Package ‘shelltrace’

October 6, 2017

Type Package

Title Bivalve Growth and Trace Element Accumulation Model

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Depends R (>= 3.1.0)

Imports xlsx, bmp, tiff, grDevices, stats

Description Contains all the formulae of the growth and trace element uptake model described in the equally-named Geoscientific Model Development paper (de Winter, 2017, <doi:10.5194/gmd-2017-137>). The model takes as input a file with X- and Y-coordinates of digitized growth increments recognized on a longitudinal cross section through the bivalve shell, as well as a BMP file of an elemental map of the cross section surface with chemically distinct phases separated by phase analysis. It proceeds by a step-by-step process described in the paper, by which digitized growth increments are used to calculate changes in shell height, shell thickness, shell volume, shell mass and shell growth rate through the bivalve's life time. Then, results of this growth modelling are combined with the trace element mapping results to trace the incorporation of trace elements into the bivalve shell. Results of various modelling parameters can be exported in the form of XLSX files.

License GPL-3

LazyData true

URL https://github.com/nielsjdewinter/ShellTrace,
    https://doi.org/10.5194/gmd-2017-137-supplement,
    http://nidewint.wixsite.com/nielsdewinter

BugReports https://github.com/nielsjdewinter/ShellTrace/issues

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### R topics documented:

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BMP image of phase map of cross section of modern oyster.

Description

An image of the microXRF phase map of the cross section used for this model from the Crassostre gigas #1 oyster used as an example in de Winter (2017)

Usage

data(BMP)

Format

A BMP image imported into R as a large data array

Source

https://doi.org/10.5194/gmd-2017-137-supplement
cross_section

Description
A dataset containing X- and Y-coordinates of digitized growth increments from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) resampled to fit the same X-axis.

Usage
data(cross_section)

Format
A data frame with 101 rows and 10 variables:

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>X-coordinates in mm</td>
</tr>
<tr>
<td>44</td>
<td>Empty column, title contains day of the year the shell started growing (estimated)</td>
</tr>
<tr>
<td>0</td>
<td>Y-coordinates of digitized increment 0 (top of shell), title contains age in days</td>
</tr>
<tr>
<td>30</td>
<td>Y-coordinates of digitized increment 1, title contains age in days</td>
</tr>
<tr>
<td>90</td>
<td>Y-coordinates of digitized increment 2, title contains age in days</td>
</tr>
<tr>
<td>270</td>
<td>Y-coordinates of digitized increment 3, title contains age in days</td>
</tr>
<tr>
<td>420</td>
<td>Y-coordinates of digitized increment 4, title contains age in days</td>
</tr>
<tr>
<td>780</td>
<td>Y-coordinates of digitized increment 5, title contains age in days</td>
</tr>
<tr>
<td>1050</td>
<td>Y-coordinates of digitized increment 6, title contains age in days</td>
</tr>
<tr>
<td>1290</td>
<td>Y-coordinates of digitized increment 7 (bottom of shell), title contains age in days</td>
</tr>
</tbody>
</table>

Source
https://doi.org/10.5194/gmd-2017-137-supplement

el_time

Description
A dataset containing the concentrations of every element measured in the phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in de Winter (2017) reconstructed in every subincrement.

Usage
data(el_time)
**image_length**

**Format**
A data frame with 24 rows and 1291 variables:

**Source**
https://doi.org/10.5194/gmd-2017-137-supplement

**Description**
A single value of the image length in mm

**Usage**
data(image_length)

**Format**
A single value:
Length in mm of digitized shell cross section

**Source**
https://doi.org/10.5194/gmd-2017-137-supplement

**incg**
Interpolated subincrements in cross section of modern oyster rescaled to the same X-axis.

**Description**
A dataset containing X- and Y-coordinates of subincrements interpolated between digitized growth increments from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sampled to fit a common X-axis. A Xstep of 0.1, a Tstep of 1 and a growth season of 250 days are used.

**Usage**
data(incg)

**Format**
A large data frame with 101 rows and 1291 variables:

**Source**
https://doi.org/10.5194/gmd-2017-137-supplement
Description
A dataset containing specific parameters calculated for all digitized growth increments from the Crassostre gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage
data(incr_matrix0)

Format
A data frame with 8 rows and 3 variables:

- **growth band** name of the growth increment
- **age (days)** Age associated with the deposition of the growth increment
- **age_cal (days)** Age associated with the deposition of the growth increment, calibrated to the seasonal cycle

Source
https://doi.org/10.5194/gmd-2017-137-supplement

Description
A dataset containing specific parameters calculated for all digitized growth increments from the Crassostre gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage
data(incr_matrix1)

Format
A data frame with 8 rows and 5 variables:

- **growth band** name of the growth increment
- **age (days)** Age associated with the deposition of the growth increment
- **age_cal (days)** Age associated with the deposition of the growth increment, calibrated to the seasonal cycle
- **incr_area** area between subsequent increments
- **incr_cumarea** area between increment and the top of the shell
**incr_matrix2**

Source

https://doi.org/10.5194/gmd-2017-137-supplement

---

**incr_matrix2**  
*Matrix containing data calculated for each growth band.*

---

**Description**

A dataset containing specific parameters calculated for all digitized growth increments from the *Crassostre gigas* #1 oyster used as an example in de Winter (2017) sorted per increment.

**Usage**

```r
data(incr_matrix2)
```

**Format**

A data frame with 8 rows and 6 variables:

- **growth band**  name of the growth increment
- **age (days)**  Age associated with the deposition of the growth increment
- **age_cal (days)**  Age associated with the deposition of the growth increment, calibrated to the seasonal cycle
- **incr_area**  area between subsequent increments
- **incr_cumarea**  area between increment and the top of the shell
- **av_thickness**  average thickness of area between increment and the top of the shell

Source

https://doi.org/10.5194/gmd-2017-137-supplement

---

**incr_matrix3**

*Matrix containing data calculated for each growth band.*

---

**Description**

A dataset containing specific parameters calculated for all digitized growth increments from the *Crassostre gigas* #1 oyster used as an example in de Winter (2017) sorted per increment.

**Usage**

```r
data(incr_matrix3)
```
Format

A data frame with 8 rows and 11 variables:

- **growth band**: name of the growth increment
- **age (days)**: Age associated with the deposition of the growth increment
- **age_cal (days)**: Age associated with the deposition of the growth increment, calibrated to the seasonal cycle
- **incr_area**: area between subsequent increments
- **incr_cumarea**: area between increment and the top of the shell
- **av_thickness**: average thickness of area between increment and the top of the shell
- **p1x**: X-value of first (leftmost) point in growth increment
- **p1y**: Y-value of first (leftmost) point in growth increment
- **p2x**: X-value of last (rightmost) point in growth increment
- **p2y**: Y-value of last (rightmost) point in growth increment
- **shell_height**: Height of shell during deposition of shell increment

Source

https://doi.org/10.5194/gmd-2017-137-supplement

---

`lengthfactor`  
*Multiplier used to convert shell cross section from pixels to mm*

Description

A single value of the amount of mm contained in one pixel

Usage

`data(lengthfactor)`

Format

A single value:

Length in mm of one pixel in the digitized shell cross section

Source

https://doi.org/10.5194/gmd-2017-137-supplement
**M_el_mat**

*Matrix of modelled mass accumulation rates per trace element*

**Description**

A dataset containing trace element accumulation modelled for every based on the a phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in de Winter (2017)

**Usage**

`data(M_el_mat)`

**Format**

A data frame with 5 rows and 24 variables:

