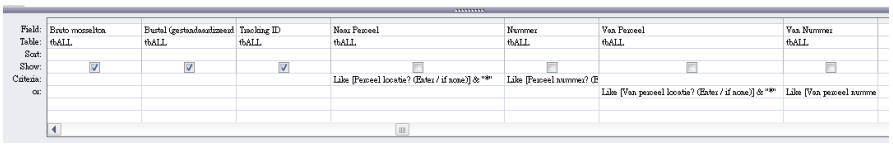
Building parameter expressions. Create a new query, go to design view. Type in a parameter expression under the field that needs to be queried.

Only one type of parameter expression was used in this project: Like [question that appear on the parameter input box] & "*"

All the things that were typed in a square bracket would appear as a pop up box that require the user to type in a parameter value. The symbol * indicates to show all the information that fits with the parameter value inputted.

Criteria rows. Make use of criteria rows in query design view to build parameter expressions. Criteria rows are like asking "If" questions, so if the expressions A & B are placed on the same criteria row, the query would display the data according to: if the data fits with parameter A and parameter B. If the expressions A & B are placed on different criteria rows, the query would display data according to: if the data fits with parameter A or parameter B. Below are two screenshots of making use of criteria rows.





Showing fields. There is also another function that allow showing or hiding of certain fields but still has influence to the query. Simply click on the [Show] checkbox to show or hide fields.

The search parameter fields were hidden in the screenshots above to not show the same information several times in the query table, but the parameters searches were done according to those fields.

7.3 DETAILED STEPS: ARCGIS MAP PRODUCTION (SECTION 2.3)

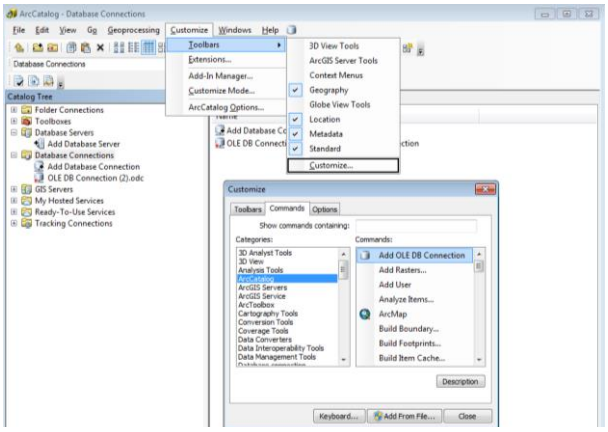
This manual is written based on ESRI ArcGIS 10.2.1. The set ups and tools used might vary from other versions of the software.

Step 1: Connect Access database onto ArcGIS

Why is this step required? Before combining data on an Access database with the already-existing plot data on GIS, a connection between the Access database and ArcGIS must be established through ArcCatalog. It is impossible to extract information from Access tables without this step.

Format of Access database document. It is recommended to use .mdb which is the older format of Access databases (before Access 2007) instead of .accdb which is the newer format. The reason is that ArcCatalog only recognizes .mdb files through the connection method that will be introduced next. Simply convert .accdb databases into .mdb through [file] > [save as] on Access. If an error occurred when converting file formats, create a blank new .mdb file, then copy and paste all the tables, queries and forms over and save the new file.

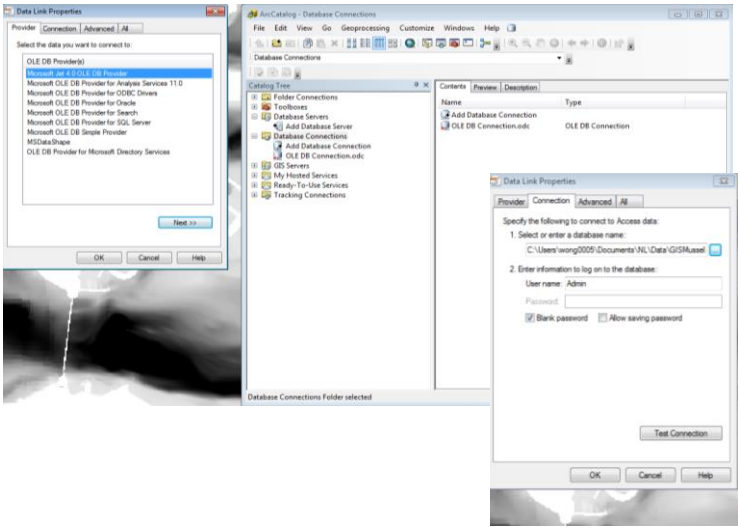
Making the connection. After making sure the format of the Access document is .mdb, open ArcCatalog – another software program installed with the ArcGIS package. Once the program is launched, it is more convenient to create a shortcut of [Add OLE DB Connection] according to the screenshot on the right:



