StrathE2E2: an R package for modelling the dynamics of marine food webs and fisheries

Technical manual – documentation of input and output R-objects and file structures

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MODEL CONFIGURATION AND INPUTS

Folder structure for model input files

The data which define a model (parameters and driving data) are held in a specific folder structure for each implementation. The R-package has a demonstration model of the North Sea embedded in it which can be used as a template for user-defined models. The location of the North Sea demonstration model data within the folder structure of the R-package is shown in Figure 1, and the structure expected for any user-defined models in Figure 2.

The North Sea demonstration model is read-only within the folder structure of the R-package. The basic functions of the package will operate perfectly well from these folders, but the more advanced optimization functions require to write data back into the Parameter sub-folders. To use these function it wil be necessary to create an editable copy of the demonstartion models in a local work-space. Copies of the North Sea model can also be used as a template for development new models. This can be done using using any file manager or the e2e_copy() function provided with the package:

```
e2e_copy ("North_Sea", "1970-1999")
```

The above example copies the default NorthSea model variant “1970-1999” and the associated documentation which are provided within the package, to a folder “Models” in the current user workspace, creating the folder if necessary.

Figure 1. Locations of the definition data folders for the North Sea demonstration model and its two variants in the structure of the R-package.

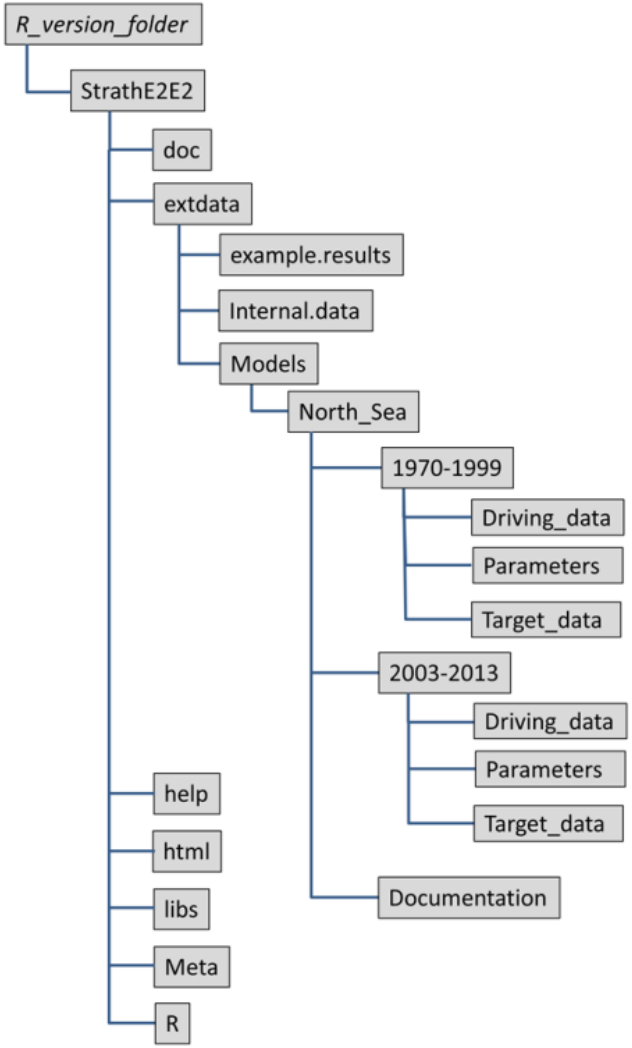
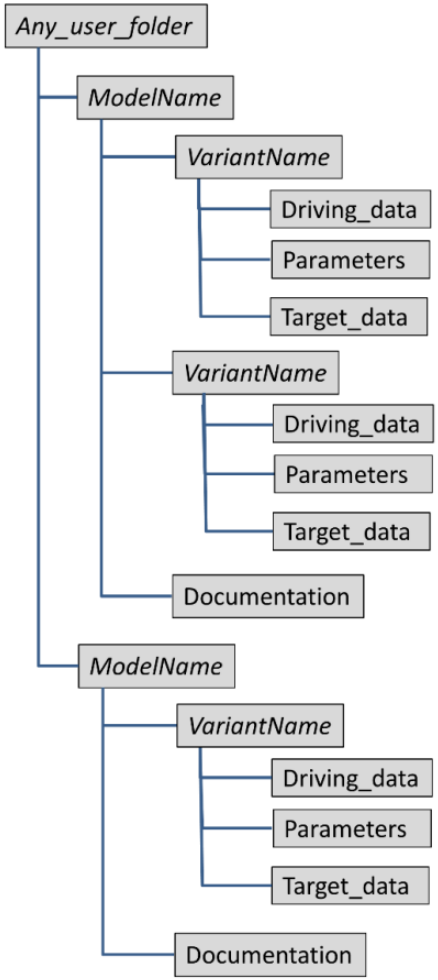


Figure 2. Organisation of model definition data folders in any user-defined work-space. Italicised folder names are free for user specification.



Model configuration file

The configuration of a model run is managed at the highest level by a comma-separated (*.csv*) setup file which resides in the '*version*' sub-folder of each '*model_region*' folder. This must have the name "*MODEL_SETUP.csv*" in every case. User created "*MODEL_SETUP.csv*" can be edited in e.g. Excel or any text-editor.

The *MODEL_SETUP* file contains details of the 24 *.csv* parameter and data files that are required to define the ecology and fishing fleet models and provide the driving conditions for the system. These files must reside in three sub-directories of the model version folder, as listed in Table 1. Names for most of the files may be user defined, within the constraint that each must contain at least a core text-string (Table 2). The setup file also includes a free-text column for users to store brief details of e.g. the origins of data contained in each *,csv* file (Table 3).

Table 1. Expected locations of "*.csv*" data files in the folder structure hierarchy of a model setup, and details of which sub-folders and file-names are editable without breaking the dataflow through the model functions. The contents of all "*.csv*" files are editable.

Level 1	Level 2	Level 3	Level 4	Level 5	Names editable
Model folder					Yes
	Version sub-folders				Yes
		"*MODEL_SETUP.csv*" file			No
		"*Driving_data*" sub-folder			No
			Driving data files (*.csv*)		Yes
		"*Parameters*" sub-folder			No
			Parameter data files (*.csv*)		Yes
			"*Parameter_SD_control*" sub-folder		No
				SD_control files (*.csv*)	No
		"*Target_data*" sub-folder			No
			Target data files (*.csv*)		Yes

Table 2. Description, mandatory sub-directory location, and mandatory core text string required for the file-name of each of the *.csv* parameter and data files defining the model.

Brief description	**Expected sub-directory of model version folder**	**Mandatory text string in file name**
Physical parameters (areas thickness and sediments)	*/Parameters*	*physical_parameters*
Physics drivers (ocean inflows temperature etc)	*/Driving_data*	*physics_drivers*
Chemistry drivers (boundary nutrients etc)	*/Driving_data*	*boundary_data*
Initial state of each state variable	*/Parameters*	*model_endstate_export*
Biological event timing parameters	*/Parameters*	*biological_event_timing_parameters*
Fixed parameters for consumer guilds	*/Parameters*	*fixed_parameters_for_consumer_groups*
Fixed miscellaneous parameters (Q10s etc)	*/Parameters*	*fixed_parameters_miscellaneous*
Fitted prey preference matrix	*/Parameters*	*fitted_parameters_preference_matrix*
Fitted uptake and mortality parameters	*/Parameters*	*fitted_parameters_uptake_and_mortality_rates*
Fitted microibiology and other parameters	*/Parameters*	*fitted_parameters_microbiology_and_others*
Fishing fleet basic parameters	*/Parameters*	*fishing_fleet_parameters*
Fishing activity and seabed abrasion rates for each gear	*/Parameters*	*fishing_activity_parameters*
Fishing power parameters for each gear and guild	*/Parameters*	*fishing_power_parameters*
Discard rates for each gear and guild	*/Parameters*	*fishing_discard_parameters*
Processing at sea ratyes for each gear and guild	*/Parameters*	*fishing_processing_at_sea_parameters*
Spatial distribution of activity rates across habitats	*/Parameters*	*fishing_distribution_parameters*
Gear activity multipliers (used to define fishing scenarios)	*/Parameters*	*fishing_activity_multiplier*
Harvest ratio multipliers (used to define fishing scenarios)	*/Parameters*	*harvest_ratio_multiplier*
Food web flow matrix template	*/Parameters*	*food_web_flow_matrix_template*
Relationships between gear activity rates over time	*/Parameters*	*fishing_fleet_gear_linkages*
Annual target data	*/Target_data*	*annual_target_data*
Monthly target data	*/Target_data*	*monthly_target_data*
Independently estimates guild harvest ratios (whole domain)	*/Target_data*	*known_regional_harvest_ratios*
Inshore and offshore harvest ratios from a prior model run	*/Target_data*	*fishing_fleet_target_harvest_ratios*

Table 3. Example of a *MODEL_SETUP.csv* file for the 2003-2013 version of the North Sea model included with the package.

Filename	**Expected_subdir**	**Description**	**Comments**
physical_parameters_NORTH_SEA.csv	*Parameters*	Physical parameters (areas thickness and sediments)	North Sea model data
physics_drivers_NORTH_SEA_2003-2013.csv	*Driving_data*	Physics drivers (ocean inflows temperature etc)	North Sea 2003-2013 data from NEMO-ERSEM and elsewhere
boundary_data_NORTH_SEA_2003-2013.csv	*Driving_data*	Chemistry drivers (boundary nutrients etc)	North Sea 2003-2013 data from NEMO-ERSEM World Ocean Atlas and elsewhere
model_endstate_export_NORTH_SEA_2003-2013.csv	*Parameters*	Initial state of each state variable	Data exported from end of run for stationary state North Sea 2003-2013 model
biological_event_timing_parameters_NORTH_SEA_2003-2013.csv	*Parameters*	Biological event timing parameters	North Sea spawning recruitment and mackerel migrations in the 2003-2013 period
fixed_parameters_for_consumer_groups_NORTH_SEA_2003-2013.csv	*Parameters*	Fixed parameters for consumer guilds	Mostly generic parameters for European temperate waters with minor variation in harvestable fraction for carniv zoo for 2003-2013
fixed_parameters_miscellaneous.csv	*Parameters*	Fixed miscellaneous parameters (Q10s etc)	Miscellaneous fixed parameters for European temperate waters
fitted_parameters_preference_matrix_NORTH_SEA.csv	*Parameters*	Fitted prey preference matrix	North Sea preference matrix generic for both 1970-1999 and 2003-2013 periods
fitted_parameters_uptake_and_mortality_rates_NORTH_SEA.csv	*Parameters*	Fitted uptake and mortality parameters	North Sea parameters generic for both 1970-1999 and 2003-2013 periods
fitted_parameters_microbiology_and_others_NORTH_SEA.csv	*Parameters*	Fitted microibiology and other parameters	North Sea parameters generic for both 1970-1999 and 2003-2013 periods
fishing_fleet_parameters_NORTH_SEA_2003-2013.csv	*Parameters*	Fishing fleet basic parameters	North Sea fleet parameters for the 2003-2013 period (uses demersal discard rates from csv file)
fishing_activity_parameters_NORTH_SEA_2003-2013.csv	*Parameters*	Fishing activity and seabed abrasion rates	North Sea gear activity rates from STECF and Norway for the 2003-

		for each gear	2013 period
fishing_power_parameters_NORTH_SEA.csv	*Parameters*	Fishing power parameters for each gear and guild	North Sea power parameters derived from 2003-2013 STECF data - used generically for both 1970-1999 and 2003-2013 periods
fishing_discard_parameters_NORTH_SEA.csv	*Parameters*	Discard rates for each gear and guild	North Sea discard rates from 2003-2013 STECF data - used generically for both 1970-1999 and 2003-2013 - EXCEPT for demersal fish rates need to be set to internally derived in 1970-1999
fishing_processing_at_sea_parameters_NORTH_SEA.csv	*Parameters*	Processing at sea ratyes for each gear and guild	North Sea processing-at-sea rates generic for both 1970-1999 and 2003-2013 periods
fishing_distribution_parameters_NORTH_SEA.csv	*Parameters*	Spatial distribution of activity rates across habitats	North Sea gear activity distributions from 2003-2013 STECF data - used generically for both the 1970-1999 and 2003-2013 periods
fishing_activity_multiplier_NORTH_SEA.csv	*Parameters*	Gear activity multipiers	Multipliers to be applied to activity rates of gears used in the North Sea (values >=0)
harvest_ratio_multiplier.csv	*Parameters*	Harvest ratio multipliers	Multipliers to be applied to guild harvest ratios (values >=0)
food_web_flow_matrix_template.csv	*Parameters*	Food web flow matrix template	Template file for the creation of a mass flow matrix for the final year of the model run – should never be edited.
fishing_fleet_gear_linkages.csv	*Parameters*	Relationships between gear activity rates over time	North Sea estimates _ only required by utility programme to seek activity rates generating given patterns of harvest ratios
annual_target_data_NORTH_SEA_2003-2013.csv	*Target_data*	Annual target data	Compilation of annual observational data on the mean state of the North Sea during 2003-2013
monthly_target_data_NORTH_SEA_2003-2013.csv	*Target_data*	Monthly target data	Compilation of monthly

			observational data on the mean state of the North Sea during 2003-2013
known_regional_harvest_ratios_2003-2013.csv	*Target_data*	Independently estimates guild harvest ratios	North Sea 2003-2013 guild HRs from ICES stock assessments and survey data and regional ecosystem review - only required by utility programme to calculate HRscale parameters given known regional harvest ratios
fishing_fleet_target_harvest_ratios_2003-2013.csv	*Target_data*	Inshore and offshore harvest ratios	North Sea 2003-2013 inshore and offshore harvest ratios genertaed by a prior run of the model - only required by utility programme to seek activity rates generating given patterns of harvest ratios

Parameter and data input files

Tables 4-30 provide details of all of the input files which are listed in the configuration file *MODEL_SETUP.csv*

Table 4. Details of the physical configuration file for the ecology model ("*physical_parameters*.csv*"). The file consists of two columns of data, the first being data values, second being a descriptive text field. Each row corresponds to a different parameter.

Row number (excl. header)	Units	Description of each data row
1	m	Offshore zone upper layer thickness
2	m	Offshore zone lower layer thickness
3	m	Inshore zone thickness
4	m	Bottom boundary layer thickness for benthos (must be less than the thicknesses of offshore zone lower layer and inshore zone)
5		Whole model domain area-proportion of inshore rock habitat s0 (sum of all 8 habitat areas must=1)
6		Whole model domain area-proportion of inshore sediment habitat s1 (sum of all 8 habitat areas must=1)
7		Whole model domain area-proportion of inshore sediment habitat s2 (sum of all 8 habitat areas must=1)
8		Whole model domain area-proportion of inshore sediment habitat s3 (sum of all 8 habitat areas must=1)
9		Whole model domain area-proportion of offshore rock habitat d0 (sum of all 8 habitat areas must=1)
10		Whole model domain area-proportion of offshore sediment habitat d1 (sum of all 8 habitat areas must=1)
11		Whole model domain area-proportion of offshore sediment habitat d2 (sum of all 8 habitat areas must=1)
12		Whole model domain area-proportion of offshore sediment habitat d3 (sum of all 8 habitat areas must=1)
13	mm	Inshore sediment s1 median grain size (muddy sediment, if set to 0 denotes rock)
14	mm	Inshore sediment s2 median grain size (sandy sediment, if set to 0 denotes rock)
15	mm	Inshore sediment s3 median grain size (gravelly sediment, if set to 0 denotes rock)
16	mm	Offshore sediment d1 median grain size (muddy sediment, if set to 0 denotes rock)
17	mm	Offshore sediment d2 median grain size (sandy sediment, if set to 0 denotes rock)
18	mm	Offshore sediment d3 median grain size (gravelly sediment, if set to 0 denotes rock)
19	mm	Reference grain size for baseline geochemisty rates
20		Parameter p1 for relationship between porosity and grainsize 10^(p3+p4*(1/(1+exp(-($\log_{10}$(grainsize)-p1)/p2))))
21		Parameter p2 for relationship between porosity and grainsize 10^(p3+p4*(1/(1+exp(-($\log_{10}$(grainsize)-p1)/p2))))

22		Parameter p3 for relationship between porosity and grainsize 10^(p3+p4*(1/(1+exp(-($\log_{10}$(grainsize)-p1)/p2))))
23		Parameter p4 for relationship between porosity and grainsize 10^(p3+p4*(1/(1+exp(-($\log_{10}$(grainsize)-p1)/p2))))
24		Parameter p1 for relationship between permeability and grainsize (10^p1)*(grainsize^p2)
25		Parameter p2 for relationship between permeability and grainsize (10^p1)*(grainsize^p2)
26		Parameter p1 for relationship between mud% and grainsize (10^p1)*(grainsize^p2)
27		Parameter p2 for relationship between mud% and grainsize (10^p1)*(grainsize^p2)
28		Parameter p1 for relationship between Total Nitrogen as a percentage if dry weight (Total Nitrogen%)and mud percentage by dry weight (mud%) (10^p1)*(mud%^p2)
29		Parameter p2 for relationship between Total Nitrogen as a percentage if dry weight (Total Nitrogen%) and mud percentage by dry weight (mud%) (10^p1)*(mud%^p2)
30		Ratio of inshore zone Total Nitrogen % in sediments to whole domain Total Nitrogen% at any given grain size
31		Ratio of offshore zone Total Nitrogen % in sediments to whole domain Total Nitrogen% at any given grain size
32		Proportion of measured sediment Total Nitrogen estimated to be refractory
33		SWITCH to determine how sediment porosity is provided (0=calculated from parameterised relationship / 1=defined below as values)
34		Defined porosity of inshore sediment s1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
35		Defined porosity of inshore sediment s2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
36		Defined porosity of inshore sediment s3 if not calculated internally (gravlly sediment, if set to 0 denotes rock)
37		Defined porosity of offshore sediment d1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
38		Defined porosity of offshore sediment d2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
39		Defined porosity of offshore sediment d3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
40		SWITCH to determine how sediment permeability is provided (0=calculated from parameterised relationship / 1=defined below as values)
41	m^{-2}	Defined permeability of inshore sediment s1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
42	m^{-2}	Defined permeability of inshore sediment s2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
43	m^{-2}	Defined permeability of inshore sediment s3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
44	m^{-2}	Defined permeability of offshore sediment d1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
45	m^{-2}	Defined permeability of offshore sediment d2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
46	m^{-2}	Defined permeability of offshore sediment d3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
47		SWITCH to determine how sediment Total Nitrogen% is provided (0=calculated from parameterised relationship / 1=defined below as values)
48		Defined Total Nitrogen% of inshore sediment s1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
49		Defined Total Nitrogen% of inshore sediment s2 if not calculated internally (sandy sediment, if set to 0 denotes rock)

50		Defined Total Nitrogen% of inshore sediment s3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
51		Defined Total Nitrogen% of offshore sediment d1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
52		Defined Total Nitrogen% of offshore sediment d2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
53		Defined Total Nitrogen% of offshore sediment d3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
54		SWITCH to determine how sediment layer thicknesses are provided (0=calculated from parameterised relationship (RECOMMENDED) / 1=defined below as values (RISKS TRIGGERING SHORT TIME STEPS))
55	m	Defined thickness of inshore sediment s1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
56	m	Defined thickness of inshore sediment s2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
57	m	Defined thickness of inshore sediment s3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
58	m	Defined thickness of offshore sediment d1 if not calculated internally (muddy sediment, if set to 0 denotes rock)
59	m	Defined thickness of offshore sediment d2 if not calculated internally (sandy sediment, if set to 0 denotes rock)
60	m	Defined thickness of offshore sediment d3 if not calculated internally (gravelly sediment, if set to 0 denotes rock)
61	m	Penetration depth of benthos infauna burrows into the sediments
62	m	Penetration depth of natural erosion scour into the sediment (m)
63		Parameter p1 of relationship between light attenuation coefficient (base e) and suspended particulate matter (SPM; $mg.m^{-3}$) Attenuation = p1 + (p2*SPM)
64		Parameter p2 of relationship between light attenuation coefficient (base e) and suspended particulate matter (SPM; $mg.m^{-3}$) Attenuation = p1 + (p2*SPM)
65		Proportion of inshore zone water column depth layer occupied by phytoplankton (set a value less than or equal to 1.0)
66		Proportion of inshore water column layer thickness in the rock (macrophyte) habitat (set a value less than or equal to 1.0)

Table 5. Details of the file specifying the time-dependent physical driving data file for the ecology model ("*physics_drivers*.csv*"). The data are presented as a rectangular matrix with the rows (1-12) being months of a repeating annual cycle, and the columns corresponding to different monthly resolution data time-series.

Column header	Units	Description
Month		Values 1 – 12
Slight	$E.m^{-2}.d^{-1}$	Daily integrated sea surface irradiance
SO_LogeSPM	$mg.m^{-3}$	Log_e transformed suspended particulate matter concentration in the offshore zone upper layer
SI_LogeSPM	$mg.m^{-3}$	Log_e transformed suspended particulate matter concentration in the inshore zone
SO_temp	°C	Monthly mean temperature in the offshore zone upper layer
D_temp	°C	Monthly mean temperature in the offshore zone lower layer
SI_temp	°C	Monthly mean temperature in the inshore zone
Rivervol_SI	d^{-1}	Daily river outflow into the inshore zone as a proportion of inshore zone volume
log10Kvert	$m^2.s^{-1}$	Log_{10} transformed vertical diffusion coefficient per unit length at the interface between the lower and upper layers in the offshore zone
mixLscale		Length scale over which vertical diffusion acts in the offshore zone (equivalent to the thickness of the pycnocline layer) as a proportion of offshore zone depth (values between 0 and 1)
Upwelling	d^{-1}	Daily upwelling volume in the inshore zone as a proportion of the upper layer volume
SO_OceanIN	d^{-1}	Daily volume flux across the ocean boundary into the offshore zone upper layer, as a proportion of the layer volume
D_OceanIN	d^{-1}	Daily volume flux across the ocean boundary into the offshore zone lower layer, as a proportion of the layer volume
SI_OceanIN	d^{-1}	Daily volume flux into the inshore zone from across the adjacent shelf boundary, as a proportion of the inshore volume
SI_OceanOUT	d^{-1}	Daily volume flux out of the inshore zone across the adjacent shelf boundary, as a proportion of the inshore volume
SO_SI_flow	d^{-1}	Daily volume flux from the offshore zone into the inshore zone, as a proportion of the inshore volume
habS1_pdist	d^{-1}	Inshore zone sediment habitat 1; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
habS2_pdist	d^{-1}	Inshore zone sediment habitat 2; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
habS3_pdist	d^{-1}	Inshore zone sediment habitat 3; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
habD1_pdist	d^{-1}	Offshore zone sediment habitat 1; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
habD2_pdist	d^{-1}	Offshore zone sediment habitat 2; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
habD3_pdist	d^{-1}	Offshore zone sediment habitat 3; daily area-proportion disturbed by natural bed shear stress (see Wilson et al. 2018)
Inshore_waveheight	m	Monthly mean significant wave height in the inshore zone

Table 6. Details of the file specifying the time-dependent chemical boundary driving data file for the ecology model ("*boundary_data*.csv*"). The data are presented as a rectangular matrix with the rows (1-12) being months of a repeating annual cycle, and the columns corresponding to different monthly resolution data time-series.

Column header	Units	Description
Month		Values 1 – 12
SO_nitrate	$mMN.m^{-3}$	Flow-weighted monthly mean nitrate concentration at the ocean boundary of the offshore zone upper layer
SO_ammonia	$mMN.m^{-3}$	Flow-weighted monthly mean ammonia concentration at the ocean boundary of the offshore zone upper layer
SO_phyt	$mMN.m^{-3}$	Flow-weighted monthly mean phytoplankton concentration at the ocean boundary of the offshore zone upper layer
SO_detritus	$mMN.m^{-3}$	Flow-weighted monthly mean suspended detritus concentration at the ocean boundary of the offshore zone upper layer
D_nitrate	$mMN.m^{-3}$	Flow-weighted monthly mean nitrate concentration at the ocean boundary of the offshore zone lower layer
D_ammonia	$mMN.m^{-3}$	Flow-weighted monthly mean ammonia concentration at the ocean boundary of the offshore zone lower layer
D_phyt	$mMN.m^{-3}$	Flow-weighted monthly mean phytoplankton concentration at the ocean boundary of the offshore zone lower layer
D_detritus	$mMN.m^{-3}$	Flow-weighted monthly mean suspended detritus concentration at the ocean boundary of the offshore zone lower layer
SI_nitrate	$mMN.m^{-3}$	Flow-weighted monthly mean nitrate concentration at the adjacent shelf boundary of the infshore zone
SI_ammonia	$mMN.m^{-3}$	Flow-weighted monthly mean ammonia concentration at the adjacent shelf boundary of the infshore zone
SI_phyt	$mMN.m^{-3}$	Flow-weighted monthly mean phytoplankton concentration at the adjacent shelf boundary of the infshore zone
SI_detritus	$mMN.m^{-3}$	Flow-weighted monthly mean suspended detritus concentration at the adjacent shelf boundary of the infshore zone
RIV_nitrate	$mMN.m^{-3}$	Flow-weighted monthly mean nitrate concentration in rivers flowing into the inshore zone
RIV_ammonia	$mMN.m^{-3}$	Flow-weighted monthly mean ammonia concentration in rivers flowing into the inshore zone
RIV_detritus	$mMN.m^{-3}$	Flow-weighted monthly mean suspended detritus concentration in rivers flowing into the inshore zone
SO_ATM_nitrate_flux	$mMN.m^{-2}.d^{-1}$	Monthly mean atmospheric deposition rate of oxidised nitrogen to the offshore zone
SO_ATM_ammonia_flux	$mMN.m^{-2}.d^{-1}$	Monthly mean atmospheric deposition rate of reduced nitrogen to the offshore zone
SI_ATM_nitrate_flux	$mMN.m^{-2}.d^{-1}$	Monthly mean atmospheric deposition rate of oxidised nitrogen to the inshore zone
SI_ATM_ammonia_flux	$mMN.m^{-2}.d^{-1}$	Mointhly mean atmospheric deposition rate of reduced nitrogen to the inshore zone
SI_other_nitrate_flux	$mMN.m^{-2}.d^{-1}$	Monthly mean emission rate of oxidised nitrogen to the inshore zone from other sources, e.g. industry
SI_other_ammonia_flux	$mMN.m^{-2}.d^{-1}$	Monthly mean emission rate of reduced nitrogen to the inshore zone from other sources, e.g. industry

Table 7. Details of the initial conditions file ("*model_endstate_export*.csv*") setting starting values for each state variable in the model (units mMN in the model domain, scaled to a whole-domain sea surface area of $1m^2$). The file comprises two columns, with no header row. The first column contains the variable name within the model code; the second column contains the initial values. Each row represents a different model variable. xxxx indicates that an numeric value is expected. The grey shaded column is included here to provide a description of each variable and is not present in the operational filke. In practice this file would rarely ever be manually created by the user but created automatically at the end of a stationary state model run using the function e2e_extract_start() provided with the package.

Variable name within the model code	**Numeric value**	**Variable description**
detritus_so	xxxx	Offshore zone upper layer suspended detritus
detritus_d	xxxx	Offshore zone lower layer suspended detritus
x_detritus_s1	xxxx	Labile sediment detritus inshore zone habitat 1
x_detritus_s2	xxxx	Labile sediment detritus inshore zone habitat 2
x_detritus_s3	xxxx	Labile sediment detritus inshore zone habitat 3
x_detritus_d1	xxxx	Labile sediment detritus offshore zone habitat 1
x_detritus_d2	xxxx	Labile sediment detritus offshore zone habitat 2
x_detritus_d3	xxxx	Labile sediment detritus offshore zone habitat 3
xR_detritus_s1	xxxx	Refractory sediment detritus inshore zone habitat 1
xR_detritus_s2	xxxx	Refractory sediment detritus inshore zone habitat 2
xR_detritus_s3	xxxx	Refractory sediment detritus inshore zone habitat 3
xR_detritus_d1	xxxx	Refractory sediment detritus offshore zone habitat 1
xR_detritus_d2	xxxx	Refractory sediment detritus offshore zone habitat 2
xR_detritus_d3	xxxx	Refractory sediment detritus offshore zone habitat 3
discard_o	xxxx	Fishery discards in the offshore zone
corpse_s1	xxxx	Seabed corpses in the inshore zone habitat 1
corpse_s2	xxxx	Seabed corpses in the inshore zone habitat 2
corpse_s3	xxxx	Seabed corpses in the inshore zone habitat 3
corpse_d1	xxxx	Seabed corpses in the offshore zone habitat 1
corpse_d2	xxxx	Seabed corpses in the offshore zone habitat 2
corpse_d3	xxxx	Seabed corpses in the offshore zone habitat 3
ammonia_so	xxxx	Water column ammonia in the offshore zone upper layer
ammonia_d	xxxx	Water column ammonia in the offshore zone lower layer

x_ammonia_s1	xxxx	Porewater ammonia in the inshore zone habitat 1
x_ammonia_s2	xxxx	Porewater ammonia in the inshore zone habitat 2
x_ammonia_s3	xxxx	Porewater ammonia in the inshore zone habitat 3
x_ammonia_d1	xxxx	Porewater ammonia in the offshore zone habitat 1
x_ammonia_d2	xxxx	Porewater ammonia in the offshore zone habitat 2
x_ammonia_d3	xxxx	Porewater ammonia in the offshore zone habitat 3
nitrate_so	xxxx	Water column nitrate in the offshore zone upper layer
nitrate_d	xxxx	Water column nitrate in the offshore zone lower layer
x_nitrate_s1	xxxx	Porewater nitrate in the inshore zone habitat 1
x_nitrate_s2	xxxx	Porewater nitrate ia in the inshore zone habitat 2
x_nitrate_s3	xxxx	Porewater nitrate in the inshore zone habitat 3
x_nitrate_d1	xxxx	Porewater nitrate in the offshore zone habitat 1
x_nitrate_d2	xxxx	Porewater nitrate in the offshore zone habitat 2
x_nitrate_d3	xxxx	Porewater nitrate in the offshore zone habitat 3
phyt_so	xxxx	Phytoplankton in the offshore zone upper layer
phyt_d	xxxx	Phytoplankton in the offshore zone lower layer
herb_o	xxxx	Omnivorous zooplankton in the offshore zone
carn_o	xxxx	Carnivorous zooplankton in the offshore zone
benthslar_o	xxxx	Larvae of susp/dep feeding benthis in the offshore zone
benths_o	xxxx	Susp/dep feeding benthos in the offshore zone
benthclar_o	xxxx	Larvae of carn/scav feeding benthis in the offshore zone
benthc_o	xxxx	Carn/scav feeding benthos in the offshore zone
fishp_o	xxxx	Planktivorous fish in the offshore zone
fishplar_o	xxxx	Larvae of planktivorous fish in the offshore zone
fishd_o	xxxx	Demersal fish in the offshore zone
fishdlar_o	xxxx	Larvae of demersal fish in the offshore zone
fishm_o	xxxx	Migratoryl fish in the offshore zone
bird_o	xxxx	Birds in the offshore zone
detritus_si	xxxx	Suspended detritus in the inshore zone
ammonia_si	xxxx	Water column ammonia in the inshore zone

nitrate_si	xxxx	Water column nitrate in the inshore zone
phyt_si	xxxx	Phytoplankton in the inshore zone
benthslar_i	xxxx	Larvae of susp/dep feeding benthos in the inshore zone
benthclar_i	xxxx	Larvae of carn/scav feeding benthos in the inshore zone
benths_i	xxxx	Susp/dep feeding benthos in the inshore zone
benthc_i	xxxx	Carn/scav feeding benthos in the inshore zone
discard_i	xxxx	Discards in the inshore zone
herb_i	xxxx	Omnivorous zooplankton in the inshore zone
carn_i	xxxx	Carnivorous zooplankton in the inshore zone
fishplar_i	xxxx	Larvae of planktivorous fish in the inshore zone
fishdlar_i	xxxx	Larvae of demersal fish in the inshore zone
fishp_i	xxxx	Planktivorous fish in the inshore zone
fishm_i	xxxx	Migratory fish in the inshore zone
fishd_i	xxxx	Demersal fish in the inshore zone
bird_i	xxxx	Birds in the inshore zone
seal_o	xxxx	Pinnipeds in the offshore zone
seal_i	xxxx	Pinnipeds in the inshore zone
ceta_o	xxxx	Cetaceans in the offshore zone
ceta_i	xxxx	Cetaceans in the inshore zone
corpse_s0	xxxx	Seabed corpses in the inshore zone habitat 0 (exposed rock)
corpse_d0	xxxx	Seabed corpses in the offshore zone habitat 0 (exposed rock)
kelpC	xxxx	Macrophyte carbon mass
kelpN	xxxx	Macrophyte nitrogen mass
Kelpdebris	xxxx	Macrophyte debris nitrogen mass

Table 8. Layout of the input file defining timings of biological events in the ecology model ("*biological_event_timing_parameters*.csv*"). Each row corresponds to a different parameter with a numeric value and a text description field. Day-of-the-year assumes a 360-day year of 30 days per month. xxxx indicates that a numeric value is expected. The grey-shaded columns are provided here to aid clairity and are not present in the operational file.

Value	Description	Units	Additional description
xxxx	Planktivorous_fish_spawning_start_day	Day of the year	Start date of spawning by planktivorous fish
xxxx	Planktivorous _fish_spawning_duration_(days)	Days	Duration of spawning by planktivorous fish
xxxx	Planktivorous _fish_recruitment_start_day	Day of the year	Start date of recruitment of planktivorous fish larvae to the adult guild
xxxx	Planktivorous _fish_recruitment_duration_(days)	Days	Duration of recruitment to the planktivorous fish guild
xxxx	Demersal_fish_spawning_start_day	Day of the year	Start date of spawning by demersal fish
xxxx	Demersal_fish_spawning_duration_(days)	Days	Duration of spawning by demersal fish
xxxx	Demersal_fish_recruitment_start_day	Day of the year	Start date of recruitment of demersal fish larvae to the adult guild
xxxx	Demersal_fish_recruitment_duration_(days)	Days	Duration of recruitment to the demersal fish guild
xxxx	Susp/dep_benthos_spawning_start_day	Day of the year	Start date of spawning by suspension/deposit feeding benthos
xxxx	Susp /dep_benthos_spawning_duration_(days)	Days	Duration of spawning by suspension/deposit feeding benthos
xxxx	Susp /dep_benthos_recruitment_start_day	Day of the year	Start date of recruitment of suspension/deposit feeding benthos larvae to the settled guild
xxxx	Susp /dep_benthos_recruitment_duration_(days)	Days	Duration of recruitment to the suspension/deposit feeding benthos guild
xxxx	Carn/scav_benthos_spawning_start_day	Day of the year	Start date of spawning by carnivore/scavenge feeding benthos
xxxx	Carn/scav_benthos_spawning_duration_(days)	Days	Duration of spawning by carnivore/scavenge feeding benthos
xxxx	Carn/scav_benthos_recruitment_start_day	Day of the year	Start date of recruitment of carnivore/scavenge feeding benthos larvae to the settled guild
xxxx	Carn/scav_benthos_recruitment_duration_(days)	Days	Duration of recruitment to the carnivore/scavenge feeding benthos guild
xxxx	Migratory_fish_switch_(0=off_1=on)		Switch to enable or disable external boundary migrations of migratory fish
xxxx	Migratory_fish_ocean_biomass_(Tonnes_wet_weight)	Tonnes wet weight	'Global' stock biomass of migratory fish, a proportion of which may be enabled to enter the model domain
xxxx	Migratory_fish_carbon_to_wet_weight_(g/g)	$g.g^{-1}$	Carbon content of migratory fish as a proportion of wet weight
xxxx	Model_domain_sea_surface_area_(km2)	km^2	Sea surface atrea of the whole model domain
xxxx	Propn_of_ocean_population_entering_model_domain_each_year		Proportion of the 'global' stock of migratory fish entering the model domain each year
xxxx	Immigration_start_day	Day of the year	Start date of the annual immigration of migratory fish into the

			model domain
xxxx	Immigration_end_day_(must_be_later_than_start_day_even_if_migration_disabled)	Day of the year	End date of the annual immigration of migratory fish into the model domain
xxxx	Propn_of_peak_popn_in_model_domain_which_remains_and_does_not_emigrate		Proportion of the peak annual biomass of migratory fish in the model domain which remains behind after the end-of-emigration date
xxxx	Emigration_start_day	Day of the year	End date of the annual emigration of migratory fish from the model domain
xxxx	Emigration_end_day_(must_be_later_than_start_day_even_if_migration_disabled)	Day of the year	End date of the annual emigration of migratory fish from the model domain

Table 9. Layout of the fixed parameters input file for each guild in the ecology model ("*fixed_parameters_for_consumer_groups*.csv*"). These data are not affected by the simulated annealing optimization function provided with the package, and must be manually edited by a user. Rows = ecology model guilds, columns = parameter types. The grey-shaded column is provided here to aid clairity and is not present in the operational file. NA indicates a non-functional guild/parameter combination; xxxx indicates that a numeric value is required. Exponential format is acceptable for numeric values, e.g. x.xxxE-x. Annual weight specific fecundity is the proportion by weight of each guild shed annually as eggs. Units of the "threshold exploitable biomass" and "minimum inedible biomass" parameters are $mMN.m^{-2}$.