- C  Mass accumulation of C in subincrement
- O  Mass accumulation of O in subincrement
- Na Mass accumulation of Na in subincrement
- Mg Mass accumulation of Mg in subincrement
- Al Mass accumulation of Al in subincrement
- Si Mass accumulation of Si in subincrement
- P  Mass accumulation of P in subincrement
- S  Mass accumulation of S in subincrement
- Cl Mass accumulation of Cl in subincrement
- K  Mass accumulation of K in subincrement
- Ca Mass accumulation of Ca in subincrement
- Ti Mass accumulation of Ti in subincrement
- Cr Mass accumulation of Cr in subincrement
- Mn Mass accumulation of Mn in subincrement
- Fe Mass accumulation of Fe in subincrement
- Ni Mass accumulation of Ni in subincrement
- Cu Mass accumulation of Cu in subincrement
- Zn Mass accumulation of Zn in subincrement
- Br Mass accumulation of Br in subincrement
- Rb Mass accumulation of Rb in subincrement
- Sr Mass accumulation of Sr in subincrement
- Rh Mass accumulation of Rh in subincrement
- Ba Mass accumulation of Ba in subincrement
- Pb Mass accumulation of Pb in subincrement

**Source**

[https://doi.org/10.5194/gmd-2017-137-supplement](https://doi.org/10.5194/gmd-2017-137-supplement)
### Description

A dataset containing mass accumulation of trace elements modelled for every based on the a phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in de Winter (2017)

### Usage

```r
data(M_el_mat_c)
```

### Format

A data frame with 5 rows and 24 variables:

- **C** Cumulative mass accumulation of C in subincrement
- **O** Cumulative mass accumulation of O in subincrement
- **Na** Cumulative mass accumulation of Na in subincrement
- **Mg** Cumulative mass accumulation of Mg in subincrement
- **Al** Cumulative mass accumulation of Al in subincrement
- **Si** Cumulative mass accumulation of Si in subincrement
- **P** Cumulative mass accumulation of P in subincrement
- **S** Cumulative mass accumulation of S in subincrement
- **Cl** Cumulative mass accumulation of Cl in subincrement
- **K** Cumulative mass accumulation of K in subincrement
- **Ca** Cumulative mass accumulation of Ca in subincrement
- **Ti** Cumulative mass accumulation of Ti in subincrement
- **Cr** Cumulative mass accumulation of Cr in subincrement
- **Mn** Cumulative mass accumulation of Mn in subincrement
- **Fe** Cumulative mass accumulation of Fe in subincrement
- **Ni** Cumulative mass accumulation of Ni in subincrement
- **Cu** Cumulative mass accumulation of Cu in subincrement
- **Zn** Cumulative mass accumulation of Zn in subincrement
- **Br** Cumulative mass accumulation of Br in subincrement
- **Rb** Cumulative mass accumulation of Rb in subincrement
- **Sr** Cumulative mass accumulation of Sr in subincrement
- **Rh** Cumulative mass accumulation of Rh in subincrement
- **Ba** Cumulative mass accumulation of Ba in subincrement
- **Pb** Cumulative mass accumulation of Pb in subincrement
Digitized growth increments in cross section of modern oyster.

A dataset containing X- and Y-coordinates of digitized growth increments from the Crassostrea gigas #1 oyster used as an example in de Winter (2017)

Usage

data(01_input)

Format

A data frame with 181 rows and 26 variables:

- **x_base**: X-coordinate in pixels of bottom line on image
- **y_base**: Y-coordinate in pixels of bottom line on image, second row value represents the day of the year
- **x_top**: X-coordinate in pixels of top of Crassostrea gigas shell #1 (increment 0)
- **y_top**: Y-coordinate in pixels of top of Crassostrea gigas shell #1 (increment 0), second row value represents the age in days (=0)
- **x_1**: X-coordinate in pixels of increment 1
- **y_1**: Y-coordinate in pixels of increment 1, second row value represents the age in days
- **x_2**: X-coordinate in pixels of increment 2
- **y_2**: Y-coordinate in pixels of increment 2, second row value represents the age in days
- **x_3**: X-coordinate in pixels of increment 3
- **y_3**: Y-coordinate in pixels of increment 3, second row value represents the age in days
- **x_4**: X-coordinate in pixels of increment 4
- **y_4**: Y-coordinate in pixels of increment 4, second row value represents the age in days
- **x_5**: X-coordinate in pixels of increment 5
- **y_5**: Y-coordinate in pixels of increment 5, second row value represents the age in days

Source

https://doi.org/10.5194/gmd-2017-137-supplement
**O1_phase**

**EMPTY7** Empty column

**x_6** X-coordinate in pixels of increment 6

**y_6** Y-coordinate in pixels of increment 6, second row value represents the age in days

**EMPTY8** Empty column

**x_bottom** X-coordinate in pixels of bottom of Crassostrea gigas shell #1

**y_bottom** Y-coordinate in pixels of bottom of Crassostrea gigas shell #1, second row value represents the age in days (= age of death)

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement

---

**Characteristics of phase in XRF map of oyster**

**Description**

A dataset containing trace element concentrations and RGB colour values of a phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in de Winter (2017)

**Usage**

`data(O1_phase)`

**Format**

A data frame with 5 rows and 30 variables:

- **Description** Description of phase
- **Name** Name of phase
- **R** R-value of phase colour
- **G** G-value of phase colour
- **B** B-value of phase colour
- **density** specific density of different phases
- **C** Concentration of C in phase
- **O** Concentration of O in phase
- **Na** Concentration of Na in phase
- **Mg** Concentration of Mg in phase
- **Al** Concentration of Al in phase
- **Si** Concentration of Si in phase
- **P** Concentration of P in phase
- **S** Concentration of S in phase
**Oyster_accumulation**

Cl  Concentration of Cl in phase
K  Concentration of K in phase
Ca  Concentration of Ca in phase
Ti  Concentration of Ti in phase
Cr  Concentration of Cr in phase
Mn  Concentration of Mn in phase
Fe  Concentration of Fe in phase
Ni  Concentration of Ni in phase
Cu  Concentration of Cu in phase
Zn  Concentration of Zn in phase
Br  Concentration of Br in phase
Rb  Concentration of Rb in phase
Sr  Concentration of Sr in phase
Rh  Concentration of Rh in phase
Ba  Concentration of Ba in phase
Pb  Concentration of Pb in phase

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement

**Description**

Function that combines the concentrations of trace elements per sub-increment with a smoothed record of mass accumulation with time to calculate the rate of accumulation of each element through the lifetime of the bivalve. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

Oyster_accumulation(el_time, subincr_matrix, npma = 10)

**Arguments**

el_time  Matrix of trace element concentrations through time
subincr_matrix  Data frame that contains characteristics of every sub-increment
npma  Integer n-value determining the window size of the moving average smoothing of the mass accumulation record
Details

A record of mass accumulation of the shell is smoothed using a moving average. This mass accumulation record is multiplied with the records of trace element concentrations per sub-increment to obtain a record of mass accumulation of each trace element through time and a record of cumulative trace element accumulation through time.