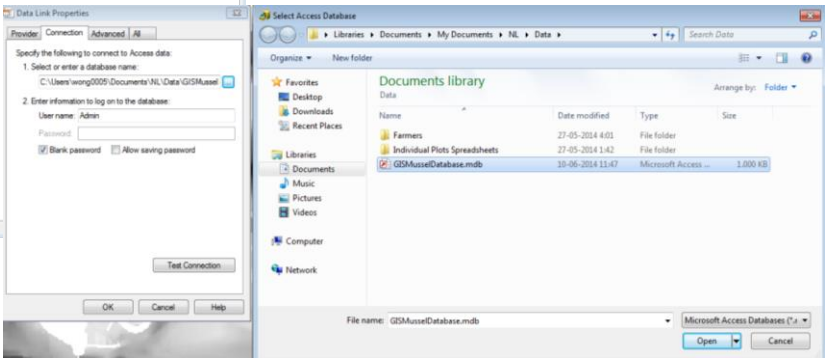
Once the shortcut is created, click on the shortcut and continue on step 3 in the list below:

Steps:

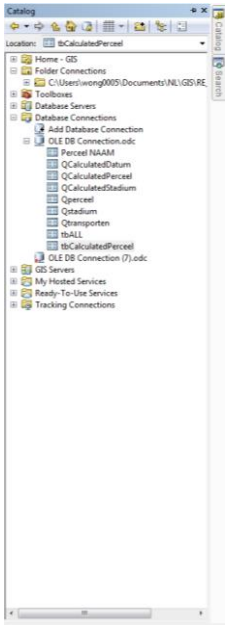
1. In ***ArcCatalog***, double-click the **Database Connections** folder.
2. Double-click **Add OLE DB Connections**.
3. Click the **Provider** tab.
4. Click **Microsoft Jet 4.0 OLE DB Provider**.
5. Click **Next.**
6. On the **Connection** tab, specify the database or browse to it in section one. If the database has a password, enter that information in section two.
7. Click **Test Connection** to verify that you can connect to the database.
8. Click **OK** if the connection test was successful.
9. Type a new name for the connection and press ENTER.
10. To use the Access table, browse to the table through the OLE DB connection and add it to ArcMap.
    Access tables, like other tables without associated features, are only shown on when the ArcMap Table of Contents window is listed by source.



These two screenshots show the OLE DB connection window.



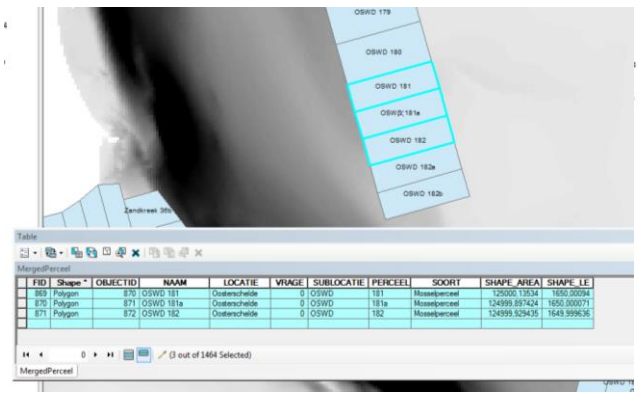
Launch ArcMap once the connection on ArcCatalog is made. Open the ArcCatalog in ArcMap (shortcut button can be found in the top toolbars or on the right of the window, next to the scrollbar). Once Catalog is open, the connected Access database can be found under “Database Connections”. Right click the connected .odc file and click “Connect”. Once the connection is made, the tables and queries in the Access database can be dragged over and added to the map layers.