Model guild	consumer	assimilation_efficiency	background_metabolic_rate	annual_weight_specific_fecundity	threshold_exploitable_biomass	minimum_inedible_biomass
Macrophytes	kelp	NA	NA	NA	xxxx	NA
Phytoplankton	phyt	NA	NA	NA	NA	NA
Omnivorous zooplankton	omnivzoo	xxxx	xxxx	NA	NA	NA
Carnivorous zooplankton	carnzoo	xxxx	xxxx	NA	xxxx	xxxx
Larvae of planktivorous fish	fishplar	xxxx	xxxx	NA	NA	NA
Larvae of demersal fish	fishdlar	xxxx	xxxx	NA	NA	NA
Planktivorous fish	fishp	xxxx	xxxx	xxxx	xxxx	NA
Migratory fish	fishm	xxxx	xxxx	NA	xxxx	NA
Demersal fish	fishd	xxxx	xxxx	xxxx	xxxx	NA

Larvae of suspension/deposit feeding benthos	benthslar	xxxx	xxxx	NA	NA	NA
Larvae of carnivorous/ scavenge feeding benthos	benthclar	xxxx	xxxx	NA	NA	NA
Suspension/ deposit feeding benthos	benths	xxxx	xxxx	xxxx	xxxx	NA
Carnivorous/ scavenge feeding benthos	benthc	xxxx	xxxx	xxxx	xxxx	NA
Birds	bird	xxxx	xxxx	NA	xxxx	NA
Pinnipeds	seal	xxxx	xxxx	NA	xxxx	NA
Cetaceans	ceta	xxxx	xxxx	NA	xxxx	NA

Table 10. Layout of the miscellaneous fixed parameters input file for the ecology model ("*fixed_parameters_miscellaneous*.csv*"). The file is not affected by the simulated annealing optimization function provided with the package, and must be manually edited by a user. Each row corresponds to a different parameter with a numeric value and a text description field ; xxxx indicates that a numeric value is required. Exponential format is acceptable for numeric values, e.g. x.xxxE-x. The grey-shaded columns are provided here to aid clairity and are not present in the operational file.

Value	Description	**Units**	**Additional description**
xxxx	Irradiance_at_maximum_carbon_uptake_by_kelp	$E.m^{-2}.d^{-1}$	Applies to macrophytes
xxxx	Minimum_NC_ratio_for_kelp	Molar nitrogen to carbon ratio	Applies to macrophytes
xxxx	Maximum_NC_ratio_for_kelp	Molar nitrogen to carbon ratio	Applies to macrophytes
xxxx	Irradiance_at_maximum_nutrient_uptake_by_phytoplankton	$E.m^{-2}.d^{-1}$	Applies tro phytoplankton
xxxx	Autotroph_Q10_value	$(10°C)^{-1}$	Q_{10} for maximum uptake rates of phytoplanktion and macrophytes
xxxx	Heterotroph_uptake_Q10_value	$(10°C)^{-1}$	Q_{10} for maximum uptake rates for all claases of zooplankton, benthos and their larvae, fish and their larvae. Also applied as an inverse Q_{10} effect on metabolic rates of birds, pinnipeds and cetaceans. Maximum uptake erates of birds, pinnipeds and cetaceans are independent of temperature
xxxx	Metabolic_and_bacterial_Q10_value	$(10°C)^{-1}$	Q_{10} for metabolic rates of all living guilds except macrophytes and phytoplankton, birds, pinnipeds and cetaceans
xxxx	Q10_reference_temperature	°C	Q_{10} reference temperature for temperature dependent processes in the model

Table 11. Details of the preference matrix input file for the ecology model ("*fitted_parameters_preference_matrix*.csv*"). The file is structured as a rectangular table with rows = source terms, columns = consumers. Values in each column (consumers) must sum to 1. The grey-shades columns/rows shown here are provided to aid clairity and are not present in the operational file. Also, the column names in the operational file are the text row names 8 – 23, rather than the numeric ID's shown here. NA indicates a non-functional source-consumer link; x.xxx indicates a numeric value ≤1 is required, which may be 0., The file is generated automatically by the simulated annealing optimization function, and would not normally be manually edited by a user.

			Consumers															
Description	**ID**	**Row name**	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Water column ammonia	1	ammonia	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Water column nitrate	2	nitrate	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Suspended detritus	3	suspdet	NA	NA	**x.xxx**	NA	NA	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA
Sediment detritus	4	seddet	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.478	NA	NA	NA	NA
Macrophyte debris	5	kelpdebris	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA
Corpses	6	corpses	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA
Fishery discards	7	discards	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**
Macrophytes	8	kelp	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA
Phytoplankton	9	phyt	NA	NA	**x.xxx**	NA	NA	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA
Omnivorous zooplankton	10	omnivzoo	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA	**x.xxx**
Carnivorous zooplankton	11	carnzoo	NA	NA	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**
Larvae of planktivorous fish	12	fishplar	NA	NA	NA	**x.xxx**	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA
Larvae of demersal fish	13	fishdlar	NA	NA	NA	**x.xxx**	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA
Planktivorous fish	14	fishp	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**
Migratory fish	15	fishm	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**
Demersal fish	16	fishd	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**
Larvae of suspension/deposit feeding benthos	17	benthslar	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA	NA
Larvae of carnivorous/scavenge feeding benthos	18	benthclar	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**	NA	NA	NA	NA	NA	NA	NA	NA
Suspension/deposit feeding benthos	19	benths	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**	**x.xxx**
Carnivorous/scavenge feeding benthos	20	benthc	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	NA	NA	NA	NA	**x.xxx**	**x.xxx**	**x.xxx**

Birds	21	Bird	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**	**x.xxx**
Pinnipeds	22	seal	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**x.xxx**
Cetaceans	23	Ceta	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 12. Layout of the uptake and mortality rate parameter file for the ecology model ("*fitted_parameters_uptake_and_mortality_rates*.csv*"). The file is generated automatically by the simulated annealing optimization function, but can also be manually edited by a user. Rows = living guilds in the model network, columns = different parameter types. The grey-shades columns/rows shown here are provided to aid clairity and are not present in the operational file. NA indicates a non-functional guild/parameter combination; xxxx indicates that a numeric value is required. Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Consumer guild	**Row name**	**Maximum carbon uptake rate**	**Density dependent carbon exudation rate**	**Maximum nitrogen uptake rate**	**Nitrogen uptake half-saturation coefficient**	**Beddington-DeAngelis parameter**	**Density dependent mortality coefficient**	**Active migration coefficient**	**Maximum exploitable fraction of the stock**
Column name	**Consumer**	**Cumax**	**Cddexud**	**Numax**	**Nhsat**	**BdeApar**	**Ddmort**	**migration_coef**	**max_exploitable_f**
Macrophytes	Kelp	xxxx	xxxx	xxxx	xxxx	NA	xxxx	NA	xxxx
Phytoplankton - shallow	phyt_s	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Phytoplankton - deep	phyt_d	NA	NA	NA	NA	NA	xxxx	NA	NA
Omnivorous zooplankton	Omnivzoo	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Carnivorous zooplankton	Carnzoo	NA	NA	xxxx	xxxx	NA	xxxx	NA	xxxx
Larvae of planktivorous fish	Fishplar	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Larvae of demersal fish	Fishdlar	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Planktivorous fish	Fishp	NA	NA	xxxx	xxxx	NA	xxxx	xxxx	xxxx
Migratory fish	Fishm	NA	NA	xxxx	xxxx	NA	xxxx	xxxx	xxxx
Demersal fish	Fishd	NA	NA	xxxx	xxxx	NA	xxxx	xxxx	xxxx
Larvae of suspension/deposit feeding benthos	Benthslar	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Larvae of carnivorous/scavenge feeding benthos	Benthclar	NA	NA	xxxx	xxxx	NA	xxxx	NA	NA
Suspension/deposit feeding benthos	Benths	NA	NA	xxxx	xxxx	NA	xxxx	NA	xxxx
Carnivorous/scavenge	Benthc	NA	NA	xxxx	xxxx	NA	xxxx	NA	xxxx

feeding benthos									
Birds	Bird	NA	NA	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Pinnipeds	Seal	NA	NA	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Cetaceans	Ceta	NA	NA	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

Table 13. Layout of the microbiology and other parameters file for the ecology model ("*fitted_parameters_microbiology_and_others*.csv*").. The file is generated automatically by the simulated annealing optimization function, but can also be manually edited by a user. Each row corresponds to a specific parameter and includes a numeric value and a text description field. The grey-shades columns shown here are provided to aid clairity and are not present in the operational file. xxxx indicates that a numeric value is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Value	Description	Units	Additional description
xxxx	water_column_detritus_mineralisation_rate	d^{-1}	Proportion of suspended detritus converted to ammonia per day at the Q_{10} reference temperature
xxxx	upper_layer_water_column_nitrification_rate	d^{-1}	Proportion of upper layer ammonia converted to nitrate per day at the Q_{10} reference temperature
xxxx	upper_layer_water_column_denitrification_rate	d^{-1}	Proportion of upper layer nitrate converted to nitrogen gas per day at the Q_{10} reference temperature
xxxx	lower_layer_water_column_nitrification_rate	d^{-1}	Proportion of lower layer ammonia converted to nitrate per day at the Q_{10} reference temperature
xxxx	lower_layer_water_column_denitrification_rate	d^{-1}	Proportion of lower layer nitrate converted to nitrogen gas per day at the Q_{10} reference temperature
xxxx	proportion_of_detritus_or_corpses_converted_to_refractory_material_max_0.5		Proportion of sediment detritus or corpses converted to refractory detritus during the mineralisation or disintegration process (capped at 0.5)
xxxx	mineralisation_rate_scaling_parameter_for_refractory_detritus		Mineralisation rate of refractory detritus is a fixed proportion of the ambient rate for labile sediment detritus
xxxx	proportion_of_refractory_detritus_digestible_by_benthos		Proportion of ingested refractory detritus digestible by benthos - refractory detritus is less efficiently digested by suspension and deposit feeding benthos than labile detritus
xxxx	sediment_detritus_mineralisation_rate	d^{-1}	Proportion of sediment labile detritus converted to ammonia per day at the Q_{10} reference temperature and the reference value of median grain size specified in the physical configuration file
-xxxx	grain_size_sensitivity_for_sediment_detritus_mineralisation_rate	mm^{-1}	Sensitivity parameter for the relationship between labile sediment detritus mineralisation rate and sediment median grain size. **Expecting a negative number here.**

xxxx	sediment_ nitrification_rate	d^{-1}	Proportion of sediment porewater ammonia converted to nitrate per day at the Q_{10} reference temperature and the reference value of median grain size specified in the physical configuration file
-xxxx	grain_size_sensitivity_for_sediment_ nitrification_rate	mm^{-1}	Sensitivity parameter for the relationship between sediment detritus nitrification rate and sediment median grain size. **Expecting a negative number here.**
xxxx	sediment_ denitrification_rate	d^{-1}	Proportion of sediment porewater nitrate converted to nitrogen gas per day at the Q_{10} reference temperature and the reference value of median grain size specified in the physical configuration file
xxxx	grain_size_sensitivity_for_sediment_ denitrification_rate	mm^{-1}	Sensitivity parameter for the relationship between sediment denitrification rate and sediment median grain size
xxxx	conversion_rate_of_discards_to_corpses	d^{-1}	Proportion of discards concerted to seabed corpses per day at the Q_{10} reference temperature
xxxx	conversion_rate_of_corpses_to_sediment_detritus	d^{-1}	Proportion of seabed corpses converted to sediment detritus per day at the Q_{10} reference temperature
xxxx	conversion_rate_of_kelp_debris_to_detritus	d^{-1}	Proportion of macrophyte debris converted to sediment detritus per day at the Q_{10} reference temperature
xxxx	detritus_sinking_rate_in_the_upper_layers	d^{-1}	Proportion of offshore zone upper layer supended detritus sinking into the lower layer per day
xxxx	detritus_sinking_rate_in_the_lower_layer	d^{-1}	Proportion of offshore zone lower layer and inshore zone supended detritus sinking onto the seabed per day
xxxx	density_dependent_self_shading_parameter_for_kelp	$(mMN.m^{-2})^{-1}$	Attenuation rate of light available to macrophytes as a function of macrophyte biomass
xxxx	Wave_dependent_beach_cast_rate_for_kelp_debris	m^{-1}	Proportion of macrophyte debris exported from the model as beach-cast per metre of significant wave height
xxxx	fitting_parameter_for_undersize_demersal_fish_function		Fitting parameter aligning the biomass-dependent undersize fraction of demersal fish in model catches to those observed in reality – expected to be close to 1.0

Table 14. Gear-independent parameters for the fishing fleet model ("*fishing_fleet_parameters*.csv*"). Each row corresponds to a specific parameter and includes a numeric value and a text description field. xxxx indicates that a numeric value is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x . The grey-shaded column shown here is provided to aid clairity and is not present in the operational file.

Value	Description	Additional description
xxxx	parameter_a_in_Pdemersal_catch_NONQUOTA= a*exp(-b*(1stJan_demersal_biomass)))_set_to_0_and_all_demfish_treated_as_quota_limited	Parameter value in the empirically based relationship between proportion of non-quota demersal species in commercial catches and demersal biomass
xxxx	parameter_b_in_Pdemersal_catch_NONQUOTA=a* exp(-b*(1stJan_demersal_biomass)))	Parameter value in the empirically based relationship between proportion of non-quota demersal species in commercial catches and demersal biomass
xxxx	parameter_a_in_Pundersize_NONQUOTA = a*exp(-b*1stJan_demersal_biomass))	Parameter value in the empirically based relationship between proportion of non-quota demersal species in commercial catches which are undersize and demersal biomass
xxxx	parameter_b_in_Pundersize_NONQUOTA = a*exp(-b*1stJan_demersal_biomass))	Parameter value in the empirically based relationship between proportion of non-quota demersal species in commercial catches which are undersize and demersal biomass
xxxx	parameter_a_in_Pundersize_QUOTA = a*exp(-b*1stJan_demersal_biomass))	Parameter value in the empirically based relationship between proportion of quota-limiteddemersal species in commercial catches which are undersize and demersal biomass
xxxx	parameter_b_in_Pundersize_QUOTA = a*exp(-b*1stJan_demersal_biomass))	Parameter value in the empirically based relationship between proportion of quota-limiteddemersal species in commercial catches which are undersize and demersal biomass
xxxx	DF_HR_SWITCH_(0=use_externally_defined_DFharvestratio/1=improved_selectivity_ie_reduce_Dfharvestratio_to_ match_no_undersize_catch)	Switch to select alternative demersal harvest ratio selectivity scenarios – **see separate table below for details**
xxxx	DF_DISC_SWITCH_(0=use_internally_derived_density_dependent_DF_discard_rates/1=use_DF_discard_rates_from_ parameter_file/2=only_discard_undersize_NQDF/3=no_DF_discards_ie_land_everything)	Switch to select alternative demersal discard rate scenarios – **see separate table below for details**
xxxx	Seabed_penetration_depth_of_gears_(m)	Depth to which towed gears which abrade the seabed penetrate into the sediment
xxxx	Mortality_inflicted_per_seabed_contact_trawl_pass_on_susp/deposit_feeding_benthos	Proportion of suspension/deposit feeding benthos biomass conveted to corpses as a result of a pass-over by a seabed-contact gear
xxxx	Mortality_inflicted_per_seabed_contact_trawl_pass_on_carnivore/scavenge_feeding_benthos	Proportion of carnivore/scavenge feeding benthos biomass conveted to corpses as a result of a pass-over by a seabed-contact gear

xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Planktivorous_fish	Parameter linking planktivorous fish effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Demersal_fish	Parameter linking demersal fish effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Migratory_fish	Parameter linking migratory fish effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Susp/deposit_feeding_benthos	Parameter linking suspension/deposit feeding benthos effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Carnivore/scavenge_feeding_benthos	Parameter linking carnivore/scavenge feeding benthos effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Carnivorous_zooplankton	Parameter linking carnivorous zooplankton effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Birds	Parameter linking seabird effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Seals	Parameter linking pinniped effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Cetaceans	Parameter linking cetacean effort-density integrated across all gears to harvest ratio
xxxx	Scaling_between_effort_per_day_and_harvest_ratio_per_day_Kelp	Parameter linking macrophyte effort-density integrated across all gears to harvest ratio
xxxx	Offal_as_proportion_of_live_weight_of_fish_and_shellfish	Proportion of live weight which is regarded as offal during at-sea processing

Table 15. Configuration scenarios for the fishing fleet model as a result of the range of possible combinations of settings for the demersal fish harvest ratio switch (DF_HR_SWITCH) and discarding switch (DF_DISC_SWITCH) in the fishing fleet model parameter file *fishing_fleet_parameters*.csv*

DF_HR_SWITCH	DF_DISC_SWITCH	Harvest ratio action	Discard rate action
0	0	Harvest ratios for demersal fish according to the external data on gear activity and power (selectivity), as processed by the fleet model.	Discard rates for demersal fish set internally by the ecology model to equal the undersize fractions of quota-limited and non-quota fractions, overriding the externally supplied discard rates.
1	0	Implicit changes in gear selectivity to minimise catches of undersize fish - the externally set harvest ratios for demersal fish are attenuated by a factor equal to the lesser of the proportion of undersize quota-limited and non-quota fish in catches, as derived by the ecology model.	Discard rates for demersal fish set internally by the ecology model, overriding the externally supplied discard rates. But, due to the implicit changes in selectivity, there are no undersize catches of either quota-limited or non-quota demersal fish so discard rates are set to zero.

0	1	Harvest ratios for demersal fish according to the external data on gear activity and power (selectivity), as processed by the fleet model.	Discard rate of demersal fish set according to the external data in the discard rate parameter file for the fleet model. The ecology model first attempts to meet this rate by discarding the internally derived undersize fractions of quota-limited and non-quota fish. If this is insufficient to meet the external rate then the code increases discards of quota-limited fish - i.e. implicitly representing high-grading or over-quota discards. If the external rate is less than the internal rate arising from undersize quota-limited and non-quota fish then the code reduce discards of non-quota fish until to overall rate equals the externally set value.
1	1	Implicit changes in gear selectivity to minimise catches of undersize fish - the externally set harvest ratios for demersal fish are attenuated by a factor equal to the lesser of the proportion of undersize quota-limited and non-quota fish in catches, as derived by the ecology model.	Discard rate of demersal fish set according to the external data in the discard rate parameter file for the fleet model. But as a result of the implicit changes in selectivity there are no catches of undersize fish. So the implication is that all discards represent high-grading or over-quota discarding. Hence, the ecology model attempts to meet the externally defined overall discard rate first by increasing the discard rate of quota-limited fish, and if this is insufficient then by increasing the discard rate of non-quota fish.
0	2	Harvest ratios for demersal fish according to the external data on gear activity and power (selectivity), as processed by the fleet model.	Discard rates for non-quota demersal fish are set internally by the ecology model to equal the undersize fraction. Discard rates for quota-limited demersal fish are set to zero regardless of external data or the internally derived undersize fraction - i.e. this forces all the catch of quota-limited to be landed including undersize fish. This option mimics the EU Common Fisheries Policy Landing Obligation.
1	2	Implicit changes in gear selectivity to minimise catches of undersize fish - the externally set harvest ratios for demersal fish are attenuated by a factor equal to the lesser of the proportion of undersize quota-limited and non-quota fish in catches, as derived by the ecology model.	This has the same effect as setting discard rate switch to 0, i.e. due to the implicit changes in selectivity, there are no undersize catches of either quota-limited or non-quota demersal fish so discard rates are set to zero.
0	3	Harvest ratios for demersal fish according to the external data on gear activity and power (selectivity), as processed by the fleet model.	Discard rates for both quota-limited and non-quota demersal fish are set to zero regardless of external data or the internally derived undersize fractions - i.e. this forces all the catch of all demersal fish to be landed including undersize fish.
1	3	Implicit changes in gear selectivity so that there are no catches of undersize fish - the externally set harvest ratios for demersal fish are attenuated by an amount proportional to the undersize fractions of quota-limited and non-quota fish in catches, as derived by the ecology model.	This has the same effect as setting the discard rate switch to 0, i.e. due to the implicit changes in selectivity, there are no undersize catches of either quota-limited or non-quota demersal fish so discard rates are set to zero.

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Table 16. Definitions of the gear types, their activity rates and seabed abrasion rates in the fishing fleet model ("*fishing_activity_parameters*.csv*"). Each gear is assigned a name, a short-code used in some plotting functions, and activity density (seconds of deployment. $m^{-2}.d^{-1}$), and a seabed abrasion (ploughing) rate (m^2 abraded.s^{-1}). The gear names and codes shown here are for the North Sea model included with the package; xxxx indicates that a numeric value is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Gear_name	**Gear_code**	**Activity_(s/m^2/d)**	**Plough_rate_(m^2/s)**
Pelagic_Trawl+Seine	PTS	xxxx	xxxx
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	xxxx	xxxx
Longline_mackerel	LLm	xxxx	xxxx
Beam_Trawl_BT1+BT2	BTf	xxxx	xxxx
Demersal_Seine	DS	xxxx	xxxx
Demersal_Otter_Trawl_TR1	OT	xxxx	xxxx
Gill_Nets+Longline_demersal	LLd	xxxx	xxxx
Beam_Trawl_shrimp	BTs	xxxx	xxxx
Nephrops_Trawl_TR2	NT	xxxx	xxxx
Creels	CR	xxxx	xxxx
Mollusc_Dredge	MD	xxxx	xxxx
Whaler	Wh	xxxx	xxxx

Table 17. Catching power of each gear with respect to each of the harvestable resource guilds in the ecology model ("*fishing_power_parameters*.csv*"). Gear names and codes (rows) must correspond with those defined in the gear activity file. Numeric values along each row define the selectivity pattern of each gear. The grey-shaded row shown here is provided to aid clairity and is not present in the operational file. The gear names and codes shown here are for the North Sea model included with the package; xxxx indicates that a numeric value is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Guild definition		Planktivorous fish	Demersal fish	Migratory fish	Susp/dep feeding benthos	Carn/scav feeding benthos	Carniv. zooplankton	Birds	Pinnipeds	Cetaceans	Macrophytes
Gear_name	Gear_code	Power_PF	Power_DF	Power_MF	Power_FDB	Power_CSB	Power_CZ	Power_BD	Power_SL	Power_CT	Power_KP
Pelagic_Trawl+Seine	PTS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Longline_mackerel	LLm	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_BT1+BT2	BTf	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Seine	DS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Otter_Trawl_TR1	OT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Gill_Nets+Longline_demersal	LLd	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_shrimp	BTs	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Nephrops_Trawl_TR2	NT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Creels	CR	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Mollusc_Dredge	MD	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Whaler	Wh	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

Table 18. Discard rate (proportion of catch discarded) by each gear with respect to each of the harvestable resource guilds in the ecology model ("*fishing_discard_parameters*.csv*"). Gear names and codes (rows) must correspond with those defined in the gear activity file. Numeric values along each row define the selectivity pattern of each gear. The grey-shaded row shown here is provided to aid clairity and is not present in the operational file. The gear names and codes shown here are for the North Sea model included with the package; xxxx indicates that a numeric value ≤1 is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Guild definition		Planktivorous fish	Demersal fish	Migratory fish	Susp/dep feeding benthos	Carn/scav feeding benthos	Carniv. zooplankton	Birds	Pinnipeds	Cetaceans	Macrophytes
Gear_name	Gear_code	Discardrate_PF	Discardrate_DF	Discardrate_MF	Discardrate_FDB	Discardrate_CSB	Discardrate_CZ	Discardrate_BD	Discardrate_SL	Discardrate_CT	Discardrate_KP
Pelagic_Trawl+Seine	PTS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Longline_mackerel	LLm	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_BT1+BT2	BTf	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Seine	DS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Otter_Trawl_TR1	OT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Gill_Nets+Longline_demersal	LLd	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_shrimp	BTs	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Nephrops_Trawl_TR2	NT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Creels	CR	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Mollusc_Dredge	MD	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Whaler	Wh	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

Table 19. Processing-at-sea rate (proportion of retained catch weight which is processed) for each gear with respect to each of the harvestable resource guilds in the ecology model ("*fishing_processing_at_sea_parameters*.csv*"). Gear names and codes (rows) must correspond with those defined in the gear activity file. The grey-shaded row shown here is provided to aid clairity and is not present in the operational file. Gear names and codes shown here are for the North Sea model included with the package; xxxx indicates that a numeric value ≤1 is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Guild definition		Planktivorous fish	Demersal fish	Migratory fish	Susp/dep feeding benthos	Carn/scav feeding benthos	Carniv. zooplankton	Birds	Pinnipeds	Cetaceans	Macrophytes
Gear_name	Gear_ code	Propgutted_ PF	Propgutted_ DF	Propgutted_ MF	Propgutted_ FDB	Propguttede_ CSB	Propgutted_ CZ	Propgutted_ BD	Propgutted_ SL	Propgutted_ CT	Propgutted_ KP
Pelagic_Trawl+Seine	PTS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Longline_mackerel	LLm	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_BT1+BT2	BTf	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Seine	DS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Otter_Trawl_TR1	OT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Gill_Nets+Longline_demersal	LLd	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_shrimp	BTs	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Nephrops_Trawl_TR2	NT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Creels	CR	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Mollusc_Dredge	MD	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Whaler	Wh	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

Table 20. Spatial distributions of activity for each gear type in the fishing fleet model ("*fishing_distribution_parameters*.csv*"). Gear names and codes (rows) must correspond with those defined in the gear activity file. Numeric values in each row must sum to 1.0, and define the proportion of activity by each gear which is deployed over each of the seabed habitats defined in the model configuration. Habitats s0 and d0 are hard-wired to be seabed rock in the inshore (s) and offshore (d) zones respectively. Other habitats would typically be configured to represent sediment habitats. Gear names and codes shown here are for the North Sea model included with the package; xxxx indicates that a numeric value ≤1 is required; Exponential format is acceptable for numeric values, e.g. x.xxxE-x .

Gear_name	Gear_code	Habitat_s0	Habitat_s1	Habitat_s2	Habitat_s3	Habitat_d0	Habitat_d1	Habitat_d2	Habitat_d3
Pelagic_Trawl+Seine	PTS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Longline_mackerel	LLm	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_BT1+BT2	BTf	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Seine	DS	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Demersal_Otter_Trawl_TR1	OT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Gill_Nets+Longline_demersal	LLd	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Beam_Trawl_shrimp	BTs	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Nephrops_Trawl_TR2	NT	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Creels	CR	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Mollusc_Dredge	MD	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx
Whaler	Wh	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx	xxxx

Table 21. Fishing gear activity multiplier file ("*fishing_activity_multiplier*.csv*"). Gear names and codes (rows) must correspond with those defined in the gear activity file. The multiplier values in the third column are automatically applied to the activity density values for each gear defined in the "*fishing_activity_parameters*.csv*" file before being piped into the ecology model. Hence the default values of 1.0 shown here have no effect on activity rates. Manual or programmed editing of the multiplier values is a convenient route to configuring fishing scenarios for the model. Gear names and codes shown here are for the North Sea model included with the package.

Gear_name	**Gear_code**	**Multiplier_to_be_applied_to_activity**
Pelagic_Trawl+Seine	PTS	1
Sandeel+sprat_trawl(Otter30-70mm+TR3)	SST	1
Longline_mackerel	LLm	1
Beam_Trawl_BT1+BT2	BTf	1
Demersal_Seine	DS	1
Demersal_Otter_Trawl_TR1	OT	1
Gill_Nets+Longline_demersal	LLd	1
Beam_Trawl_shrimp	BTs	1
Nephrops_Trawl_TR2	NT	1
Creels	CR	1
Mollusc_Dredge	MD	1
Whaler	Wh	1

Table 22. Harvest ratio multiplier file ("*harvest_ratio_multiplier*.csv*"). The multiplier values in the second column are automatically applied to the integrated harvest ratios for each resource guild derived by the fleet model, before being piped into the ecology model. Hence the default values of 1.0 shown here have no effect on ecology model. Manual or programmed editing of the multiplier values is a convenient route to configuring fishing scenarios for the model, but note that this only changes the harvest ratios and not the other collateral effects of fishing such as seabed abrasion associated with gear activity.

Guild	Harvest_ratio_multiplier
Planktivorous_fish	1
Demersal_fish	1
Migratory_fish	1
Benthos_susp-dep	1
Benthos_carn-scav	1
Zooplankton_carn	1
Birds	1
Pinnipeds	1
Cetaceans	1
Macrophytes	1

Table 23. Details of the food web flow matrix template file ("*food web flow matrix template.csv*"). The flow-matrix defines all of the flows in the model from every source to every destination. The template file is populated with null values to acts as a template for the code which creates the whole-domain flow-matrix required by the NetIndices R-package to derive network indices for the final year of a model run. There should be no requirement for a user to edit the file. The rows of the matrix are all the sources of flows in the network - state variables and import sources to the model. The columns are all the destinations for flows in the network - state variables, import sources and export destinations for the model. The matrix contains additional columns (exports to fishery landings and exports to macrophyte beachcast) which are not represented in the rows.

Row/column number	Row/column name	Description
1	Wcammonia	Water column ammonia
2	Sedammonia	Sediment porewater ammonia
3	Wcnitrate	Water column nitrate
4	Sednitrate	Sediment porewater nitrate

5	Wcdetritus	Water column detritus and bacteria
6	Seddetritus	Sediment labile detritus and bacteria
7	seddetritusR	Sediment refractory detritus
8	kelpdebris	Macrophyte debris
9	corpses	Corpses
10	discards	Fishery discards
11	kelp	Macrophytes
12	phyt	Phytoplankton
13	omnivzoo	Omnivorous zooplankton
14	carnzoo	Carnivorous zooplankton
15	pfishlar	Larvae of planktivorous fish
16	dfishlar	Larvae of demersal fish
17	pfish	Planktivorous fish
18	mfish	Migratory fish
19	dfish	Demersal fish
20	benthslar	Larvae of susp/dep feeding benthos
21	benthclar	Larvae of carn/scav feeding benthos
22	benths	Susp/dep feeding benthos
23	benthc	Carn/scav feeding benthos
24	bird	Birds
25	seal	Pinnipeds
26	ceta	Cetaceans
27	ocean	External ocean outside the model domain
28	rivers	Rivers flowing into the model domain
29	atmosphere	Atmosphere above the model domain
30	seabed	Seabed sediments beneath the active modelled layer in the model
(31)	landings	Fishery landings (processed weight) (column-data only)
(32)	beachcast	Macrophyte beachcast (column-data ony)

Table 24. Details of the fishing fleet gear linkages file (*fishing_fleet_gear_linkages.csv*). The table shows an example for the North Sea. The file is required only by the simulated annealing function e2e_optimize_hr() to find the combination of gear activity scaling values producing the best fit of the harvest ratios generated the fleet model to prior estimate inshore and offshore values, given a known relative spatial distribution of each gear and known effort-harvest ratio scaling values. The table specifies which gear activity rates are forced to vary in concert during the fitting process, as opposed to varying independently. The value of the linkage coefficient defines the scaling of changes in the activity rate of a dependent gear relative to its linked independent gear – for example gear 8 is permitted to vary independently (value in column 3 and 4 = NA), but gear 9 is dependent on gear 8 – the activity rate of gear 9 = (0.645 ± some random variation) * (activity of gear 8). Similarly for gear 10.

Gear_id	Gear name	Gear to which linked	Linkage coefficient	Comments
1	Pelagic_Trawl+Seine	NA	NA	Independent of other gears
2	Sandeel+sprat_trawl(Otter30-70mm+TR3)	1	1.5	Based on ICES ecosystem review
3	Longline_mackerel	1	1	Guess
4	Beam_Trawl_BT1+BT2	NA	NA	Independent of other gears
5	Demersal_Seine	6	1	Based on ICES ecosystem review
6	Demersal_Otter_Trawl_TR1	NA	NA	Independent of other gears
7	Gill_Nets+Longline_demersal	6	1	Guess
8	Beam_Trawl_shrimp	NA	NA	Independent of other gears
9	Nephrops_Trawl_TR2	8	0.645	Based on ICES ecosystem review
10	Creels	8	0.606	Based on ICES ecosystem review
11	Mollusc_Dredge	NA	NA	Independent of other gears
12	Whaler	NA	NA	Independent of other gears

Table 25. Column details in the database of observed annual-based indices of the state of the ecosystem in the model domain during the period corresponding to the physical and chemical driving data ("*annual_target_data*.csv*"). The annual measures referred to in column 1 are listed in Table 26.

Column number	Column name	Description	User editable
1	Annual_measure	Mean annual numeric value of the measure specified by the descriptior in column "Name". Missing values denoted by NA.	Yes
2	SD_of_measure	Standard deviation of the mean annual numeric value. Missing values denoted by NA.	Yes
3	Use1_0	Switch setting to determine whether the measure is included in likelihood calculations (1 = yes, 0 = no)	Yes
4	Name	Name used to identify the measure in the model code	No
5	Units	Units of the annual measure	No
6	Description	Text describing each measure	No
7	Region	Free-text describing the region in which the observations were collected	Yes
8	Time_period	Free-text describing the time period over which the observations were collected	Yes
9	Source	Free-text describing the literature or data-centre source the observations	Yes

Table 26. Row details in the database (Table 25) of observed annual-based indices of the state of the ecosystem in the model domain during the period corresponding to the physical and chemical driving data ("*annual_target_data*.csv*").