Value

Matrices of trace element accumulation per sub-increment and cumulative trace element accumulation

\[ M_{el\_mat} \] Matrix of mass accumulation per trace element

\[ M_{el\_mat\_c} \] Matrix of cumulative mass accumulation per trace element

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


See Also

"Oyster_el_time"

Examples

\[
\text{AccL} \leftarrow \text{Oyster\_accumulation(el\_time, subincr\_matrix6, npma = 10)}
\]
Description


Usage

```
oyster_combined_run(raw_data, image_length, season_length=250, Xstep=0.1, Tstep=1, 
oyster_height, Oyster_length, name_file="Oyster_growth_model", phases_name, 
image_name, image_ext, npma=10, name_shell)
```

Arguments

- `raw_data`: Numeric data frame containing the X- and Y-coordinates digitized in Adobe Illustrator or another image processing software
- `image_length`: Measured maximum length of the area of the cross section that is represented in "raw_data"
- `season_length`: Length (in days) of the growth season of the studied bivalve
- `Xstep`: The step size (dx) in X-direction used to interpolate coordinates of shell increments
- `Tstep`: The step size (dt) in time (days) used to interpolate the existing shell increments
- `Oyster_height`: Measured maximum height of the shell
- `Oyster_length`: Measured maximum length of the shell in anterio-posterior direction
- `name_file`: String indicating the name that should be added to all exported model results
- `phases_name`: String of full name (including extension!) of the CSV file that contains information about the phases in the map
- `image_name`: String of full name of the BMP that needs to be imported, excluding extension
- `image_ext`: Extension of phase map file ("BMP" or "TIF")
- `npma`: Window size of the moving average used to smooth mass gain record from the bivalve growth model
- `name_shell`: string indicating the name that should be added to all exported model results

Details

Oyster_growth_run and Oyster_phase_run, bundling and exporting the model results
Value

Exports matrices containing oyster growth parameters for each sub-increment as well as matrices containing trace element accumulation rates and concentration changes through the shells life time resulting from the trace element model. All these matrices are also exported as a list containing:

- `subincr_matrix`: Revised version of the "incr_matrix" data frame that contains characteristics calculated for every sub-increment
- `phase_stat`: Matrix of statistics of trace elements and phases in the total map
- `el_time`: Matrix of trace element concentrations through time
- `M_el_mat`: Matrix of mass accumulation per trace element
- `M_el_mat_c`: Matrix of cumulative mass accumulation per trace element

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

- GitHub
- Manuscript
- Supplementary data
- Author website

References


See Also

"Oyster_growth_run" and "Oyster_phase_run"

Description

Takes XY data of digitized growth increments in a shell cross section and converts them to a common X-axis with the correct lengths in millimeters. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>
Usage

Oyster_Convert_cross_section(raw_data, image_length, Xstep = 0.1)

Arguments

- `raw_data`: Numeric data frame containing the X- and Y-coordinates digitized in Adobe Illustrator or another image processing software.
- `image_length`: Measured maximum length of the area of the cross section that is represented in "raw_data".
- `Xstep`: The step size (dx) in X-direction used to interpolate coordinates of shell increments.

Details

First step in growth modelling: Converting XY data of increments to a common X-axis.

Value

List of two data sets and one value:

- `cross_section`: Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis.
- `year_trace`: Digitized cross section of shell increments without addition of top and bottom of the shell to the increment Y-values.
- `lengthfactor`: Factor of actual shell length relative to shell length in cross section.
- `incr_matrix`: Matrix containing ages and calibrated ages for each shell increment.

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

**Examples**

```r
Llist<-Oyster_Convert_cross_section(O1_input, image_length, Xstep=1)
```

---

**Oyster_ellipse_parameters**

*Function that calculates the parameters of the base ellipse used for bivalve growth modelling*

---

**Description**

Calculates the parameters a and b of the ellipse that forms the base of the shell in growth modelling. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_ellipse_parameters(subincr_matrix, IncG, Oyster_height, Oyster_length)
```

**Arguments**

- `subincr_matrix`: Data frame that contains characteristics of every sub-increment
- `IncG`: Matrix of X- and Y-coordinates of all interpolated sub-increments
- `Oyster_height`: Measured maximum height of the shell
- `Oyster_length`: Measured maximum length of the shell in anterio-posterior direction

**Details**

Parameters of the base ellipse of the shell are calculated by calculating the ratio between measured shell height and length and the endpoints of all sub-increments

**Value**

- `subincr_matrix`: Updated data frame that contains characteristics of every sub-increment, with ellipse parameters added

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website
Oyster_el_time

References


See Also

"Oyster_av_thickness"

Examples

subincr_matrix<-Oyster_ellipse_parameters(subincr_matrix3,IncG,Oyster_height,Oyster_height)

| Oyster_el_time | Calculate concentrations of trace elements per sub-increment |

Description

Function that takes the matrix of phase pixels per sub-increment together with the matrix of concentrations per phase to calculate the concentration of each trace element in every sub-increment.


Usage

Oyster_el_time(phase_mat, phases)

Arguments

phase_mat Matrix of amounts of pixels of each phase per sub-increment
phases Matrix containing colour and trace element data of the phases in the XRF phase map

Details

For every sub-increment, the relative contribution of phases is multiplied with the trace element concentrations of the phases to calculate the average concentration of trace elements in each sub-increment

Value

Matrix of trace element concentrations per sub-increment

el_time Matrix of trace element concentrations through time

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model
Oyster_Export

Author(s)
Niels J. de Winter

Source
GitHub
Manuscript
Supplementary data
Author website

References


See Also
"Oyster_Volumes"

Examples

```r
el_time<-Oyster_el_time(phase_matL o1_phase)
```

---

**Oyster_Export**

*Function that exports data of the growth model*

**Description**

Function that exports the results of the bivalve growth model as tables in the form of XLSX files. 

**Usage**

```
Oyster_Export(subincr_matrix, name_file)
```

**Arguments**

- `subincr_matrix` Data frame that contains characteristics of every sub-increment
- `name_file` String containing the name of the file to be exported

**Details**

Results are exported as "<name file>.xlsx?" in the working directory

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model
Oyster_growth_run

Author(s)
Niels J. de Winter

Source
GitHub
Manuscript
Supplementary data
Author website

References

See Also
"Oyster_av_thickness"

Examples

```r
## Not run:
Oyster_Export(subincr_matrix6, "test_export")

## End(Not run)
```

Oyster_growth_run  Runs the entire growth model

Description
Function that runs all functions contained in Step 2-4 of the growth model. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

```r
Oyster_growth_run(LOG=T, raw_data, image_length, season_length=250,
Xstep=0.1, Tstep=1, Oyster_height, Oyster_length,
name_file="Oyster_growth_model")
```

Arguments

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOG</td>
<td>Boolean parameter specifying if a LOG should be printed detailing the parameters entered into this function</td>
</tr>
<tr>
<td>raw_data</td>
<td>Numeric data frame containing the X- and Y-coordinates digitized in Adobe Illustrator or another image processing software</td>
</tr>
</tbody>
</table>
**image_length**  Measured maximum length of the area of the cross section that is represented in "raw_data"

**season_length**  Length (in days) of the growth season of the studied bivalve

**Xstep**  The step size (dx) in X-direction used to interpolate coordinates of shell increments

**Tstep**  The step size (dt) in time (days) used to interpolate the existing shell increments

**Oyster_height**  Measured maximum height of the shell

**Oyster_length**  Measured maximum length of the shell in anterio-posterior direction

**name_file**  string indicating the name that should be added to all exported model results

**Details**

Runs Oyster_run_sec2, Oyster_run_sec3, Oyster_run_sec4 and Oyster_Export

**Value**

Matrix containing all parameters of the shell calculated per sub-increment and CSV file containing this matrix

**subincr_matrix**  Revised version of the "incr_matrix" data frame that contains characteristics calculated for every sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub

Manuscript

Supplementary data

Author website

**References**


**Examples**

```r
### Not run:
GList<-Oyster_growth_run(TRUE, O1_input, image_length, season_length=250,
Xstep=1, Tstep=1, Oyster_height, Oyster_length, name_file="test_export")
### End(Not run)
```
Oyster_height  

Description

A single value containing the measured height in mm of the Crassostrea gigas #1 oyster used as an example in de Winter (2017) GMD.

Usage

data(Oyster_height)

Format

A single value:

Height in mm of the Crassostrea gigas #1 shell

Source

https://doi.org/10.5194/gmd-2017-137-supplement

Oyster_import_BMP  

Function that imports a BMP of an XRF map

Description


Usage

Oyster_import_BMP(file_name)

Arguments

file_name  

String of full name of the BMP that needs to be imported, excluding the extension

Details

Requires "bmp" package to work

Value

BMP  

"BMP" file representing the BMP image in R session
**Oyster_import_phases**

**Description**
Function that imports a table (in CSV format) containing the specifics of phases that make up the phase XRF map used in the trace element model. De Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```
Oyster_import_phases(file_name)
```

**Arguments**

- `file_name` String containing the name of the CSV file to be imported, including its extension

**Details**
This function imports a table containing trace element concentration and RGB colour data. Table needs to be of the same format as the example shown in de Winter, N.J., GMD, in review. The amount of phases represented in the table by rows is unlimited.