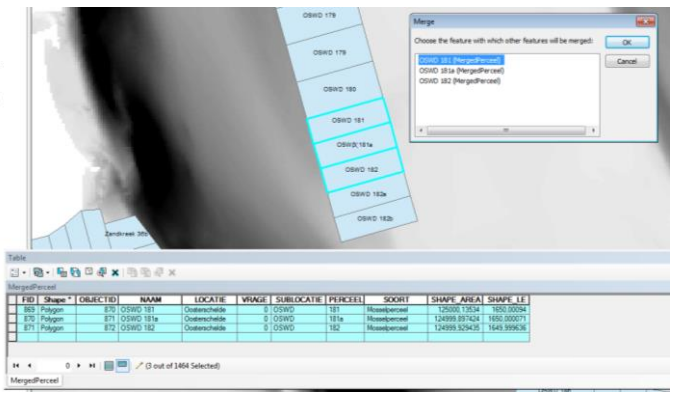


Step 2: Merging Blocks

Why is block merging required? There are several culture plots that farmers combined when placing and growing mussels. However, on the existing data in ArcGIS, the combined culture plots are separated. If the plot blocks are not merged, the data for combined plots will not be recognized when adding data to the plot shape file through join attributes.

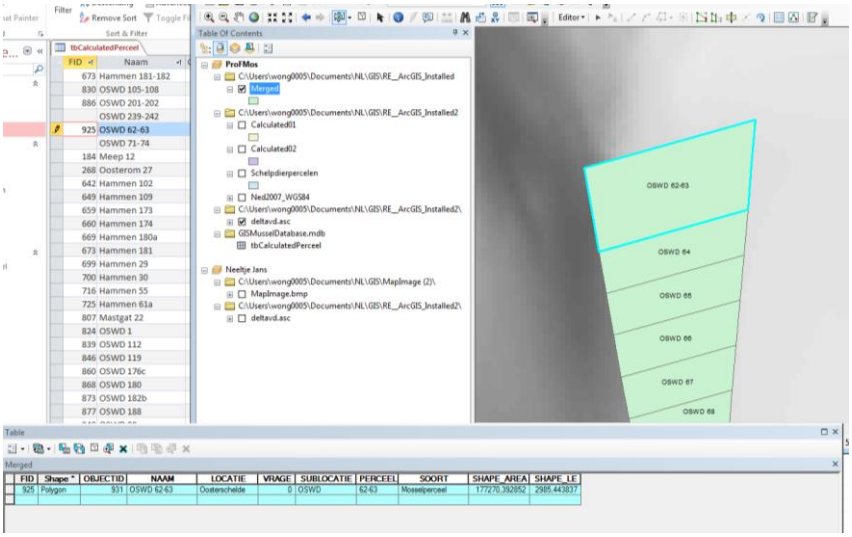
Using the Editor toolbar. The Editor toolbar can be opened through [Customize] > [Toolbars] > [Editor]. Once the Editor toolbar is activated, click on [Editor] drop down list > [Start Editing]. Start merging blocks by selecting all the blocks that need to be merged. After





selection, click on [Editor] > [Merge], a pop up box would appear asking which feature with

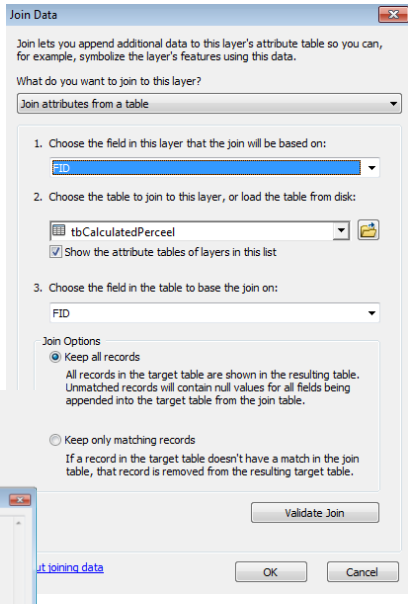
which others features will be merged. Choose the feature that the attributes of the merged block would be based on after merging, this step does not really matter because shape attributes can be edited with the Editor mode on as well after merging, so that the plot names can fit with the data on the Access database. Below is the attribute table and map view of a merged block.