Row number	**Name in the model code**	**Units**	**Description**
1	Obs_TAPP	$mMN.m^{-2}.y^{-1}$	Annual total primary production
2	Obs_NP	$mMN.m^{-2}.y^{-1}$	Annual new production from depth integrated nitrate draw-down plus summer river and atmospheric inputs
3	Obs_KelpP	$gC.m^{-2}.y^{-1}$	Annual within forest net production of macrophytes
4	Obs_OmnizooP	$mMN.m^{-2}.y^{-1}$	Annual omnivorous zooplankton gross production
5	Obs_CarnzooP	$mMN.m^{-2}.y^{-1}$	Annual carnivorous zooplankton gross production
6	Obs_PFishP	$mMN.m^{-2}.y^{-1}$	Annual planktivorous fish gross production
7	Obs_DFishP	$mMN.m^{-2}.y^{-1}$	Annual demersal fish gross production
8	Obs_BensuspP	$mMN.m^{-2}.y^{-1}$	Annual suspensiondeposit feeding benthos gross production
9	Obs_BencarnP	$mMN.m^{-2}.y^{-1}$	Annual carnivore/scavenge feeding benthos gross production

10	Obs_birdP	$mMN.m^{-2}.y^{-1}$	Annual net production of birds
11	Obs_sealP	$mMN.m^{-2}.y^{-1}$	Annual net production of pinnipeds
12	Obs_cetaP	$mMN.m^{-2}.y^{-1}$	Annual net production of cetaceans
13	Obs_maxbenthslar	$mMN.m^{-3}$	Annual monthly max concentration of benthos suspension/deposit feeder larvae
14	Obs_maxbenthclar	$mMN.m^{-3}$	Annual monthly max concentration of benthos carnivore/scavenge feeder larvae
15	Obs_Conpfishfish	$mMN.m^{-2}.y^{-1}$	Annual consumption of planktivorous fish by fish
16	Obs_Condfishfish	$mMN.m^{-2}.y^{-1}$	Annual consumption of demersal fish by fish
17	Obs_Conzoofish	$mMN.m^{-2}.y^{-1}$	Annual consumption of omnivorous zooplankton by fish and fish larvae
18	Obs_Conzoocarnz	$mMN.m^{-2}.y^{-1}$	Annual consumption of omnivorous zooplankton by carnivorous zooplankton
19	Obs_Conbenfish	$mMN.m^{-2}.y^{-1}$	Annual consumption of benthos by fish
20	Obs_Contotal_bird	$mMN.m^{-2}.y^{-1}$	Annual food consumption by birds
21	Obs_Proppfishbird	Dimensionless	Proportion planktivorous fish in diet of birds
22	Obs_Propdfishbird	Dimensionless	Proportion demersal fish in diet of birds
23	Obs_Propmfishbird	Dimensionless	Proportion migratory fish in diet of birds
24	Obs_Propdiscbird	Dimensionless	Proportion discards in diet of birds
25	Obs_Contotal_seal	$mMN.m^{-2}.y^{-1}$	Annual food consumption by pinnipeds
26	Obs_Proppfishseal	Dimensionless	Proportion planktivorous fish in diet of pinnipeds
27	Obs_Propdfishseal	Dimensionless	Proportion demersal fish in diet of pinnipeds
28	Obs_Propmfishseal	Dimensionless	Proportion migratory fish in diet of pinnipeds
29	Obs_Contotal_ceta	$mMN.m^{-2}.y^{-1}$	Annual food consumption by cetaceans
30	Obs_Proppfishceta	Dimensionless	Proportion planktivorous fish in diet of cetaceans
31	Obs_Propdfishceta	Dimensionless	Proportion demersal fish in diet of cetaceans
32	Obs_Propmfishceta	Dimensionless	Proportion migratory fish in diet of cetaceans
33	Obs_Pland_livewt	$mMN.m^{-2}.y^{-1}$	Annual planktivorous fish landings (live weight)
34	Obs_Dland_livewt	$mMN.m^{-2}.y^{-1}$	Annual demersal fish landings (live weight)
35	Obs_Mland_livewt	$mMN.m^{-2}.y^{-1}$	Annual migratory fish landings (live weight)
36	Obs_Bsland_livewt	$mMN.m^{-2}.y^{-1}$	Annual suspension/deposit feeding benthos landings (live weight)
37	Obs_Bcland_livewt	$mMN.m^{-2}.y^{-1}$	Annual carnivore/scavenge feeding benthos landings (live weight)
38	Obs_Zcland_livewt	$mMN.m^{-2}.y^{-1}$	Annual carnivorous zooplankton landings (live weight)
39	Obs_Kland_livewt	$mMN.m^{-2}.y^{-1}$	Annual macrophyte landings (live weight)
40	Obs_kelp_pb	y^{-1}	Annual carbon gross PB ratio of macrophytes

41	Obs_benslar_pb	y^{-1}	Annual gross PB ratio larvae of suspension/deposit feeding benthos
42	Obs_benclar_pb	y^{-1}	Annual gross PB ratio larvae of carnivore/scavenge feeding benthos
43	Obs_bens_pb	y^{-1}	Annual gross PB ratio suspension/deposit feeding benthos
44	Obs_benc_pb	y^{-1}	Annual gross PB ratio carnivore/scavenge feeding benthos
45	Obs_herb_pb	y^{-1}	Annual gross PB ratio omnivorous zooplankton
46	Obs_carn_pb	y^{-1}	Annual gross PB ratio carnivorous zooplankton
47	Obs_fishplar_pb	y^{-1}	Annual gross PB ratio larvae of planktivorous fish
48	Obs_fishdlar_pb	y^{-1}	Annual gross PB ratio larvae of demersal fish
49	Obs_fishp_pb	y^{-1}	Annual gross PB ratio planktivorous fish
50	Obs_fishd_pb	y^{-1}	Annual gross PB ratio demersal fish
51	Obs_fishm_pb	y^{-1}	Annual gross PB ratio migratory fish
52	Obs_bird_pb	y^{-1}	Annual net PB ratio birds
53	Obs_seal_pb	y^{-1}	Annual net PB ratio pinnipeds
54	Obs_ceta_pb	y^{-1}	Annual net PB ratio cetaceans
55	Obs_exud_C_kelp	Dimensionless	Annual average proportion of macrophyte C uptake which is exuded
56	Obs_kelp_NC	Dimensionless	Annual average molar NC ratio of macrophytes
57	Obs_Denitrif	$mMN.m^{-2}.y^{-1}$	Annual denitrification
58	Obs_Dfdiscardp	Dimensionless	Proportion of demersal fish catch discarded
59	Obs_s_x_ammonia	$mMN.m^{-3}$	Annual average ammonia concentration in porewater of sand grain size 0.25mm
60	Obs_d_x_ammonia	$mMN.m^{-3}$	Annual average ammonia concentration in porewater of mud grain size 0.12mm
61	Obs_s_x_nitrate	$mMN.m^{-3}$	Annual average nitrate concentration in porewater of sand grain size 0.25mm
62	Obs_d_x_nitrate	$mMN.m^{-3}$	Annual average nitrate concentration in porewater of mud grain size 0.12mm
63	Obs_s_x_TON	%N ($gN.(g\ dry\ sed)^{-1}$)	Annual average organic N content of sand grain size 0.25mm (0.19-0.43mm)
64	Obs_d_x_TON	%N ($gN.(g\ dry\ sed)^{-1}$)	Annual average organic N content of mud grain size 0.12mm (0.03-0.07mm)
65	Obs_NDJF_s_nitrate	$mMN.m^{-3}$	Average winter (Nov-Feb) nitrate concentration shallow layer
66	Obs_MJJA_s_nitrate	$mMN.m^{-3}$	Average summer (May-Aug) nitrate concentration shallow layer
67	Obs_NDJF_d_nitrate	$mMN.m^{-3}$	Average winter (Nov-Feb) nitrate concentration deep layer
68	Obs_MJJA_d_nitrate	$mMN.m^{-3}$	Average summer (May-Aug) nitrate concentration deep layer
69	Obs_NDJF_s_ammonia	$mMN.m^{-3}$	Average winter (Nov-Feb) ammonia concentration shallow layer
70	Obs_MJJA_s_ammonia	$mMN.m^{-3}$	Average summer (May-Aug) ammonia concentration shallow layer
71	Obs_NDJF_d_ammonia	$mMN.m^{-3}$	Average winter (Nov-Feb) ammonia concentration deep layer

72	Obs_MJJA_d_ammonia	$mMN.m^{-3}$	Average summer (May-Aug) ammonia concentration deep layer
73	Obs_carn_io_ratio	Dimensionless	Inshore offshore ratio of annual mean carnivorous zooplankton depth averaged concentration
74	Obs_herb_io_ratio	Dimensionless	Inshore offshore ratio of annual mean omnivorous zooplankton depth averaged concentration
75	Obs_phyt_io_ratio	Dimensionless	Inshore offshore ratio of annual mean phytoplankton surface layer concentration
76	Obs_nit_io_ratio	Dimensionless	Inshore offshore ratio of annual mean nitrate surface layer concentration
77	Obs_amm_io_ratio	Dimensionless	Inshore offshore ratio of annual mean ammonia surface layer concentration
78	Obs_pfish_io_ratio	Dimensionless	Inshore offshore ratio of annual mean planktivorous fish density (m^{-2})
79	Obs_dfish_io_ratio	Dimensionless	Inshore offshore ratio of annual mean demersal fish density (m^{-2})
80	Obs_birddisc	$mMN.m^{-2}.y^{-1}$	Annual (discarded) bycatch of birds
81	Obs_sealdisc	$mMN.m^{-2}.y^{-1}$	Annual (discarded) bycatch of pinnipeds
82	Obs_cetadisc	$mMN.m^{-2}.y^{-1}$	Annual (discarded) bycatch of cetaceans
83	Obs_kelp_beachcast	Dimensionless	Proportion of macrophyte annual nitrogen uptake exported as beach-cast
84	Obs_Ctland_livewt	$mMN.m^{-2}.y^{-1}$	Cetacean landed (live weight) by whale hunters

Table 27. Column details in the database of observed monthly-based indices of nutrient and plankton concentrations in the model domain during the period corresponding to the physical and chemical driving data ("*annual_target_data*.csv*"). Details of the variables referred to in column 2 are given in Table 28.

Column number	Column name	Description	User editable
1	Month	Values 1-12 denoting months January – December	No
2	Variable	Name used in the model code to identify each variable	No
3	median	Median of observed values in the model domain over the period corresponding to the model driving data	Yes
4	lower_centile	Lower centile value of observed values in the model domain over the period corresponding to the model driving data	Yes
5	upper_centile	Upper centile value of observed values in the model domain over the period corresponding to the model driving data	Yes
6	Units	Units of the observed data	No
7	low_cent_value	Lower centile level (either 5% or 17%)	Yes

8	upp_cent_value	Upper centile level (either 83% or 95%)	Yes
9	Comments	Free text to describe the provenance of the observed data	Yes

Table 28. Details of the variables in the database (Table 27) of observed monthly-based indices of of nutrient and plankton concentrations in the model domain during the period corresponding to the physical and chemical driving data ("*monthly_target_data*.csv*").

Variable name	Units	Description
surface_nitrate	$mMNm^{-3}$	Nitrate concentrations in the combined volume of the inshore zone and the upper layer of the offshore zone
deep_nitrate	$mMNm^{-3}$	Nitrate concentrations in the lower layer of the offshore zone
surface_ammonia	$mMNm^{-3}$	Ammonia concentrations in the combined volume of the inshore zone and the upper layer of the offshore zone
deep_ammonia	$mMNm^{-3}$	Ammonia concentrations in the lower layer of the offshore zone
surface_chlorophyll	mgm^{-3}	Chlorophyll concentrations in the combined volume of the inshore zone and the upper layer of the offshore zone
omniv_zooplankton	$mMNm^{-3}$	Omnivorous zooplankton concentrations in the combined volume of the inshore and offshore zones
carniv_zooplankton	$mMNm^{-3}$	Carnivorous zooplankton concentrations in the combined volume of the inshore and offshore zones
larvae_susp_dep_benthos	$mMNm^{-3}$	Larvae of suspension/deposit feeding benthos - concentrations in the combined volume of the inshore and offshore zones
larvae_carniv_scav_benthos	$mMNm^{-3}$	Larvae of carnivorous/scavenge feeding benthos - concentrations in the combined volume of the inshore and offshore zones

Table 29. Table of independently known regional harvest ratios for each guild for the whole model domain (aggregated over the inshore and offshore zones). Illustrated by the data file for the 2003-2013 North Sea model. This file is required only for calculating an initial rough estimate of values for the effort-harvest ratio scaling coefficients, given known gear activity rates, using the function e2e_calculate_hrscale().

Guild	Regional harvest ratio (d^{-1})	Comments
Planktivorous_fish	2.6387E-04	1970-1999 harvest ratio from Heath 2012 upscaled to account for discards and rescaled to 03_13 from ICES ecoreview
Demersal_fish	3.2340E-04	1970-1999 harvest ratio from Heath 2012 upscaled to account for discards and rescaled to 03_13 from ICES ecoreview
Migratory_fish	1.6101E-04	1970-1999 harvest ratio from Heath 2012 upscaled to account for discards and rescaled to 03_13 from ICES ecoreview

Benthos_susp-dep	1.0637E-04	1970-1999 harvest ratio from Heath 2012 upscaled to account for discards and rescaled to 03_13 from ICES ecoreview
Benthos_carn-scav	4.0802E-04	1970-1999 harvest ratio from Heath 2012 upscaled to account for discards and rescaled to 03_13 from ICES ecoreview
Zooplankton_carn	4.9460E-04	Guess at harvest ratio for squid
Birds	1.6492E-06	Rough estimate for harvest ratio from synthesis of bycatch data
Pinnipeds	2.6053E-05	Rough estimate for harvest ratio from synthesis of bycatch data
Cetaceans	1.2055E-04	Rough estimate for harvest ratio from synthesis of bycatch data and strandings data
Macrophytes	0.0000E+00	No kelp harvesting in the North Sea

Table 30. Details of the file specifying target inshore and offshore harvest ratios of each guild (*fishing_fleet_target_harvest_ratios*.csv*). The file is required only by the simulated annealing function e2e_optimize_act(… , selection="HR", …) to find the combination of gear activity scaling values producing the best fit of the harvest ratios generated the fleet model to prior estimate inshore and offshore values, given a known relative spatial distribution of each gear and known effort-harvest ratio scaling values. The numeric values in the table (indicated here by xxxx) could be generated by compiling a model object using the e2e_read() function with inputs being gear activity densities (Table 16) and distributions (Table 20), and harvest ratio scaling parameters (Table 14) commensurate with the regional harvest ratios in Table 29. The 'Comments' column is free text and a possible example is shown here.

Guild	**Inshore harvest ratio (d^{-1})**	**Offshore harvest ratio (d^{-1})**	**Use 1=yes,0=no**	**Comments**
Planktivorous_fish	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Demersal_fish	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Migratory_fish	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Benthos_susp-dep	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Benthos_carn-scav	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Zooplankton_carn	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Birds	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs

Pinnipeds	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Cetaceans	xxxx	xxxx	1	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs
Macrophytes	xxxx	xxxx	0	Harvest ratios extracted from the model object for a run with fleet model parameters calibrated against known regional_HRs

Anciliary parameter files – control files for simulated annualing, sensitivity analysis and credible interval estimation

Table 31. Details of the control file **"***annealing_SD_ecology.csv*" which is located in the "*Parameter_SD_control*" sub-directory of the "Parameters" folder for each model version. This file should not be renamed. However, the values in column 1 (examples shown here) can be edited during a simulated annealing run to fit the ecology model parameters and have an immediate effect on the real-time plot of the fitting progress and on the search band-width for each group of parameters.

Value	Description - these can all be edited DURING a run and have immediate effect
0	Axis_minimum_for_realtime_plot
0.6	Axis_maximum_for_realtime_plot
0.02	CV_ie_SD/mean_for_preference_parameters
0.01	CV_ie_SD/mean_for_maximum_uptake_rates_may_need_to_be_up_to_10x_smaller_than_other_classes
0.01	CV_ie_SD/mean_for_half_saturation_coefficients_may_need_to_be_up_to_10x_smaller_than_other_classes
0.04	CV_ie_SD/mean_for_microbial_rates_may_need_to_be_upto_10x_larger_than_other_classes
0.02	CV_ie_SD/mean_for_density_dependent_mortality_parameters
0.02	CV_ie_SD/mean_for_other_parameters

Table 32. Details of the control file **"***annealing_SD_fishing.csv*" which is located in the "*Parameter_SD_control*" sub-directory of the "Parameters" folder for each model version. This file should not be renamed. However, the values in column 1 (examples shown here) can be edited during a simulated annealing run to fit either the the fishing activity rates or the harvest ratio scaling values and have an immediate effect on the real-time plot of the fitting progress and on the search band-width for the parameters.

Value	Description - these can all be edited DURING a run and have immediate effect
0	Axis_minimum_for_realtime_plot
0.3	Axis_maximum_for_realtime_plot
0.05	CV_ie_SD/mean_for_fishing_fleet_parameters

Table 33. Details of the control file **"***OATsensitivity_SD.csv*" which is located in the "*Parameter_SD_control*" sub-directory of the "Parameters" folder for each model version. This file should not be renamed. However, the values in column 1 (examples shown here) can be edited during a sensitivity analysis run to control the axis range of the real-time plot which monitors the progress of the analysis.

Value	**Description - these can all be edited DURING a run and have immediate effect**
0	Axis_minimum_for_realtime_plot
0.6	Axis_maximum_for_realtime_plot

Table 34. Details of the control file **"***CredIntSim_SD.csv*" which is located in the "*Parameter_SD_control*" sub-directory of the "Parameters" folder for each model version. This file should not be renamed. However, the axis range values in column 1 (examples shown here) can be edited during a credible interval simulation run run to control the real-time plot which monitors the progress of the analysis. The CV values for each group of variables should not be edited during a run but can be reset to some other values ahead of a run.

Value	**Description – axis ranges can be edited DURING a run and have immediate effect – do not edit the CVs during a run**
0	Axis_minimum_for_realtime_plot
0.6	Axis_maximum_for_realtime_plot
0.1	CV_ie_SD/mean_for_preference_parameters
0.1	CV_ie_SD/mean_for_maximum_uptake_rates
0.1	CV_ie_SD/mean_for_half_saturation_coefficients
0.1	CV_ie_SD/mean_for_microbial_rates
0.1	CV_ie_SD/mean_for_density_dependent_mortality_parameters
0.1	CV_ie_SD/mean_for_other_parameters

READING THE MODEL INPUT FILES

The function:

```
e2e_ls(user.path = ”“)
```

provides a list of the models and their variants available in the designated folder.

Arguments

user.path	Full path to users top level model folder. Default = the “extdata/Models” folder in the package.

The function:

```
e2e_read(model.name, model.variant, model.ident = "base", model.subdir = "", user.path = "")
```

creates an R-list object which contains all of the input data gathered from the “’.*csv*” files which define the model setup, parameters and driving data (Table 35).

Arguments

model.name	Name of model to read
model.variant	Read the designated model variant (no default)
model.ident	Text appended to output files (e.g. OFFSHORE_model_annualresults-TAG.csv instead of just OFFSHORE_model_annualresults.csv. Default = “base”.
model.subdir	Store results in this sub directory of the main results folder. Default = “results” in the users home directory.
user.path	Full path to users top level model folder. Default = the “extdata/Models” folder in the package.

Example

```
model <- e2e_read("North_Sea", "1970-1999")
```

Table 35. Structure and contents of the R-list object created by the e2e_read() function

Primary-level object name	Secondary-level object name	Tertiary level object name	Data type	Description
$setup			List (7 elements)	List object containing details of the paths to the model configuration data, and results identifiers
	$read.only		Logical	Internal setting – set to "read.only" if the model is loaded from the internally provided folders in the package - to prevent functions writing back to the installation.
	$model.name		Character string	Name of the model to be run, located in the the $model.path folder
	$model.variant		Character string	Name of the model variant, located in the $model.name folder
	$model.ident		Character string	Identifier to be appended to all output *.csv file-names
	$model.subdir		Character string	Sub-directory of of $resultsdir to be created if necessary, to hold outputs files from the modle run
	$model.path		Character string	Full path to the folder containinhg the model definition directories
	$resultsdir		Character string	Relative path to the results folder for model output
$data			List (8 elements)	List object comprising the compiled input data to the ecology model
	$fixed.parameters		List (51 elements)	Fixed parameter values gathered from the "*fixed_parameter*.csv*" files
	$fitted.parameters		List (171 elements)	Fixed parameter values gathered from the "*fitted_parameter*.csv*" files
	$physical.parameters		List (63 elements)	Physical parameters defning the model configuration (layer thicknesses, areas, etc.)
	$physics.drivers		Dataframe	Monthly values of physics driving

			data defining the repeating annual cycle of divers to be applied to the model
$chemistry.drivers		Dataframe	Monthly values of boundary chemical driving data defining the repeating annual cycle of divers to be applied to the model
$biological.events		Dataframe	Parameters defining the timing of biological events in the model
$fleet.model		List (19 elements)	List object comprising the compiled input data to the fishing fleet model
	$gear_labels	Factor with 12 levels	Names of the up to 12 fishing gear defined in the model
	$gear_codes	Factor with 12 levels	Short names (2 or 3 letter codes) for each fishing gear
	$gear_activity	Numeric vector	Activity rates of each fishing gear
	$gear_group_rel_power	Dataframe	Catching power for each fishing gear with respect to each harvestable guild in the ecology model
	$gear_group_discard	Dataframe	Externally defined discard rate for each fishing gear with respect to each harvestable guild in the ecology model
	$gear_group_gutting	Dataframe	Processing-at-sea rate for each fishing gear with respect to each harvestable guild in the ecology model
	$gear_ploughing_rate	Numeric vector	Seabed abrasion rate for each fishing gear
	$gear_habitat_activity	Dataframe	Proportional distribution of the activity of each fishing gear across the up to 8 seabed habitats in the model
	$HRscale_vector	Named numeric vector	Scaling values linking effort applied to each harvestable guild (integrated across all gears) to the harvest ratio (mortality rate).

				Ordering of values as in the input *.csv* file (see Table 14).
		$HRscale_vector_multiplier	Named numeric vector	Multipliers to be applied to harvest ratio values before being piped into the ecology model – useful for setting up fishing scenarios
		$offal_prop_live_weight	Numeric value	Proportion of live weight which is discarded as offal during processing at sea
		$gear_mult	Numeric vector	Multipliers to be applied to gear activity rates before being integrated and converted into harvest ratios – useful for setting up fishing scenarios
		$quota_nonquota_parms_vector	Numeric vector	Parameters of the empirically based relationships linking undersize and non-quota species fraction of demersal fish catch to demersal biomass
		$DFsize_SWITCH	Numeric value	Switch defining how the ecology model represents demersal fish size selectivity
		$DFdiscard_SWITCH	Numeric value	Switch defining how the ecology model represents discarding of demersal fish
		$plough_thickness	Numeric value	Penetration depth of fishing gears into seabed sediments
		$plough_depth_vector	Numeric vector	Proportion of each seabed sediment layer thickness penetrated by fishing gears.
	$initial.state		List (403 elements)	Initial values for the state variable in the model (typically originating from a prior long-run to stationary state of the model), plus zero values for all of the fluxes and derived variables output by the model

Writing your own code to create model scenarios

Typical use of the model might involve

- comparing a baseline run with a scenario run involving some changes in driving data (e.g. different temperature conditions or different activity rates of selected gears),
- conducting an analysis of the sensitivity to systematic changes in driving data (e.g. incrememts in harvest ratio over some range of values).

Users have two options for configuring such experiments

- manually edit the *.csv* input files as required and rerun the model,
- use coding to alter the required elements of the R list object created by the e2e_read() function, assigning a unique identifier to the outputs from each run.

Below are two examples of code to configure and run scenario cases of the the 2003-2013 North Sea model provided with the package. The first example runs 2003-2013 North Sea model as a baseline, and then adds an increment to the temperatures in all spatial zones and reruns the model. The second example iterates through seven levels of demersal fish harvest ratio ranging from 0 to 3-times the value in the 2003-2013 model (in steps of 0.5-times). Note that the changes in harvest ratio are not accompanied by any changes in fishing gear activity.

Example 1

```
# Example of code to run a baseline case of the North Sea model with 2003-2013 conditions, and then edit the
# model list object to create a scenario run with the temperature in all zones increased by 2 deg-C
#-------------------------------------------------------
# Read the embedded North Sea 2003-2013 model and assign an identifier for the results
baseTemp_model<-e2e_read("North_Sea", "2003-2013",model.ident="baseTemp")
# Run the model for 10 years and save the results to a named list object
baseTemp_results<-e2e_run(baseTemp_model,nyears=10)
# Visualise the output from the run (should show a repeating annual cycle with no trend)
e2e_plot_ts(baseTemp_model,baseTemp_results,selection=””ECO”)
#-------------------------------------------------------
T_rise<-2    # temperature increase to add to all temperatures in the model drivers
# copy the baseline model list object to a new model list
baseTemp_plusTC_model<-baseTemp_model
# add temperature increase to upper layer offshore temperatures
```

```
baseTemp_plusTC_model$data$physics.drivers$so_temp <- baseTemp_model$data$physics.drivers$so_temp+T_rise
# add temperature increase to inshore temperatures
baseTemp_plusTC_model$data$physics.drivers$si_temp <- baseTemp_model$data$physics.drivers$si_temp+T_rise
# add temperature increase to lower layer offshore temperatures
baseTemp_plusTC_model$data$physics.drivers$d_temp  <- baseTemp_model$data$physics.drivers$d_temp+T_rise
# Assign a unique identifier for the .csv outputs
baseTemp_plusTC_model$setup$model.ident <- "baseTemp_plusTC"
# Run the model for 10 years and save the results to a named list object
baseTemp_plusTC_results<-e2e_run(baseTemp_plusTC_model,nyears=10)
# Visualise the output from the run (should show trends in outputs due to change in T)
e2e_plot_ts(baseTemp_plusTC_model,baseTemp_plusTC_results,selection="ECO")
#-------------------------------------------------------
```

Example 2

```
# Example of code to loop through a set of seven levels of demersal fish harvest ratio ranging from 0 to 3-times
# the baseline value for the 2003-2013 North Sea model. The .csv outputs for each level are saved to unique
# filenames but the results list-object is discarded. The baseline case is the third level (HScale=1). Each level
# is run for 40 years.
#-------------------------------------------------------
model<-e2e_read("North_Sea", "2003-2013")                  # Read the embedded North Sea 2003-2013 model
for(i in 1:7) {                                            # Start loop through seven model scenarios
  HScale <- (i-1)*0.5                                      # HScale becomes 0 to 3 in steps of 0.5
     # Assign a unique identifier for each set of .csv outputs
  model$setup$model.ident <- paste("Dem_HR_scale_",HScale,sep="")
     # Set the demersal fish harvest ratio multipler to HScale
  model$data$fleet.model$HRscale_vector_multiplier[2] <- HScale
          # Run the model, save the .csv results, overwrite any previous list-object
  results<-e2e_run(model,nyears=40)
  print(paste("Harvest Ratio scaling = ",HScale,sep=""))   # Print a screen message to monitor progress
  print("-----------------------------------")             # Print a screen message to moinitor progress
  e2e_plot_ts(model,results,selection="ECO")               # Visualise the output from each run

}                                                          # End loop through scenarios
#-------------------------------------------------------
```

OUTPUTS FROM A BASIC SINGLE RUN OF THE MODEL

Structure of the output data

The function

```
e2e_run(model, nyears)
```

performs a single run of the model with the current R-list object defining the model setup.

Arguments

model	current model configuration (list-object created by e2e_read())
nyears	number of years to run the model, default = 5

Example

```
model <- e2e_read("North_Sea", "1970-1999")
results <- e2e_run(model,nyears=20)
```

The outputs from running the basic model are a set of comma-separated-variable (.csv) files, and an R list object ("results" in the example above) which contains 7 primary data structures (Table 36). The contents of the *.csv* outputs are replicated in the R list.

Output *.csv* files are directed to a "*results*" folder either in the user home workspace by default, or to a workspace defined in the arguments of the e2e_read() function (Figure 3). The *.csv* files each have a generic file name plus an alpha-numeric identifier (model.ident) assigned by the user as an argument of the e2e_read() function (default = "base"). An abbreviated view of the contents of the results object can be obtained by the R-function str() (e.g. str(results)). To view the names of primary level objects in the results list, use the function names() (e.g. names(results)). Tables 37-46 provide details of the R-list object, and of each individual data element of the object and corresponding *.csv* file where applicable.

Figure 3. Folder structure for model results. Italicised folder names are free for user specification. The folder structure will be automatically created in the user working directory by the running model unless otherwise specified in the model setup. "*Model_region"* and "*Variant* folders" will be auto-created to replicate the structure in the model definition folders unless already existing. The "CredInt" subfolder wil be auto-created on the first instance of the Mont-Carlo function in the package.

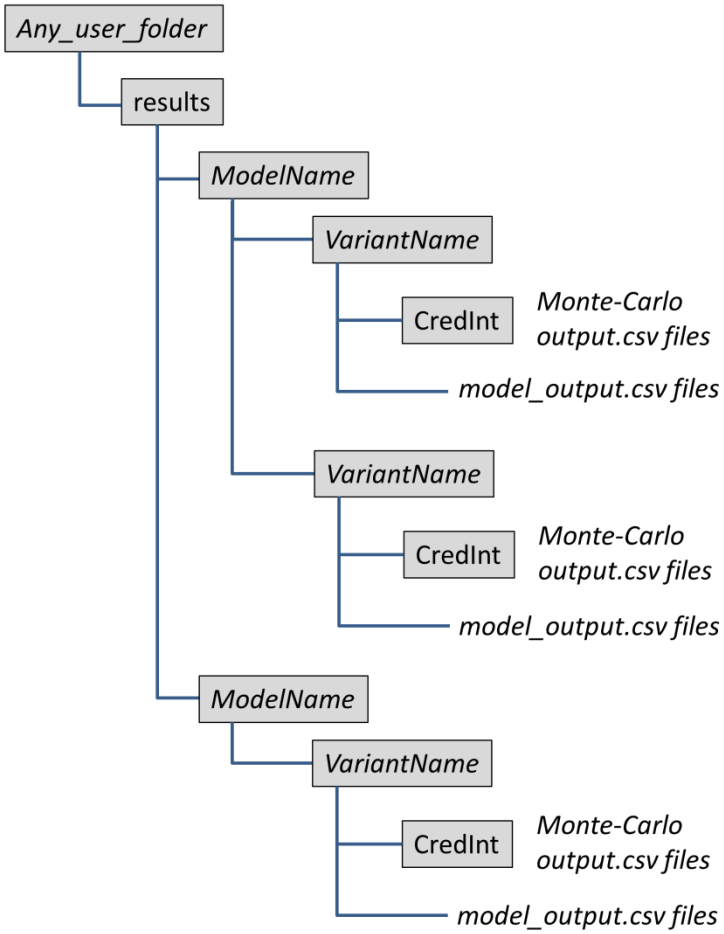

Table 36. High-level details of the 7 data objects contained in the R-list created by running the model.

Object name	Data-type	Description
$build	List	Objects defining all the input conditions for the model run
$output	Dataframe	Primary output from the ecology model.
$aggregates	Dataframe	Aggregates of primary outputs from the model
$fleet.output	List	Datasets output from the fleet model.
$total.annual.catch	List	Annually integrated catch data for each model guild, for each successive year of the model run.
$annual.catch.by.gear	List	Annually integrated catch data for each successive year of the model run, disaggregated by fishing gears
$final.year.outputs	List	Data products derived from the final year only of the model run.

Table 37. Details of the contents of each of the 7 data objects saved within the R-list created by running the model, and the corresponding *.csv* file names where applicable.

Primary-level object name	Secondary-level object name	Tertiary-level object name	R data type	.csv file name where applicable	Brief description
$build			List		List of objects defining all the input conditions for the model run
	$model.parameters		Named numeric vector		Vector of parameter values, compile dfrom al the input data, which is piped into the ecology model
	$run		List		List of objects defining the duration and timing of events in the run
		$nyears	Numeric value		Number of simulation years for the model run
		$ndays	Numeric value		Number of simulation days for the model run
		$drndays	Numeric value		Number of values in the sequence of driving data supplied for the modle run
		$times	Numeric vector		Times in days at which output is expected from the model. Vector

					length = $ndays
		$drtimes	Numeric vector		Times in days at which driving data are defined for the model run. Vector length = $drndays
		$sprectimes	Numeric vector		Times in days at which spawning and recruitment events occur
		$daynum	Numeric vector		Sequence of days defining an annual cycle (0 – 360 in intervals of 1)
	$drivers		List of 51		Set of R-functions whish return the values of model drivers at any given day number e.g $driversslight() returns the sea surface light intensity on a given day.
	$forcings		List of 53		Values of all the drivers generated by $drivers at times defined by rundrtimes which are piped into the ecoloy model
$output			Dataframe		Primary output from the ecology model. First column is the time (days from the beginning of the run) of each output event, and the remaining columns are the values of the state variables (mMN) and a range of cumulative fluxes at the sequence of daily intervals (rows).
$aggregates			List of 130		Aggregates of primary outputs. List of 124 numeric vectors of length equal to the number of rows in “output”, plus six numeric values (vectotrs length 1) of aggregated volumetric data. The aggregates of the primary outputs are *e.g.* the combined mass of all material in the model, or the combined

					mass of a property in the whole model domain, obtained by summing across state variables or summing the values in the inshore and offshore zones.
$fleet.output			List		List of datasets output from the fleet model.
	$fleet_vector		Numeric vector		Parameters generated by the fleet model which become embedded in the ecology model parameter set (model.parameters).
	$offshore_gear_group_prop_effort		Dataframe		Final year proportional distribution of offshore effort density across gears for each guild (rows = gears, columns = guilds, column values sum to 1). Used to disaggregate total catch output from the model into catches by gears.
	$inshore_gear_group_prop_effort		Dataframe		As above for the inshore zone.
	$offshore_gear_to_region_discard_rate_ratio		Dataframe		Final year ratios of gear-discard rate in the offshore zone, to the regional effort weighted all-gear discard rate of each guild (rows = gears, columns = guilds). Used to disaggregate total catch output from the model into catches by gears.
	$inshore_gear_to_region_discard_rate_ratio		Dataframe		As above for the inshore zone.
	$offshore_gear_group_props		Dataframe		Combines and flattens the data provided in the dataframes offshore_gear_group_prop_effort and offshore_gear_to_region_discard_rate_ratio, and replicates for each year of the model run. Rows = years of the run; columns : [1] = year, [2:13] = proportional distribution of

					planktivorous fish effort across trhe 12 gears, [14:25] = proportional distribution of demersal fish `effort across trhe 12 gears, etc to column 121; [122:133] = ratios of planktivorous fish discard rate for each gear, [134:145] = ratios of demersal fish discard rate for each gear, etc to comumn 241. Used to disaggregate total catch output from the model into catches by gears.
	$inshore_gear_group_props		Dataframe		As above for the inshore zone.
$total.annual.catch			List		List of annually integrated catch datasets for each successive year of the model run.
	$offshore_annual_group_land_disc		Dataframe	model_offshore_annual_landings_discards-*	Annual landings and discards (mMN.y^{-1}) of each harvestable guild in the offshore zone, for each year of the model run
	$inshore_annual_group_land_disc		Dataframe	model_inshore_annual_landings_discards-*	As above for the inshore zone
$annual.catch.by.gear			List		List of annually catch datasets for each successive year of the model run, disaggregated by fishing gears
	$offshore_annual_group_gear_land_disc		Dataframe		Annual integrals of landings and discards (mMN.y^{-1}) of each harvestable guild in the offshore zone, disaggregated by gear (columns), for each year of the model run (rows).
	$inshore_annual_group_gear_land_disc		Dataframe		As above for the inshore zone.
$final.year.outputs			List		List of data products derived from the final year only of the model run.
	$inshore_catchmat		Array	INSHORE_catchcomposition_by_gear-*	Catch mass (mMN.y^{-1}) in the inshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears).