---

**Note**
Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**
Niels J. de Winter

**Source**
GitHub
Manuscript
Supplementary data
Author website

**References**

**See Also**
"Oyster_av_thickness"
**Value**

| phases          | Matrix containing colour, density and trace element data of the phases in the XRF phase map |

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub  
Manuscript  
Supplementary data  
Author website

**References**


**See Also**

"Oyster_av_thickness"

---

**Oyster_import_TIF**  
*Function that imports a TIF file*

**Description**

Function that imports an image in TIF or TIFF format of an XRF map. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

Oyster_import_TIF(file_name)

**Arguments**

| file_name | String of full name of the TIF(F) that needs to be imported, including extension |

**Details**

Requires "tiff" package to work
**Value**

TIF  "TIF" file representing the TIF(F) image in R session

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub
Manuscript
Supplementary data
Author website

**References**


**See Also**

"Oyster_av_thickness"

---

**Oyster_incr_area**  
*Area between shell increments*

**Description**

Calculates the area between this shell increment and the previous increment and the cumulative shell cross section area at the moment of deposition of the current increment and adds these to the previously created increment matrix. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```
Oyster_incr_area(cross_section, incr_matrix)
```

**Arguments**

- **cross_section**  
  Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis

- **incr_matrix**  
  Matrix containing ages and calibrated ages for each shell increment
**Details**

Areas between shell increments are calculated by iterating through increments in X-direction (dx) and adding differences in Y-values between increments.

**Value**

| incr_matrix | Matrix containing ages and calibrated ages for each shell increment |

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

**Author(s)**

Niels J. de Winter

**Source**

GitHub  
Manuscript  
Supplementary data  
Author website

**References**


**Examples**

```
incr_matrix1<-Oyster_incr_area(cross_section, incr_matrix0)
```

---

**Description**

Formula that takes the coordinates of digitized shell increments and interpolates a number of sub-increments between them to increase the time resolution of the growth model. The number of interpolated shell increments as well as the relative thickness of these increments is determined by a sinusoidal seasonal model that simulates seasonal variations in shell growth rate. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>
**Usage**

\[ \text{Oyster}_\text{incr}_\text{cross}_\text{section}(\text{incr}_\text{matrix}, \text{cross}_\text{section}, \text{season}_\text{length}, \text{Tstep}=1, \text{Xstep}=0.1) \]

**Arguments**

- **incr_matrix**: Matrix listing characteristics of each digitized increment
- **cross_section**: Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis
- **season_length**: Length (in days) of the growth season of the studied bivalve
- **Tstep**: The step size (dt) in time (days) used to interpolate the existing shell increments
- **Xstep**: The step size (dx) in X-direction used to interpolate coordinates of shell increments

**Details**

Sub-increments are reconstructed by interpolating Y-values between the digitized shell increments

**Value**

List of two data frames:

- **IncG**: Matrix of X- and Y-coordinates of all interpolated sub-increments
- **subincr_matrix**: Revised version of the "incr_matrix" data frame that contains characteristics (sub-increment number, X-value of start of increment) recalculated for every sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website

**References**

**Oyster_length**

**Examples**

```r
lsub<-Oyster_incr_cross_section(incr_matrix3, cross_section, season_length=250, Tstep=1, Xstep=1)
```

---

**Oyster_length**  
*Measured length of the shell*

**Description**

A single value containing the measured length (in anterio-posterior direction) in mm of the Crassostrea gigas #1 oyster used as an example in de Winter (2017) GMD.

**Usage**

```r
data(Oyster_length)
```

**Format**

A single value:

Length in mm of the Crassostrea gigas #1 shell

**Source**

[https://doi.org/10.5194/gmd-2017-137-supplement](https://doi.org/10.5194/gmd-2017-137-supplement)

---

**Oyster_Mass_gain**  
*Formula that calculates mass increase of bivalve shell with time*

**Description**

Formula that takes the modelled volume of a bivalve shell by sub-increment and calculates mass increase using variable shell density. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_Mass_gain(subincr_matrix, phase_mat, phases)
```

**Arguments**

- `subincr_matrix`: Data frame that contains characteristics of every sub-increment
- `phase_mat`: Matrix of amounts of pixels of each phase per sub-increment
- `phases`: Matrix containing colour, density and trace element data of the phases in the XRF phase map
Details
Calculates mass gain from modelled changes in volume based on the shell density

Value

subincr_matrix  Updated data frame that contains characteristics of every sub-increment with modelled shell mass calculations added to the matrix

Note
Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)
Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


See Also
"Oyster_av_thickness"

Examples

subincr_matrix6<-Oyster_Mass_gain(subincr_matrix5, phase_mat, 01_phase)

Export results of trace element model

Description
A function that takes all the matrices with results of the trace element model and exports them as XLSX files. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage
Oyster_phase_export(phase_stat, el_time, M_el_mat, M_el_mat_c, name_shell)
**Arguments**

- `phase_stat`: matrix of statistics of trace elements and phases in the total map
- `el_time`: Matrix of trace element concentrations through time
- `M_el_mat`: Matrix of mass accumulation per trace element
- `M_el_mat_c`: Matrix of cumulative mass accumulation per trace element
- `name_shell`: Name of the shell used in the model to be incorporated into the file names

**Details**

All matrices fed to the function are exported as XLSX files in the working directory using the "write.xlsx" function of the "xlsx" package

**Value**

XLSX files of all result matrices of the trace element model

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub

Manuscript

Supplementary data

Author website

**References**


**See Also**

"Oyster_Export"

**Examples**

```r
## Not run:
Oyster_phase_export(phase_stat, el_time, M_el_mat, M_el_mat_c, "test")

## End(Not run)```
Description


Usage

Oyster_phase_matrix_BMP(BMP, phases)

Arguments

BMP  "BMP" file representing the BMP image in R session
phases Matrix containing colour, density and trace element data of the phases in the XRF phase map

Details

This function compares the colour data from the "BMP" object with colour codes of phases in "phases" table to assign a phase to every pixel in the BMP

Value

phasemat matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

See Also

"Oyster_av_thickness"

Examples

```r
## Not run:
phasemat<-Oyster_phase_matrix_BMP(BMP, 01_phase)

## End(Not run)
```

---

**Oyster_phase_matrix_TIF**

*Function that calculates phase matrix*

---

**Description**


**Usage**

`Oyster_phase_matrix_TIF(TIF, phases)`

**Arguments**

- `TIF` : "TIF" file representing the TIF(F) image in R session
- `phases` : Matrix containing colour and trace element data of the phases in the XRF phase map.

**Details**

This function compares the colour data from the "TIF" object with colour codes of phases in "phases" table to assign a phase to every pixel in the TIF(F)

**Value**

- `phasemat` : matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel.

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

**Author(s)**

Niels J. de Winter
**Oyster_phase_run**

**Source**

GitHub
Manuscript
Supplementary data
Author website

**References**


**See Also**

"Oyster_av_thickness"

**Examples**

```r
## Not run:
phasemat<-Oyster_phase_matrix_TIF(TIF, 01_phase)