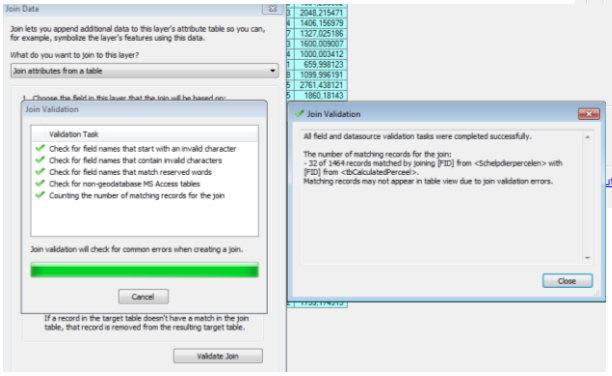


Step 3: Join Attributes

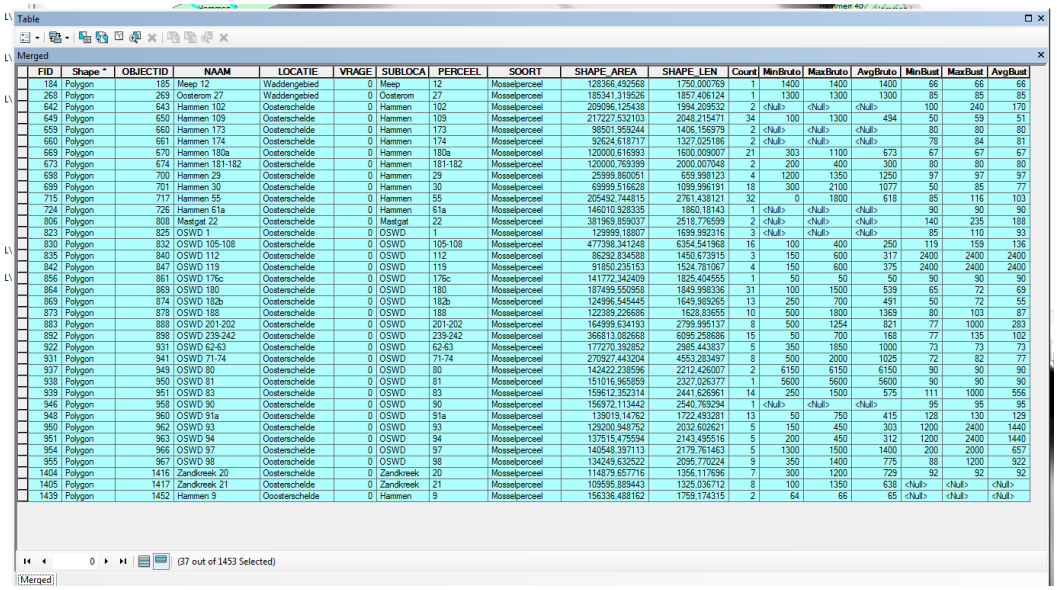
What is attribute joining? On ArcGIS, spatial information are commonly stored as attributes on shape files, such as culture plots in this case. Once After inputting Access database onto the ArcMap layer and merging blocks, attributes from the database can be joined with the plot shape file.

Joining attributes. Once the Access table or query is dragged to the map layer, right click on the shape file in the table of contents that the table or query has to be linked with > [Joins and Relates] > [Join…]. A wizard would pop out like the screenshot on the right. Go through the wizard (which is fairly self-explanatory) then [Validate Join]. This part is where it is possible to check if all the data on the database match with attributes in the GIS shape file. There will be another pop-up window after validation showing how many data were matched.





If not all the data was matched, it is advised to compare the data on the database with the attributes in the shape file before confirming the join.