	$inshore_discmat		Array	INSHORE_discardcomposition_by_gear-*	Landed live mass (mMN.y^{-1}) from the inshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears).
	$inshore_landmat		Array	INSHORE_landingcomposition_by_gear-*	Discarded live mass (mMN.y^{-1}) in the inshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears)
	$offshore_catchmat		Array	OFFSHORE_catchcomposition_by_gear-*	Catch mass (mMN.y^{-1}) in the offshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears).
	$offshore_landmat		Array	OFFSHORE_landingcomposition_by_gear-*	Landed live mass (mMN.y^{-1}) from the offshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears).
	$offshore_discmat		Array	OFFSHORE_discardcomposition_by_gear-*	Discarded live mass (mMN.y^{-1}) in the offshore zone distributed across guilds and fishing gears (rows = guilds, columns = gears).
	$monthly.averages		Dataframe	model_monthlyresults-*	Monthly averages of water column nutrients,chlorophyll, and zooplankton classes including meroplankton concentratiions (mMN.m^{-3}, except chlorophyll mg.m^{-3}) averaged over the whole model domain. Rows: months, columns: variable averages. Chlorophyll estimated assuming a fixed Redfield molar carbon:nitrogen ratio (106:16) and carbon:chlorophyll weight ratio of 40.
	$mass_results_inshore		Dataframe	INSHORE_model_anav_biomass-*	Final year annual mean mass (mMN) of each state variable in the inshore zone, plus the area-

					proportions and thicknesses of water column and sediment layers to enable mass data to be converted to area-densities (mMN.m^{-2}) or layer concentrations (mMN.m^{-3})
	$maxmass_results_inshore		Dataframe	INSHORE_model_maximum_biomass-*	Final year annual maximum mass (mMN) of each state variable in the inshore zone, plus the area-proportions and thicknesses of water column and sediment layers to enable mass data to be converted to area-densities (mMN.m^{-2}) or layer concentrations (mMN.m^{-3})
	$minmass_results_inshore		Dataframe	INSHORE_model_minimum_biomass-*	Final year annual minimum mass (mMN) of each state variable in the inshore zone, plus the area-proportions and thicknesses of water column and sediment layers to enable mass data to be converted to area-densities (mMN.m^{-2}) or layer concentrations (mMN.m^{-3})
	$annual_flux_results_inshore		Dataframe	INSHORE_model_annualresults-*	A range of final year annual fluxes (mMN.y^{-1}) – boundary influxes and efluxes (including live and gutted landed weights) for the inshore zone; gross and net production rates; feeding and excretion fluxes; egg production and recruitment; plus the area-proportions and thicknesses of water column and sediment layers to enable mass fluxes to be converted to area-density fluxes (mMN.m^{-2}.y^{-1}) or layer-concentration fluxes (mMN.m^{-3}.y^{-1}).
	$mass_results_offshore		Dataframe	OFFSHORE_model_anav_biomass-*	As above for the offshore zone
	$maxmass_results_offshore		Dataframe	OFFSHORE_model_maximum_biomass-*	As above for the offshore zone

	$minmass_results_offshore		Dataframe	OFFSHORE_model_minimum_biomass-*	As above for the offshore zone
	$annual_flux_results_offshore		Dataframe	OFFSHORE_model_annualresults-*	As above for the offshore zone
	$mass_results_wholedomain		Dataframe	WHOLEDOMAIN_model_anav_biomass-*	As above for the whole model domain (inshore and offshore combined)
	$maxmass_results_wholedomain		Dataframe	WHOLEDOMAIN _model_maximum_biomass-*	As above for the whole model domain (inshore and offshore combined)
	$minmass_results_wholedomain		Dataframe	WHOLEDOMAIN _model_minimum_biomass-*	As above for the whole model domain (inshore and offshore combined)
	$annual_flux_results_wholedomain		Dataframe	WHOLEDOMAIN _model_annualresults-*	As above for the whole model domain (inshore and offshore combined)
	$flow_matrix_all_fluxes		Dataframe	flow_matrix_all_fluxes-*	Final year matrix of annual integrated flows through the whole model domain network of state variable between sources (rows) and destinations (columns), including model boundary flows and spawning and recruitments fluxes between adult and egg/larvae stages.
	$flow_matrix_excl_spawn_recruit		Dataframe	flow_matrix_excl_spawn_recuit-*	As above but exluding the fluxes due to spawning and recruitment.
	$NetworkIndexResults		Dataframe	Network_indices_output-*	Table of results from applying the flow matrix data above to the functions provided in the NetIndices R package
	$annual.target.data		Dataframe		Input data on the ‘real life’ observed data on annual metrics (annual target data) copied directly for the input *.csv* file (Tables 25, 26). These data are included here so that they are easily available for plotting and comparison with model outputs.
	$monthly.target.data		Dataframe		Input data on the ‘real life’

					observed data on monthly averages of nutrient and plankton state variables (monthly target data) copied directly for the input *.csv* file (Tables 27, 28). These data are included here so that they are easily available for plotting and comparison with model outputs
	$annual_obj		Numeric value		Single value corresponding to the likelihood of the observed annual target data given the model structure, driving data and parameters.
	$partial_chi		Dataframe	model_likelihood_results-*	Table of the partial likelihoods corresponding to each element of the observed annual target data.
	$opt_results		Dataframe	model_target_annualresults_plus_chi-*	Table combining the input observed annual target data (*$annual.target.data*) with the corresponding annual model ouputs, and the "chi-squared" value for each observation (data column labelled "Chi"). The likelihood of each observed value (see *$partial_chi*) is given by exp-(Chi))

Table 38. Key data (area and volumetric parameters) saved in the vector "$build$model.parameters" of the R-list generated by the model, that will be required by users for post-processing of results. These parameters are needed to convert state variable mass and fluxes into area-densities and layer concentrations. The notation ..$parameter.name denotes the prefix results.object.name$build$model.parameters

Variable name (prefixed by ..$build$model.parameters	Description	Units
..$shallowprop	Area-proportion of the inshore zone	Dimensionless
..$thik_so	Thickness of the offshore zone upper water column layer	m

..$thik_d	Thickness of the offshore zone lower water column layer	m
..$thik_si	Thickness of the inshore zone water column layer	m
..$area_s0	Area-proportion of the inshore rock habitat	Dimensionless
..$area_s1	Area-proportion of the inshore zone sediment habitat 1	Dimensionless
..$area_s2	Area-proportion of the inshore zone sediment habitat 2	Dimensionless
..$area_s3	Area-proportion of the inshore zone sediment habitat 3	Dimensionless
..$area_d0	Area-proportion of the offshore rock habitat	Dimensionless
..$area_d1	Area-proportion of the offshore zone sediment habitat 1	Dimensionless
..$area_d2	Area-proportion of the offshore zone sediment habitat 2	Dimensionless
..$area_d3	Area-proportion of the offshore zone sediment habitat 3	Dimensionless
..$thik_x_s1	Thickness of the inshore zone sediment habitat 1	m
..$thik_x_s2	Thickness of the inshore zone sediment habitat 2	m
..$think_x_s3	Thickness of the inshore zone sediment habitat 3	m
..$thik_x_d1	Thickness of the offshore zone sediment habitat 1	m
..$thik_x_d2	Thickness of the offshore zone sediment habitat 2	m
..$think_x_d3	Thickness of the offshore zone sediment habitat 3	m
..$porosity_s1	Porosity (fluid volume-proportion) of the inshore zone sediment habitat 1	Dimensionless
..$porosity _s2	Porosity (fluid volume-proportion) of the inshore zone sediment habitat 2	Dimensionless
..$porosity_s3	Porosity (fluid volume-proportion) of the inshore zone sediment habitat 3	Dimensionless
..$porosity_d1	Porosity (fluid volume-proportion) of the offshore zone sediment habitat 1	Dimensionless
..$porosity_d2	Porosity (fluid volume-proportion) of the offshore zone sediment habitat 2	Dimensionless
..$porosity_d3	Porosity (fluid volume-proportion) of the offshore zone sediment habitat 3	Dimensionless

Details of the raw data outputs from the model

Table 39. Details of the data columns in the dataframe "$output" generated by the model. Rows in the dataframe are the sequential outputs at daily intervals. State variable mass columns (2:78) are the masses of nitrogen or carbon associate with the state variables in the model; cumulative flux columns (79:404) are the accumulated flows of mass over time between the given compartments. The rate of flow over any given interval is given by the difference in cumulative flux between appropriate rows in the dataframe. The notional sea surface area of the whole model domain is $1m^2$; the configuration parameters defining vertical layer thicknesses and horizontal area-proportions in the inshore and offshore zone and in the seabed habitats are given in the "$build$model.parameters" object (see Table 38). These parameters are required to convert state variable mass and fluxes output from the model into area densities (m^{-2}) and layer concentrations (m^{-3}).

Column number	Column name	Data type	Description	Units
1	Time	Cumulative time	Time from start of run (0 to 360 x number of years)	Days
2	detritus_so	State variable mass	Offshore upper layer suspended detritus and bacteria	mMN
3	detritus_d	State variable mass	Offshore lower layer suspended detritus and bacteria	mMN
4	x_detritus_s1	State variable mass	Inshore sediment class 1 labile detritus and bacteria	mMN
5	x_detritus_s2	State variable mass	Inshore sediment class 2 labile detritus and bacteria	mMN
6	x_detritus_s3	State variable mass	Inshore sediment class 3 labile detritus and bacteria	mMN
7	x_detritus_d1	State variable mass	Offshore sediment class 1 labile detritus and bacteria	mMN
8	x_detritus_d2	State variable mass	Offshore sediment class 2 labile detritus and bacteria	mMN
9	x_detritus_d3	State variable mass	Offshore sediment class 3 labile detritus and bacteria	mMN
10	xR_detritus_s1	State variable mass	Inshore sediment class 1 refractory detritus	mMN
11	xR_detritus_s2	State variable mass	Inshore sediment class 2 refractory detritus	mMN
12	xR_detritus_s3	State variable mass	Inshore sediment class 3 refractory detritus	mMN
13	xR_detritus_d1	State variable mass	Offshore sediment class 1 refractory detritus	mMN
14	xR_detritus_d2	State variable mass	Offshore sediment class 2 refractory detritus	mMN
15	xR_detritus_d3	State variable mass	Offshore sediment class 3 refractory detritus	mMN
16	discard_o	State variable mass	Offshore discarded material from fisheries	mMN
17	corpse_s1	State variable mass	Inshore sediment class 1 seabed corpses	mMN
18	corpse_s2	State variable mass	Inshore sediment class 2 seabed corpses	mMN

19	corpse_s3	State variable mass	Inshore sediment class 3 seabed corpses	mMN
20	corpse_d1	State variable mass	Offshore sediment class 1 seabed corpses	mMN
21	corpse_d2	State variable mass	Offshore sediment class 2 seabed corpses	mMN
22	corpse_d3	State variable mass	Offshore sediment class 3 seabed corpses	mMN
23	ammonia_so	State variable mass	Offshore upper layer ammonia	mMN
24	ammonia_d	State variable mass	Offshore lower layer ammonia	mMN
25	x_ammonia_s1	State variable mass	Inshore sediment class 1 porewater ammonia	mMN
26	x_ammonia_s2	State variable mass	Inshore sediment class 2 porewater ammonia	mMN
27	x_ammonia_s3	State variable mass	Inshore sediment class 3 porewater ammonia	mMN
28	x_ammonia_d1	State variable mass	Offshore sediment class 1 porewater ammonia	mMN
29	x_ammonia_d2	State variable mass	Offshore sediment class 2 porewater ammonia	mMN
30	x_ammonia_d3	State variable mass	Offshore sediment class 3 porewater ammonia	mMN
31	nitrate_so	State variable mass	Offshore upper layer nitrate	mMN
32	nitrate_d	State variable mass	Offshore lower layer nitrate	mMN
33	x_nitrate_s1	State variable mass	Inshore sediment class 1 porewater nitrate	mMN
34	x_nitrate_s2	State variable mass	Inshore sediment class 2 porewater nitrate	mMN
35	x_nitrate_s3	State variable mass	Inshore sediment class 3 porewater nitrate	mMN
36	x_nitrate_d1	State variable mass	Offshore sediment class 1 porewater nitrate	mMN
37	x_nitrate_d2	State variable mass	Offshore sediment class 2 porewater nitrate	mMN
38	x_nitrate_d3	State variable mass	Offshore sediment class 3 porewater nitrate	mMN
39	phyt_so	State variable mass	Offshore upper layer phytoplankton	mMN
40	phyt_d	State variable mass	Offshore lower layer phytoplankton	mMN
41	herb_o	State variable mass	Offshore omnivorous zooplankton	mMN
42	carn_o	State variable mass	Offshore carnivorous zooplankton	mMN
43	benthslar_o	State variable mass	Offshore larvae of susp/dep feeding benthos	mMN
44	benths_o	State variable mass	Offshore susp/dep feeding benthos	mMN
45	benthclar_o	State variable mass	Offshore larvae of carn/scav feeding benthos	mMN
46	benthc_o	State variable mass	Offshore carn/scav feeding benthos	mMN
47	fishp_o	State variable mass	Offshore planktivorous fish	mMN
48	fishplar_o	State variable mass	Offshore larvae of planktivorous fish	mMN

49	fishd_o	State variable mass	Offshore demersal fish	mMN
50	fishdlar_o	State variable mass	Offshore larvae of demersal fish	mMN
51	fishm_o	State variable mass	Offshore migratory fish	mMN
52	bird_o	State variable mass	Offshore birds	mMN
53	detritus_si	State variable mass	Inshore suspended detritus and bacteria	mMN
54	ammonia_si	State variable mass	Inshore ammonia	mMN
55	nitrate_si	State variable mass	Inshore nitrate	mMN
56	phyt_si	State variable mass	Inshore phytoplankton	mMN
57	benthslar_i	State variable mass	Inshore larvae of susp/dep feeding benthos	mMN
58	benthclar_i	State variable mass	Inshore larvae of carn/scav feeding benthos	mMN
59	benths_i	State variable mass	Inshore susp/dep feeding benthos	mMN
60	benthc_i	State variable mass	Inshore carn/scav feeding benthos	mMN
61	discard_i	State variable mass	Inshore disarded material from fisheries	mMN
62	herb_i	State variable mass	Inshore omnivorous zooplankton	mMN
63	carn_i	State variable mass	Inshore carnivorous zooplankton	mMN
64	fishplar_i	State variable mass	Inshore larvae of planktivorous fish	mMN
65	fishdlar_i	State variable mass	Inshore larvae of demersal fish	mMN
66	fishp_i	State variable mass	Inshore planktivorous fish	mMN
67	fishm_i	State variable mass	Inshore migratory fish	mMN
68	fishd_i	State variable mass	Inshore demersal fish	mMN
69	bird_i	State variable mass	Inshore birds	mMN
70	seal_o	State variable mass	Offshore pinnipeds	mMN
71	seal_i	State variable mass	Inshore pinnipeds	mMN
72	ceta_o	State variable mass	Offshore cetaceans	mMN
73	ceta_i	State variable mass	Inshore cetaceans	mMN
74	corpse_s0	State variable mass	Inshore rock seabed corpses	mMN
75	corpse_d0	State variable mass	Offshore rock seabed corpses	mMN
76	kelpC	State variable mass	Inshore macrophyte carbon	mMC
77	kelpN	State variable mass	Inshore macrphyte nitrogen	mMN
78	kelpdebris	State variable mass	Inshore macrophyte debris	mMN

79	netpprod_o	Cumulative flux	Offshore phytoplankton net production	mMN
80	netpprod_i	Cumulative flux	Inshore phytoplankton net production	mMN
81	PNP_o	Cumulative flux	Offshore net nitrate draw-down (PNP)	mMN
82	PNP_i	Cumulative flux	Inshore net nitrate draw-down (PNP)	mMN
83	phytgrossprod_o	Cumulative flux	Offshore phytoplankton gross production	mMN
84	phytgrossprod_i	Cumulative flux	Inshore phytoplankton gross production	mMN
85	kelpCprod_i	Cumulative flux	Inshore macrophyte carbon production	mMC
86	kelpCexud_i	Cumulative flux	Inshore macrophyte carbon exudation	mMC
87	kelpNprod_i	Cumulative flux	Inshore macrophyte nitrogen production	mMN
88	herbgrossprod_o	Cumulative flux	Offshore omnivorous zooplankton gross production	mMN
89	herbgrossprod_i	Cumulative flux	Inshore omnivorous zooplankton gross production	mMN
90	carngrossprod_o	Cumulative flux	Offshore carnivorous zooplankton gross production	mMN
91	carngrossprod_i	Cumulative flux	Inshore carnivorous zooplankton gross production	mMN
92	pfishlargrossprod_o	Cumulative flux	Offshore larvae of planktivorous fish gross production	mMN
93	pfishlargrossprod_i	Cumulative flux	Inshore larvae of planktivorous fish gross production	mMN
94	dfishlargrossprod_o	Cumulative flux	Offshore larvae of demersal fish gross production	mMN
95	dfishlargrossprod_i	Cumulative flux	Inshore larvae of demersal fish gross production	mMN
96	pfishgrossprod_o	Cumulative flux	Offshore planktivorous fish gross production	mMN
97	pfishgrossprod_i	Cumulative flux	Inshore planktivorous fish gross production	mMN
98	mfishgrossprod_o	Cumulative flux	Offshore migratory fish gross production	mMN
99	mfishgrossprod_i	Cumulative flux	Inshore migratory fish gross production	mMN
100	dfishgrossprod_o	Cumulative flux	Offshore demersal fish gross production	mMN
101	dfishgrossprod_i	Cumulative flux	Inshore demersal fish gross production	mMN
102	benthslargrossprod_o	Cumulative flux	Offshore larvae of susp/dep feeding benthos gross production	mMN
103	benthslargrossprod_i	Cumulative flux	Inshore larvae of susp/dep feeding benthos gross production	mMN
104	benthclargrossprod_o	Cumulative flux	Offshore larvae of carn/scav feeding benthos gross production	mMN
105	benthclargrossprod_i	Cumulative flux	Inshore larvae of carn/scav feeding benthos gross production	mMN
106	benthsgrossprod_o	Cumulative flux	Offshore susp/dep feeding benthos gross production	mMN
107	benthsgrossprod_i	Cumulative flux	Inshore susp/dep feeding benthos gross production	mMN
108	benthcgrossprod_o	Cumulative flux	Offshore fsuspdep feeding benthos gross production	mMN

109	benthcgrossprod_i	Cumulative flux	Inshore susp/dep feeding benthos gross production	mMN
110	birdgrossprod_o	Cumulative flux	Offshore birds gross production	mMN
111	birdgrossprod_i	Cumulative flux	Inshore birds gross production	mMN
112	sealgrossprod_o	Cumulative flux	Offshore pinnipeds gross production	mMN
113	sealgrossprod_i	Cumulative flux	Inshore pinnipeds gross production	mMN
114	cetagrossprod_o	Cumulative flux	Offshore cetaceans gross production	mMN
115	cetagrossprod_i	Cumulative flux	Inshore cetaceans gross production	mMN
116	wcdenitrif_o	Cumulative flux	Offshore water column denitrification	mMN
117	wcdenitrif_i	Cumulative flux	Inshore water column denitrification	mMN
118	seddenitrif_o	Cumulative flux	Offshore sediment denitrification	mMN
119	seddenitrif_i	Cumulative flux	Inshore sediment denitrification	mMN
120	fluxsedamm_wcamm	Whole domain cumulative flux	Sediment to water column ammonia	mMN
121	fluxwcdet_wcamm	Whole domain cumulative flux	Suspended detritus to water column ammonia	mMN
122	fluxherb_wcamm	Whole domain cumulative flux	Omnivorous zooplankton ammonia excretion	mMN
123	fluxcarn_wcamm	Whole domain cumulative flux	Carnivorous zooplankton ammonia excretion	mMN
124	fluxpfishlar_wcamm	Whole domain cumulative flux	Larvae of planktivorous fish ammonia excretion	mMN
125	fluxdfishlar_wcamm	Whole domain cumulative flux	Larvae of demersal fish ammonia excretion	mMN
126	fluxpfish_wcamm	Whole domain cumulative flux	Planktivorous fish ammonia excretion	mMN
127	fluxmfish_wcamm	Whole domain cumulative flux	Migratory fish ammonia excretion	mMN
128	fluxdfish_wcamm	Whole domain cumulative flux	Demersal fish ammonia excretion	mMN
129	fluxbenthslar_wcamm	Whole domain cumulative flux	Larvae of susp/dep feeding benthos ammonia excretion	mMN
130	fluxbenthclar_wcamm	Whole domain cumulative flux	Larvae of carn/scav feeding benthos ammonia excretion	mMN
131	fluxbenths_wcamm	Whole domain cumulative flux	Susp/dep feeding benthos ammonia excretion	mMN
132	fluxbenthc_wcamm	Whole domain cumulative flux	Carn/scav feeding benthos ammonia excretion	mMN
133	fluxbird_wcamm	Whole domain cumulative flux	Birds ammonia excretion	mMN
134	fluxseal_wcamm	Whole domain cumulative flux	Pinnipeds ammonia excretion	mMN
135	fluxceta_wcamm	Whole domain cumulative flux	Cetaceans ammonia excretion	mMN
136	fluxxdet_sedamm	Whole domain cumulative flux	Sediment labile detritus to porewater ammonia	mMN
137	fluxxRdet_sedamm	Whole domain cumulative flux	Sediment refractory detritus to porewater ammonia	mMN
138	fluxwcamm_wcnit	Whole domain cumulative flux	Water column ammonia to water column nitrate	mMN

139	fluxsednit_wcnit	Whole domain cumulative flux	Sediment porewater nitrate to water column nitrate	mMN
140	fluxsedamm_sednit	Whole domain cumulative flux	Sediment porewater ammonia to porewater nitrate	mMN
141	fluxxdet_wcdet	Whole domain cumulative flux	Sediment labile detritus to water column detritus	mMN
142	fluxkelpdebris_wcdet	Whole domain cumulative flux	Macrophyte debris to water column detritus	mMN
143	fluxcorp_wcdet	Whole domain cumulative flux	Seabed corpses to water column detritus	mMN
144	fluxphyt_wcdet	Whole domain cumulative flux	Phytoplankton to water column detritus	mMN
145	fluxherb_wcdet	Whole domain cumulative flux	Omnivorous zooplankton to water column detritus	mMN
146	fluxcarn_wcdet	Whole domain cumulative flux	Carnivorous zooplankton to water column detritus	mMN
147	fluxpfishlar_wcdet	Whole domain cumulative flux	Larvae of planktivorous fish to water column detritus	mMN
148	fluxdfishlar_wcdet	Whole domain cumulative flux	Larvae of demersal fish to water column detritus	mMN
149	fluxpfish_wcdet	Whole domain cumulative flux	Planktivorous fish to water column detritus	mMN
150	fluxmfish_wcdet	Whole domain cumulative flux	Migratory fish to water column detritus	mMN
151	fluxdfish_wcdet	Whole domain cumulative flux	Demersal fish to water column detritus	mMN
152	fluxbenthslar_wcdet	Whole domain cumulative flux	Larvae of susp/dep feeding benthos to water column detritus	mMN
153	fluxbenthclar_wcdet	Whole domain cumulative flux	Larvae of carn/scav feeding benthos to water column detritus	mMN
154	fluxbenths_wcdet	Whole domain cumulative flux	Susp/dep feeding benthos to water column detritus	mMN
155	fluxbenthc_wcdet	Whole domain cumulative flux	Carn/scav feeding benthos to water column detritus	mMN
156	fluxbird_wcdet	Whole domain cumulative flux	Birds to water column detritus	mMN
157	fluxseal_wcdet	Whole domain cumulative flux	Pinnipeds to water column detritus	mMN
158	fluxceta_wcdet	Whole domain cumulative flux	Cetaceans to water column detritus	mMN
159	fluxwcdet_xdet	Whole domain cumulative flux	Water column detritus to sediment labile detritus	mMN
160	fluxcorp_xdet	Whole domain cumulative flux	Corpses to sediment labile detritus	mMN
161	fluxbenths_xdet	Whole domain cumulative flux	Sups/dep feeding benthos to sediment labile detritus	mMN
162	fluxbenthc_xdet	Whole domain cumulative flux	Carn/scav feeding benthos to sediment labile detritus	mMN
163	fluxxdet_xRdet	Whole domain cumulative flux	Sediment labile detritus to refractory detritus	mMN
164	fluxkelpdebris_xRdet	Whole domain cumulative flux	Macrophyte debris to refractory detritus	mMN
165	fluxcorp_xRdet	Whole domain cumulative flux	Corpses to refractory detritus	mMN
166	fluxkelp_kelpdebris	Whole domain cumulative flux	Macrophytes to macrophyte debris	mMN
167	fluxdisc_corp	Whole domain cumulative flux	Fishery discarded material to seabed corpse	mMN
168	fluxpfish_corp	Whole domain cumulative flux	Planktivorous fish to seabed corpse	mMN

169	fluxmfish_corp	Whole domain cumulative flux	Migratory fish to seabed corpse	mMN
170	fluxdfish_corp	Whole domain cumulative flux	Demersal fish to seabed corpse	mMN
171	fluxbenths_corp	Whole domain cumulative flux	Susp/dep feeding benthos to seabed corpse	mMN
172	fluxbenthc_corp	Whole domain cumulative flux	Carn/scav feeding benthos to seabed corpse	mMN
173	fluxbird_corp	Whole domain cumulative flux	Birds to seabed corpse	mMN
174	fluxseal_corp	Whole domain cumulative flux	Pinnipeds to seabed corpse	mMN
175	fluxceta_corp	Whole domain cumulative flux	Cetaceans to seabed corpses	mMN
176	fluxwcamm_kelp	Whole domain cumulative flux	Uptake of water column ammonia by macrophytes	mMN
177	fluxwcnit_kelp	Whole domain cumulative flux	Uptake of water column nitrate by macrophytes	mMN
178	fluxwcamm_phyt_o	Cumulative flux	Offshore uptake of water column ammonia by phytoplankton	mMN
179	fluxwcamm_phyt_i	Cumulative flux	Inshore uptake of water column ammonia by phytoplankton	mMN
180	fluxwcnit_phyt_o	Cumulative flux	Offshore uptake of water column nitrate by phytoplankton	mMN
181	fluxwcnit_phyt_i	Cumulative flux	Inshore uptake of water column nitrate by phytoplankton	mMN
182	fluxwcdet_herb	Whole domain cumulative flux	Consumption of suspended detritus by omnivorous zooplankton	mMN
183	fluxphyt_herb	Whole domain cumulative flux	Consumption of phytoplankton by omnivorous zooplankton	mMN
184	fluxbenthslar_herb	Whole domain cumulative flux	Consumption of larvae of susp/dep benthos by omnivorous zooplankton	mMN
185	fluxbenthclar_herb	Whole domain cumulative flux	Consumption of larvae of carn/scav benthos by omnivorous zooplankton	mMN
186	fluxherb_carn	Whole domain cumulative flux	Consumption of omnivorous zooplankton by carnivorous zooplankton	mMN
187	fluxpfishlar_carn	Whole domain cumulative flux	Consumption of larvae of planktivorous fish by carnivorous zooplankton	mMN
188	fluxdfishlar_carn	Whole domain cumulative flux	Consumption of larvae of demersal fish by carnivorous zooplankton	mMN
189	fluxbenthslar_carn	Whole domain cumulative flux	Consumption of larvae of susp/dep benthos by carnivorous zooplankton	mMN
190	fluxbenthclar_carn	Whole domain cumulative flux	Consumption of larvae of carn/scav benthos by carnivorous zooplankton	mMN
191	fluxherb_pfishlar	Whole domain cumulative flux	Consumption of omnivorous zooplankton by larvae of planktivorous fish	mMN
192	fluxbenthslar_pfishlar	Whole domain cumulative flux	Consumption of larvae of susp/dep feeding benthos by larvae of planktivorous fish	mMN
193	fluxbenthclar_pfishlar	Whole domain cumulative flux	Consumption of larvae of carn/scav feeding benthos by larvae of planktivorous fish	mMN
194	fluxherb_dfishlar	Whole domain cumulative flux	Consumption of omnivorous zooplankton by larvae of demersal fish	mMN
195	fluxbenthslar_dfishlar	Whole domain cumulative flux	Consumption of larvae of susp/dep feeding benthos by larvae of demersal fish	mMN
196	fluxbenthclar_dfishlar	Whole domain cumulative flux	Consumption of larvae of carn/scav feeding benthos by larvae of demersal fish	mMN
197	fluxherb_pfish	Whole domain cumulative flux	Consumption of omnivorous zooplankton by planktivorous fish	mMN
198	fluxcarn_pfish	Whole domain cumulative flux	Consumption of carnivorous zooplankton by planktivorous fish	mMN

199	fluxpfishlar_pfish	Whole domain cumulative flux	Consumption of larvae of planktivorous fish by planktivorous fish	mMN
200	fluxdfishlar_pfish	Whole domain cumulative flux	Consumption of larvae of demersal fish by planktivorous fish	mMN
201	fluxbenthslar_pfish	Whole domain cumulative flux	Consumption of larvae of susp/dep feeding benthos by planktivorous fish	mMN
202	fluxbenthclar_pfish	Whole domain cumulative flux	Consumption of larvae of carn/scav feeding benthos by planktivorous fish	mMN
203	fluxherb_mfish	Whole domain cumulative flux	Consumption of omnivorous zooplankton by migratory fish	mMN
204	fluxcarn_mfish	Whole domain cumulative flux	Consumption of carnivorous zooplankton by migratory fish	mMN
205	fluxpfishlar_mfish	Whole domain cumulative flux	Consumption of larvae of planktivorous fish by migratory fish	mMN
206	fluxdfishlar_mfish	Whole domain cumulative flux	Consumption of larvae of demersal fish by migratory fish	mMN
207	fluxbenthslar_mfish	Whole domain cumulative flux	Consumption of larvae of susp/dep feeding benthos by migratory fish	mMN
208	fluxbenthclar_mfish	Whole domain cumulative flux	Consumption of larvae of carn/scav feeding benthos by migratory fish	mMN
209	fluxcorp_dfish	Whole domain cumulative flux	Consumption of seabed corpses by demersal fish	mMN
210	fluxdisc_dfish	Whole domain cumulative flux	Consumption of fishery discards by demersal fish	mMN
211	fluxcarn_dfish	Whole domain cumulative flux	Consumption of carnivorous zooplankton by demersal fish	mMN
212	fluxpfishlar_dfish	Whole domain cumulative flux	Consumption of larvae of planktivorous fish by demersal fish	mMN
213	fluxdfishlar_dfish	Whole domain cumulative flux	Consumption of larvae of demersal fish by demersal fish	mMN
214	fluxpfish_dfish	Whole domain cumulative flux	Consumption of planktivorous fish by demersal fish	mMN
215	fluxmfish_dfish	Whole domain cumulative flux	Consumption of migratory fish by demersal fish	mMN
216	fluxdfish_dfish	Whole domain cumulative flux	Consumption of demersal fish by demersal fish	mMN
217	fluxbenths_dfish	Whole domain cumulative flux	Consumption of susp/dep feeding benthos by demersal fish	mMN
218	fluxbenthc_dfish	Whole domain cumulative flux	Consumption of carn/scav feeding benthos by demersal fish	mMN
219	fluxwcdet_benthslar	Whole domain cumulative flux	Consumption of water column detritus by larvae of susp/dep feeding benthos	mMN
220	fluxphyt_benthslar	Whole domain cumulative flux	Consumption of phytoplankton by larvae of susp/dep feeding benthos	mMN
221	fluxwcdet_benthclar	Whole domain cumulative flux	Consumption of water column detritus by larvae of carn/scav feeding benthos	mMN
222	fluxphyt_benthclar	Whole domain cumulative flux	Consumption of phytoplankton by larvae of carn/scav feeding benthos	mMN
223	fluxwcdet_benths	Whole domain cumulative flux	Consumption of water column detritus by susp/dep feeding benthos	mMN
224	fluxxdet_benths	Whole domain cumulative flux	Consumption of sediment labile detritus by susp/dep feeding benthos	mMN
225	fluxxRdet_benths	Whole domain cumulative flux	Consumption of sediment refractory detritus by susp/dep feeding benthos	mMN
226	fluxphyt_benths	Whole domain cumulative flux	Consumption of phytoplankton by susp/dep feeding benthos	mMN
227	fluxkelp_benthc	Whole domain cumulative flux	Consumption of macrophytes by carn/scav feeding benthos	mMN
228	fluxkelpdebris_benthc	Whole domain cumulative flux	Consumption of macrophyte debris by carn/scav feeding benthos	mMN

229	fluxcorp_benthc	Whole domain cumulative flux	Consumption of seabed corpses by carn/scav feeding benthos	mMN
230	fluxbenths_benthc	Whole domain cumulative flux	Consumption of susp/dep feeding benthos by carn/scav feeding benthos	mMN
231	fluxcorp_bird	Whole domain cumulative flux	Consumption of seabed corpses by birds	mMN
232	fluxdisc_bird	Whole domain cumulative flux	Consumption of fishery discards by birds	mMN
233	fluxcarn_bird	Whole domain cumulative flux	Consumption of carnivorous zooplankton by birds	mMN
234	fluxpfish_bird	Whole domain cumulative flux	Consumption of planktivorous fish by birds	mMN
235	fluxmfish_bird	Whole domain cumulative flux	Consumption of migratory fish by birds	mMN
236	fluxdfish_bird	Whole domain cumulative flux	Consumption of demersal fish by birds	mMN
237	fluxbenths_bird	Whole domain cumulative flux	Consumption of susp/dep feeding benthos by birds	mMN
238	fluxbenthc_bird	Whole domain cumulative flux	Consumption of carn/scav feeding benthos by birds	mMN
239	fluxcorp_seal	Whole domain cumulative flux	Consumption of seabed corpses by pinnipeds	mMN
240	fluxdisc_seal	Whole domain cumulative flux	Consumption of fishery discards by pinnipeds	mMN
241	fluxcarn_seal	Whole domain cumulative flux	Consumption of carnivorous zooplankton by pinnipeds	mMN
242	fluxpfish_seal	Whole domain cumulative flux	Consumption of planktivorous fish by pinnipeds	mMN
243	fluxmfish_seal	Whole domain cumulative flux	Consumption of migratory fish by pinnipeds	mMN
244	fluxdfish_seal	Whole domain cumulative flux	Consumption of demersal fish by pinnipeds	mMN
245	fluxbenths_seal	Whole domain cumulative flux	Consumption of susp/dep feeding benthos by pinnipeds	mMN
246	fluxbenthc_seal	Whole domain cumulative flux	Consumption of carn/scav feeding benthos by pinnipeds	mMN
247	fluxbird_seal	Whole domain cumulative flux	Consumption of birds by pinnipeds	mMN
248	fluxdisc_ceta	Whole domain cumulative flux	Consumption of fishery discards by cetaceans	mMN
249	fluxherb_ceta	Whole domain cumulative flux	Consumption of omnnivorous zooplankton by cetaceans	mMN
250	fluxcarn_ceta	Whole domain cumulative flux	Consumption of carnnivorous zooplankton by cetaceans	mMN
251	fluxpfish_ceta	Whole domain cumulative flux	Consumption of planktivorous fish by cetaceans	mMN
252	fluxmfish_ceta	Whole domain cumulative flux	Consumption of migratory fish by cetaceans	mMN
253	fluxdfish_ceta	Whole domain cumulative flux	Consumption of demersal fish by cetaceans	mMN
254	fluxbenths_ceta	Whole domain cumulative flux	Consumption of susp/dep feeding benthos by cetaceans	mMN
255	fluxbenthc_ceta	Whole domain cumulative flux	Consumption of carn/scav feeding benthos by cetaceans	mMN
256	fluxbird_ceta	Whole domain cumulative flux	Consumption of birds by cetaceans	mMN
257	fluxseal_ceta	Whole domain cumulative flux	Consumption of pinnipeds by cetaceans	mMN
258	Bs_spawn	Whole domain cumulative flux	Egg production by susp/dep feeding benthos	mMN

259	Bs_recruit	Whole domain cumulative flux	Recruitment of susp/dep feeding benthos	mMN
260	Bc_spawn	Whole domain cumulative flux	Egg production by carn/scav feeding benthos	mMN
261	Bc_recruit	Whole domain cumulative flux	Recruitment of carn/scav feeding benthos	mMN
262	Pfish_spawn	Whole domain cumulative flux	Egg production by planktivorous fish	mMN
263	Pfish_recruit	Whole domain cumulative flux	Recruitment of planktivorous fish	mMN
264	Dfish_spawn	Whole domain cumulative flux	Egg production by demersal fish	mMN
265	Dfish_recruit	Whole domain cumulative flux	Recruitment of demersal fish	mMN
266	fluxwcnit_Ngas	Whole domain cumulative flux	Water column nitrate to nitrogen gas	mMN
267	fluxsednit_Ngas	Whole domain cumulative flux	Sediment porewater nitrate to nitrogen gas	mMN
268	fluxkelpdebris_beachexport	Whole domain cumulative flux	Beach-cast of macrophyte debris	mMN
269	fluxAMMoutflow_o	Cumulative flux	Offshore boundary export of water column ammonia	mMN
270	fluxNITоutflow_o	Cumulative flux	Offshore boundary export of water column nitrate	mMN
271	fluxAMMoutflow_i	Cumulative flux	Inshore boundary export of water column ammonia	mMN
272	fluxNITоutflow_i	Cumulative flux	Inshore boundary export of water column nitrate	mMN
273	fluxPHYToutflow_o	Cumulative flux	Offshore boundary export of phytoplankton	mMN
274	fluxDEToutflow_o	Cumulative flux	Offshore boundary export of water column detritus	mMN
275	fluxPHYToutflow_i	Cumulative flux	Inshore boundary export of phytoplankton	mMN
276	fluxDEToutflow_i	Cumulative flux	Inshore boundary export of water column detritus	mMN
277	mfish_emigration	Cumulative flux	Offshore migratory fish emigration from the domain	mMN
278	fluxsedboundary_o	Cumulative flux	Offshore net burial in seabed sediments	mMN
279	fluxsedboundary_i	Cumulative flux	Inshore net burial in seabed sediments	mMN
280	fluxAMMinflow_o	Cumulative flux	Offshore boundary import of water column ammonia	mMN
281	fluxNITinflow_o	Cumulative flux	Offshore boundary import of water column nitrate	mMN
282	fluxAMMinflow_i	Cumulative flux	Inshore boundary import of water column ammonia	mMN
283	fluxNITinflow_i	Cumulative flux	Inshore boundary import of water column nitrate	mMN
284	fluxPHYTinflow_o	Cumulative flux	Offshore boundary import of phytoplankton	mMN
285	fluxDETinflow_o	Cumulative flux	Offshore boundary import of water column detritus	mMN
286	fluxPHYTinflow_i	Cumulative flux	Inshore boundary import of phytoplankton	mMN
287	fluxDETinflow_i	Cumulative flux	Inshore boundary import of water column detritus	mMN
288	mfish_imigration	Cumulative flux	Offshore migratory fish immigration to the domain	mMN

289	atmosAMMinput_o	Cumulative flux	Offshore atmospheric deposition of ammonia	mMN
290	atmosNITinput_o	Cumulative flux	Offshore atmospheric deposition of nitrate	mMN
291	atmosAMMinput_i	Cumulative flux	Inshore atmospheric deposition of ammonia	mMN
292	atmosNITinput_i	Cumulative flux	Inshore atmospheric deposition of nitrate	mMN
293	rivAMMinflow	Cumulative flux	Inshore river inflow of ammonia	mMN
294	rivNITinflow	Cumulative flux	Inshore river inflow of nitrate	mMN
295	rivPARTinflow	Cumulative flux	Inshore river inflow of detritus	mMN
296	DINflux_i_o	Cumulative flux	Inshore to offshore flux of total dissolved inorganic nitrogen	mMN
297	DINflux_o_i	Cumulative flux	Offshore to inshore flux of total dissolved inorganic nitrogen	mMN
298	PARTflux_i_o	Cumulative flux	Inshore to offshore passive flux of total particulate nitrogen	mMN
299	PARTflux_o_i	Cumulative flux	Offshore to inshore passive flux of total particulate nitrogen	mMN
300	activemigpelfish_i_o	Cumulative flux	Inshore to offshore active migration of planktivoroius fish	mMN
301	activemigmigfish_i_o	Cumulative flux	Inshore to offshore active migration of migratory fish	mMN
302	activemigdemfish_i_o	Cumulative flux	Inshore to offshore active migration of demersal fish	mMN
303	activemigbird_i_o	Cumulative flux	Inshore to offshore active migration of birds	mMN
304	activemigseal_i_o	Cumulative flux	Inshore to offshore active migration of pinnipeds	mMN
305	activemigceta_i_o	Cumulative flux	Inshore to offshore active migration of cetaceans	mMN
306	activemigpelfish_o_i	Cumulative flux	Offshore to inshore active migration of planktivoroius fish	mMN
307	activemigmigfish_o_i	Cumulative flux	Offshore to inshore active migration of migratory fish	mMN
308	activemigdemfish_o_i	Cumulative flux	Offshore to inshore active migration of demersal fish	mMN
309	activemigbird_o_i	Cumulative flux	Offshore to inshore active migration of birds	mMN
310	activemigseal_o_i	Cumulative flux	Offshore to inshore active migration of pinnipeds	mMN
311	activemigceta_o_i	Cumulative flux	Offshore to inshore active migration of cetaceans	mMN
312	vertnitflux	Whole domain cumulative flux	Vertical mixing and advection of nitrate	mMN
313	horiznitflux	Whole domain cumulative flux	Upper layers horizontal mixing and advection of nitrate	mMN
314	landp_o	Cumulative flux	Offshore landings of planktivorous fish (live weight)	mMN
315	landd_quota_o	Cumulative flux	Offshore landings of quota-limited demersal fish (live weight)	mMN
316	landd_nonquota_o	Cumulative flux	Offshore landings of non-quota demersal fish (live weight)	mMN
317	landm_o	Cumulative flux	Offshore landings of migratory fish (live weight)	mMN
318	landsb_o	Cumulative flux	Offshore landings of susp/dep feeding benthos (live weight)	mMN