## End(Not run)
```

---

**Description**


**Usage**

```r
Oyster_phase_run(LOG=T, phases_name, image_name, image_ext, IncG, pixelsize, subincr_matrix, npma=10, name_shell, name_file)
```

**Arguments**

- **LOG**  
  Boolean parameter specifying if a LOG should be printed detailing the parameters entered into this function
- **phases_name**  
  String of full name (including extension!) of the CSV file that contains information about the phases in the map
- **image_name**  
  String of full name of the BMP that needs to be imported, excluding extension
- **image_ext**  
  Extention of phase map file ("BMP" or "TIF")
- **IncG**  
  Matrix of X- and Y-coordinates of all interpolated sub-increments
- **pixelsize**  
  Size of pixels in phase map in micrometers
subincr_matrix  Revised version of the "yearly_matrix" data frame that contains characteristics calculated for every sub-increment
npma  Window size of the moving average used to smooth mass gain record from the bivalve growth model
name_shell  string indicating the name that should be added to all exported model results
name_file  string indicating the name of the exported results file

Details

Runs Oyster_run_sec5, Oyster_run_sec6 and Oyster_phase_export

Value

XLSX files of all result matrices of the trace element model as well as a list containing these matrices:

phase_stat  matrix of statistics of trace elements and phases in the total map
el_time  Matrix of trace element concentrations through time
M_el_mat  Matrix of mass accumulation per trace element
M_el_mat_c  Matrix of cumulative mass accumulation per trace element

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

Oyster_phase_stats  

Function that exports phase statistics

Description

Function that searches through the matrix of phases per pixel and exports the statistics of representation of different phases in the map as well as the bulk composition of pixels in the map. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_phase_stats(phasemat, phases)

Arguments

phasemat  
matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel

phases  
Matrix containing colour and trace element data of the phases in the XRF phase map

Details

Phase statistics are calculated by looping through the matrix of phases created from the XRF phase map and comparing with the "phases" statistics table

Value

phase_stat  
matrix of statistics of trace elements and phases in the total map

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

See Also

"Oyster_phase_matrix_BMP"

Examples

```r
phase_stat<-Oyster_phase_stats(phasemat, 01_phase)
```

---

**Oyster_plot_cross_section**

*Plot the converted shell cross section*

---

**Description**

Simple function that returns a plot of the shell cross section after it has been converted to a common X-axis. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_plot_cross_section(cross_section)
```

**Arguments**

- `cross_section` Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis

**Details**

Plotting of digitized cross section after first modelling step to verify the correct digitization of the shell increments

**Value**

Opens a new plotting window to plot the shell cross section based on its X- and Y-coordinates

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub
Manuscript
Supplementary data
Author website
References


Examples

Oyster_plot_cross_section(cross_section)

Oyster_plot_incr_CS  Plot the result of interpolation of sub-increments

Description

Formula that plots the result of the interpolation of digitized shell growth increments to reconstruct sub-increments to provide a check on the progress of the model. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_plot_incr_CS(IncG, incr_matrix, Tstep)

Arguments

IncG Matrix of X- and Y-coordinates of all interpolated sub-increments
incr_matrix Matrix listing characteristics of each digitized increment
Tstep The step size (dt) in time (days) used to interpolate the existing shell increments

Details

In order to prevent overcrowding the plot area and slowing the plotting process, only original shell increments and sub-increments halfway between original increments are plotted. Sub-increments are colored blue

Value

No data is exported, but a plot showing interpolated sub-increments is given in a separate window.

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter
Oyster_plot_incr_fill

Source

GitHub
Manuscript
Supplementary data
Author website

References


Examples

Oyster_plot_incr_CS(IncG,incr_matrix3,Tstep=1)

Description

Formula that plots the result of the interpolation of digitized shell growth increments to reconstruct sub-increments to provide a check on the progress of the model. Areas between sub-increments are coloured in direction of growth using the heat colour palette. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_plot_incr_fill(IncG)

Arguments

IncG Matrix of X- and Y-coordinates of all interpolated sub-increments

Details

Areas between sub-increments are represented by coloured polygons, while digitized increments are plotted using black lines. High numbers of interpolated sub-increments can cause plotting to become slow

Value

No data is exported, but a coloured plot showing interpolated sub-increments is given in a separate window.
Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


Examples

```r
Oyster_plot_incr_fill(IncG)
```

```
Oyster_run_sec2          Runs complete Step 2 of the growth model
```

Description

Function that combines all functions in Step 2 of the bivalve growth model and runs them consecutively given the right input. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

```r
Oyster_run_sec2(raw_data, image_length, Xstep)
```

Arguments

- `raw_data`: Numeric data frame containing the X- and Y-coordinates digitized in Adobe Illustrator or another image processing software
- `image_length`: Measured maximum length of the area of the cross section that is represented in `raw_data`
- `Xstep`: The step size (dx) in X-direction used to interpolate coordinates of shell increments
**Details**

This function runs the functions Oyster_Convert_cross_section, Oyster_plot_cross_section, Oyster_incr_area, Oyster_Shell_thickness and Oyster_Shell_height consecutively.

**Value**

List of three items:

- **cross_section**: Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis.
- **incr_matrix**: Matrix listing characteristics of each digitized increment.
- **lengthfactor**: Factor of actual shell length relative to shell length in cross section, used to constrain pixelsize in phase map.

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website

**References**


**Examples**

List2<-Oyster_run_sec2(O1_input, image_length, Xstep=1)
Oyster_run_sec3

Runs complete Step 3 of the growth model

Description
Function that combines all functions in Step 3 of the bivalve growth model and runs them consecutively given the right input. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage
Oyster_run_sec3(cross_section, incr_matrix, season_length=250, Xstep=0.1, Tstep=1, Oyster_height, Oyster_length)

Arguments
- **cross_section**: Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis
- **incr_matrix**: Matrix listing characteristics of each digitized increment
- **season_length**: Length (in days) of the growth season of the studied bivalve
- **Xstep**: The step size (dx) in X-direction used to interpolate coordinates of shell increments
- **Tstep**: The step size (dt) in time (days) used to interpolate the existing shell increments
- **Oyster_height**: Measured maximum height of the shell
- **Oyster_length**: Measured maximum length of the shell in anterio-posterior direction

Details
This function runs the functions Oyster_Increment_cross_section, Oyster_plot_Inc_CS, Oyster_Inc_fill, Oyster_subincr_area, Oyster_subincr_shell_height, Oyster_subincr_av_thickness and Oyster_ellipse_parameters consecutively

Value
List of two items:
- **IncG**: Matrix of X- and Y-coordinates of all interpolated sub-increments
- **subincr_matrix**: Revised version of the "yearly_matrix" data frame that contains characteristics (sub-increment number, X-value of start of increment) recalculated for every sub-increment

Note
Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)
Niels J. de Winter
Source

GitHub
Manuscript
Supplementary data
Author website

References


Examples

```r
list3<-Oyster_run_sec4(cross_sectionL incr_matrixSL season_length=250, Xstep=1,
Tstep=1, Oyster_height, Oyster_length)
```

---

**Oyster_run_sec4**

*Runs complete Step 4 of the growth model*

**Description**

Function that combines all functions in Step 4 of the bivalve growth model and runs them consecutively given the right input. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_run_sec4(IncG, subincr_matrix, Xstep = 0.1)
```

**Arguments**

- `IncG`: Matrix of X- and Y-coordinates of all interpolated sub-increments
- `subincr_matrix`: Revised version of the "yearly_matrix" data frame that contains characteristics calculated for every sub-increment
- `Xstep`: The step size (dx) in X-direction used to interpolate coordinates of shell increments

**Details**

This function runs the functions `Oyster_Z_matrices` and `Oyster_Volumes` consecutively

**Value**

A list of two items:

- `subincr_matrix`: Revised version of the "incr_matrix" data frame that contains characteristics calculated for every sub-increment
- `IncGAnet`: Matrix of areas of cross sections in YZ-directions sorted by X-values and by sub-increment
Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


Examples

```r
## Not run:
List4<-Oyster_run_sec4(IncG, subincr_matrix4, Xstep = 1)

## End(Not run)
```

---

**Oyster_run_sec5**  
*Runs complete Step 5 of the trace element model*

Description

Function that combines all functions in Step 5 of the bivalve trace element model and runs them consecutively given the right input. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