FID	Shape *	OBJECTID	NAAM	LOCATIE	VRAGE	SUBLOCA	PERCEEL	SOORT	SHAPE_AREA	SHAPE_LEN	Count	MinBruto	MaxBruto	AvgBruto	MinBust	MaxBust	AvgBust
184	Polygon	185	Meep 12	Waddengebied	0	Meep	12	Mosselperceel	128366.492568	1750.000769	1	1400	1400	1400	66	66	66
268	Polygon	269	Oosterom 27	Waddengebied	0	Oosterom	27	Mosselperceel	185341.319526	1857.406124	1	1300	1300	1300	85	85	85
642	Polygon	643	Hammen 102	Oosterschelde	0	Hammen	102	Mosselperceel	209096.125438	1994.209532	2	<Null>	<Null>	<Null>	100	240	170
649	Polygon	650	Hammen 109	Oosterschelde	0	Hammen	109	Mosselperceel	217227.532103	2048.215471	34	100	1300	494	50	59	51
659	Polygon	660	Hammen 173	Oosterschelde	0	Hammen	173	Mosselperceel	98501.959244	1406.156579	2	<Null>	<Null>	<Null>	80	80	80
660	Polygon	661	Hammen 174	Oosterschelde	0	Hammen	174	Mosselperceel	92624.618717	1327.026186	2	<Null>	<Null>	<Null>	78	84	81
669	Polygon	670	Hammen 180a	Oosterschelde	0	Hammen	180a	Mosselperceel	120000.616993	1600.009007	21	303	1100	673	67	67	67
673	Polygon	674	Hammen 181-182	Oosterschelde	0	Hammen	181-182	Mosselperceel	120000.769399	2000.007048	2	200	400	300	80	80	80
698	Polygon	700	Hammen 29	Oosterschelde	0	Hammen	29	Mosselperceel	25999.860051	659.998123	4	1200	1350	1250	97	97	97
699	Polygon	701	Hammen 30	Oosterschelde	0	Hammen	30	Mosselperceel	69999.516628	1099.996191	18	300	2100	1077	50	85	77
715	Polygon	717	Hammen 55	Oosterschelde	0	Hammen	55	Mosselperceel	205492.744915	2761.438121	32	0	1800	618	85	116	103
724	Polygon	726	Hammen 61a	Oosterschelde	0	Hammen	61a	Mosselperceel	146010.928335	1860.18143	1	<Null>	<Null>	<Null>	90	90	90
806	Polygon	808	Mastgat 22	Oosterschelde	0	Mastgat	22	Mosselperceel	381969.859037	2518.776599	2	<Null>	<Null>	<Null>	140	235	188
823	Polygon	825	OSWD 1	Oosterschelde	0	OSWD	1	Mosselperceel	129999.18807	1699.992316	3	<Null>	<Null>	<Null>	85	110	93
830	Polygon	832	OSWD 105-108	Oosterschelde	0	OSWD	105-108	Mosselperceel	477398.341248	6354.541968	16	100	400	250	119	159	136
835	Polygon	840	OSWD 112	Oosterschelde	0	OSWD	112	Mosselperceel	86292.834588	1450.673915	3	150	600	317	2400	2400	2400
842	Polygon	847	OSWD 119	Oosterschelde	0	OSWD	119	Mosselperceel	91850.235153	1524.781067	4	150	600	375	2400	2400	2400
856	Polygon	861	OSWD 176c	Oosterschelde	0	OSWD	176c	Mosselperceel	141772.342409	1825.404555	1	50	50	50	90	90	90
864	Polygon	869	OSWD 180	Oosterschelde	0	OSWD	180	Mosselperceel	187499.550958	1849.998336	31	100	1500	539	65	72	69
869	Polygon	874	OSWD 182b	Oosterschelde	0	OSWD	182b	Mosselperceel	124996.545445	1649.989265	13	250	700	491	50	72	55
873	Polygon	878	OSWD 188	Oosterschelde	0	OSWD	188	Mosselperceel	122389.226686	1628.83655	10	500	1800	1369	80	103	87
883	Polygon	888	OSWD 201-202	Oosterschelde	0	OSWD	201-202	Mosselperceel	164999.634193	2799.995137	8	500	1254	821	77	1000	283
892	Polygon	898	OSWD 239-242	Oosterschelde	0	OSWD	239-242	Mosselperceel	366813.082668	6095.258686	15	50	700	168	77	135	102
922	Polygon	931	OSWD 62-63	Oosterschelde	0	OSWD	62-63	Mosselperceel	177270.392852	2985.443837	5	350	1850	1000	73	73	73
931	Polygon	941	OSWD 71-74	Oosterschelde	0	OSWD	71-74	Mosselperceel	270927.443204	4553.283497	8	500	2000	1025	72	82	77
937	Polygon	949	OSWD 80	Oosterschelde	0	OSWD	80	Mosselperceel	142422.238596	2212.426007	2	6150	6150	6150	90	90	90
938	Polygon	950	OSWD 81	Oosterschelde	0	OSWD	81	Mosselperceel	151016.965859	2327.026377	1	5600	5600	5600	90	90	90
939	Polygon	951	OSWD 83	Oosterschelde	0	OSWD	83	Mosselperceel	159612.352314	2441.626961	14	250	1500	575	111	1000	556
946	Polygon	958	OSWD 90	Oosterschelde	0	OSWD	90	Mosselperceel	156972.113442	2540.769294	1	<Null>	<Null>	<Null>	95	95	95
948	Polygon	960	OSWD 91a	Oosterschelde	0	OSWD	91a	Mosselperceel	139019.14762	1722.493281	13	50	750	415	128	130	129
950	Polygon	962	OSWD 93	Oosterschelde	0	OSWD	93	Mosselperceel	129200.948752	2032.602621	5	150	450	303	1200	2400	1440
951	Polygon	963	OSWD 94	Oosterschelde	0	OSWD	94	Mosselperceel	137515.475594	2143.495516	5	200	450	312	1200	2400	1440
954	Polygon	966	OSWD 97	Oosterschelde	0	OSWD	97	Mosselperceel	140548.397113	2179.761463	5	1300	1500	1400	200	2000	657
955	Polygon	967	OSWD 98	Oosterschelde	0	OSWD	98	Mosselperceel	134249.632522	2095.770224	9	350	1400	775	88	1200	922
1404	Polygon	1416	Zandkreek 20	Oosterschelde	0	Zandkreek	20	Mosselperceel	114879.657716	1356.117696	7	300	1200	729	92	92	92
1405	Polygon	1417	Zandkreek 21	Oosterschelde	0	Zandkreek	21	Mosselperceel	109595.889443	1325.036712	8	100	1350	638	<Null>	<Null>	<Null>
1439	Polygon	1452	Hammen 9	Oosterschelde	0	Hammen	9	Mosselperceel	156336.488162	1759.174315	2	64	66	65	<Null>	<Null>	<Null>