319	landcb_o	Cumulative flux	Offshore landings of carn/scav feeding benthos (live weight)	mMN
320	landcz_o	Cumulative flux	Offshore landings of carnivorous zooplankton (live weight)	mMN
321	landbd_o	Cumulative flux	Offshore landings of birds (live weight)	mMN
322	landsl_o	Cumulative flux	Offshore landings of pinnipeds (live weight)	mMN
323	landct_o	Cumulative flux	Offshore landings of cetaceans (live weight)	mMN
324	discpel_o	Cumulative flux	Offshore discards of planktivorous fish (live weight)	mMN
325	discdem_quota_o	Cumulative flux	Offshore discards of quota-limited demersal fish (live weight)	mMN
326	discdem_nonquota_o	Cumulative flux	Offshore discards of non-quota demersal fish (live weight)	mMN
327	discmig_o	Cumulative flux	Offshore discards of migratory fish (live weight)	mMN
328	discsb_o	Cumulative flux	Offshore discards of susp/dep feeding benthos (live weight)	mMN
329	disccb_o	Cumulative flux	Offshore discards of carn/scav feeding benthos (live weight)	mMN
330	disccz_o	Cumulative flux	Offshore discards of carnivorous zooplankton (live weight)	mMN
331	discbd_o	Cumulative flux	Offshore discards of birds (live weight)	mMN
332	discsl_o	Cumulative flux	Offshore discards of pinnipeds (live weight)	mMN
333	discct_o	Cumulative flux	Offshore discards of cetaceans (live weight)	mMN
334	landp_i	Cumulative flux	Inshore landings of planktivorous fish (live weight)	mMN
335	landd_quota_i	Cumulative flux	Inshore landings of quota-limited demersal fish (live weight)	mMN
336	landd_nonquota_i	Cumulative flux	Inshore landings of non-quota demersal fish (live weight)	mMN
337	landm_i	Cumulative flux	Inshore landings of migratory fish (live weight)	mMN
338	landsb_i	Cumulative flux	Inshore landings of susp/dep feeding benthos (live weight)	mMN
339	landcb_i	Cumulative flux	Inshore landings of carn/scav feeding benthos (live weight)	mMN
340	landcz_i	Cumulative flux	Inshore landings of carnivorous zooplankton (live weight)	mMN
341	landbd_i	Cumulative flux	Inshore landings of birds (live weight)	mMN
342	landsl_i	Cumulative flux	Inshore landings of pinnipeds (live weight)	mMN
343	landct_i	Cumulative flux	Inshore landings of cetaceans (live weight)	mMN
344	landkp_i	Cumulative flux	Inshore landings of macrophytes (live weight)	mMN
345	discpel_i	Cumulative flux	Inshore discards of planktivorous fish (live weight)	mMN
346	discdem_quota_i	Cumulative flux	Inshore discards of quota-limited demersal fish (live weight)	mMN
347	discdem_nonquota_i	Cumulative flux	Inshore discards of non-quota demersal fish (live weight)	mMN
348	discmig_i	Cumulative flux	Inshore discards of migratory fish (live weight)	mMN

349	discsb_i	Cumulative flux	Inshore discards of susp/dep feeding benthos (live weight)	mMN
350	disccb_i	Cumulative flux	Inshore discards of carn/scav feeding benthos (live weight)	mMN
351	disccz_i	Cumulative flux	Inshore discards of carnivorous zooplankton (live weight)	mMN
352	discbd_i	Cumulative flux	Inshore discards of birds (live weight)	mMN
353	discsl_i	Cumulative flux	Inshore discards of pinnipeds (live weight)	mMN
354	discct_i	Cumulative flux	Inshore discards of cetaceans (live weight)	mMN
355	disckp_i	Cumulative flux	Inshore discards of macrophytes (live weight)	mMN
356	offalpel_o	Cumulative flux	Offshore offal from processing of planktivorous fish catch	mMN
357	offaldem_quota_o	Cumulative flux	Offshore offal from processing of quota-limited demersal fish catch	mMN
358	offaldem_nonquota_o	Cumulative flux	Offshore offal from processing of non-quota demersal fish catch	mMN
359	offalmig_o	Cumulative flux	Offshore offal from processing of migratory fish catch	mMN
360	offalsb_o	Cumulative flux	Offshore offal from processing of fsusp/dep feeding benthos catch	mMN
361	offalcb_o	Cumulative flux	Offshore offal from processing of carn/scav feeding benthos catch	mMN
362	offalcz_o	Cumulative flux	Offshore offal from processing of carnivorous zooplankton catch	mMN
363	offalbd_o	Cumulative flux	Offshore offal from processing of bird catch	mMN
364	offalsl_o	Cumulative flux	Offshore offal from processing of pinniped catch	mMN
365	offalct_o	Cumulative flux	Offshore offal from processing of cetacean catch	mMN
366	offalpel_i	Cumulative flux	Inshore offal from processing of planktivorous fish catch	mMN
367	offaldem_quota_i	Cumulative flux	Inshore offal from processing of quota-limited demersal fish catch	mMN
368	offaldem_nonquota_i	Cumulative flux	Inshore offal from processing of non-quota demersal fish catch	mMN
369	offalmig_i	Cumulative flux	Inshore offal from processing of migratory fish catch	mMN
370	offalsb_i	Cumulative flux	Inshore offal from processing of susp/dep feeding benthos catch	mMN
371	offalcb_i	Cumulative flux	Inshore offal from processing of carn/scav feeding benthos catch	mMN
372	offalcz_i	Cumulative flux	Inshore offal from processing of carnivorous zooplankton catch	mMN
373	offalbd_i	Cumulative flux	Inshore offal from processing of bird catch	mMN
374	offalsl_i	Cumulative flux	Inshore offal from processing of pinniped catch	mMN
375	offalct_i	Cumulative flux	Inshore offal from processing of cetacean catch	mMN
376	offalkp_i	Cumulative flux	Inshore offal from processing of macrophyte catch	mMN
377	herbnetprod_o	Cumulative flux	Offshore omnivorous zooplanton net production	mMN
378	herbnetprod_i	Cumulative flux	Inshore omnivorous zooplanton net production	mMN

379	carnnetprod_o	Cumulative flux	Offshore carnivorous zooplanton net production	mMN
380	carnnetprod_i	Cumulative flux	Inshore carnivorous zooplanton net production	mMN
381	pfishlarnetprod_o	Cumulative flux	Offshore larvae of planktivorous fish net production	mMN
382	pfishlarnetprod_i	Cumulative flux	Inshore larvae of planktivorous fish net production	mMN
383	dfishlarnetprod_o	Cumulative flux	Offshore larvae of demersal fish net production	mMN
384	dfishlarnetprod_i	Cumulative flux	Inshore larvae of demersal fish net production	mMN
385	pfishnetprod_o	Cumulative flux	Offshore planktivorous fish net production	mMN
386	pfishnetprod_i	Cumulative flux	Inshore planktivorous fish net production	mMN
387	mfishnetprod_o	Cumulative flux	Offshore migratory fish net production	mMN
388	mfishnetprod_i	Cumulative flux	Inshore migratory fish net production	mMN
389	dfishnetprod_o	Cumulative flux	Offshore demersal fish net production	mMN
390	dfishnetprod_i	Cumulative flux	Inshore demersal fish net production	mMN
391	benthslarnetprod_o	Cumulative flux	Offshore larvae of susp/dep feeding benthos net production	mMN
392	benthslarnetprod_i	Cumulative flux	Inshore larvae of susp/dep feeding benthos net production	mMN
393	benthclarnetprod_o	Cumulative flux	Offshore larvae of carn/scav feeding benthos net production	mMN
394	benthclarnetprod_i	Cumulative flux	Inshore larvae of carn/scav feeding benthos net production	mMN
395	benthsnetprod_o	Cumulative flux	Offshore susp/dep feeding benthos net production	mMN
396	benthsnetprod_i	Cumulative flux	Inshore susp/dep feeding benthos net production	mMN
397	benthcnetprod_o	Cumulative flux	Offshore carn/scav feeding benthos net production	mMN
398	benthcnetprod_i	Cumulative flux	Inshore carn/scav feeding benthos net production	mMN
399	birdnetprod_o	Cumulative flux	Offshore birds net production	mMN
400	birdnetprod_i	Cumulative flux	Inshore birds net production	mMN
401	sealnetprod_o	Cumulative flux	Offshore pinnipeds net production	mMN
402	sealnetprod_i	Cumulative flux	Inshore pinnipeds net production	mMN
403	cetanetprod_o	Cumulative flux	Offshore cetaceans net production	mMN
404	cetanetprod_i	Cumulative flux	Inshore cetaceans net production	mMN

Table 40. Details of the data columns in the list object "$aggregates" generated by the model. The list comprises 124 numeric vectors representing the sequential outputs at daily intervals. Hence the length of these vectors is exactly the same number of rows in the dataframe "$outputs". Objects 1:34 in the list are the masses of nitrogen or carbon associated with the state variables in the model aggregated to the whole model domain; objects 35 to 124 are cumulative fluxes accumulated over time between the given compartments aggregated to the whole model domain. The rate of flow over any given interval is given by the difference in cumulative flux between appropriate rows in the dataframe. The final 6 objects in the list are single numeric values (vectors length 1) of the volumetric data for the layers and zones aggregared over the whole model domain. The notional sea surface area of the whole model domain is $1m^2$; the configuration parameters defining vertical layer thicknesses and horizontal area-proportions in the inshore and offshore zone and in the seabed habitats are given in the "$build$model.parameters" object (see Table 38). The aggregates of these parameters are required to convert aggregated state variable mass and fluxes output from the model into area densities (m^{-2}) and concentrations (m^{-3}).

Column number	Column name	Data type	Description	Units
1	totalN	Derived mass	Whole domain mass of all forms of organic and inorganic nitrogen	mMN
2	totalN_o	Derived mass	Offshore mass of all forms of organic and inorganic nitrogen	mMN
3	totalN_i	Derived mass	Inshore mass of all forms of organic and inorganic nitrogen	mMN
4	x_detritus	Derived mass	Whole domain sediment labile and refratory detritus	mMN
5	x_detritus_o	Derived mass	Offshore sediment labile and refractory detritus	mMN
6	x_detritus_i	Derived mass	Inshore sediment labile and refractory detritus	mMN
7	corpse	Derived mass	Whole domain seabed corpses	mMN
8	corpse_o	Derived mass	Offshore seabed corpses	mMN
9	corpse_i	Derived mass	Inshore seabed corpses	mMN
10	x_ammonia	Derived mass	Whole domain sediment porweater ammonia	mMN
11	x_ammonia_o	Derived mass	Offshore sediment porweater ammonia	mMN
12	x_ammonia_i	Derived mass	Inshore sediment porweater ammonia	mMN
13	x_nitrate	Derived mass	Whole domain sediment porweater nitrate	mMN
14	x_nitrate_o	Derived mass	Offshore sediment porweater nitrate	mMN
15	x_nitrate_i	Derived mass	Inshore sediment porweater nitrate	mMN
16	s_detritus	Derived mass	Whole domain upper layers water column detritus	mMN
17	s_ammonia	Derived mass	Whole domain upper layers water column ammonia	mMN
18	s_nitrate	Derived mass	Whole domain upper layers water column nitrate	mMN
19	s_phyt	Derived mass	Whole domain upper layers phytoplankton	mMN

20	benthslar	Derived mass	Whole domain larvae of susp/dep feeding benthos	mMN
21	benthclar	Derived mass	Whole domain larvae of carn/scav feeding benthos	mMN
22	benths	Derived mass	Whole domain susp/dep feeding benthos	mMN
23	benthc	Derived mass	Whole domain carn/scav feeding benthos	mMN
24	discard	Derived mass	Whole domain discarded material from fisheries	mMN
25	herb	Derived mass	Whole domain omnivorous zooplankton	mMN
26	carn	Derived mass	Whole domain carnivorous zooplankton	mMN
27	fishp	Derived mass	Whole domain planktivorous fish	mMN
28	fishd	Derived mass	Whole domain demersal fish	mMN
29	fishm	Derived mass	Whole domain migratory fish	mMN
30	bird	Derived mass	Whole domain birds	mMN
31	seal	Derived mass	Whole domain pinnipeds	mMN
32	ceta	Derived mass	Whole domain cetaceans	mMN
33	fishplar	Derived mass	Whole domain larvae of planktivorous fish	mMN
34	fishdlar	Derived mass	Whole domain larvae of demersal fish	mMN
35	PNP	Derived cumulative flux	Whole domain nitrate draw-down (PNP)	mMN
36	netpprod	Derived cumulative flux	Whole domain phytoplankton net production	mMN
37	fluxwcamm_phyt	Derived cumulative flux	Whole domain uptake of ammonia by phytoplankton	mMN
38	fluxwcnit_phyt	Derived cumulative flux	Whole domain uptake of nitrate by phytoplankton	mMN
39	phytgrossprod	Derived cumulative flux	Whole domain phytoplankton gross production	mMN
40	herbgrossprod	Derived cumulative flux	Whole domain omnivorous zooplankton gross production	mMN
41	carngrossprod	Derived cumulative flux	Whole domain carnivorous zooplankton gross production	mMN
42	pfishlargrossprod	Derived cumulative flux	Whole domain larvae of planktivorous fish gross production	mMN
43	dfishlargrossprod	Derived cumulative flux	Whole domain larvae of demersal fish gross production	mMN
44	pfishgrossprod	Derived cumulative flux	Whole domain planktivorous fish gross production	mMN
45	mfishgrossprod	Derived cumulative flux	Whole domain migratory fish gross production	mMN
46	dfishgrossprod	Derived cumulative flux	Whole domain demersal fish gross production	mMN
47	benthslargrossprod	Derived cumulative flux	Whole domain larvae of susp/dep feeding benthos gross production	mMN
48	benthclargrossprod	Derived cumulative flux	Whole domain larvae of carn/scav feeding benthos gross production	mMN
49	benthsgrossprod	Derived cumulative flux	Whole domain susp/dep feeding benthos gross production	mMN

50	benthcgrossprod	Derived cumulative flux	Whole domain carn/scav feeding benthos gross production	mMN
51	birdgrossprod	Derived cumulative flux	Whole domain birds gross production	mMN
52	sealgrossprod	Derived cumulative flux	Whole domain pinnipeds gross production	mMN
53	cetagrossprod	Derived cumulative flux	Whole domain cetaceans gross production	mMN
54	herbnetprod	Derived cumulative flux	Whole domain omnivorous zooplankton net production	mMN
55	carnnetprod	Derived cumulative flux	Whole domain carnivorous zooplankton net production	mMN
56	pfishlarnetprod	Derived cumulative flux	Whole domain larvae of planktivorous fish net production	mMN
57	dfishlarnetprod	Derived cumulative flux	Whole domain larvae of demersal fish net production	mMN
58	pfishnetprod	Derived cumulative flux	Whole domain planktivorous fish net production	mMN
59	mfishnetprod	Derived cumulative flux	Whole domain migratory fish net production	mMN
60	dfishnetprod	Derived cumulative flux	Whole domain demersal fish net production	mMN
61	benthslarnetprod	Derived cumulative flux	Whole domain larvae of susp/dep feeding benthos net production	mMN
62	benthclarnetprod	Derived cumulative flux	Whole domain larvae of carn/scav feeding benthos net production	mMN
63	benthsnetprod	Derived cumulative flux	Whole domain susp/dep feeding benthos net production	mMN
64	benthcnetprod	Derived cumulative flux	Whole domain carn/scav feeding benthos net production	mMN
65	birdnetprod	Derived cumulative flux	Whole domain birds net production	mMN
66	sealnetprod	Derived cumulative flux	Whole domain pinnipeds net production	mMN
67	cetanetprod	Derived cumulative flux	Whole domain cetaceans net production	mMN
68	wcdenitrif	Derived cumulative flux	Whole domain water column denitrification	mMN
69	seddenitrif	Derived cumulative flux	Whole domain sediment denitrification	mMN
70	fluxsedboundary	Derived cumulative flux	Whole domain net burial in seabed sediments	mMN
71	DIN_NET_flux_o_i	Derived cumulative flux	Offshore to inshore net flux of dissolved inorganic nitrogen	mMN
72	PART_NET_flux_o_i	Derived cumulative flux	Offshore to inshore net passive flux of particulate nitrogen	mMN
73	NET_activemigpelfish_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of planktivorous fish	mMN
74	NET_activemigmigfish_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of migratory fish	mMN
75	NET_activemigdemfish_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of demersal fish	mMN
76	NET_activemigbird_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of birds	mMN
77	NET_activemigseal_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of pinnipeds	mMN
78	NET_activemigceta_o_i	Derived cumulative flux	Offshore to inshore net active migrationflux of cetaceans	mMN
79	NET_mfish_ext_o	Derived cumulative flux	Offshore boundary net migration flux of migratory fish	mMN

80	fluxDINinflow	Derived cumulative flux	Whole domain import of dissolved inorganic nitrogen	mMN
81	fluxDINoutflow	Derived cumulative flux	Whole domain export of dissolved inorganic nitrogen	mMN
82	fluxPARTinflow	Derived cumulative flux	Whole domain import of particulate organic nitrogen	mMN
83	fluxPARToutflow	Derived cumulative flux	Whole domain export of particulate organic nitrogen	mMN
84	atmosDINinput	Derived cumulative flux	Whole domain atmospheric deposition of dissolved inorganic nitrogen	mMN
85	rivDINinflow	Derived cumulative flux	Whole domain river inflow of dissolved inorganic nitrogen	mMN
86	landp	Derived cumulative flux	Whole domain landings of planktivorous fish (live weight)	mMN
87	landd	Derived cumulative flux	Whole domain landings of all demersal fish (live weight)	mMN
88	landd_o	Derived cumulative flux	Offshore landings of all demersal fish (live weight)	mMN
89	landd_i	Derived cumulative flux	Inshore landings of all demersal fish (live weight)	mMN
90	landd_quota	Derived cumulative flux	Whole domain landings of quota-limited demersal fish (live weight)	mMN
91	landd_nonquota	Derived cumulative flux	Whole domain landings of non-quota demersal fish (live weight)	mMN
92	landm	Derived cumulative flux	Whole domain landings of migratory fish (live weight)	mMN
93	landsb	Derived cumulative flux	Whole domain landings of susp/dep feeding benthos (live weight)	mMN
94	landcb	Derived cumulative flux	Whole domain landings of carn/scav feeding benthos (live weight)	mMN
95	landcz	Derived cumulative flux	Whole domain landings of carnivorous zooplankton (live weight)	mMN
96	landbd	Derived cumulative flux	Whole domain landings of birds (live weight)	mMN
97	landsl	Derived cumulative flux	Whole domain landings of pinnipeds (live weight)	mMN
98	landct	Derived cumulative flux	Whole domain landings of cetaceans (live weight)	mMN
99	discpel	Derived cumulative flux	Whole domain discards of planktivorous fish (live weight)	mMN
100	discdem	Derived cumulative flux	Whole domain discards of all demersal fish (live weight)	mMN
101	discdem_o	Derived cumulative flux	Offshore discards of all demersal fish (live weight)	mMN
102	discdem_i	Derived cumulative flux	Inshore discards of all demersal fish (live weight)	mMN
103	discdem_quota	Derived cumulative flux	Whole domain discards of quota-limited demersal fish (live weight)	mMN
104	discdem_nonquota	Derived cumulative flux	Whole domain discards of non-quota demersal fish (live weight)	mMN
105	discmig	Derived cumulative flux	Whole domain discards of migratory fish (live weight)	mMN
106	discsb	Derived cumulative flux	Whole domain discards of susp/dep feeding benthos (live weight)	mMN
107	disccb	Derived cumulative flux	Whole domain discards of carn/scav feeding benthos (live weight)	mMN
108	disccz	Derived cumulative flux	Whole domain discards of carnivorous zooplankton (live weight)	mMN
109	discbd	Derived cumulative flux	Whole domain discards of birds (live weight)	mMN

110	discsl	Derived cumulative flux	Whole domain discards of pinnipeds (live weight)	mMN
111	discct	Derived cumulative flux	Whole domain discards of cetaceans (live weight)	mMN
112	offalpel	Derived cumulative flux	Whole domain offal from processing of planktivorous fish catch	mMN
113	offaldem	Derived cumulative flux	Whole domain offal from processing of all demersal fish catch	mMN
114	offaldem_o	Derived cumulative flux	Offshore offal from processing of all demersal fish catch	mMN
115	offaldem_i	Derived cumulative flux	Inshore offal from processing of all demersal fish catch	mMN
116	offaldem_quota	Derived cumulative flux	Whole domain offal from processing of quota-limited demersal fish catch	mMN
117	offaldem_nonquota	Derived cumulative flux	Whole domain offal from processing of non-quota demersal fish catch	mMN
118	offalmig	Derived cumulative flux	Whole domain offal from processing of migratory fish catch	mMN
119	offalsb	Derived cumulative flux	Whole domain offal from processing of susp/dep feeding benthos catch	mMN
120	offalcb	Derived cumulative flux	Whole domain offal from processing of carn/scav feeding benthos catch	mMN
121	offalcz	Derived cumulative flux	Whole domain offal from processing of carnivorous zooplankton catch	mMN
122	offalbd	Derived cumulative flux	Whole domain offal from processing of bird catch	mMN
123	offalsl	Derived cumulative flux	Whole domain offal from processing of pinniped catch	mMN
124	offalct	Derived cumulative flux	Whole domain offal from processing of cetacean catch	mMN

Table 41. Details of the data columns in the dataframes "$offshore_annual_group_land_disc" and "$inshore_annual_group_land_disc" which are saved in the object "$total.annual.catch" of the list generated by the model. The data are integrals of the daily landings and discards of each guild over successive years of the model run. Rows in the dataframe represent the sequential data from each year. Units of landings and discards: $mMN.y^{-1}$.

Column number	Column name	Description
1	year	Year-number in the model run
2	PFland	Planktivorous fish landings
3	DFQland	Quota-limited demersal fish landings
4	DFNQland	Non-quota demersal fish landings
5	MFland	Migratory fish landings
6	SBland	Susp/dep feeding benthos landings
7	CBland	Carn/scav feeding benthos landings
8	CZland	Carnivorous zooplankton landings
9	BDland	Birds landings
10	SLland	Pinnipeds landings
11	CTland	Cetaceans landings
12	KPland	Macrophytes landings
13	PFdisc	Planktivorous fish discards
14	DFQdisc	Quota-limited demersal fish discards
15	DFNQdisc	Non-quota demersal fish discards
16	MFdisc	Migratory fish discards
17	SBdisc	Susp/dep feeding benthos discards
18	CBdisc	Carn/scav feeding benthos discards
19	CZdisc	Carnivorous zooplankton discards
20	BDdisc	Birds discards
21	SLdisc	Pinnipeds discards
22	CTdisc	Cetaceans discards
23	KPdisc	Macrophytes discards

Table 42. Details of the data columns in the dataframes "$offshore_annual_group_gear_land_disc" and "$inshore_annual_group_gear_land_disc" which are saved in the object "$total.annual.catch" of the list generated by the model. The data are dis-aggregations of the annual landings and discards of each guild contained in "$total.annuaal.catch" of the list generated by the model into the fractions attributable to each fishing gear. Rows in the dataframe represent the sequential data for each year of the model run. Units of landings and discards: $mMN.y^{-1}$.

Column number	Column name	Description
1	year	Year-number in the model run
2	PF_1_L	Planktivorous fish, gear id 1, landings
3	PF_2_L	Planktivorous fish, gear id 2, landings
4	PF_3_L	Planktivorous fish, gear id 3, landings
5	PF_4_L	Planktivorous fish, gear id 4, landings
6	PF_5_L	Planktivorous fish, gear id 5, landings
7	PF_6_L	Planktivorous fish, gear id 6, landings
8	PF_7_L	Planktivorous fish, gear id 7, landings
9	PF_8_L	Planktivorous fish, gear id 8, landings
10	PF_9_L	Planktivorous fish, gear id 9, landings
11	PF_10_L	Planktivorous fish, gear id 10, landings
12	PF_11_L	Planktivorous fish, gear id 11, landings
13	PF_12_L	Planktivorous fish, gear id 12, landings
14	DFQ_1_L	Quota-limited demersal fish, gear id 1, landings
15	DFQ_2_L	Quota-limited demersal fish, gear id 2, landings
16	DFQ_3_L	Quota-limited demersal fish, gear id 3, landings
17	DFQ_4_L	Quota-limited demersal fish, gear id 4, landings
18	DFQ_5_L	Quota-limited demersal fish, gear id 5, landings
19	DFQ_6_L	Quota-limited demersal fish, gear id 6, landings
20	DFQ_7_L	Quota-limited demersal fish, gear id 7, landings
21	DFQ_8_L	Quota-limited demersal fish, gear id 8, landings
22	DFQ_9_L	Quota-limited demersal fish, gear id 9, landings
23	DFQ_10_L	Quota-limited demersal fish, gear id 10, landings

24	DFQ_11_L	Quota-limited demersal fish, gear id 11, landings
25	DFQ_12_L	Quota-limited demersal fish, gear id 12, landings
26	DFNQ_1_L	Non-quota demersal fish, gear id 1, landings
27	DFNQ_2_L	Non-quota demersal fish, gear id 2, landings
28	DFNQ_3_L	Non-quota demersal fish, gear id 3, landings
29	DFNQ_4_L	Non-quota demersal fish, gear id 4, landings
30	DFNQ_5_L	Non-quota demersal fish, gear id 5, landings
31	DFNQ_6_L	Non-quota demersal fish, gear id 6, landings
32	DFNQ_7_L	Non-quota demersal fish, gear id 7, landings
33	DFNQ_8_L	Non-quota demersal fish, gear id 8, landings
34	DFNQ_9_L	Non-quota demersal fish, gear id 9, landings
35	DFNQ_10_L	Non-quota demersal fish, gear id 10, landings
36	DFNQ_11_L	Non-quota demersal fish, gear id 11, landings
37	DFNQ_12_L	Non-quota demersal fish, gear id 12, landings
38	MF_1_L	Migratory fish, gear id 1, landings
39	MF_2_L	Migratory fish, gear id 2, landings
40	MF_3_L	Migratory fish, gear id 3, landings
41	MF_4_L	Migratory fish, gear id 4, landings
42	MF_5_L	Migratory fish, gear id 5, landings
43	MF_6_L	Migratory fish, gear id 6, landings
44	MF_7_L	Migratory fish, gear id 7, landings
45	MF_8_L	Migratory fish, gear id 8, landings
46	MF_9_L	Migratory fish, gear id 9, landings
47	MF_10_L	Migratory fish, gear id 10, landings
48	MF_11_L	Migratory fish, gear id 11, landings
49	MF_12_L	Migratory fish, gear id 12, landings
50	SB_1_L	Susp/dep feeding benthos, gear id 1, landings
51	SB_2_L	Susp/dep feeding benthos, gear id 2, landings
52	SB_3_L	Susp /dep feeding benthos, gear id 3, landings

53	SB_4_L	Susp /dep feeding benthos, gear id 4, landings
54	SB_5_L	Susp /dep feeding benthos, gear id 5, landings
55	SB_6_L	Susp /dep feeding benthos, gear id 6, landings
56	SB_7_L	Susp /dep feeding benthos, gear id 7, landings
57	SB_8_L	Susp /dep feeding benthos, gear id 8, landings
58	SB_9_L	Susp /dep feeding benthos, gear id 9, landings
59	SB_10_L	Susp /dep feeding benthos, gear id 10, landings
60	SB_11_L	Susp /dep feeding benthos, gear id 11, landings
61	SB_12_L	Susp /dep feeding benthos, gear id 12, landings
62	CB_1_L	Carn/scav feeding benthos, gear id 1, landings
63	CB_2_L	Carn/scav feeding benthos, gear id 2, landings
64	CB_3_L	Carn/scav feeding benthos, gear id 3, landings
65	CB_4_L	Carn/scav feeding benthos, gear id 4, landings
66	CB_5_L	Carn/scav feeding benthos, gear id 5, landings
67	CB_6_L	Carn/scav feeding benthos, gear id 6, landings
68	CB_7_L	Carn/scav feeding benthos, gear id 7, landings
69	CB_8_L	Carn/scav feeding benthos, gear id 8, landings
70	CB_9_L	Carn/scav feeding benthos, gear id 9, landings
71	CB_10_L	Carn/scav feeding benthos, gear id 10, landings
72	CB_11_L	Carn/scav feeding benthos, gear id 11, landings
73	CB_12_L	Carn/scav feeding benthos, gear id 12, landings
74	CZ_1_L	Carnivorous zooplankton, gear id 1, landings
75	CZ_2_L	Carnivorous zooplankton, gear id 2, landings
76	CZ_3_L	Carnivorous zooplankton, gear id 3, landings
77	CZ_4_L	Carnivorous zooplankton, gear id 4, landings
78	CZ_5_L	Carnivorous zooplankton, gear id 5, landings
79	CZ_6_L	Carnivorous zooplankton, gear id 6, landings
80	CZ_7_L	Carnivorous zooplankton, gear id 7, landings
81	CZ_8_L	Carnivorous zooplankton, gear id 8, landings

82	CZ_9_L	Carnivorous zooplankton, gear id 9, landings
83	CZ_10_L	Carnivorous zooplankton, gear id 10, landings
84	CZ_11_L	Carnivorous zooplankton, gear id 11, landings
85	CZ_12_L	Carnivorous zooplankton, gear id 12, landings
86	BD_1_L	Birds, gear id 1, landings
87	BD_2_L	Birds, gear id 2, landings
88	BD_3_L	Birds, gear id 3, landings
89	BD_4_L	Birds, gear id 4, landings
90	BD_5_L	Birds, gear id 5, landings
91	BD_6_L	Birds, gear id 6, landings
92	BD_7_L	Birds, gear id 7, landings
93	BD_8_L	Birds, gear id 8, landings
94	BD_9_L	Birds, gear id 9, landings
95	BD_10_L	Birds, gear id 10, landings
96	BD_11_L	Birds, gear id 11, landings
97	BD_12_L	Birds, gear id 12, landings
98	SL_1_L	Pinnipeds, gear id 1, landings
99	SL_2_L	Pinnipeds, gear id 2, landings
100	SL_3_L	Pinnipeds, gear id 3, landings
101	SL_4_L	Pinnipeds, gear id 4, landings
102	SL_5_L	Pinnipeds, gear id 5, landings
103	SL_6_L	Pinnipeds, gear id 6, landings
104	SL_7_L	Pinnipeds, gear id 7, landings
105	SL_8_L	Pinnipeds, gear id 8, landings
106	SL_9_L	Pinnipeds, gear id 9, landings
107	SL_10_L	Pinnipeds, gear id 10, landings
108	SL_11_L	Pinnipeds, gear id 11, landings
109	SL_12_L	Pinnipeds, gear id 12, landings
110	CT_1_L	Cetaceans, gear id 1, landings

111	CT_2_L	Cetaceans, gear id 2, landings
112	CT_3_L	Cetaceans, gear id 3, landings
113	CT_4_L	Cetaceans, gear id 4, landings
114	CT_5_L	Cetaceans, gear id 5, landings
115	CT_6_L	Cetaceans, gear id 6, landings
116	CT_7_L	Cetaceans, gear id 7, landings
117	CT_8_L	Cetaceans, gear id 8, landings
118	CT_9_L	Cetaceans, gear id 9, landings
119	CT_10_L	Cetaceans, gear id 10, landings
120	CT_11_L	Cetaceans, gear id 11, landings
121	CT_12_L	Cetaceans, gear id 12, landings
122	KP_1_L	Macrophytes, gear id 1, landings
123	KP_2_L	Macrophytes, gear id 2, landings
124	KP_3_L	Macrophytes, gear id 3, landings
125	KP_4_L	Macrophytes, gear id 4, landings
126	KP_5_L	Macrophytes, gear id 5, landings
127	KP_6_L	Macrophytes, gear id 6, landings
128	KP_7_L	Macrophytes, gear id 7, landings
129	KP_8_L	Macrophytes, gear id 8, landings
130	KP_9_L	Macrophytes, gear id 9, landings
131	KP_10_L	Macrophytes, gear id 10, landings
132	KP_11_L	Macrophytes, gear id 11, landings
133	KP_12_L	Macrophytes, gear id 12, landings
134	PF_1_D	Planktivorous fish, gear id 1, discards
135	PF_2_D	Planktivorous fish, gear id 2, discards
136	PF_3_D	Planktivorous fish, gear id 3, discards
137	PF_4_D	Planktivorous fish, gear id 4, discards
138	PF_5_D	Planktivorous fish, gear id 5, discards
139	PF_6_D	Planktivorous fish, gear id 6, discards

140	PF_7_D	Planktivorous fish, gear id 7, discards
141	PF_8_D	Planktivorous fish, gear id 8, discards
142	PF_9_D	Planktivorous fish, gear id 9, discards
143	PF_10_D	Planktivorous fish, gear id 10, discards
144	PF_11_D	Planktivorous fish, gear id 11, discards
145	PF_12_D	Planktivorous fish, gear id 12, discards
146	DFQ_1_D	Quota-limited demersal fish, gear id 1, discards
147	DFQ_2_D	Quota-limited demersal fish, gear id 2, discards
148	DFQ_3_D	Quota-limited demersal fish, gear id 3, discards
149	DFQ_4_D	Quota-limited demersal fish, gear id 4, discards
150	DFQ_5_D	Quota-limited demersal fish, gear id 5, discards
151	DFQ_6_D	Quota-limited demersal fish, gear id 6, discards
152	DFQ_7_D	Quota-limited demersal fish, gear id 7, discards
153	DFQ_8_D	Quota-limited demersal fish, gear id 8, discards
154	DFQ_9_D	Quota-limited demersal fish, gear id 9, discards
155	DFQ_10_D	Quota-limited demersal fish, gear id 10, discards
156	DFQ_11_D	Quota-limited demersal fish, gear id 11, discards
157	DFQ_12_D	Quota-limited demersal fish, gear id 12, discards
158	DFNQ_1_D	Non-quota demersal fish, gear id 1, discards
159	DFNQ_2_D	Non-quota demersal fish, gear id 2, discards
160	DFNQ_3_D	Non-quota demersal fish, gear id 3, discards
161	DFNQ_4_D	Non-quota demersal fish, gear id 4, discards
162	DFNQ_5_D	Non-quota demersal fish, gear id 5, discards
163	DFNQ_6_D	Non-quota demersal fish, gear id 6, discards
164	DFNQ_7_D	Non-quota demersal fish, gear id 7, discards
165	DFNQ_8_D	Non-quota demersal fish, gear id 8, discards
166	DFNQ_9_D	Non-quota demersal fish, gear id 9, discards
167	DFNQ_10_D	Non-quota demersal fish, gear id 10, discards
168	DFNQ_11_D	Non-quota demersal fish, gear id 11, discards

169	DFNQ_12_D	Non-quota demersal fish, gear id 12, discards
170	MF_1_D	Migratory fish, gear id 1, discards
171	MF_2_D	Migratory fish, gear id 2, discards
172	MF_3_D	Migratory fish, gear id 3, discards
173	MF_4_D	Migratory fish, gear id 4, discards
174	MF_5_D	Migratory fish, gear id 5, discards
175	MF_6_D	Migratory fish, gear id 6, discards
176	MF_7_D	Migratory fish, gear id 7, discards
177	MF_8_D	Migratory fish, gear id 8, discards
178	MF_9_D	Migratory fish, gear id 9, discards
179	MF_10_D	Migratory fish, gear id 10, discards
180	MF_11_D	Migratory fish, gear id 11, discards
181	MF_12_D	Migratory fish, gear id 12, discards
182	SB_1_D	Susp/dep feeding benthos, gear id 1, discards
183	SB_2_D	Susp/dep feeding benthos, gear id 2, discards
184	SB_3_D	Susp/dep feeding benthos, gear id 3, discards
185	SB_4_D	Susp/dep feeding benthos, gear id 4, discards
186	SB_5_D	Susp/dep feeding benthos, gear id 5, discards
187	SB_6_D	Susp/dep feeding benthos, gear id 6, discards
188	SB_7_D	Susp/dep feeding benthos, gear id 7, discards
189	SB_8_D	Susp/dep feeding benthos, gear id 8, discards
190	SB_9_D	Susp/dep feeding benthos, gear id 9, discards
191	SB_10_D	Susp/dep feeding benthos, gear id 10, discards
192	SB_11_D	Susp/dep feeding benthos, gear id 11, discards
193	SB_12_D	Susp/dep feeding benthos, gear id 12, discards
194	CB_1_D	Carn/scav feeding benthos, gear id 1, discards
195	CB_2_D	Carn/scav feeding benthos, gear id 2, discards
196	CB_3_D	Carn/scav feeding benthos, gear id 3, discards
197	CB_4_D	Carn/scav feeding benthos, gear id 4, discards

198	CB_5_D	Carn/scav feeding benthos, gear id 5, discards
199	CB_6_D	Carn/scav feeding benthos, gear id 6, discards
200	CB_7_D	Carn/scav feeding benthos, gear id 7, discards
201	CB_8_D	Carn/scav feeding benthos, gear id 8, discards
202	CB_9_D	Carn/scav feeding benthos, gear id 9, discards
203	CB_10_D	Carn/scav feeding benthos, gear id 10, discards
204	CB_11_D	Carn/scav feeding benthos, gear id 11, discards
205	CB_12_D	Carn/scav feeding benthos, gear id 12, discards
206	CZ_1_D	Carnivorous zooplankton, gear id 1, discards
207	CZ_2_D	Carnivorous zooplankton, gear id 2, discards
208	CZ_3_D	Carnivorous zooplankton, gear id 3, discards
209	CZ_4_D	Carnivorous zooplankton, gear id 4, discards
210	CZ_5_D	Carnivorous zooplankton, gear id 5, discards
211	CZ_6_D	Carnivorous zooplankton, gear id 6, discards
212	CZ_7_D	Carnivorous zooplankton, gear id 7, discards
213	CZ_8_D	Carnivorous zooplankton, gear id 8, discards
214	CZ_9_D	Carnivorous zooplankton, gear id 9, discards
215	CZ_10_D	Carnivorous zooplankton, gear id 10, discards
216	CZ_11_D	Carnivorous zooplankton, gear id 11, discards
217	CZ_12_D	Carnivorous zooplankton, gear id 12, discards
218	BD_1_D	Birds, gear id 1, discards
219	BD_2_D	Birds, gear id 2, discards
220	BD_3_D	Birds, gear id 3, discards
221	BD_4_D	Birds, gear id 4, discards
222	BD_5_D	Birds, gear id 5, discards
223	BD_6_D	Birds, gear id 6, discards
224	BD_7_D	Birds, gear id 7, discards
225	BD_8_D	Birds, gear id 8, discards
226	BD_9_D	Birds, gear id 9, discards

227	BD_10_D	Birds, gear id 10, discards
228	BD_11_D	Birds, gear id 11, discards
229	BD_12_D	Birds, gear id 12, discards
230	SL_1_D	Pinnipeds, gear id 1, discards
231	SL_2_D	Pinnipeds, gear id 2, discards
232	SL_3_D	Pinnipeds, gear id 3, discards
233	SL_4_D	Pinnipeds, gear id 4, discards
234	SL_5_D	Pinnipeds, gear id 5, discards
235	SL_6_D	Pinnipeds, gear id 6, discards
236	SL_7_D	Pinnipeds, gear id 7, discards
237	SL_8_D	Pinnipeds, gear id 8, discards
238	SL_9_D	Pinnipeds, gear id 9, discards
239	SL_10_D	Pinnipeds, gear id 10, discards
240	SL_11_D	Pinnipeds, gear id 11, discards
241	SL_12_D	Pinnipeds, gear id 12, discards
242	CT_1_D	Cetaceans, gear id 1, discards
243	CT_2_D	Cetaceans, gear id 2, discards
244	CT_3_D	Cetaceans, gear id 3, discards
245	CT_4_D	Cetaceans, gear id 4, discards
246	CT_5_D	Cetaceans, gear id 5, discards
247	CT_6_D	Cetaceans, gear id 6, discards
248	CT_7_D	Cetaceans, gear id 7, discards
249	CT_8_D	Cetaceans, gear id 8, discards
250	CT_9_D	Cetaceans, gear id 9, discards
251	CT_10_D	Cetaceans, gear id 10, discards
252	CT_11_D	Cetaceans, gear id 11, discards
253	CT_12_D	Cetaceans, gear id 12, discards
254	KP_1_D	Macrophytes, gear id 1, discards
255	KP_2_D	Macrophytes, gear id 2, discards

256	KP_3_D	Macrophytes, gear id 3, discards
257	KP_4_D	Macrophytes, gear id 4, discards
258	KP_5_D	Macrophytes, gear id 5, discards
259	KP_6_D	Macrophytes, gear id 6, discards
260	KP_7_D	Macrophytes, gear id 7, discards
261	KP_8_D	Macrophytes, gear id 8, discards
262	KP_9_D	Macrophytes, gear id 9, discards
263	KP_10_D	Macrophytes, gear id 10, discards
264	KP_11_D	Macrophytes, gear id 11, discards
265	KP_12_D	Macrophytes, gear id 12, discards

Details of $final.year.outputs data saved in the results list object and output to *.csv* files

On completion of the differential equation solving phase of the model run, the code generates a set of standard outputs based on the last annual cycle of the run. If the model has been run to a stationary state then the final year represents a repeating annual cycle of output given the repeating annual cycle of model driving data.