```r
Oyster_run_sec5(phases_name, image_name, image_ext)
```

Arguments

- **phases_name**: String of full name (including extension!) of the CSV file that contains information about the phases in the map
- **image_name**: String of full name of the BMP that needs to be imported, excluding extension
- **image_ext**: Extension of phase map file ("BMP" or "TIF")
**Details**

This function runs the functions `Oyster_import_phases`, `Oyster_phase_matrix_BMP`, `Oyster_phase_matrix_TIF` and `Oyster_phase_stat` consecutively.

**Value**

List of two items:

- `phasemat`: matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel
- `phase_stat`: matrix of statistics of trace elements and phases in the total map
- `phases`: Matrix containing colour, density and trace element data of the phases in the XRF phase map

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model.

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website

**References**


---

**Oyster_run_sec6**

 Runs complete Step 6 of the trace element model

**Description**

Function that combines all functions in Step 6 of the bivalve trace element model and runs them consecutively given the right input. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_run_sec6(phasemat, IncG, pixelsize, phases, subincr_matrix, npma, name_file)
```
Arguments

phasemat  matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel
IncG  Matrix of X- and Y-coordinates of all interpolated sub-increments
pixelsize  size of pixels in the phase map in micrometer
phases  Matrix containing colour and trace element data of the phases in the XRF phase map
subincr_matrix  Data frame that contains characteristics of every sub-increment
npma  Integer n-value determining the window size of the moving average smoothing of the mass accumulation record
name_file  string indicating the name of the exported results file

Details

This function runs the functions Oyster_subincr_phases, Oyster_Mass_gain Oyster_el_time and Oyster_accumulation consecutively

Value

List of three items:
el_time  Matrix of trace element concentrations through time
M_el_mat  Matrix of mass accumulation per trace element
M_el_mat_c  Matrix of cumulative mass accumulation per trace element
subincr_matrix  Data frame that contains characteristics of every sub-increment

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

**Oyster_Shell_height**

Formula that calculates shell height through time

**Description**

Formula that calculates shell height at the moment of deposition of each shell increment from X- and Y-coordinates of the shell increments and adds the result to the matrix of increment characteristics.


**Usage**

`Oyster_Shell_height(cross_section, incr_matrix)`

**Arguments**

- `incr_matrix` Matrix listing characteristics of each digitized increment
- `cross_section` Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis

**Details**

Shell height is calculated via the Pythagorean Theorem using the X- and Y-coordinates of both ends of the shell increment with extreme X-values

**Value**

- `incr_matrix` Updated matrix listing characteristics of each digitized increment, shell height values as well as the coordinates of both ends of the shell increments are added

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter
**Oyster_Shell_thickness**

**Source**
- GitHub
- Manuscript
- Supplementary data
- Author website

**References**

**Examples**

```r
incr_matrix3<-Oyster_Shell_height(cross_section, incr_matrix2)
```

---

**Description**

Formula that calculates average shell thickness at the moment of deposition of each shell increment from X- and Y-coordinates of the shell increments and adds the result to the matrix of increment characteristics. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

```r
Oyster_Shell_thickness(cross_section, incr_matrix)
```

**Arguments**

- `incr_matrix`  Matrix listing characteristics of each digitized increment
- `cross_section`  Digitized cross section of the shell with shell top, bottom and growth increments relative to a common X-axis

**Details**

Shell thickness is calculated as the average difference in Y-values between the shell increment and the top of the shell (Increment 0)

**Value**

- `incr_matrix`  Updated matrix listing characteristics of each digitized increment, shell thickness values are added

A plot of the change in shell thickness with shell age based on the digitized growth increments is produced in a new window


**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub
Manuscript
Supplementary data
Author website

**References**


**Examples**

```r
incr_matrix2 <- Oyster_Shell_thickness(cross_section, incr_matrix1)
```

---

**Oyster_subincr_area**  
*Formula that calculates area between sub-increments*

**Description**

Formula that calculates cross section area between each sub-increment and the previous sub-increment.  

**Usage**

```r
Oyster_subincr_area(IncG, subincr_matrix, Xstep)
```

**Arguments**

<table>
<thead>
<tr>
<th>Argument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>IncG</td>
<td>Matrix of X- and Y-coordinates of all interpolated sub-increments</td>
</tr>
<tr>
<td>subincr_matrix</td>
<td>Data frame that contains characteristics of every sub-increment</td>
</tr>
<tr>
<td>Xstep</td>
<td>Step value in X-direction for the interpolation of sub-increments</td>
</tr>
</tbody>
</table>

**Details**

Areas between sub-increments are calculated by averaging the difference in Y-values between sub-increments and multiplying them with the step in X-values (dx)
Value

subincr_matrix  Revised version of the "incr_matrix" data frame that contains cross section area recalculated for every sub-increment

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


See Also

"Oyster_Shell_length"

Examples

  subincr_matrix1<-Oyster_subincr_area(IncG, subincr_matrix0, Xstep=1)

Oyster_subincr_av_thickness

*Formula that calculates average shell thickness through time*

Description

Formula that calculates average shell thickness at the moment of deposition of each shell sub-increment from cross section area and shell length and adds the result to the matrix of increment characteristics. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_subincr_av_thickness(subincr_matrix)
**Arguments**

`subincr_matrix` Data frame that contains characteristics of every sub-increment

**Details**

Shell thickness is calculated as the ratio between cross section area and shell length (Increment 0)

**Value**

`subincr_matrix` Revised version of the "incr_matrix" data frame that contains average shell thickness recalculated for every sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub  
Manuscript  
Supplementary data  
Author website

**References**


**See Also**

"Oyster_av_thickness"

**Examples**

`subincr_matrix3<-Oyster_subincr_av_thickness(subincr_matrix2)`
Oyster_subincr_av_thickness_X

Formula that calculates average shell thickness through time

**Description**

Formula that calculates average shell thickness at the moment of deposition of each shell sub-increment from X- and Y-coordinates of the shell increments and adds the result to the matrix of increment characteristics. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Usage**

Oyster_subincr_av_thickness_X(IncG, subincr_matrix)

**Arguments**

IncG  
Matrix of X- and Y-coordinates of all interpolated sub-increments

subincr_matrix  
Data frame that contains characteristics of every sub-increment

**Details**

Shell thickness is calculated as the average difference in Y-values between the shell sub-increment and the top of the shell (Increment 0)

**Value**

subincr_matrix  
Revised version of the "incr_matrix" data frame that contains average shell thickness recalculated for every sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

GitHub
Manuscript
Supplementary data
Author website

**References**

Oyster_subincr_phases

See Also

"Oyster_av_thickness"

Examples

subincr_matrix3<-Oyster_subincr_av_thickness(X(IncG, subincr_matrix2)

Oyster_subincr_phases  Calculates proportion of phases in each sub-increment

Description

Function that takes the matrix of sub-increment positions and the matrix of phases and calculates the amount of pixels of each phase that is contained in each sub-increment based on pixelsize and phase characteristics. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_subincr_phases(IncG, phasemat, pixelsize, phases)

Arguments

IncG  Matrix of X- and Y-coordinates of all interpolated sub-increments
phasemat  matrix of phases of each pixel sorted by X- and Y-coordinate of the pixel
pixelsize  size of pixels in the phase map in millimeter
phases  Matrix containing colour and trace element data of the phases in the XRF phase map

Details

For every sub-increment, all pixels that cover area in the sub-increment are identified based on the pixel size of the phase map and the X- and Y-positions of the sub-increments. The amount of pixels of each phase in the sub-increment is saved in a new matrix of phases per sub-increment

Value

A matrix of the amount of pixels for each phase found in every sub-increment

phase_mat  Matrix of amounts of pixels of each phase per sub-increment

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter
Oyster_subincr_shell_height

Source
GitHub
Manuscript
Supplementary data
Author website

References


See Also
"Oyster_Suby_av_thickness"

Examples

```r
## Not run:
phase_mat<-Oyster_subincr_phases(IncG, phasemat, pixelsize, 01_phase)

## End(Not run)
```