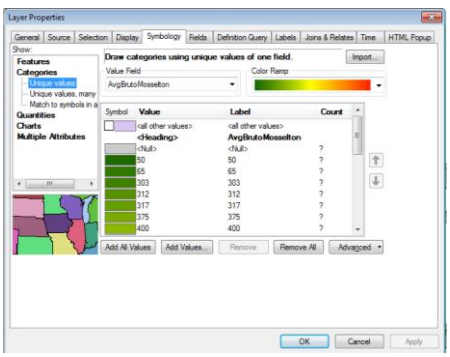
This is the attribute table showing merged blocks and joined attributes. To open attribute tables, right-click on the shape layer on the table of contents > [Open Attribute Table].

Step 4: Symbology

What are symbologies? Symbologies are used to display attributes in shape files using colours, symbols or charts. This function can classify and group attributes into different classifications, or do calculations to show desired results for spatial analysis.

How to use symbologies. Each layer can only display one type of symbology at a time. Double click on the shape layer that requires symbology displays, a property table would pop up, or simply right click on the layer > [Properties] > [Symbology].

There are five main categories of symbologies, and the recommended types to use in this project are: Categories – unique values, Quantities – graduated colours and Quantities – graduated symbols.



The unique values symbology is recommended to use for a small number of attributes to be analyzed using colours. Steps: click on [Categories] > [Unique Values] > choose the Value Field that needs to be analyzed in the drop down list > [Add All Values] > choose desired colour to display in the colour ramp.

The graduated colours symbology is better for dealing with a larger number of attributes using colours as well. Steps: click on [Quantities] >

[Graduated Colours] > choose the field to be analyzed > choose the classification system in [Classify…] and number of classes in the Classification session > choose desired colour to display in the colour ramp.

The graduated symbols symbology works the same way as graduated colours, but it displays symbols instead. Steps: click on [Quantities] > [Graduated Symbols] > choose the field to be analyzed > choose the classification system in [Classify…] and number of classes in the Classification session > symbol sizes can be changed from the Symbol Size session, symbol types and colours can be changed in the Template session. Background colours can be added behind the symbols on the shape blocks in the Background session. For an advanced way to modify symbol designs, double click on the symbol for each class to manually modify the colours, types and sizes.

Overlaying of symbologies Map layers are shown according to how they are placed in the table of contents. To change the layering of different shape files, go to the [List by Drawing Order] display mode of the table of contents. Simply drag the map layers up and down to reorder the layering.