The final year standard outputs are embedded in the R-list object generated by the model run (see Table 36, 37), and replicated in a set of *.csv* output files directed to the users' working directory. A variety of plotting functions are provided with the package which can be used to display these single run data. However, it is expected that users will wish to write their own code to create other tables and graphics which, for example compare results from a scenario run of the model with a basline run. To facilitate user access to the standard final year outputs, either from the R-list object or the *.csv* files, each of the data structures is documented in Tables 43-47.

Table 43. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run - the data fields within the dataframe "$monthly.averages". The same data are also output as a standard *.csv* file. Rows (12 in total) are the averages of the set of variable (columns) over each successive 30 day interval of model output during the final year (corresponding to months). The variables are designed to correspond to the observational month data in the file */Target_data/ monthly_target_data_*.csv*

Column number	Column name	Data description
1	surfnitratemMm3	Nitrate concentration ($mMN.m^{-3}$) aggregated across the inshore zone and the offshore upper layer
2	deepnitratemMm3	Nitrate concentration ($mMN.m^{-3}$) in the offshore lower layer
3	surfammoniamMm3	Ammonia concentration ($mMN.m^{-3}$) aggregated across the inshore zone and the offshore upper layer
4	deepammoniamMm3	Ammonia concentration ($mMN.m^{-3}$) in the offshore lower layer
5	surfchlmgm3	Chlorophyll concentration ($mg.m^{-3}$) aggregated across the inshore zone and the offshore upper layer. Chlorophyll derived assuming Redfield carbon:nitrogen molar ratio and a carbon:chlorophyll weight ratio of 40
6	omnizoomMNm3	Omnivorous zooplanktoin concentration ($mMN.m^{-3}$) aggregated across the inshore and offshore zones
7	carnzoomMNm3	Carnivorous zooplanktoin concentration ($mMN.m^{-3}$) aggregated across the inshore and offshore zones
8	benthslarmMNm3	Larvae of susp/dep feeding benthos concentration ($mMN.m^{-3}$) aggregated across the inshore and offshore zones
9	benthclarmMNm3	Larvae of carn/scav feeding benthos concentration ($mMN.m^{-3}$) aggregated across the inshore and offshore zones

Table 44. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run - the data fields within the dataframes "$mass_results_inshore", "$maxmass_results_inshore" and "$minmass_results_inshore", and the corresponding dataframes for the offshore zone and the whole model domain. The same data are also output as standard .csv files. Columns are (1) the data value, (2) units (text field), and (3) a description of the data (text field). Certain outputs are not available for the inshore and offshore zones so the data value for these rows is given as NA which R interprets as a missing value. Lower layer outputs are not available for the inshore zone. Kelp and kelp detritus values are not available for the offshore zone. Units for the state variables correspond to the mass in the whole model domain which is notionally 1 m^2. Area and volumetric parameters are appended at the bottom of the .csv table to enable the mass values to be converted to area densities or layer concentrations, but not in the dataframes within "$final.year.outputs" since these parameters are available in $build$model.parameters, as detailed in Table 38.

Row number	Units	Description
1	mMN in the whole model domain (1 m^2)	Surface layer detritus (and bacteria)
2	mMN in the whole model domain (1 m^2)	Deep layer detritus (and bacteria)
3	mMN in the whole model domain (1 m^2)	Sediment labile plus refractory detritus (and bacteria)
4	mMN in the whole model domain (1 m^2)	Sediment refractory detritus
5	mMN in the whole model domain (1 m^2)	Fishery discards
6	mMN in the whole model domain (1 m^2)	Corpses
7	mMN in the whole model domain (1 m^2)	Kelp debris
8	mMN in the whole model domain (1 m^2)	Surface layer ammonia
9	mMN in the whole model domain (1 m^2)	Deep layer ammonia
10	mMN in the whole model domain (1 m^2)	Sediment porewater ammonia
11	mMN in the whole model domain (1 m^2)	Surface layer nitrate
12	mMN in the whole model domain (1 m^2)	Deep layer nitrate
13	mMN in the whole model domain (1 m^2)	Sediment porewater nitrate
14	mMN in the whole model domain (1 m^2)	Kelp nitrogen
15	mMN in the whole model domain (1 m^2)	Surface layer phytoplankton
16	mMN in the whole model domain (1 m^2)	Deep layer phytoplankton
17	mMN in the whole model domain (1 m^2)	Omnivorous zooplankton
18	mMN in the whole model domain (1 m^2)	Carnivorous zooplankton
19	mMN in the whole model domain (1 m^2)	Benthos susp/dep feeders larvae

20	mMN in the whole model domain (1 m^2)	Benthos susp/dep feeders
21	mMN in the whole model domain (1 m^2)	Benthos carn/scav feeders larvae
22	mMN in the whole model domain (1 m^2)	Benthos carn/scav feeders
23	mMN in the whole model domain (1 m^2)	Planktivorous fish larvae
24	mMN in the whole model domain (1 m^2)	Planktivorous fish
25	mMN in the whole model domain (1 m^2)	Migratory fish
26	mMN in the whole model domain (1 m^2)	Demersal fish larvae
27	mMN in the whole model domain (1 m^2)	Demersal fish
28	mMN in the whole model domain (1 m^2)	Bird
29	mMN in the whole model domain (1 m^2)	Seals
30	mMN in the whole model domain (1 m^2)	Cetaceans
31	mMN in the whole model domain (1 m^2)	Total nitrogen mass
32	Dimensionless	Area proportion of inshore zone **(only in the *.csv* output file)**
33	M	Thickness of inshore surface layer **(only in the *.csv* output file)**
34	M	Thickness of offshore surface layer **(only in the *.csv* output file)**
35	M	Thickness of offshore deep layer **(only in the *.csv* output file)**
36	Dimensionless	Area proportion inshore rock **(only in the *.csv* output file)**
37	Dimensionless	Area proportion inshore sediment s1 **(only in the *.csv* output file)**
38	Dimensionless	Area proportion inshore sediment s2 **(only in the *.csv* output file)**
39	Dimensionless	Area proportion inshore sediment s3 **(only in the *.csv* output file)**
40	Dimensionless	Area proportion offshore rock **(only in the *.csv* output file)**
41	Dimensionless	Area proportion offshore sediment d1 **(only in the *.csv* output file)**
42	Dimensionless	Area proportion offshore sediment d2 **(only in the *.csv* output file)**
43	Dimensionless	Area proportion offshore sediment d3 **(only in the *.csv* output file)**
44	M	Thickness of inshore sediment layer s1 **(only in the *.csv* output file)**
45	M	Thickness of inshore sediment layer s2 **(only in the *.csv* output file)**
46	M	Thickness of inshore sediment layer s3 **(only in the *.csv* output file)**
47	M	Thickness of offshore sediment layer d1 **(only in the *.csv* output file)**
48	M	Thickness of offshore sediment layer d2 **(only in the *.csv* output file)**
49	M	Thickness of offshore sediment layer d3 **(only in the *.csv* output file)**

50	Dimensionless	Porosity of inshore sediment layer s1 **(only in the *.csv* output file)**
51	Dimensionless	Porosity of inshore sediment layer s2 **(only in the *.csv* output file)**
51	Dimensionless	Porosity of inshore sediment layer s3 **(only in the *.csv* output file)**
53	Dimensionless	Porosity of offshore sediment layer d1 **(only in the *.csv* output file)**
54	Dimensionless	Porosity of offshore sediment layer d2 **(only in the *.csv* output file)**
55	Dimensionless	Porosity of offshore sediment layer d3 **(only in the *.csv* output file)**

Table 45. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run - the data fields within the dataframe "$annual_flux_results_inshore", and the corresponding dataframes for the offshore zone and the whole model domain. The same data are also output as standard *.csv* files. Columns are (1) the data value, (2) units (text field), and (3) a description of the data (text field). Certain outputs are not available for the inshore and offshore zones so the data value for these rows is given as NA which R interprets as a missing value. Lower layer outputs are not available for the inshore zone. Kelp and kelp detritus values are not available for the offshore zone. Units for the fluxes correspond to the mass flux per unikt time in the whole model domain which is notionally 1 m^2. Area and volumetric parameters are appended at the bottom of the .csv table to enable the mass values to be converted to area densities or layer concentrations, but not in the dataframes within "$final.year.outputs" since these parameters are available in $build$model.parameters, as detailed in Table 38.

Row number	Units	Description
1	mMN.y^{-1} in the whole model domain (1 m^2)	DIN inflow (nitrate + ammonia inflow from the external ocean)
2	mMN.y^{-1} in the whole model domain (1 m^2)	DIN outflow (nitrate + ammonia outflow from the model to the ocean)
3	mMN.y^{-1} in the whole model domain (1 m^2)	Particulate inflow (detritus & bacteria + phytoplankton inflow from the ocean)
4	mMN.y^{-1} in the whole model domain (1 m^2)	Particulate outflow (detritus & bacteria + phytoplankton outflow from the model to the ocean)
5	mMN.y^{-1} in the whole model domain (1 m^2)	Atmosphere DIN input (deposition of nitrate and ammonia on the sea surface)
6	mMN.y^{-1} in the whole model domain (1 m^2)	River DIN inflow (inflow of nitrate and ammonia from rivers)
7	mMN.y^{-1} in the whole model domain (1 m^2)	River particulate inflow (inflow of suspended detritus from rivers)
8	mMN in the whole model domain (1 m^2) during	Summer DIN inflow (nitrate + ammonia inflow from the external ocean)

	summer months only (April-September)	
9	mMN in the whole model domain (1 m^2) during summer months only (April-September)	Summer DIN outflow (nitrate + ammonia outflow from the model to the ocean)
10	mMN in the whole model domain (1 m^2) during summer months only (April-September)	Summer particulate inflow (detritus & bacteria + phytoplankton inflow from the ocean)
11	mMN in the whole model domain (1 m^2) during summer months only (April-September)	Summer particulate outflow (detritus & bacteria + phytoplankton outflow from the model to the ocean)
12	mMN in the whole model domain (1 m^2) during summer months only (April-September)	Summer river DIN inflow (inflow of nitrate and ammonia from rivers)
13	mMN in the whole model domain (1 m^2) during summer months only (April-September)	Summer atmosphere DIN input (deposition of nitrate and ammonia on the sea surface)
14	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Vertical nitrate flux
15	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Surface horizontal nitrate flux
16	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Net import/export flux in the sediment
17	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Beachcast export of kelp debris
18	$mMN.y^{-1}$ in the whole model domain (1 m^2)	DIN Net flux offshore to inshore
19	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Particulate net flux offshore to inshore
20	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Plank.fish net active migration offshore to inshore
21	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Mig.fish net active migration offshore to inshore
22	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Dem.fish net active migration offshore to inshore
23	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Bird net active migration offshore to inshore
24	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Seal net active migration offshore to inshore
25	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Cetacean net active migration offshore to inshore
26	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Mig.fish net migration external offshore
27	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Mig.fish annual immigration
28	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Mig.fish annual emigration
29	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Phytoplankton net primary production
30	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Phytoplankton new production (nitrate drawdown)
31	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Phytoplankton new production (traditional)
32	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Phytoplankton new production (Heath&Beare)
33	$mMN.y^{-1}$ in the whole model domain (1 m^2)	Phytoplankton nitrate uptake

34	mMN.y^{-1} in the whole model domain (1 m^2)	Phytoplankton ammonia uptake
35	mMN.y^{-1} in the whole model domain (1 m^2)	Phytoplankton fratio (H&B/NetPP)
36	mMN.y^{-1} in the whole model domain (1 m^2)	Phytoplankton fratio (traditional)
37	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp nitrate uptake
38	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp ammonia uptake
39	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp gross production
40	mMN.y^{-1} in the whole model domain (1 m^2)	Phytoplankton gross production
41	mMN.y^{-1} in the whole model domain (1 m^2)	Omniv.zooplankton gross production
42	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton gross production
43	mMN.y^{-1} in the whole model domain (1 m^2)	Planktiv.fish larvae gross production
44	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish larvae gross production
45	mMN.y^{-1} in the whole model domain (1 m^2)	Planktiv.fish gross production
46	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish gross production
47	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish gross production
48	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos susp/dep larvae gross production
49	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos carn/scav larvae gross production
50	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos susp/dep gross production
51	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos carn/scav gross production
52	mMN.y^{-1} in the whole model domain (1 m^2)	Bird gross production
53	mMN.y^{-1} in the whole model domain (1 m^2)	Seal gross production
54	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean gross production
55	mMN.y^{-1} in the whole model domain (1 m^2)	Omniv.zooplankton net production
56	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton net production
57	mMN.y^{-1} in the whole model domain (1 m^2)	Planktiv.fish larvae net production
58	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish larvae net production
59	mMN.y^{-1} in the whole model domain (1 m^2)	Planktiv.fish net production
60	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish net production
61	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish net production
62	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos susp/dep larvae net production
63	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos carn/scav larvae net production

64	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos susp/dep net production
65	mMN.y^{-1} in the whole model domain (1 m^2)	Benthos carn/scav net production
66	mMN.y^{-1} in the whole model domain (1 m^2)	Bird net production
67	mMN.y^{-1} in the whole model domain (1 m^2)	Seal net production
68	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean net production
69	mMN.y^{-1} in the whole model domain (1 m^2)	Water column detritus production
70	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment detritus production
71	mMN.y^{-1} in the whole model domain (1 m^2)	Corpse production
72	mMN.y^{-1} in the whole model domain (1 m^2)	Flux of detritus from water to sediment
73	mMN.y^{-1} in the whole model domain (1 m^2)	Flux of discards to corpses
74	mMN.y^{-1} in the whole model domain (1 m^2)	Pelagic fauna ammonia production
75	mMN.y^{-1} in the whole model domain (1 m^2)	Benthic fauna ammonia production
76	mMN.y^{-1} in the whole model domain (1 m^2)	Water column detritus mineralisation
77	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment detritus mineralisation
78	mMN.y^{-1} in the whole model domain (1 m^2)	Water column nitrification
79	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment nitrification
80	mMN.y^{-1} in the whole model domain (1 m^2)	Water column denitrification
81	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment denitrification
82	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment to water ammonia flux
83	mMN.y^{-1} in the whole model domain (1 m^2)	Sediment to water nitrate flux
84	mMN.y^{-1} in the whole model domain (1 m^2)	Flux detritus to omniv.zooplankton
85	mMN.y^{-1} in the whole model domain (1 m^2)	Flux phytoplankton to omniv.zooplankton
86	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to omniv.zooplankton
87	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to omniv.zooplankton
88	mMN.y^{-1} in the whole model domain (1 m^2)	Flux omniv.zooplankton to carniv.zooplankton
89	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish.larvae to carniv.zooplankton
90	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish.larvae to carniv.zooplankton
91	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to carniv.zooplankton
92	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to carniv.zooplankton
93	mMN.y^{-1} in the whole model domain (1 m^2)	Flux omniv.zooplankton to plank.fish.larvae

94	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to plank.fish.larvae
95	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to plank.fish.larvae
96	mMN.y^{-1} in the whole model domain (1 m^2)	Flux omniv.zooplankton to dem.fish.larvae
97	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to dem.fish.larvae
98	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to dem.fish.larvae
99	mMN.y^{-1} in the whole model domain (1 m^2)	Flux omniv.zooplankton to plank.fish
100	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to plank.fish
101	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish.larvae to plank.fish
102	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish.larvae to plank.fish
103	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to plank.fish
104	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to plank.fish
105	mMN.y^{-1} in the whole model domain (1 m^2)	Flux omniv.zooplankton to mig.fish
106	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to mig.fish
107	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish.larvae to mig.fish
108	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish.larvae to mig.fish
109	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d.larvae to mig.fish
110	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s.larvae to mig.fish
111	mMN.y^{-1} in the whole model domain (1 m^2)	Flux corpses to dem.fish
112	mMN.y^{-1} in the whole model domain (1 m^2)	Flux discards to dem.fish
113	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to dem.fish
114	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish.larvae to dem.fish
115	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish.larvae to dem.fish
116	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish to dem.fish
117	mMN.y^{-1} in the whole model domain (1 m^2)	Flux mig.fish to dem.fish
118	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish to dem.fish
119	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d to dem.fish
120	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s to dem.fish
121	mMN.y^{-1} in the whole model domain (1 m^2)	Flux detritus to Benthoss/d.larvae
122	mMN.y^{-1} in the whole model domain (1 m^2)	Flux phytoplankton to Benthoss/d.larvae
123	mMN.y^{-1} in the whole model domain (1 m^2)	Flux detritus to benthosc/s.larvae

124	mMN.y^{-1} in the whole model domain (1 m^2)	Flux phytoplankton to benthosc/s.larvae
125	mMN.y^{-1} in the whole model domain (1 m^2)	Flux detritus to Benthoss/d
126	mMN.y^{-1} in the whole model domain (1 m^2)	Flux sediment.detritus to Benthoss/d
127	mMN.y^{-1} in the whole model domain (1 m^2)	Flux phytoplankton to Benthoss/d
128	mMN.y^{-1} in the whole model domain (1 m^2)	Flux kelp.debris to benthosc/s
129	mMN.y^{-1} in the whole model domain (1 m^2)	Flux corpses to benthosc/s
130	mMN.y^{-1} in the whole model domain (1 m^2)	Flux kelp to benthosc/s
131	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d to benthosc/sc
132	mMN.y^{-1} in the whole model domain (1 m^2)	Flux corpses to birds
133	mMN.y^{-1} in the whole model domain (1 m^2)	Flux discards to birds
134	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to birds
135	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish to birds
136	mMN.y^{-1} in the whole model domain (1 m^2)	Flux mig.fish to birds
137	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish to birds
138	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d to birds
139	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s to birds
140	mMN.y^{-1} in the whole model domain (1 m^2)	Flux corpses to seals
141	mMN.y^{-1} in the whole model domain (1 m^2)	Flux discards to seals
142	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to seals
143	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish to seals
144	mMN.y^{-1} in the whole model domain (1 m^2)	Flux mig.fish to seals
145	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish to seals
146	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d to seals
147	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s to seals
148	mMN.y^{-1} in the whole model domain (1 m^2)	Flux birds to seals
149	mMN.y^{-1} in the whole model domain (1 m^2)	Flux discards to cetaceans
150	mMN.y^{-1} in the whole model domain (1 m^2)	Flux ominiv.zooplankton to cetaceans
151	mMN.y^{-1} in the whole model domain (1 m^2)	Flux carniv.zooplankton to cetaceans
152	mMN.y^{-1} in the whole model domain (1 m^2)	Flux plank.fish to cetaceans
153	mMN.y^{-1} in the whole model domain (1 m^2)	Flux mig.fish to cetaceans

154	mMN.y^{-1} in the whole model domain (1 m^2)	Flux dem.fish to cetaceans
155	mMN.y^{-1} in the whole model domain (1 m^2)	Flux Benthoss/d to cetaceans
156	mMN.y^{-1} in the whole model domain (1 m^2)	Flux benthosc/s to cetaceans
157	mMN.y^{-1} in the whole model domain (1 m^2)	Flux birds to cetaceans
158	mMN.y^{-1} in the whole model domain (1 m^2)	Flux seals to cetaceans
159	mMN.y^{-1} in the whole model domain (1 m^2)	Net production of all secondary and higher trophic levels
160	mMN.y^{-1} in the whole model domain (1 m^2)	Export from secondary producers
161	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish annual spawning
162	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish annual recruitment
163	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish annual spawning
164	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish annual recruitment
165	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d annual spawning
166	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d annual recruitment
167	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/s annual spawning
168	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/sc annual recruitment
169	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish landings live weight
170	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish landings live weight
171	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish landings live weight
172	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish quota limited landings live weight
173	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish non.quota landings live weight
174	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d landings live weight
175	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/s landings live weight
176	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton landings live weight
177	mMN.y^{-1} in the whole model domain (1 m^2)	Bird landings live weight
178	mMN.y^{-1} in the whole model domain (1 m^2)	Seal landings live weight
179	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean landings live weight
180	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp landings live weight
181	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish discards
182	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish discards
183	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish discards

184	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish quota limited discards
185	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish non.quota discards
186	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d discards
187	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/s discards
188	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton discards
189	mMN.y^{-1} in the whole model domain (1 m^2)	Bird discards
190	mMN.y^{-1} in the whole model domain (1 m^2)	Seal discards
191	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean discards
192	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp discards
193	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish offal
194	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish offal
195	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish offal
196	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish quota limited offal
197	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish non.quota offal
198	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d offal
199	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/s offal
200	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton offal
201	mMN.y^{-1} in the whole model domain (1 m^2)	Bird offal
202	mMN.y^{-1} in the whole model domain (1 m^2)	Seal offal
203	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean offal
204	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp offal
205	mMN.y^{-1} in the whole model domain (1 m^2)	Plank.fish landings processed weight
206	mMN.y^{-1} in the whole model domain (1 m^2)	Mig.fish landings processed weight
207	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish landings processed weight
208	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish quota limited landings processed weight
209	mMN.y^{-1} in the whole model domain (1 m^2)	Dem.fish non.quota landings processed weight
210	mMN.y^{-1} in the whole model domain (1 m^2)	Benthoss/d landings processed weight
211	mMN.y^{-1} in the whole model domain (1 m^2)	Benthosc/s landings processed weight
212	mMN.y^{-1} in the whole model domain (1 m^2)	Carniv.zooplankton landings processed weight
213	mMN.y^{-1} in the whole model domain (1 m^2)	Bird landings processed weight

214	mMN.y^{-1} in the whole model domain (1 m^2)	Seal landings processed weight
215	mMN.y^{-1} in the whole model domain (1 m^2)	Cetacean landings processed weight
216	mMN.y^{-1} in the whole model domain (1 m^2)	Kelp landings processed weight
217	Dimensionless	Area proportion of inshore zone **(only in the *.csv* output file)**
218	m	Thickness of inshore surface layer **(only in the *.csv* output file)**
219	m	Thickness of offshore surface layer **(only in the *.csv* output file)**
220	m	Thickness of offshore deep layer **(only in the *.csv* output file)**
221	Dimensionless	Area proportion inshore rock **(only in the *.csv* output file)**
222	Dimensionless	Area proportion inshore sediment s1 **(only in the *.csv* output file)**
223	Dimensionless	Area proportion inshore sediment s2 **(only in the *.csv* output file)**
224	Dimensionless	Area proportion inshore sediment s3 **(only in the *.csv* output file)**
225	Dimensionless	Area proportion offshore rock **(only in the *.csv* output file)**
226	Dimensionless	Area proportion offshore sediment d1 **(only in the *.csv* output file)**
227	Dimensionless	Area proportion offshore sediment d2 **(only in the *.csv* output file)**
228	Dimensionless	Area proportion offshore sediment d3 **(only in the *.csv* output file)**
229	m	Thickness of inshore sediment layer s1 **(only in the *.csv* output file)**
230	m	Thickness of inshore sediment layer s2 **(only in the *.csv* output file)**
231	m	Thickness of inshore sediment layer s3 **(only in the *.csv* output file)**
232	m	Thickness of offshore sediment layer d1 **(only in the *.csv* output file)**
233	m	Thickness of offshore sediment layer d2 **(only in the *.csv* output file)**
234	m	Thickness of offshore sediment layer d3 **(only in the *.csv* output file)**
235	Dimensionless	Porosity of inshore sediment layer s1 **(only in the *.csv* output file)**
236	Dimensionless	Porosity of inshore sediment layer s2 **(only in the *.csv* output file)**
237	Dimensionless	Porosity of inshore sediment layer s3 **(only in the *.csv* output file)**
238	Dimensionless	Porosity of offshore sediment layer d1 **(only in the *.csv* output file)**
239	Dimensionless	Porosity of offshore sediment layer d2 **(only in the *.csv* output file)**
240	Dimensionless	Porosity of offshore sediment layer d3 **(only in the *.csv* output file)**

Table 46. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run – row and column details for the dataframe forming the matrix "$flow_matrix_all_fluxes". These data are for the whole model domain, and the same structure is also output as a standard *.csv* file. The data are in the format expected by the NetIndices package for the derivation of network indices (see Table 47). The rows of the matrix are all the sources of flows in the network - state variables and import sources to the model. The columns are all the destinations for flows in the network - state variables, import sources and export destinations for the model. The matrix contains additional columns (exports to fishery landings and exports to macrophyte beachcast) which are not represented in the rows.

Row/column number	Row/column name	Details
1	Wcammonia	Water column ammonia
2	Sedammonia	Sediment porewater ammonia
3	Wcnitrate	Water column nitrate
4	Sednitrate	Sediment porewater nitrate
5	Wcdetritus	Water column detritus and bacteria
6	Seddetritus	Sediment labile detritus and bacteria
7	seddetritusR	Sediment refractory detritus
8	Kelpdebris	Macrophyte debris
9	Corpses	Corpses
10	Discards	Fishery discards
11	Kelp	Macrophytes
12	Phyt	Phytoplankton
13	Omnivzoo	Omnivorous zooplankton
14	Carnzoo	Carnivorous zooplankton
15	Pfishlar	Larvae of planktivorous fish
16	Dfishlar	Larvae of demersal fish
17	Pfish	Planktivorous fish
18	Mfish	Migratory fish
19	Dfish	Demersal fish
20	Benthslar	Larvae of susp/dep feeding benthos
21	Benthclar	Larvae of carn/scav feeding benthos

22	Benths	Susp/dep feeding benthos
23	Benthc	Carn/scav feeding benthos
24	Bird	Birds
25	Seal	Pinnipeds
26	Ceta	Cetaceans
27	Ocean	External ocean outside the model domain
28	Rivers	Rivers flowing into the model domain
29	Atmosphere	Atmosphere above the model domain
30	Seabed	Seabed sediments beneath the active modelled layer in the model
(31)	Landings	Fishery landings (processed weight) (column-data only)
(32)	Beachcast	Macrophyte beachcast (column-data ony)

Table 47. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run – details of the $NetworkIndexReults object containing results generated by the NetIndices R package from the flow matrix data assembled for the final year of a model run. The same data are also output as a standard *.csv* file. The column 'Function in NetIndices' shows the specific function within the NetIndices package which is used to generate each output variable. For details of these functions see the documentation for the R NetIndices package (Kones et al., 2009, Soetaert & Kones, 2014).

Row number	Row name	Function in NetIndices	Explanation
1	wcammonia_trophiclevel	TrophInd	Annual mean tropic level of ammonia (always = 1)
2	sedammonia_trophiclevel	TrophInd	Annual mean tropic level of sediment ammonia (always = 1)
3	wcnitrate_trophiclevel	TrophInd	Annual mean tropic level of nitrate (always = 1)
4	sednitrate_trophiclevel	TrophInd	Annual mean tropic level of sediment nitrate (always = 1)
5	wcdetritus_trophiclevel	TrophInd	Annual mean tropic level of detritus and bacteria (always = 1)
6	seddetritus_trophiclevel	TrophInd	Annual mean tropic level of sediment labile detritus and bacteria (always = 1)
7	seddetritusR_trophiclevel	TrophInd	Annual mean tropic level of refractory detritus (always = 1)
8	kelpdebris_trophiclevel	TrophInd	Annual mean tropic level of macrophyte debris (always = 1)
9	corpses_trophiclevel	TrophInd	Annual mean tropic level of corpses (always = 1)
10	discards_trophiclevel	TrophInd	Annual mean tropic level of fishery discards (always = 1)

11	kelp_trophiclevel	TrophInd	Annual mean tropic level of macrophytes (always = 2)
12	phyt_trophiclevel	TrophInd	Annual mean tropic level of phytoplankton (always = 2)
13	omnivzoo_trophiclevel	TrophInd	Annual mean tropic level of omnivorous zooplankton
14	carnzoo_trophiclevel	TrophInd	Annual mean tropic level of carnivorous zooplankton
15	pfishlar_trophiclevel	TrophInd	Annual mean tropic level of larvae of planktivorous fish
16	dfishlar_trophiclevel	TrophInd	Annual mean tropic level of larvae of demersal fish
17	pfish_trophiclevel	TrophInd	Annual mean tropic level of planktivorous fish
18	mfish_trophiclevel	TrophInd	Annual mean tropic level of migratory fish
19	dfish_trophiclevel	TrophInd	Annual mean tropic level of demersal fish
20	benthslar_trophiclevel	TrophInd	Annual mean tropic level of larvae of susp/dep feeding benthos
21	benthclar_trophiclevel	TrophInd	Annual mean tropic level of larvae of carn/scav feeding benthos
22	benths_trophiclevel	TrophInd	Annual mean tropic level of susp/dep feeding benthos
23	benthc_trophiclevel	TrophInd	Annual mean tropic level of carn/scav feeding benthos
24	bird_trophiclevel	TrophInd	Annual mean tropic level of birds
25	seal_trophiclevel	TrophInd	Annual mean tropic level of pinnipeds
26	ceta_trophiclevel	TrophInd	Annual mean tropic level of cetaceans
27	wcammonia_omnivoryindex	TrophInd	Omnivory index for ammonia (always = 0)
28	sedammonia_omnivoryindex	TrophInd	Omnivory index for sediment ammonia (always = 0)
29	wcnitrate_omnivoryindex	TrophInd	Omnivory index for nitrate (always = 0)
30	sednitrate_omnivoryindex	TrophInd	Omnivory index for sediment nitrate (always = 0)
31	wcdetritus_omnivoryindex	TrophInd	Omnivory index for detritus and bacteria (always = 0)
32	seddetritus_omnivoryindex	TrophInd	Omnivory index for sediment labile detritus and bacteria (always = 0)
33	seddetritusR_omnivoryindex	TrophInd	Omnivory index for sediment refractory detritus (always = 0)
34	kelpdebris_omnivoryindex	TrophInd	Omnivory index for macrophyte debris (always = 0)
35	corpses_omnivoryindex	TrophInd	Omnivory index for corpses (always = 0)
36	discards_omnivoryindex	TrophInd	Omnivory index for fishery discards (always = 0)
37	kelp_omnivoryindex	TrophInd	Omnivory index for macrophytes
38	phyt_omnivoryindex	TrophInd	Omnivory index for phytoplankton
39	omnivzoo_omnivoryindex	TrophInd	Omnivory index for omnivorous zooplankton

40	carnzoo_omnivoryindex	TrophInd	Omnivory index for carnivorous zooplankton
41	pfishlar_omnivoryindex	TrophInd	Omnivory index for larvae of planktivorous fish
42	dfishlar_omnivoryindex	TrophInd	Omnivory index for larvae of demersal fish
43	pfish_omnivoryindex	TrophInd	Omnivory index for planktivorous fish
44	mfish_omnivoryindex	TrophInd	Omnivory index for migratory fish
45	dfish_omnivoryindex	TrophInd	Omnivory index for demersal fish
46	benthslar_omnivoryindex	TrophInd	Omnivory index for larvae of susp/dep feeding benthos
47	benthclar_omnivoryindex	TrophInd	Omnivory index for larvae of carn/scav feeding bnenthos
48	benths_omnivoryindex	TrophInd	Omnivory index for susp/dep feeding benthos
49	benthc_omnivoryindex	TrophInd	Omnivory index for carn/scav feeding bnenthos
50	bird_omnivoryindex	TrophInd	Omnivory index for birds
51	seal_omnivoryindex	TrophInd	Omnivory index for pinnipeds
52	ceta_omnivoryindex	TrophInd	Omnivory index for cetaceans
53	Ascendency_total	AscInd	Total ascendency of the network
54	Ascendency_internal	AscInd	Ascendency excluding external inflows and outflows
55	Ascendency_import	AscInd	Ascendency - import flows
56	Ascendency_external	AscInd	Ascendency - export flows including dissipation
57	Ascendency_dissipation	AscInd	Ascendency – usable and unusable flows
58	Overhead_total	AscInd	Total overhead of the network
59	Overhead_internal	AscInd	Overhead excluding external inflows and outflows
60	Overhead_import	AscInd	Overhead - import flows
61	Overhead_external	AscInd	Overhead - export flows including dissipation
62	Overhead_dissipation	AscInd	Overhead – usable and unusable flows
63	Capacity_total	AscInd	Total capacity of the network
64	Capacity_internal	AscInd	Capacity excluding external inflows and outflows
65	Capacity_import	AscInd	Capacity - import flows
66	Capacity_external	AscInd	Capacity - export flows including dissipation
67	Capacity_dissipation	AscInd	Capacity – usable and unusable flows
68	ACratio_total	AscInd	Ratio of total ascendency to total capacity

69	ACratio_internal	AscInd	Ascendency/capacity - excluding external inflows and outflows
70	ACratio_import	AscInd	Ascendency/capacity - import flows
71	ACratio_external	AscInd	Ascendency/capacity - export flows including dissipation
72	ACratio_dissipation	AscInd	Ascendency/capacity – usable and unusable flows
73	Total_system_cycled_thoughflow_TSTC	PathInd	Total system cycled thoughflow (TSTC)
74	Non_cycled_throughflow_TSTS	PathInd	Non cycled throughflow (TSTS)
75	Finns_cycling_index_FCI	PathInd	Finns cycling index (FCI)
76	Revised_Finns_cycling_index_FCIb	PathInd	Revised Finns cycling index (FCIb)
77	Average_path_length	PathInd	Average path length
78	Number_of_compartments_N	GenInd	Number of compartments (N)
79	Total_system_throughput_T	GenInd	Total system throughput (T)
80	Total_system_throughflow_TST	GenInd	Total system throughflow (TST)
81	Number_of_internal_links_Lint	GenInd	Number of internal links (Lint)
82	Total_number_of_links_Ltot	GenInd	Total number of links (Ltot)
83	Link_density_LD	GenInd	Link density (LD)
84	Connectance_C	GenInd	Connectance ©
85	Average_link_weight_Tijbar	GenInd	Average link weight (Tijbar)
86	Average_compartment_thoughflow_TSTbar	GenInd	Average compartment thoughflow (TSTbar)
87	Compartmentalization_Cbar	GenInd	Compartmentalization (Cbar)
88	Network_aggradation_NAG	EnvInd	Network aggradation (NAG)
89	Homogenization_index_HP	EnvInd	Homogenization index (HP)
90	Synergism_BC	EnvInd	Synergism (BC)
91	Dominance_of_indirect_effects_ID	EnvInd	Dominance of indirect effects (ID)
92	Mean_of_non_dimension_flowmatrix_MN	EnvInd	Mean of non-dimensional flowmatrix (MN)
93	Mean_of_direct_flowmatrix_MG	EnvInd	Mean of direct flowmatrix (MG)
94	CV_of_non_dimension_flowmatrix_MN	EnvInd	CV of non-dimensional flowmatrix (MN)
95	CV_of_direct_flowmatrix_MG	EnvInd	CV of direct flowmatrix (MG)
96	Effective_connectance_CZ	EffInd	Effective connectance (CZ)
97	Effective_flows_FZ	EffInd	Effective flows (FZ)

98	Effective_nodes_NZ	EffInd	Effective nodes (NZ)
99	Effective_roles_RZ	EffInd	Effective roles (RZ)

Table 48. Details of data-object within the "$final.year.outputs" object of the main results list generated by the model run –** details of the **$opt_results object containing the model outputs corresponding to the set of observational indices to which the model parameters are optimized by the simulated annealing schemes in the package. The dataframe merges some of the columns of the target data set (Tables 25, 26) with the model outputs. The row details are as Table 26. This table provides the Column details of the datafarme.