Description

A formula to calculate shell height per sub-increment

Usage

```r
Oyster_subincr_shell_height(subincr_matrix, IncG, Xstep)
```

Arguments

- `subincr_matrix`: Data frame that contains characteristics of every sub-increment
- `IncG`: Matrix of X- and Y-coordinates of all interpolated sub-increments
- `Xstep`: Step value in X-direction for the interpolation of sub-increments

Details

Shell height is calculated via the Pythagorean Theorem using the X- and Y-coordinates of both ends of the shell sub-increment with extreme X-values
Value

subincr_matrix  Revised version of the "incr_matrix" data frame that contains shell height recalculated for every sub-increment

Note

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)

Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References


See Also

"Oyster_Shell_height"

Examples

subincr_matrix2<-Oyster_subincr_shell_height(subincr_matrix1,IncG,Xstep=1)

Oyster_Volumes  *Formula that calculates volume of the shell through time*

Description

Formula that calculates the volume of the bivalve shell during the time of deposition of each sub-increment. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

Usage

Oyster_Volumes(subincr_matrix, Z_mat, IncG, Xstep = 0.1)
**Arguments**

- `subincr_matrix`  Data frame that contains characteristics of every sub-increment
- `Z_mat`  Matrix of Z-values for each X-value and each sub-increment
- `IncG`  Matrix of X- and Y-coordinates of all interpolated sub-increments
- `xstep`  Step value in X-direction for the interpolation of sub-increments

**Details**

Volume is calculated for each sub-increment and each X-value based on cross sections perpendicular to the XY-plane. Area of the shell in this cross section is calculated by constructing a circle section through the intercept with the base ellipse and the top of the shell sub-increment. See paper de Winter, GMD (in review) for details and illustrations.

**Value**

A list of two data frames:

- `subincr_matrix`  Updated data frame that contains characteristics of every sub-increment with modelled shell volumes added to the matrix
- `IncGANet`  Matrix of areas of cross sections in YZ-directions sorted by X-values and by sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website

**References**


**See Also**

"Oyster_av_thickness"
Oyster_Z_matrices

Examples

```r
## Not run:
diagL<-Oyster_Volumes(subincr_matrix4, Z_mat4, IncG, Xstep = 1)

## End(Not run)
```

---

**Oyster_Z_matrices**  
*Function that calculates matrices of Z-values for all sub-increments and all X-values*

**Description**

Function that calculates Z-values that form the edge of the shell in terms of distance from the X-axis in direction of the width of the shell. de Winter, N. J. (2017) [doi:10.5194/gmd-2017-137]

**Usage**

```r
Oyster_Z_matrices(IncG, subincr_matrix)
```

**Arguments**

- **IncG**: Matrix of X- and Y-coordinates of all interpolated sub-increments
- **subincr_matrix**: Data frame that contains characteristics of every sub-increment

**Details**

Z-values are calculated using the standard formulae of an ellipse, the parameters calculated in "Oyster_Oval_parameters" and the X-coordinates of each sub-increment

**Value**

- **Z_mat4**: Matrix of Z-values for each X-value and each sub-increment

**Note**

Please cite Geoscientific Model Development paper dealing with the ShellTrace model

**Author(s)**

Niels J. de Winter

**Source**

- GitHub
- Manuscript
- Supplementary data
- Author website
References


See Also

"Oyster_av_thickness"

Examples

```r
phasemat <- Oyster_Z_matrices(IncL, subincr_matrix4)
```

Description

A dataset containing names of phases for every pixel in the phase map measured on a cross section through the Crassostrea gigas #1 oyster used as an example in dé Winter (2017).

Usage

data(phasemat)

Format

A large data frame with 2258 rows and 2383 variables:

Source

https://doi.org/10.5194/gmd-2017-137-supplement

Description

A dataset containing the amounts of pixels of each phase in the phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in dé Winter (2017) represented in every subincrement.

Usage

data(phase_mat)
Format

A data frame with 4 rows and 1291 variables:

Source

https://doi.org/10.5194/gmd-2017-137-supplement

Description

A dataset containing trace element concentrations and fractions of a phase map of the XRF mapped surface of the Crassostrea gigas #1 oyster used as an example in de Winter (2017)

Usage

data(phase_stat)

Format

A data frame with 5 rows and 27 variables:

Names  Names of phases
pixels  Amount of pixels representing the phase
fraction  Fraction of map surface represented by phase
C  Concentration of C in phase
O  Concentration of O in phase
Na  Concentration of Na in phase
Mg  Concentration of Mg in phase
Al  Concentration of Al in phase
Si  Concentration of Si in phase
P  Concentration of P in phase
S  Concentration of S in phase
Cl  Concentration of Cl in phase
K  Concentration of K in phase
Ca  Concentration of Ca in phase
Ti  Concentration of Ti in phase
Cr  Concentration of Cr in phase
Mn  Concentration of Mn in phase
Fe  Concentration of Fe in phase
Ni  Concentration of Ni in phase
Cu  Concentration of Cu in phase
Zn  Concentration of Zn in phase
Br  Concentration of Br in phase
Rb  Concentration of Rb in phase
Sr  Concentration of Sr in phase
Rh  Concentration of Rh in phase
Ba  Concentration of Ba in phase
Pb  Concentration of Pb in phase

Source

https://doi.org/10.5194/gmd-2017-137-supplement

---

**pixelsize**  
*Size of pixels in phase map in mm*

**Description**

A single value of the amount of mm contained in one pixel rounded up to the nearest micrometer.

**Usage**

data(pixelsize)

**Format**

A single value:

Length in mm of one pixel in the digitized shell cross section rounded up to the nearest micrometer

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement
Function to do an n-point moving average

Description

Usage
pma(x, i, n)

Arguments

x A numeric data frame containing the data set to be smoothed, X-values should be in the first column
i The index of the column that contains the Y-values
n Integer N-value determining the window size of the moving average smoothing

Value
A numeric data frame containing three columns: One with X-values, one with Y-values and one with smoothed Y-values

Note
Please cite Geoscientific Model Development paper dealing with the ShellTrace model

Author(s)
Niels J. de Winter

Source

GitHub
Manuscript
Supplementary data
Author website

References

**Examples**

```r
Nile <- as.data.frame(Nile)
Nile <- cbind(rownames(Nile), Nile)
Nile_Spm <- pma(Nile, 2, 5)
```

---

**Description**

This package contains formulae used to model the growth and development of bivalve shells based on digitized co-ordinated of shell increments in a longitudinal cross section through the shell. The growth model is combined with XRF mapping results of the same cross section and a seasonal growth rate model to model trace element concentrations and uptake rates into the bivalve shell. de Winter, N. J. (2017) <doi:10.5194/gmd-2017-137>

**Details**

Formulae in this package form the several steps of the model, and are not meant to be used individually. The order and application of these functions is outlined in the publication in Geoscientific Model Development that bears the name of the model (de Winter, in review)

**Author(s)**

Niels J. de Winter
Maintainer: Niels J. de Winter

**References**


**See Also**

[GitHub](#)
[Manuscript](#)
[Supplementary data](#)
[Author website](#)

**Examples**

```r
print("de Winter, N. J.: ShellTrace v1.0 - A new approach for modelling growth and trace element uptake in marine bivalve shells: Model verification on pacific oyster shells (Crassostrea gigas), Geosci. Model Dev. Discuss., in review, 2017.")
```
subincr_matrix0  Matrix containing data calculated for each growth band.

Description
A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage
data(subincr_matrix0)

Format
A data frame with 1291 rows and 3 variables:

Age  age (in days) of the subincrement
p1xs  X-value of the first (leftmost) point in the subincrement
p2xs  X-value of the last (rightmost) point in the subincrement

Source
https://doi.org/10.5194/gmd-2017-137-supplement

subincr_matrix1  Matrix containing data calculated for each growth band.