Column number	Column name	Description
1	Annual_measure	Numeric value of the oibservational measure specified by the description in column "Name". Missing values denoted by NA (from Table 25).
2	SD_of_measure	Standard deviation of the observational measure. Missing values denoted by NA (from Table 25).
3	Model_data	Model output value corresponding to the observational measure
4	Use1_0	Switch setting to determine whether the measure is included in likelihood calculations (1 = yes, 0 = no) (from Table 25).
5	Chi	"Error tem" between the observed and modelled values of a term (i) in the observational target data set $\chi^2_{\theta i^*} = \sum_{i=1}^{i=I}\left(\frac{(observed_i - simulated_{\theta^*,i})^2}{2\sigma_i^2}\right)$, given the parameter vector θ^*. The partial likelihood fof the observed vakue gien the parameters is then $P(observations\|\theta_i^*) = \exp(-\chi^2_{\theta_i^*})$
6	Name	Name used to identify the measure in the model code (from Table 25).
7	Units	Units of the annual measure (from Table 25).
8	Description	Text describing each measure (from Table 25).

Writing your own code to extract and process data from the single-run output object

The ..$final.year.outputs element of the list object created by a model run, and the corresponding *.csv* files which are output to the results folder, contain a comprehensive set of derived results from the final year of a simulation. However, users may wish to generate their own additional derivatives, and guidance on how to do this is set out here.

For a set of model results created using the e2e_read() and e2e_run() functions :

```
model <- e2e_read(model.name, model.variant, model.ident = "base", model.subdir = "", user.path = "")
results <- e2e_run(model, nyears)
```

The raw data from the model run are contained in the objects results$output and results$aggregates.

The first row of the "$output" (and "$aggregates") dataframe corresponds to time=0, i.e. the initial conditions passed to the differential equation solver at the start of the run. A calendar year of output corresponds to a time interval of 360 days, i.e. 361 rows of output data (time = 0:360), so the total number of rows of output will be ((360*nyears)+1), where nyears is the specified length of the model run in years.

Assuming that the "$output" (or "$aggregates") dataframe has been extracted from the results object into a named dataframe "*out*" as follows:

```
out <- results$output
```

Data for any one year specified by *Y* (*Y* ≤ *nyears*) can be extracted by the R statement:

```
# all the output corresponding to year Y (e.g. Y<-2)
    Y<-2
    out[(((Y-1)*360)+1) : ((Y*360)+1),]

# All the output for a given state variable (e.g. "phyt_si") in year Y
    out$phyt_si[(((Y-1)*360)+1) : ((Y*360)+1)]
```

To obtain annual average mass of a state variable over a given year, the R statement would be:

```
mean(out$phyt_si[(((Y-1)*360)+1) : ((Y*360)+1)])
                                                    # mean for state variable phyt_si over year Y
```

The flux terms in the dataframe are cumulative over the duration of the model run, beginning at 0 at time = 0. Hence, the time-series of instantaneous flux rates (d^{-1}) is the sequence of increments between successive rows of output. In R this can be generated e.g. for the column name “fluxphyt_herb”, by:

```
J <- nrow(out)                                  # number of rows of data in the “out” dataframe
temp <- rep(0,J)                                # creates a vector to hold temporary data
temp[1: (J-1)] <- out$fluxphyt_herb[2 : J]# copies data from the “out” into “temp” offset by 1 time increment
temp[J] <- 2*(out$fluxphyt_herb[J]) - out$fluxphyt_herb[J-1]
                                                    # fills in the terminal value of the “temp” vector by extraplotion
rate <- temp - out$fluxphyt_herb          # “rate” is a vector of the increments between successive time steps
```

To obtain the annual integral of a flux variable over a given year, the R statement would be:

```
out$fluxphyt_herb[((Y*360)+1)] - out$fluxphyt_herb[(((Y-1)*360)+1)]
                                                    # integrated flux denoted by “fluxphyt_herb” over year Y
```

All of the terms in the *$output* dataframe are in mass units (mMN or mMC) in the model domain which is is scaled to a sea-surface area of 1 m^2. To express the outputs as area densities in the inshore or offshore zones (e.g. $mMN.m^{-2}$) or layer concentrations (e.g. $mMN.m^{-3}$), the mass values need to be re-scaled to the area-proportion of the relevant zone and/or layer thickness. In addition, terms relating to sediment or sediment porewater require to be scaled by the area-proportions of seabed habitats, sediment layer thicknesses and sediment porosity. These scaling parameters are accessible to the user as elements of the object *..$build$model.parameters* which forms part of the list-object generated by a model run as shown in Table 38. Examples of R statements for converting mass outputs into area-densities and layer concentrations are shown below.

```
# Run the model and extract the $output object into a dataframe
    model <- e2e_read("North_Sea", "1970-1999")
    results <- e2e_run(model,nyears=5)
    out <- results$output
```

```
# Extract some relevant area and volumetric parameters from the $build$model.parameters object (named vector)
        inshore_area       <- as.numeric(results$build$model.parameters["shallowprop"])
        offshore_upper_thick <- as.numeric(results$build$model.parameters["thik_so"])
        offshore_lower_thick <- as.numeric(results$build$model.parameters["thik_d"])
        inshore_sed1_area    <- as.numeric(results$build$model.parameters["area_s1"])
        inshore_sed1_thick   <- as.numeric(results$build$model.parameters["thik_x_s1"])
        inshore_sed1_poros   <- as.numeric(results$build$model.parameters["porosity_s1"])

# Time series of suspended detritus and bacteria concentration in the offshore upper layer (mMN.m-3)
        out$detritus_so/((1-inshore_area)*offshore_upper_thick)

# Time series of the area-density of omnivorous zooplankton in the inshore zone (mMN.m-2)
        out$herb_i/inshore_area

# Time series of the depth averaged concentration of omnivorous zooplankton in the offshore zone (mMN.m-3)
        out$herb_i/inshore_area

# Time series of the porewater concentration of ammonia in inshore sediment habitat 1 (mMN.m-3):
        out$x_ammonia_s1/(inshore_sed1_area*inshore_sed1_thick*inshore_sed1_poros)

# Time series of labile detritus & bacterial in inshore sediment habitat 1 as a % of sediment dry weight (%gN.g-1):
        100*(out$xR_detritus_s1*(14/1000))/(inshore_sed1_area*inshore_sed1_thick*(1-inshore_sed1_poros)*2650000 )
                # (nitrogen atomic weight = 14 g.mole-1; dry sediment density = quartz density = 2.65 x 10^6 g.m-3)
```

OUTPUTS FROM OPTIMIZATION OF ECOLOGY MODEL PARAMETERS

The function

e2e_optimize_eco()

uses simulated annealing to seek a set of ecology model parameters which maximizes the likelihood of the observed annual target data on the state of the ecosystem (in the file */Target_data/ annual_target_data*.csv*) given the model structure, drivers, and the fixed ecology and fishing fleet parameters.

In this case, the input files for initilaising a simulated annealing run MUST be located in a user-workspace folder (identified by the user.path argument), since the simulated annealing function writes the best-fit parameter files back into the model variant folder (the North Sea model variant folders embedded in the package are read-only). The *MODEL_SETUP.csv* file in the user model/variant folder should point to input files of ecology model parameters which represent initial guesses of the eventual best fit values.

The ecology model parameter files written back into the */Parameters* subfolder of the model/variant folder at the end of a simulated annealing run are:

fitted_parameters_preference_matrix-.csv* (see Table 11)
fitted_parameters_uptake_and_mortality_rates-.csv* (see Table 12)
fitted_parameters_microbiology_and_others-.csv* (see Table 13)

where the identifier (*) is set by the argument model.ident in the e2e_read() function call which loads the initial model setup.

On completion of a simulated annealing run, the *MODEL_SETUP.csv* file should then be manully edited to point to the newly created parameter files instead of the previous initial guesses before any new e2e_read() function calls and model runs are carried out.

In addition to writing the final best-fit parameters back to ecology model files in the */Parameters* folder, the simulated annealing function returns the history of “proposed” and “accepted” parameter sets and the associated likelihoods as dataframes within a list and optionally saves them to *.csv* files in the current default */results/model/variant* folder. The address for this folder can be set by the model.subdir argument in the e2e_read() function call.

File names for the ‘proposed’ and ‘accepted’ history files generated by the function are as follows:

annealing_par-proposalhistory-.csv*
annealing_par-acceptedhistory-.csv*

where the identifier (*) is set by the argument model.ident in the e2e_read() function call which loads the initial model setup.

The “proposed” and “accepted” parameter history data files both have the same structure – rows are sequential iterations of the parameter set, columns are the individual parameters, with the addition of a final column providing the likelihood of the target data (Table 49). Proposed values are variants from the most recent accepted set. New proposals are tested until a likelihood threshold is exceeded whereupon the current proposal becomes a new accepted. For details of the methodology see the separate document on Parameter optimization, sensitivity and Monte Carlo analysis accessible via links in the package overview - help(StrathE2E2).

The new parameter files which are written back into the */Parameters* sub-folder of *the model/variant* folder are assembled from the final row of the ‘accepted’ parameter history.

Table 49. Column names and description for ‘proposed’ and ‘accepted’ parameter history files output from the e2e_optimize_eco() function.

Column number	Column name	Parameter description
1	PREF_NIT_kelp	Preference for uptake of nitrate uptake by macrophytes
2	PREF_AMM_kelp	Preference for uptake of ammonia uptake by macrophytes
3	PREF_NIT_phyt	Preference for uptake of nitrate uptake by phytoplankton
4	PREF_AMM_phyt	Preference for uptake of ammonia uptake by phytoplankton
5	PREF_phyt_herb	Preference for uptake of phytoplankton by omnivorous zooplankton
6	PREF_det_herb	Preference for uptake of suspended detritus by omnivorous
7	PREF_benthslar_herb	Preference for uptake of larvae of susp/dep feeding benthos by omnivorous zooplankton
8	PREF_benthclar_herb	Preference for uptake of larvae of carn/scav feeding benthos by omnivorous zooplankton
9	PREF_herb_carn	Preference for uptake of omnivorous zooplankton by carnivorous zooplankton
10	PREF_benthslar_carn	Preference for uptake of larvae of susp/dep feeding benthos by carnivorous zooplankton
11	PREF_benthclar_carn	Preference for uptake of larvae of carn/scav feeding benthos by carnivorous zooplankton
12	PREF_fishplar_carn	Preference for uptake of larvae of planktivorous fish by carnivorous zooplankton
13	PREF_fishdlar_carn	Preference for uptake of larvae of demersal fish by carnivorous zooplankton
14	PREF_herb_fishplar	Preference for uptake of omnivorous zooplankton by larvae of planktivorous fish

15	PREF_benthslar_fishplar	Preference for uptake of larvae of susp/dep feeding benthos by larvae of planktivorous fish
16	PREF_benthclar_fishplar	Preference for uptake of larvae of carn/scav feeding benthos by larvae of planktivorous fish
17	PREF_herb_fishp	Preference for uptake of omnivorous zooplankton planktivorous fish
18	PREF_carn_fishp	Preference for uptake of carnivorous zooplankton planktivorous fish
19	PREF_benthslar_fishp	Preference for uptake of larvae of susp/dep feeding benthos by planktivorous fish
20	PREF_benthclar_fishp	Preference for uptake of larvae of carn/scav feeding benthos by planktivorous fish
21	PREF_fishdlar_fishp	Preference for uptake of larvae of demersal fish by planktivorous fish
22	PREF_fishplar_fishp	Preference for uptake of larvae of planktivorous fish by planktivorous fish
23	PREF_herb_fishm	Preference for uptake of omnivorous zooplankton by migratory fish
24	PREF_carn_fishm	Preference for uptake of carnivorous zooplankton migratory fish
25	PREF_benthslar_fishm	Preference for uptake of larvae of susp/dep feeding benthos by migratory fish
26	PREF_benthclar_fishm	Preference for uptake of larvae of carn/scav feeding benthos by migratory fish
27	PREF_fishdlar_fishm	Preference for uptake of larvae of demersal fish by migratory fish
28	PREF_fishplar_fishm	Preference for uptake of larvae of planktivorous fish by migratory fish
29	PREF_herb_fishdlar	Preference for uptake of omnivorous zooplankton by larvae of demersal fish
30	PREF_benthslar_fishdlar	Preference for uptake of larvae of susp/dep feeding benthos by larvae of demersal fish
31	PREF_benthclar_fishdlar	Preference for uptake of larvae of carn/scav feeding benthos by larvae of demersal fish
32	PREF_carn_fishd	Preference for uptake of carnivorous zooplankton by demersal fish
33	PREF_benths_fishd	Preference for uptake of susp/dep feeding benthos by demersal fish
34	PREF_benthc_fishd	Preference for uptake of carn/scav feeding benthos by demersal fish
35	PREF_fishplar_fishd	Preference for uptake of larvae of planktivorous fish by demersal fish
36	PREF_fishdlar_fishd	Preference for uptake of larvae of demersal fish by demersal fish
37	PREF_fishp_fishd	Preference for uptake of planktivorous fish by demersal fosh
38	PREF_fishm_fishd	Preference for uptake of migratory fish by demersal fish
39	PREF_fishd_fishd	Preference for uptake of demersal fish by demersal fish
40	PREF_disc_fishd	Preference for uptake of discards by demersal fish
41	PREF_corp_fishd	Preference for uptake of corpses by demersal fish
42	PREF_phyt_benthslar	Preference for uptake of phytoplankton by larvae of susp/dep feeding benthos
43	PREF_phyt_benthclar	Preference for uptake of phytoplankton by larvae of carn/scav feeding benthos
44	PREF_det_benthslar	Preference for uptake of suspended detritus by larvae of susp/dep feeding benthos

45	PREF_det_benthclar	Preference for uptake of suspended detritus by larvae of carn/scav feeding benthos
46	PREF_phyt_benths	Preference for uptake of phytoplankton by susp/dep feeding benthos
47	PREF_det_benths	Preference for uptake of suspended detritus by susp/dep feeding benthos
48	PREF_sed_benths	Preference for uptake of sediment detritus by susp/dep feeding benthos
49	PREF_kelp_benthc	Preference for uptake of macrophytes by carn/scav feeding benthos
50	PREF_kelpdebris_benthc	Preference for uptake of macrophyte debris by carn/scav feeding benthos
51	PREF_benths_benthc	Preference for uptake of susp/dep feeding benthos by carn/scav feeding benthos
52	PREF_corp_benthc	Preference for uptake of corpses by carn/scav feeding benthos
53	PREF_carn_bird	Preference for uptake of carnivorous zooplankton by birds
54	PREF_benths_bird	Preference for uptake of susp/dep feeding benthos by birds
55	PREF_benthc_bird	Preference for uptake of carn/scav feeding benthos by birds
56	PREF_fishp_bird	Preference for uptake of planktivorous fish by birds
57	PREF_fishm_bird	Preference for uptake of migratory fish by birds
58	PREF_fishd_bird	Preference for uptake of demersal fish by birds
59	PREF_disc_bird	Preference for uptake of discards by birds
60	PREF_corp_bird	Preference for uptake of corpses by birds
61	PREF_carn_seal	Preference for uptake of carnivorous zooplankton by pinnipeds
62	PREF_benths_seal	Preference for uptake of susp/dep feeding benthos by pinniped
63	PREF_benthc_seal	Preference for uptake of carn/scav feeding benthos by pinniped
64	PREF_fishp_seal	Preference for uptake of planktivorous fish by pinniped
65	PREF_fishm_seal	Preference for uptake of migratory fish by pinniped
66	PREF_fishd_seal	Preference for uptake of demersal fish by pinniped
67	PREF_bird_seal	Preference for uptake of birds by pinnipeds
68	PREF_disc_seal	Preference for uptake of discards by pinnipeds
69	PREF_corp_seal	Preference for uptake of corpses by pinnipeds
70	PREF_herb_ceta	Preference for uptake of omnivorous zooplanktoin by cetaceans
71	PREF_carn_ceta	Preference for uptake of carnivorous zooplankton by cetaceans
72	PREF_benths_ceta	Preference for uptake of susp/dep feeding benthos by cetaceans
73	PREF_benthc_ceta	Preference for uptake of carn/scav feeding benthos by cetaceans
74	PREF_fishp_ceta	Preference for uptake of planktivorous fish by cetaceans

75	PREF_fishm_ceta	Preference for uptake of migratory fish by cetaceans
76	PREF_fishd_ceta	Preference for uptake of demersal fish by cetaceans
77	PREF_bird_ceta	Preference for uptake of birds by cetaceans
78	PREF_seal_ceta	Preference for uptake of pinnipeds by cetaceans
79	PREF_disc_ceta	Preference for uptake of discards by cetaceans
80	uC_kelp	Maximum carbon uptake rate of macrophytes at the Q10 reference temperature
81	ddexudC_kelp	Density dependent exudation rate parameter for macrophytes
82	u_kelp	Maximum nitrogen uptake rate of macrophytes at the Q10 reference temperature
83	u_phyt	Maximum uptake rate of phytoplankton at the Q10 reference temperature
84	u_herb	Maximum uptake rate of omnivorous zooplankton at the Q10 reference temperature
85	u_carn	Maximum uptake rate of carnivorous zooplankton at the Q10 reference temperature
86	u_fishplar	Maximum uptake rate of larvae of planktivorous fish at the Q10 reference temperature
87	u_fishp	Maximum uptake rate of at the Q10 reference temperature
88	u_fishm	Maximum uptake rate of at the Q10 reference temperature
89	u_fishdlar	Maximum uptake rate of at the Q10 reference temperature
90	u_fishd	Maximum uptake rate of at the Q10 reference temperature
91	u_benthslar	Maximum uptake rate of at the Q10 reference temperature
92	u_benthclar	Maximum uptake rate of at the Q10 reference temperature
93	u_benths	Maximum uptake rate of at the Q10 reference temperature
94	u_benthc	Maximum uptake rate of at the Q10 reference temperature
95	u_bird	Maximum uptake rate of at the Q10 reference temperature
96	u_seal	Maximum uptake rate of at the Q10 reference temperature
97	u_ceta	Maximum uptake rate of at the Q10 reference temperature
98	h_kelp	Half-saturation coefficient for uptake by macrophytes
99	h_phyt	Half-saturation coefficient for uptake by phytoplankton
100	h_herb	Half-saturation coefficient for uptake by omnivorous zooplankton
101	h_carn	Half-saturation coefficient for uptake by carnivorous zooplankton
102	h_fishplar	Half-saturation coefficient for uptake by larvae of planktivorous fish
103	h_fishp	Half-saturation coefficient for uptake byplanktivorous fish
104	h_fishm	Half-saturation coefficient for uptake by migratory fish

105	h_fishdlar	Half-saturation coefficient for uptake by larvae of demersal fish
106	h_fishd	Half-saturation coefficient for uptake by demersal fish
107	h_benthslar	Half-saturation coefficient for uptake by larvae of susp/dep feeding benthos
108	h_benthclar	Half-saturation coefficient for uptake by larvae of carn/scav feeding benthos
109	h_benths	Half-saturation coefficient for uptake by susp/dep feeding benthios
110	h_benthc	Half-saturation coefficient for uptake by carn/scav feeding benthos
111	h_bird	Half-saturation coefficient for uptake by birds
112	h_seal	Half-saturation coefficient for uptake by pinnipeds
113	h_ceta	Half-saturation coefficient for uptake by cetaceans
114	bda_par_bird	Beddington-DeAngelis uptake coefficient for birds
115	bda_par_seal	Beddington-DeAngelis uptake coefficient for pinnipeds
116	bda_par_ceta	Beddington-DeAngelis uptake coefficient for cetaceans
117	xmt	Water column detritus mineralisation rate at Q10 reference temperature
118	xnst	Upper layer water column ammonia nitrification rate at Q10 reference temperature
119	xdst	Upper layer water column nitrate nitrification rate at Q10 reference temperature
120	xndt	Lower layer water column ammonia nitrification rate at Q10 reference temperature
121	xddt	Lower layer water column nitrate nitrification rate at Q10 reference temperature
122	xqs_p1	Proportion of sediment detritus or corpses converted to refractory detritus during the mineralisation or disintegration process
123	xqs_p2	Mineralisation rate of refractory detritus is a proportion of the ambient rate for labile sediment detritus
124	xqs_p3	Proportion of ingested refractory detritus digestible by benthos
125	xmsedt	Sediement detritus mineralisation rate in reference grain size and Q10 referencce temperatre
126	xmsens	Grain size sensitivity for sediment mineralisation rate
127	xnsedt	Sediement ammonia nitrification rate in reference grain size and Q10 referencce temperatre
128	xnsens	Grain size sensitivity for sediment nitrification rate
129	xdsedt	Sediement nitrate denitrification rate in reference grain size and Q10 referencce temperatre
130	xdsens	Grain size sensitivity for sediment denitrification rate
131	xdisc_corp	Conversion rate of discards to corpses
132	xxcorp_det	Conversion rate of corpses to detritus at Q10 reference temperature
133	xkelpdebris_det	Conversion rate of macrophyte debris to detritus at Q10 reference temperature

134	xdsink_s	Suspended detritus sinking rate in the upper layers
135	xdsink_d	Suspended detruts sinking rate in the lower layer
136	xkelpshade	Self-shading coefficient for macrophytes
137	xwave_kelpdebris	Coefficent for wave-dependent export of macrophyte debris to beach-cast
138	xdfdp	Fitting coefficient for demersal fish nitrogen mass in the model to survey biomass
139	xxwave_kelp	Density dependent sensitivity of macrophytes to destruction by wave action
140	xxst	Density dependent mortality coefficient for phytoplankton in the upper layer
141	xxdt	Density dependent mortality coefficient for phytoplankton in the lower layer
142	xxherb	Density dependent mortality coefficient for omnivorous zooplankton
143	xxcarn	Density dependent mortality coefficient for carnivorous zooplankton
144	xxbenthslar	Density dependent mortality coefficient for larvae of susp/dep feeding benthos
145	xxbenthclar	Density dependent mortality coefficient for larvae of carn/scav feedinmg benthos
146	xxbenths	Density dependent mortality coefficient for susp/dep feeding benthos
147	xxbenthc	Density dependent mortality coefficient for carn/scav feeding benthos
148	xxpfishlar	Density dependent mortality coefficient for larvae of planktivorous fish
149	xxdfishlar	Density dependent mortality coefficient for larvae of demersal fish
150	xxpfish	Density dependent mortality coefficient for planktivorous fish
151	xxmfish	Density dependent mortality coefficient for migratory fish
152	xxdfish	Density dependent mortality coefficient for demersal fish
153	xxbird	Density dependent mortality coefficient for birds
154	xxseal	Density dependent mortality coefficient for pinnipeds
155	xxceta	Density dependent mortality coefficient for cetaceans
156	xpfish_migcoef	Active migration coefficient for planktivorous fish
157	xmfish_migcoef	ctive migration coefficient for migratory fish
158	xdfish_migcoef	ctive migration coefficient for demersal fish
159	xbird_migcoef	ctive migration coefficient for birds
160	xseal_migcoef	ctive migration coefficient for pinnipeds
161	xceta_migcoef	ctive migration coefficient for cetaceans
162	xmax_exploitable_f_KP	Maximum exploitable fration of biomass for macrophytes
163	xmax_exploitable_f_PF	Maximum exploitable fration of biomass for planktivorous fish

164	xmax_exploitable_f_DF	Maximum exploitable fration of biomass for demersal fish
165	xmax_exploitable_f_MF	Maximum exploitable fration of biomass for migratory fish
166	xmax_exploitable_f_SB	Maximum exploitable fration of biomass for susp/dep feeding benthos
167	xmax_exploitable_f_CB	Maximum exploitable fration of biomass for carn/scav feeding benthos
168	xmax_exploitable_f_CZ	Maximum exploitable fration of biomass for carnivorous zooplankton
169	xmax_exploitable_f_BD	Maximum exploitable fration of biomass for birds
170	xmax_exploitable_f_SL	Maximum exploitable fration of biomass for pinnipeds
171	xmax_exploitable_f_CT	Maximum exploitable fration of biomass for cetaceans
172	annual_obj	Likelihood of the target data given the model, driving data and parameters

OUTPUTS FROM OPTIMIZATION OF HARVEST RATIO SCALING PARAMETERS

The function

e2e_optimize_hr()

uses simulated annealing to seek a set of harvest ratio scaling parameters which maximize the likelihood of the observed annual target data (in the file */Target_data/ annual_target_data*.csv*) given the model structure, drivers, ecology parameters and fishing gear activity rates. This scheme would be used in a situation where ecology model parameters and gear gear activity rates are known or can be adopted e.g. from a neighbouring or similar region, but individual gear catching efficiencies (linking effort to harvest ratio) are unknown.

The argument model is the list object created by the e2e_read() function, exactly as for a basic single run of the model.

e2e_read(model.name, model.variant, model.ident = "base", model.subdir = "", user.path = "")

Harvest ratios of each resource guild in the ecology model are proportional to the fishing effort directed to each guild integrated across all gears, and scaled by a proportionality coefficient. 'Effort' is the product of activity and power for reach gear, and the integration across gears is performed by the fleet model. The proportionality coefficients are presented to the fleet model in rows 12-20 of the input file *fishing_fleet_parameters-*.csv* (see Table 14). In the process of constructing a model, these parameters need to be simply calculated if the harvest ratios are known from independent data anlaysis (see the function e2e_calculate_hrscale()), or fitted as described here using the e2e_optimize_hr() if the actual harvest ratios are unknown.

The actual harvest ratios which are applied in the ecology model are the product of values for each guild derived from gerar activity rates, power parameters and harvest ratio scaling values by the fleet model, and a set of multipler values for each guild coinhtauined in the input file */Parameters/harvest_ratio_multiplier-*.csv* (see Table 22). These multipliers are provided to facilitate the easy design of scenario experiments with the model. Starting from an initial combinatioin of harvest ratio scaling parameters in *fishing_fleet_parameters-*.csv* and multiplers in *harvest_ratio_multiplier-*.csv,* the e2e_optimize_hr() function generates a news set of multipliers which produces the maximum likelihood of the observed target data.

The new multiplier values generated at the end of simulated annealing run are written back to the */Parameters* folder for the model/variant, in a as a new version of *harvest_ratio_multiplier-*.csv* with an identifier defined by the model.ident argument in the initial e2e_read() call. Should the user wish to adopt the fitted activity rates in future runs, then there are two options:

1. Edit the *MODEL_SETUP.csv* file to point to the new version of *harvest_ratio_multiplier-*.csv*
2. Create a new version of *fishing_fleet_parameters-*.csv* in which the harvest ratio scaling parameters in rows 12-20 are the product of the original values and the new multiplier values; create a version of *harvest_ratio_multiplier-*.csv* in which the values are 1.0 for all guilds; and edit *MODEL_SETUP.csv* accordingly.

In addition to writing the final best-fit set of multiplier values back to the */Parameters* folder, the simulated annealing function returns the history of "proposed" and "accepted" parameter sets and the associated likelihoods as dataframes in a list object, and optionally saves them to *.csv* files in the current default */results/model/variant* folder. The address for this folder can be set by the model.subdir argument in the e2e_read() function call.

File names for the 'proposed' and 'accepted' history files generated by the function are as follows:

annealing_HRmult_proposalhistory-.csv*
annealing_HRmult_acceptedhistory-.csv*

where the identifier (*) is set by the argument model.ident in the e2e_read() function call which loads the initial model setup.

The "proposed" and "accepted" parameter history data files both have the same structure – rows are sequential iterations of the parameter set, columns are the multipliers for each model guild, with the addition of a final column providing the likelihood of the target data (Table 53). Proposed values are variants from the most recent accepted set. New proposals are tested until a likelihood threshold is exceeded whereupon the current proposal becomes a new accepted. For details of the methodology see the separate document on Parameter optimization, sensitivity and Monte Carlo analysis accessible via links in the package overview - help(StrathE2E2).

The new set of multiplier values which is written back into the */Parameters* sub-folder is assembled from the final row of the 'accepted' parameter history.

Table 53. Column names and description for 'proposed' and 'accepted' parameter history files output from the e2e_optimize_hr() **function.**

Column number	Column name	Parameter description
1	PF	Multiplier applied to planktivorous fish
2	DF	Multiplier applied to demersal fish
3	MF	Multiplier applied to migratory fish
4	Bfd	Multiplier applied to susp/dep feeding benthos
5	Bcs	Multiplier applied to carn/scav feeding benthos
6	Zc	Multiplier applied to carnivorous zooplankton
7	BD	Multiplier applied to birds
8	SL	Multiplier applied to pinnipeds
9	CT	Multiplier applied to cetaceans
10	KP	Multiplier applied to macrophytes
11	Lik	Likelihood of the target data given the model, driving data, parameters and harvest ratio scalings

OUTPUTS FROM OPTIMIZATION OF FISHING GEAR ACTIVITY RATES AGAINST ECOSYSTEM TARGET DATA

The function

e2e_optimize_act(… ,selection="ECO", …)

uses simulated annealing to seek a set of fishing gear activity rates which maximize the likelihood of the observed annual target data on the state of the ecosystem (in the file */Target_data/ annual_target_data*.csv*) given the model structure, drivers, and ecology and other fishing fleet parameters. This scheme would be used in a situation where ecology model parameters and gear efficiencies are known or can be adopted e.g. from a neighbouring or similar region, but individual gear activity rates and harvest ratios are unknown.

Activity rates of gears within the model are set by product of two input data sets – the activity densities defined in the file */Parameters/ fishing_activity_parameters-*.csv* (Table 16), and the activity rate multiplier values in the file */Parameters/fishing_activity_multiplier-*.csv* (Table 21). Typically, the baseline configuration of a model variant would be defined by the activity densities with the multipliers set to 1.0, and subsequent scenarios designed by manipulating the multipliers.

The initial activity conditions for an e2e_optimize_act(.. , selection="ECO", ,,) run (defined by the pointers to input files in *MODEL_SETUP.csv*), can be based on any combinations of defined activity rates and associate multipliers which provide an initial guess at the activity rates of the individual gears. The outcome of the fitting process is a new set of multiplier values which, when applied to the initial activity rate file, produce the maximum likelihood of the target data.

The new multiplier values generated at the end of simulated annealing run are written back to the */Parameters* folder for the model/variant, in a as a new version of *fishing_activity_multiplier-*.csv* with an identifier defined by the model.ident argument in the initial e2e_read() call. Should the user wish to adopt the fitted activity rates in future runs, then there are two options:

1. Edit the *MODEL_SETUP.csv* file to point to the new version of *fishing_activity_multiplier-*.csv*
2. Create a new version of *fishing_activity_parameters-*.csv* in which the activity rates are the product of the original values and the new multiplier values; create a version of *fishing_activity_multiplier-*.csv* in which the values are 1.0 for all gears; and edit *MODEL_SETUP.csv* accordingly.

In addition to writing the final best-fit set of multiplier values back to the */Parameters* folder, the simulated annealing function returns the history of "proposed" and "accepted" parameter sets and the associated likelihoods as dataframes in a list object and optionally saves to *.csv* files in

the current default */results/model/variant* folder. The address for this folder can be set by the model.subdir argument in the e2e_read() function call.

File names for the 'proposed' and 'accepted' history files generated by the function are as follows:

annealing_ACTmult_proposalhistory-.csv*

annealing_ACTmult_acceptedhistory-.csv*

where the identifier (*) is set by the argument model.ident in the e2e_read() function call which loads the initial model setup.

The "proposed" and "accepted" parameter history data files both have the same structure – rows are sequential iterations of the parameter set, columns are the individual gear multipliers, with the addition of a final column providing the likelihood of the target data (Table 50). Proposed values are variants from the most recent accepted set. New proposals are tested until a likelihood threshold is exceeded whereupon the current proposal becomes a new accepted. For details of the methodology see the separate document on Parameter optimization, sensitivity and Monte Carlo analysis accessible via links in the package overview - help(StrathE2E2).

The new set of multiplier values which is written back into the */Parameters* sub-folder is assembled from the final row of the 'accepted' parameter history.

Table 50. Column names and description for 'proposed' and 'accepted' parameter history files output from the e2e_optimize_act(… ,selection="ECO", …) **function.**

Column number	Column name	Parameter description
1	G1	Multiplier applied to gear 1
2	G2	Multiplier applied to gear 2
3	G3	Multiplier applied to gear 3
4	G5	Multiplier applied to gear 4
5	G5	Multiplier applied to gear 5
6	G6	Multiplier applied to gear 6
7	G7	Multiplier applied to gear 7
8	G8	Multiplier applied to gear 8
9	G9	Multiplier applied to gear 9
10	G10	Multiplier applied to gear 10

11	G11	Multiplier applied to gear 11
12	G12	Multiplier applied to gear 12
13	Lik	Likelihood of the target data given the model, driving data, parameters and activity rates

OUTPUTS FROM OPTIMIZATION OF FISHING GEAR ACTIVITY RATES AGAINST KNOWN HARVEST RATIOS

The function

e2e_optimize_act(… ,selection="HR", …)

uses simulated annealing to seek a set of fishing gear activity rates which maximize the likelihood of known annual target data on the harvest ratios on each guild in each spatial zone (in the file */Target_data/ annual_target_data*.csv*) given the model structure, drivers, and ecology and other fishing fleet parameters. In this case the annealing process is plied only to the fishing fleet model, not to the whole linked fleey-ecology system. This scheme would be used in a situation where ecology model parameters and gear efficiencies are known or can be adopted e.g. from a neighbouring or similar region, but individual gear activity rates are unknown.