Description
A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage
data(subincr_matrix1)

Format
A data frame with 1291 rows and 5 variables:

Age  age (in days) of the subincrement
p1xs  X-value of the first (leftmost) point in the subincrement
p2xs  X-value of the last (rightmost) point in the subincrement
areaY  Area between subsequent subincrements
areaC  Area between subincrement and top of shell
**Source**

https://doi.org/10.5194/gmd-2017-137-supplement

---

**Matrix containing data calculated for each growth band.**

**Description**

A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

**Usage**

```r
data(subincr_matrix2)
```

**Format**

A data frame with 1291 rows and 10 variables:

- **Age**: age (in days) of the subincrement
- **p1xs**: X-value of the first (leftmost) point in the subincrement
- **p2xs**: X-value of the last (rightmost) point in the subincrement
- **areaY**: Area between subsequent subincrements
- **areaC**: Area between subincrement and top of shell
- **p1y**: Y-value of the first (leftmost) point in the subincrement
- **p2y**: Y-value of the last (rightmost) point in the subincrement
- **shell_height**: Height of shell during deposition of the subincrement
- **firstl**: Row number in IncG of first (leftmost) data point belonging to the subincrement
- **lastl**: Row number in IncG of last (rightmost) data point belonging to the subincrement

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement
subincr_matrix3

*Matrix containing data calculated for each growth band.*

**Description**

A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

**Usage**

```r
data(subincr_matrix3)
```

**Format**

A data frame with 1291 rows and 11 variables:

- **Age**: age (in days) of the subincrement
- **p1xs**: X-value of the first (leftmost) point in the subincrement
- **p2xs**: X-value of the last (rightmost) point in the subincrement
- **areaY**: Area between subsequent subincrements
- **areaC**: Area between subincrement and top of shell
- **p1y**: Y-value of the first (leftmost) point in the subincrement
- **p2y**: Y-value of the last (rightmost) point in the subincrement
- **shell_height**: Height of shell during deposition of the subincrement
- **firstl**: Row number in IncG of first (leftmost) data point belonging to the subincrement
- **lastl**: Row number in IncG of last (rightmost) data point belonging to the subincrement
- **av_thickness**: Average thickness during deposition of the subincrement

**Source**

[https://doi.org/10.5194/gmd-2017-137-supplement](https://doi.org/10.5194/gmd-2017-137-supplement)

subincr_matrix4

*Matrix containing data calculated for each growth band.*

**Description**

A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

**Usage**

```r
data(subincr_matrix4)
```
Format

A data frame with 1291 rows and 15 variables:

- **Age**: age (in days) of the subincrement
- **p1xs**: X-value of the first (leftmost) point in the subincrement
- **p2xs**: X-value of the last (rightmost) point in the subincrement
- **areaY**: Area between subsequent subincrements
- **areaC**: Area between subincrement and top of shell
- **p1y**: Y-value of the first (leftmost) point in the subincrement
- **p2y**: Y-value of the last (rightmost) point in the subincrement
- **shell_height**: Height of shell during deposition of the subincrement
- **firstl**: Row number in IncG of first (leftmost) data point belonging to the subincrement
- **lastl**: Row number in IncG of last (rightmost) data point belonging to the subincrement
- **av_thickness**: Average thickness during deposition of the subincrement
- **W_ellipse**: Length of the short axis of the base ellipse of the oyster during deposition of the subincrement
- **L_ellipse_acc**: Length of the long axis of the base ellipse of the oyster during deposition of the subincrement projected on the X-axis
- **a_ellipse**: Half the length of the long axis of the base ellipse of the oyster during deposition of the subincrement
- **b_ellipse**: Half the length of the short axis of the base ellipse of the oyster during deposition of the subincrement

Source

[https://doi.org/10.5194/gmd-2017-137-supplement](https://doi.org/10.5194/gmd-2017-137-supplement)

```r
sub incr matrix5
```

Matrix containing data calculated for each growth band.

Description

A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage

```r
data(sub incr matrix5)
```
Format

A data frame with 1291 rows and 17 variables:

- **Age**  age (in days) of the subincrement
- **p1xs** X-value of the first (leftmost) point in the subincrement
- **p2xs** X-value of the last (rightmost) point in the subincrement
- **areaY** Area between subsequent subincrements
- **areaC** Area between subincrement and top of shell
- **p1y** Y-value of the first (leftmost) point in the subincrement
- **p2y** Y-value of the last (rightmost) point in the subincrement
- **shell_height** Height of shell during deposition of the subincrement
- **firstl** Row number in IncG of first (leftmost) data point belonging to the subincrement
- **lastl** Row number in IncG of last (rightmost) data point belonging to the subincrement
- **av_thickness** Average thickness during deposition of the subincrement
- **W_ellipse** Length of the short axis of the base ellipse of the oyster during deposition of the subincrement
- **L_ellipse_acc** Length of the long axis of the base ellipse of the oyster during deposition of the subincrement projected on the X-axis
- **a_ellipse** Half the length of the long axis of the base ellipse of the oyster during deposition of the subincrement
- **b_ellipse** Half the length of the short axis of the base ellipse of the oyster during deposition of the subincrement
- **VolI** Volume between subsequent subincrements
- **VolC** Volume between subincrement and top of shell

Source

https://doi.org/10.5194/gmd-2017-137-supplement

**subincr_matrix6**  
*Matrix containing data calculated for each growth band.*

Description

A dataset containing specific parameters calculated for all interpolated subincrements from the Crassostrea gigas #1 oyster used as an example in de Winter (2017) sorted per increment.

Usage

data(subincr_matrix6)
Format

A data frame with 1291 rows and 20 variables:

- **Age**: age (in days) of the subincrement
- **p1xs**: X-value of the first (leftmost) point in the subincrement
- **p2xs**: X-value of the last (rightmost) point in the subincrement
- **areaY**: Area between subsequent subincrements
- **areaC**: Area between subincrement and top of shell
- **p1y**: Y-value of the first (leftmost) point in the subincrement
- **p2y**: Y-value of the last (rightmost) point in the subincrement
- **shell_height**: Height of shell during deposition of the subincrement
- **firstl**: Row number in IncG of first (leftmost) data point belonging to the subincrement
- **lastl**: Row number in IncG of last (rightmost) data point belonging to the subincrement
- **av_thickness**: Average thickness during deposition of the subincrement
- **W_ellipse**: Length of the short axis of the base ellipse of the oyster during deposition of the subincrement
- **L_ellipse_acc**: Length of the long axis of the base ellipse of the oyster during deposition of the subincrement projected on the X-axis
- **a_ellipse**: Half the length of the long axis of the base ellipse of the oyster during deposition of the subincrement
- **b_ellipse**: Half the length of the short axis of the base ellipse of the oyster during deposition of the subincrement
- **VolI**: Volume between subsequent subincrements
- **VolC**: Volume between subincrement and top of shell
- **WeightI**: Mass of shell material between subsequent subincrements
- **Growth_rate**: Mass of shell material accumulated per day
- **WeightC**: Mass of shell material between subincrement and top of shell

Source

https://doi.org/10.5194/gmd-2017-137-supplement
**TIF**

*TIF image of phase map of cross section of modern oyster.*

**Description**

An image of the microXRF phase map of the cross section used for this model from the Crassostre gigas #1 oyster used as an example in de Winter (2017)

**Usage**

data(TIF)

**Format**

A TIF image imported into R as a large data array

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement

---

**z_mat**

*Z-values describing the base ellipse of the oyster*

**Description**

A dataset containing Z-coordinates of the base ellipse calculated for all subincrements in the Crassostrea gigas #1 oyster used as an example in de Winter (2017). A Xstep of 0.1, a Tstep of 1 and a growth season of 250 days are used.

**Usage**

data(z_mat)

**Format**

A large data frame with 101 rows and 1291 variables:

**Source**

https://doi.org/10.5194/gmd-2017-137-supplement
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