The implementation of simulated annealing in this function is slightly different to the other optimization functions in the package. In this case, because the problem of local maxima in the likelihood response surface is particularly acute (due to the potential overlap in the selectivities of different gears), so the annealing process is replicated many times from different randomly selected initial conditions. We refer to these replicates as 'trajectories'. Each trajectory follows a different pathway through the parameter space. At the end of the process, the best-fit set of activity multipliers is selected from across all the trajectories. In addition, the coefficient for jiggling the parameters is systematically attenuated with increasing iterations rather than remaining constant or potentailly being manually attenuated during the run by the user. Because the process uses only the fishing fleet model it is relatively fast so many trajectories can be run in a moderate time span.

Activity rates of gears within the model are set by product of two input data sets – the activity densities defined in the file */Parameters/ fishing_activity_parameters-*.csv* (Table 16), and the activity rate multiplier values in the file */Parameters/fishing_activity_multiplier-*.csv* (Table

21). Typically, the baseline configuration of a model variant would be defined by the activity densities with the multipliers set to 1.0, and subsequent scenarios designed by manipulating the multipliers.

The initial activity conditions for an e2e_optimize_act(… ,selection="HR", …) run (defined by the pointers to input files in *MODEL_SETUP.csv*), can be based on any combinations of defined activity rates and associate multipliers which provide an initial guess at the activity rates of the individual gears. The outcome of the fitting process is a new set of multiplier values which, when applied to the initial activity rate file, produce the maximum likelihood of the target data.

The new multiplier values generated from the at the end of the maximum likelihood simulated annealing trajectory are written back to the */Parameters* folder for the model/variant, as a new version of *fishing_activity_multiplier-*.csv* with an identifier defined by the model.ident argument in the initial e2e_read() call. Should the user wish to adopt the fitted activity rates in future runs, then there are two options:

1. Edit the *MODEL_SETUP.csv* file to point to the new version of *fishing_activity_multiplier-*.csv*
2. Create a new version of *fishing_activity_parameters-*.csv* in which the activity rates are the product of the original values and the new multiplier values; create a version of *fishing_activity_multiplier-*.csv* in which the values are 1.0 for all gears; and edit *MODEL_SETUP.csv* accordingly.

In addition to writing the final best-fit set of multiplier values back to the */Parameters* folder, the simulated annealing function returns data on the end-state of eavj trajectory (parameter values and likelihoods, and resulting harvest ratios) as dataframes in a llts object and optionally saves these as *.csv* files in the current default */results/model/variant* folder. The address for this folder can be set by the model.subdir argument in the e2e_read() function call.

File names for the 'multipler' and 'harvest ratio' distribution files generated by the function are as follows:

activity_optim_gearmult_history -.csv*
activity_optim_harvestratio_history -.csv*
activity_optim_gearmult_relinitial_history -.csv*
activity_optim_harvestratio_reltarget_history -.csv*

where the identifier (*) is set by the argument model.ident in the e2e_read() function call which loads the initial model setup. The first pair of files contain the histories of the absolute values o fthe gear multipliers and the resulting harvest ratios. The second pair of files contains these data relative to the initial values of multiplers, or the target harvest ratios.

The output files (and dataframes) all have the same structure – rows are trajectories, columns are variables (multipliers or harvest ratios) and the final column is the associated likelihood. centiles of the distribution of likelihood-weighted properties (multipliers or difference between target and modelled harvest ratio), columns are either rthe gears, or the guilds. sequential iterations of the parameter set, columns are the individual gear multipliers, with the addition of a final column providing the likelihood of the target data (Table 51, 52).

For details of the methodology see the separate document on Parameter optimization, sensitivity and Monte Carlo analysis accessible via links in the package vignette ("*vignette("StrathE2E2")*") or package overview ("*help(StraathE2E2)*").

Table 51. Column names for the table of gear multiplier histories (*activity_optim_gearmult_history* and *activity_optim_gearmult_relinitial_history*) **output from the** e2e_optimize_act(… , selection="HR", …) **function.** Rows are trajectories. G1-G12 in the Column names refers to the gear codes set up in the gear activity parameter file.

Column number	Column name	Parameter description
1	G1	Multiplier applied to gear 1
2	G2	Multiplier applied to gear 2
3	G3	Multiplier applied to gear 3
4	G5	Multiplier applied to gear 4
5	G5	Multiplier applied to gear 5
6	G6	Multiplier applied to gear 6
7	G7	Multiplier applied to gear 7
8	G8	Multiplier applied to gear 8
9	G9	Multiplier applied to gear 9
10	G10	Multiplier applied to gear 10
11	G11	Multiplier applied to gear 11
12	G12	Multiplier applied to gear 12
13	lik	Likelihood

Table 52. Column names for the table of statistics on the difference beween target and modelled harvest ratios (*activity_optim_harvestratio_history* and *activity_optim_harvestratio_reltarget_history*) **output from the** e2e_optimize_act(… , selection="HR", …) **function.**

Column number	Column name	Parameter description
1	PFi	Planktivorous fish inshore
2	PFo	Planktivorous fish offshore
3	DFi	Demersal fish inshore
4	DFo	Demersal fish offshore
5	MFi	Migratory fish inshore
6	MFo	Migratory fish offshore
7	Bsdi	Benthos susp/dep feeders inshore
8	Bsdo	Benthos susp/dep feeders offshore
9	Bcsi	Benthos carn/scav feeders inshore
10	Bcso	Benthos carn/scav feeders offshore
11	CZi	Carniv. zooplankton inshore
12	CZo	Carniv. zooplankton offshore
13	BDi	Birds inshore
14	BDo	Birds offshore
15	SLi	Pinnipeds inshore
16	SLo	Pinnipeds offshore
17	CTi	Cetaceans inshore
18	CTo	Cetaceans offshore
19	KPi	Macrophytes inshore
20	KPo	Macrophytes offshore (always NA)
21	lik	Likelihood

OUTPUTS FROM SENSITIVITY ANALYSIS

The function e2e_run_sens() conducts a "one-at-a-time" analysis of the sensitivity of the model (measured by likelihood of the observed target data in the file */Target_data/ annual_target_data*.csv*) to the drivers and parameters of the ecology and fishing fleet models, using a factorial sampling scheme based on Morris (1991).

The function includes the physical configuration parameters (layer thickness and areas), all of the fixed and fitted parameters of the ecology model, the fishing fleet parameters and environmental driving data in the sensitivity analysis.

A list of initial parameter and driving data (θ) for the sampling method, referred to as the 'parent', is defined by the input files listed in the *MODEL_SETUP.csv* file which are loaded by the e2e_read() function. This could, for example, be the parameter set producing the maximum likelihood of the target date as generated by simulated annealing.

From this parent, child lists are generated (θ^*_k , $1 \le k \le r$) by applying a separate random increment to all the parameter; $\theta^*_k = \theta + \delta[k]$ where δ[k] is a vector of random values from a gaussian distribution of mean 0 and standard deviation given by a fixed coefficient of variation. The parent and each child-lists form the baslines for model 'trajectories'

For reach trajectory, each of the parameters ($1 \le i \le n$; n=453) is incremented one-at-a-time by a fixed proportionality from the baseline value, the model re-run to a stationary state (50 years to guarantee stationarity), and the likelihood computed ($P(observations|\theta^*_{k,i})$). The proportionality increment for a given trajectory is drawn at random from a set of four fixed levels in the range ±10% of the child parameter set (Δ = {0.9, 0.95, 0.05, 0.10}). Hence, for each trajectory the model runs are repeated n+1 times, where i=0 corresponds to the baseline run for each trajectory. The total number of nested runs to support the sensitivity analysis is thus r*(n+1). Even a modest number of trajectories the number of runs required represents a significant coimputing task and the run-time may require a few days depending on the processing capabilities of the machine.

For each level-run of a trajectory the "elementary effect" (EE) of the parameter is calculated from the difference in likelihood from the baseline, as follows:

$$EE_{k,i} = \frac{P\left(observations\middle|\theta^*_{k,i}\right) - P\left(observations\middle|\theta^*_{k,0}\right)}{\Delta}$$

On completion of the runs for all trajectories, the mean (μ_i) and standard deviation (S_i) of the r elementary effects for each parameter (i) are calculated. For the mean,

$$\mu_i = \frac{1}{r}\sum_{k=1}^{r} EE_{k,i}$$

The magnitude of the mean represents the sensitivity of each parameter, and the corresponding standard deviation indicates the degree of non-linearity in the response or interaction with other parameters. The standard error of the mean for each parameter (SEM_i) is given by:

$$SEM_i = \frac{S_i}{\sqrt{r}}$$

If $S_i > |\mu_i| \cdot \frac{\sqrt{r}}{2}$ then we can approximately conclude that μ_i is significantly greater than zero.

The e2e_run_sens() function is computationally intensive, so arguments are include to enable the task to be shared across multiple processor/machines and for the results to be merged afterwards.

The e2e_run_sens() function saves a number of outputs to *.csv* files in the */results/model/variant* folder of the current user-workspace:

- table "*OAT_results-*.csv"* (Table 54) in which rows correspond to individual model runs, listing the trajectory and level identity, which parameter was incremented in the run and by what proportion, and the resulting likelihood value and elementary effect,
- table "*OAT_parameter_values-*.csv"* in which rows correspond to individual model runs as above, and the columns are the values of each parameter which was used in each run,
- table "*sorted_parameter_elemental_effects-*.csv"* (Table 55) of the mean (μ_i) and standard deviation (S_i) and significance (SEM_i; sig/ns) of the elementary effects for each parameter identity (rows), sorted by the by values of mean (μ_i).

In each case the identifier (*) for each file name is set my the model.ident argumed in the e2e_read() functiion call which loads the initial conditions for the analysis. A plotting function e2e_plot_sens_mc() is provided to visualise the data in the table of mean, sd and significance of the elementary effects.

Details of all the parameters included in the sensitivity analysis can be downloaded as a dataframe from the package using the function e2e_get_parmdoc() (Table 56).

Table 54. Details of the columns in the *OAT_results-*.csv* output file from the sensitivity analysis. Rows correspond to individual trajectory/level model runs.

Column number	Column name	Description
1	parametername	Text labels the single parameter which was incremented for a given trajectory/level model run (see Table 56 for details). Baseline runs for each trajectory (in which all parameters were randomly varied) are identified by the label “baseline”.
2	parameterid	Numeric code identifying the single parameter which was incremented for a given trajectory/level model run (see Table 56 for details). Baseline runs for each trajectory are identified by the code 0
3	trajectoryid	Trajectory number
4	levelid	Level identifier for the runs within each trajectory (values 1,2,3,4). All level runs for a given trajectory use the same level identifier.
5	delta_p	Proportionaly increment applied to each parameters in the set of levl runs for a a given trajectory. All level runs for a given trajectory use the same proportionality increment.
6	likelihood	Likelihood of the target data given the parameter values for a given trajectory/level run
7	EE	Elementary effect for the parameter incremented in a given trajectory/levl run. The elementery effects for the baseline runs of each trajectory are set to zero

Table 55. Details of the columns in the *sorted_parameter_elementary_effects-*.csv* output file from the sensitivity analysis. Rows correspond to individual parameters.

Column number	Column name	Description
1	parametername	Text labels the single parameter which was incremented for a given trajectory/level model run (see Table 56 for deaiils). Baseline runs for each trajectory (in which all parameters were randomly varied) are identified by the label “baseline”.
2	parameterid	Numeric code identifying the single parameter which was incremented for a given trajectory/level model run (see Table 56 for details). Baseline runs for each trajectory are identified by the code 0
3	fixfit	Numeric code identifying the type of parameter: 0 = fitted ecology model parameter, 1 = fixed ecology model parameter, 2 = fishing fleet parameter, 3 = harvest ratio values, 4 = environmental drivers, 5 = physical configuration parameters (see Table 56 for details).
4	EEmean	Value of the mean elementary effect (μ_i) for a given parameter (i)
5	EEsd	Value of the standard deviation of elementary effects (S_i) for a given parameter (i)
6	EEmean_non_0	Significance of the elementary effect (SEM_i) for a given parameter (i), values = “sig” or “ns”
7	Ntrajectories	Number of trajectories in the analysis
8	Parameter.class	Group to which the parameter belongs (Text field corresponding to column 3; Ecology model fixed, Ecology model

		fitted, Fishing fleet model, Harvest ratio Environmental drivers, Physical configuration)
9	Parameter.description	Text description of the parameter
10	Model.guild.or.feature	Text description o fthe guild or feature associated with the parameter

Table 56. Details of the parameters documentation available as a dataframe using the function e2e_get_parmdoc(). The column names "parametername", "parameterid" and "fixfit" refer to column names described in Tables 54 and 55. The values of "parametername" also correspond to the column header in the output file "*OAT_parameter_values-*.csv".*

parametername	parameterid	fixfit	Parameter class	Parameter description	Model guild or feature
thik_so	1	5	Physical configuration	Vertical thickness	Offshore zone upper layer
thik_d	2	5	Physical configuration	Vertical thickness	Offshore zone lower layer
thik_si	3	5	Physical configuration	Vertical thickness	Inshore zone
thik_b	4	5	Physical configuration	Vertical thickness	Benthic boundary feeding layer
porosity_s1	28	5	Physical configuration	Sediment porosity	Inshore muddy sediments
porosity_s2	29	5	Physical configuration	Sediment porosity	Inshore sandy sediments
porosity_s3	30	5	Physical configuration	Sediment porosity	Inshore coarse sediments
porosity_d1	31	5	Physical configuration	Sediment porosity	Offshore muddy sediments
porosity_d2	32	5	Physical configuration	Sediment porosity	Offshore sandy sediments
porosity_d3	33	5	Physical configuration	Sediment porosity	Offshore coarse sediments
sed_wat_dif_s1	34	5	Physical configuration	Hydraulic conductivity	Inshore muddy sediments
sed_wat_dif_s2	35	5	Physical configuration	Hydraulic conductivity	Inshore sandy sediments
sed_wat_dif_s3	36	5	Physical configuration	Hydraulic conductivity	Inshore coarse sediments
sed_wat_dif_d1	37	5	Physical configuration	Hydraulic conductivity	Offshore muddy sediments
sed_wat_dif_d2	38	5	Physical configuration	Hydraulic conductivity	Offshore sandy sediments
sed_wat_dif_d3	39	5	Physical configuration	Hydraulic conductivity	Offshore coarse sediments
sed_ref_Kxw	40	5	Physical configuration	Hydraulic conductivity	Reference value for sediment-dependent processes
bioturb_depth_s1	41	5	Physical configuration	Bioturbation depth	Inshore muddy sediments
bioturb_depth_s2	42	5	Physical configuration	Bioturbation depth	Inshore sandy sediments
bioturb_depth_s3	43	5	Physical configuration	Bioturbation depth	Inshore coarse sediments
bioturb_depth_d1	44	5	Physical configuration	Bioturbation depth	Offshore muddy sediments
bioturb_depth_d2	45	5	Physical configuration	Bioturbation depth	Offshore sandy sediments
bioturb_depth_d3	46	5	Physical configuration	Bioturbation depth	Offshore coarse sediments
erosion_depth_s1	47	5	Physical configuration	Physical disturbance depth	Inshore muddy sediments
erosion_depth_s2	48	5	Physical configuration	Physical disturbance depth	Inshore sandy sediments
erosion_depth_s3	49	5	Physical configuration	Physical disturbance depth	Inshore coarse sediments
erosion_depth_d1	50	5	Physical configuration	Physical disturbance depth	Offshore muddy sediments
erosion_depth_d2	51	5	Physical configuration	Physical disturbance depth	Offshore sandy sediments
erosion_depth_d3	52	5	Physical configuration	Physical disturbance depth	Offshore coarse sediments

lightSPM_intercept	53	5	Physical configuration	Intercept	Light attenuation coefficient vs SPM
lightSPM_slope	54	5	Physical configuration	Coefficient	Light attenuation coefficient vs SPM
inshore_phyt_prop_depth	55	5	Physical configuration	Proportion of depth range occupied	Phytoplankton inshore
inshore_kelp_prop_depth	56	5	Physical configuration	Proportion of depth range occupied	Macrophytes inshore
F_inshore_pelagic	57	3	Harvest ratio	Harvest ratio inshore	Planktivorous fish
F_offshore_pelagic	58	3	Harvest ratio	Harvest ratio offshore	Planktivorous fish
F_inshore_demersal	59	3	Harvest ratio	Harvest ratio inshore	Demersal fish
F_offshore_demersal	60	3	Harvest ratio	Harvest ratio offshore	Demersal fish
F_inshore_migratory	61	3	Harvest ratio	Harvest ratio inshore	Migratory fish
F_offshore_migratory	62	3	Harvest ratio	Harvest ratio offshore	Migratory fish
F_inshore_filtben	63	3	Harvest ratio	Harvest ratio inshore	Suspension/deposit feeding benthos
F_offshore_filtben	64	3	Harvest ratio	Harvest ratio offshore	Suspension/deposit feeding benthos
F_inshore_carnben	65	3	Harvest ratio	Harvest ratio inshore	Carnivore/scavenge feeding benthos
F_offshore_carnben	66	3	Harvest ratio	Harvest ratio offshore	Carnivore/scavenge feeding benthos
F_inshore_carnzoo	67	3	Harvest ratio	Harvest ratio inshore	Carnivorous zooplankton
F_offshore_carnzoo	68	3	Harvest ratio	Harvest ratio offshore	Carnivorous zooplankton
F_inshore_bird	69	3	Harvest ratio	Harvest ratio inshore	Birds
F_offshore_bird	70	3	Harvest ratio	Harvest ratio offshore	Birds
F_inshore_seal	71	3	Harvest ratio	Harvest ratio inshore	Pinnipeds
F_offshore_seal	72	3	Harvest ratio	Harvest ratio offshore	Pinnipeds
F_inshore_ceta	73	3	Harvest ratio	Harvest ratio inshore	Cetaceans
F_offshore_ceta	74	3	Harvest ratio	Harvest ratio offshore	Cetaceans
F_inshore_kelp	75	3	Harvest ratio	Harvest ratio inshore	Macrophytes
F_offshore_kelp	76	3	Harvest ratio	Harvest ratio offshore	Macrophytes
QnQ_coef	77	2	Fishing fleet model	Coefficient	Demersal fish non-quota proportion in catch vs nitrogen mass
QnQ_exp	78	2	Fishing fleet model	Exponent	Demersal fish non-quota proportion in catch vs nitrogen mass
NQus_coef	79	2	Fishing fleet model	Coefficient	Demersal fish non-quota undersize vs nitrogen mass
NQus_exp	80	2	Fishing fleet model	Exponent	Demersal fish non-quota undersize vs nitrogen mass
QLus_coef	81	2	Fishing fleet model	Coefficient	Demersal fish quota-limited undersize vs nitrogen mass
QLus_exp	82	2	Fishing fleet model	Exponent	Demersal fish quota-limited undersize vs nitrogen mass
D_inshore_pelagic	83	2	Fishing fleet model	Discard rate inshore	Planktivorous fish
D_offshore_pelagic	84	2	Fishing fleet model	Discard rate offshore	Planktivorous fish
D_inshore_demersal	85	2	Fishing fleet model	Discard rate inshore	Demersal fish
D_offshore_demersal	86	2	Fishing fleet model	Discard rate offshore	Demersal fish
D_demersal	87	2	Fishing fleet model	Discard rate all areas	Demersal fish all areas

D_inshore_migratory	88	2	Fishing fleet model	Discard rate inshore	Migratory fish
D_offshore_migratory	89	2	Fishing fleet model	Discard rate offshore	Migratory fish
D_inshore_filtben	90	2	Fishing fleet model	Discard rate inshore	Suspension/deposit feeding benthos
D_offshore_filtben	91	2	Fishing fleet model	Discard rate offshore	Suspension/deposit feeding benthos
D_inshore_carnben	92	2	Fishing fleet model	Discard rate inshore	Carnivore/scavenge feeding benthos
D_offshore_carnben	93	2	Fishing fleet model	Discard rate offshore	Carnivore/scavenge feeding benthos
D_inshore_carnzoo	94	2	Fishing fleet model	Discard rate inshore	Carnivorous zooplankton
D_offshore_carnzoo	95	2	Fishing fleet model	Discard rate offshore	Carnivorous zooplankton
D_inshore_bird	96	2	Fishing fleet model	Discard rate inshore	Birds
D_offshore_bird	97	2	Fishing fleet model	Discard rate offshore	Birds
D_inshore_seal	98	2	Fishing fleet model	Discard rate inshore	Pinnipeds
D_offshore_seal	99	2	Fishing fleet model	Discard rate offshore	Pinnipeds
D_inshore_ceta	100	2	Fishing fleet model	Discard rate inshore	Cetaceans
D_offshore_ceta	101	2	Fishing fleet model	Discard rate offshore	Cetaceans
D_inshore_kelp	102	2	Fishing fleet model	Discard rate inshore	Macrophytes
D_offshore_kelp	103	2	Fishing fleet model	Discard rate offshore	Macrophytes
G_inshore_pelagic	104	2	Fishing fleet model	Processing at sea rate inshore	Planktivorous fish
G_offshore_pelagic	105	2	Fishing fleet model	Processing at sea rate offshore	Planktivorous fish
G_inshore_demersal	106	2	Fishing fleet model	Processing at sea rate inshore	Demersal fish
G_offshore_demersal	107	2	Fishing fleet model	Processing at sea rate offshore	Demersal fish
G_inshore_migratory	108	2	Fishing fleet model	Processing at sea rate inshore	Migratory fish
G_offshore_migratory	109	2	Fishing fleet model	Processing at sea rate offshore	Migratory fish
G_inshore_filtben	110	2	Fishing fleet model	Processing at sea rate inshore	Suspension/deposit feeding benthos
G_offshore_filtben	111	2	Fishing fleet model	Processing at sea rate offshore	Suspension/deposit feeding benthos
G_inshore_carnben	112	2	Fishing fleet model	Processing at sea rate inshore	Carnivore/scavenge feeding benthos
G_offshore_carnben	113	2	Fishing fleet model	Processing at sea rate offshore	Carnivore/scavenge feeding benthos
G_inshore_carnzoo	114	2	Fishing fleet model	Processing at sea rate inshore	Carnivorous zooplankton
G_offshore_carnzoo	115	2	Fishing fleet model	Processing at sea rate offshore	Carnivorous zooplankton
G_inshore_bird	116	2	Fishing fleet model	Processing at sea rate inshore	Birds
G_offshore_bird	117	2	Fishing fleet model	Processing at sea rate offshore	Birds
G_inshore_seal	118	2	Fishing fleet model	Processing at sea rate inshore	Pinnipeds
G_offshore_seal	119	2	Fishing fleet model	Processing at sea rate offshore	Pinnipeds
G_inshore_ceta	120	2	Fishing fleet model	Processing at sea rate inshore	Cetaceans
G_offshore_ceta	121	2	Fishing fleet model	Processing at sea rate offshore	Cetaceans
G_inshore_kelp	122	2	Fishing fleet model	Processing at sea rate inshore	Macrophytes
G_offshore_kelp	123	2	Fishing fleet model	Processing at sea rate offshore	Macrophytes
ploughdaily_S0	286	2	Fishing fleet model	Abrasion rate by fishing gears	Inshore rock
ploughdaily_S1	287	2	Fishing fleet model	Abrasion rate by fishing gears	Inshore muddy sediments
ploughdaily_S2	288	2	Fishing fleet model	Abrasion rate by fishing gears	Inshore sandy sediments
ploughdaily_S3	289	2	Fishing fleet model	Abrasion rate by fishing gears	Inshore coarse sediments
ploughdaily_D0	290	2	Fishing fleet model	Abrasion rate by fishing gears	Offshore rock

ploughdaily_D1	291	2	Fishing fleet model	Abrasion rate by fishing gears	Offshore muddy sediments
ploughdaily_D2	292	2	Fishing fleet model	Abrasion rate by fishing gears	Offshore sandy sediments
ploughdaily_D3	293	2	Fishing fleet model	Abrasion rate by fishing gears	Offshore coarse sediments
inshore_bensdamage	294	2	Fishing fleet model	Damage mortality rate by fishing gears	Suspension/deposit feeding benthos inshore
offshore_bensdamage	295	2	Fishing fleet model	Damage mortality rate by fishing gears	Suspension/deposit feeding benthos offshore
inshore_bencdamage	296	2	Fishing fleet model	Damage mortality rate by fishing gears	Carnivore/scavenge feeding benthos inshore
offshore_bencdamage	297	2	Fishing fleet model	Damage mortality rate by fishing gears	Carnivore/scavenge feeding benthos offshore
offal_prop_live_weight	298	2	Fishing fleet model	Offal as proportion of live weight	All guilds
ploughdepth_S0	299	2	Fishing fleet model	Penetration depth by fishing gears	Inshore rock
ploughdepth_S1	300	2	Fishing fleet model	Penetration depth by fishing gears	Inshore muddy sediments
ploughdepth_S2	301	2	Fishing fleet model	Penetration depth by fishing gears	Inshore sandy sediments
ploughdepth_S3	302	2	Fishing fleet model	Penetration depth by fishing gears	Inshore coarse sediments
ploughdepth_D0	303	2	Fishing fleet model	Penetration depth by fishing gears	Offshore rock
ploughdepth_D1	304	2	Fishing fleet model	Penetration depth by fishing gears	Offshore muddy sediments
ploughdepth_D2	305	2	Fishing fleet model	Penetration depth by fishing gears	Offshore sandy sediments
ploughdepth_D3	306	2	Fishing fleet model	Penetration depth by fishing gears	Offshore coarse sediments
qtena	307	1	Ecology model fixed	Q10	Autotrophic uptake
qtenh	308	1	Ecology model fixed	Q10	Heterotrophic uptake
qtenm	309	1	Ecology model fixed	Q10	Metabolism and microbial rates
qtenr	310	1	Ecology model fixed	Q10 reference temperature	All temperature dependent processes
Lmaxup_phyt	311	1	Ecology model fixed	Saturation light intensity for uptake	Nutrient by phytoplankton
Lmaxup_kelp	312	1	Ecology model fixed	Saturation light intensity for uptake	Nutrient by macrophytes
NCmax_kelp	313	1	Ecology model fixed	N:C molar ratio maximum	Macrophytes
NCmin_kelp	314	1	Ecology model fixed	N:C molar ratio minimum	Macrophytes
wave_beach_kelpdebris	315	0	Ecology model fitted	Conversion rate	Macrophyte debris to beach-cast
umaxC_kelp	316	0	Ecology model fitted	Maximum uptake rate	Carbon by macrophytes
exudeC_kelp	317	0	Ecology model fitted	Carbon exudation rate	Macrophytes
selfshade_kelp	318	0	Ecology model fitted	Coefficient	Macrophyte self shading
uNIT_kelpt	319	0	Ecology model fitted	Maximum uptake rate	Nitate by macrophytes
hsNIT_kelp	320	0	Ecology model fitted	Uptake half saturation coefficient	Nitrate by macrophytes
uAMM_kelpt	321	0	Ecology model fitted	Maximum uptake rate	Ammonia by macrophytes
hsAMM_kelp	322	0	Ecology model fitted	Uptake half saturation coefficient	Ammonia by macrophytes
uNIT_phytt	323	0	Ecology model fitted	Maximum uptake rate	Nitrate by phytoplankton
hsNIT_phyt	324	0	Ecology model fitted	Uptake half saturation coefficient	Nitrate by phytoplankton
uAMM_phytt	325	0	Ecology model fitted	Maximum uptake rate	Ammonia by phytoplankton
hsAMM_phyt	326	0	Ecology model fitted	Uptake half saturation coefficient	Ammonia by phytoplankton
uphyt_herbt	327	0	Ecology model fitted	Maximum uptake rate	Phytoplankton by omnivorous zooplankton
hsphyt_herb	328	0	Ecology model fitted	Uptake half saturation coefficient	Phytoplankton by omnivorous zooplankton
udet_herbt	329	0	Ecology model fitted	Maximum uptake rate	Suspended detritus by omnivorous zooplankton
hsdet_herb	330	0	Ecology model fitted	Uptake half saturation coefficient	Suspended detritus by omnivorous

					zooplankton
ubenthslar_herbt	331	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by omnivorous zooplankton
hsbenthslar_herb	332	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae by omnivorous zooplankton
ubenthclar_herbt	333	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by omnivorous zooplankton
hsbenthclar_herb	334	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by omnivorous zooplankton
uherb_carnt	335	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by carnivorous zooplankton
hsherb_carn	336	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by carnivorous zooplankton
ubenthslar_carnt	337	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by carnivorous zooplankton
hsbenthslar_carn	338	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae by carnivorous zooplankton
ubenthclar_carnt	339	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by carnivorous zooplankton
hsbenthclar_carn	340	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by carnivorous zooplankton
ufishplar_carnt	341	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish larvae by carnivorous zooplankton
hsfishplar_carn	342	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish larvae by carnivorous zooplankton
ufishdlar_carnt	343	0	Ecology model fitted	Maximum uptake rate	Demersal fish larvae by carnivorous zooplankton
hsfishdlar_carn	344	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish larvae by carnivorous zooplankton
uherb_fishplart	345	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by planktivorous fish larvae
hsherb_fishplar	346	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by planktivorous fish larvae
ubenthslar_fishplart	347	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by planktivorous fish larvae
hsbenthslar_fishplar	348	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae by planktivorous fish larvae
ubenthclar_fishplart	349	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by planktivorous fish larvae
hsbenthclar_fishplar	350	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by planktivorous fish larvae
uherb_fishpt	351	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by planktivorous

					fish
hsherb_fishp	352	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by planktivorous fish
ucarn_fishpt	353	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by planktivorous fish
hscarn_fishp	354	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by planktivorous fish
ubenthslar_fishpt	355	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by planktivorous fish
hsbenthslar_fishp	356	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae by planktivorous fish
ubenthclar_fishpt	357	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by planktivorous fish
hsbenthclar_fishp	358	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by planktivorous fish
ufishdlar_fishpt	359	0	Ecology model fitted	Maximum uptake rate	Demersal fish larvae by planktivorous fish
hsfishdlar_fishp	360	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish larvae by planktivorous fish
ufishplar_fishpt	361	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish larvae by planktivorous fish
hsfishplar_fishp	362	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish larvae by planktivorous fish
uherb_fishmt	363	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by migratory fish
hsherb_fishm	364	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by migratory fish
ucarn_fishmt	365	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by migratory fish
hscarn_fishm	366	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by migratory fish
ubenthslar_fishmt	367	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by migratory fish
hsbenthslar_fishm	368	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae by migratory fish
ubenthclar_fishmt	369	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by migratory fish
hsbenthclar_fishm	370	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by migratory fish
ufishdlar_fishmt	371	0	Ecology model fitted	Maximum uptake rate	Demersal fish larvae by migratory fish
hsfishdlar_fishm	372	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish larvae by migratory fish
ufishplar_fishmt	373	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish larvae by migratory fish
hsfishplar_fishm	374	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish larvae by migratory fish
uherb_fishdlart	375	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by demersal fish larvae
hsherb_fishdlar	376	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by demersal fish larvae
ubenthslar_fishdlart	377	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos larvae by demersal fish larvae
hsbenthslar_fishdlar	378	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos larvae

					by demersal fish larvae
ubenthclar_fishdlart	379	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos larvae by demersal fish larvae
hsbenthclar_fishdlar	380	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos larvae by demersal fish larvae
ucarn_fishdt	381	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by demersal fish
hscarn_fishd	382	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by demersal fish
ubenths_fishdt	383	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos by demersal fish
hsbenths_fishd	384	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos by demersal fish
ubenthc_fishdt	385	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos by demersal fish
hsbenthc_fishd	386	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos by demersal fish
ufishplar_fishdt	387	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish larvae by demersal fish
hsfishplar_fishd	388	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish larvae by demersal fish
ufishdlar_fishdt	389	0	Ecology model fitted	Maximum uptake rate	demersal fish larvae by demersal fish
hsfishdlar_fishd	390	0	Ecology model fitted	Uptake half saturation coefficient	demersal fish larvae by demersal fish
ufishp_fishdt	391	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish by demersal fish
hsfishp_fishd	392	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish by demersal fish
ufishm_fishdt	393	0	Ecology model fitted	Maximum uptake rate	Migratory fish by demersal fish
hsfishm_fishd	394	0	Ecology model fitted	Uptake half saturation coefficient	Migratory fish by demersal fish
ufishd_fishdt	395	0	Ecology model fitted	Maximum uptake rate	Demersal fish by demersal fish
hsfishd_fishd	396	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish by demersal fish
udisc_fishdt	397	0	Ecology model fitted	Maximum uptake rate	Discards by demersal fish
hsdisc_fishd	398	0	Ecology model fitted	Uptake half saturation coefficient	Discards by demersal fish
ucorp_fishdt	399	0	Ecology model fitted	Maximum uptake rate	Corpses by demersal fish
hscorp_fishd	400	0	Ecology model fitted	Uptake half saturation coefficient	Corpses by demersal fish
uphyt_benthslart	401	0	Ecology model fitted	Maximum uptake rate	Phytoplankton by suspension/deposit feeding benthos larvae
hsphyt_benthslar	402	0	Ecology model fitted	Uptake half saturation coefficient	Phytoplankton by suspension/deposit feeding benthos larvae
udet_benthslart	403	0	Ecology model fitted	Maximum uptake rate	Suspended detritus by suspension/deposit feeding benthos larvae
hsdet_benthslar	404	0	Ecology model fitted	Uptake half saturation coefficient	Suspended detritus by suspension/deposit feeding benthos larvae
uphyt_benthclart	405	0	Ecology model fitted	Maximum uptake rate	Phytoplankton by carnivore/scavenge feeding benthos larvae
hsphyt_benthclar	406	0	Ecology model fitted	Uptake half saturation coefficient	Phytoplankton by carnivore/scavenge feeding benthos larvae
udet_benthclart	407	0	Ecology model fitted	Maximum uptake rate	Suspended detritus by carnivore/scavenge

					feeding benthos larvae
hsdet_benthclar	408	0	Ecology model fitted	Uptake half saturation coefficient	Suspended detritus by carnivore/scavenge feeding benthos larvae
uphyt_benthst	409	0	Ecology model fitted	Maximum uptake rate	Phytoplankton by suspension/deposit feeding benthos
hsphyt_benths	410	0	Ecology model fitted	Uptake half saturation coefficient	Phytoplankton by suspension/deposit feeding benthos
udet_benthst	411	0	Ecology model fitted	Maximum uptake rate	Suspended detritus by suspension/deposit feeding benthos
hsdet_benths	412	0	Ecology model fitted	Uptake half saturation coefficient	Suspended detritus by suspension/deposit feeding benthos
used_benthst	413	0	Ecology model fitted	Maximum uptake rate	Sediment detritus by suspension/deposit feeding benthos
hssed_benths	414	0	Ecology model fitted	Uptake half saturation coefficient	Sediment detritus by suspension/deposit feeding benthos
ubenths_benthct	415	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos by carnivore/scavenge feeding benthos
hsbenths_benthc	416	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos by carnivore/scavenge feeding benthos
ukelp_benthct	417	0	Ecology model fitted	Maximum uptake rate	Macrophytes by carnivorous/scavenge feeding benthos
hskelp_benthc	418	0	Ecology model fitted	Uptake half saturation coefficient	Macrophytes by carnivorous/scavenge feeding benthos
ukelpdebris_benthct	419	0	Ecology model fitted	Maximum uptake rate	Macrophyte debris by carnivorous/scavenge feeding benthos
hskelpdebris_benthc	420	0	Ecology model fitted	Uptake half saturation coefficient	Macrophyte debris by carnivorous/scavenge feeding benthos
ucorp_benthct	421	0	Ecology model fitted	Maximum uptake rate	Corpses by carnivore/scavenge feeding benthos
hscorp_benthc	422	0	Ecology model fitted	Uptake half saturation coefficient	Corpses by carnivore/scavenge feeding benthos
ucarn_bird	423	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by birds
hscarn_bird	424	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by birds&mammala
ubenths_bird	425	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos by birds
hsbenths_bird	426	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos by birds
ubenthc_bird	427	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos by birds
hsbenthc_bird	428	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos by birds
ufishp_bird	429	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish by birds
hsfishp_bird	430	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish by birds
ufishm_bird	431	0	Ecology model fitted	Maximum uptake rate	Migratory fish by birds
hsfishm_bird	432	0	Ecology model fitted	Uptake half saturation coefficient	Migratory fish by birds
ufishd_bird	433	0	Ecology model fitted	Maximum uptake rate	Demersal fish by birds

hsfishd_bird	434	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish by birds
udisc_bird	435	0	Ecology model fitted	Maximum uptake rate	Discards by birds
hsdisc_bird	436	0	Ecology model fitted	Uptake half saturation coefficient	Discards by birds
ucorp_bird	437	0	Ecology model fitted	Maximum uptake rate	Corpses by birds
hscorp_bird	438	0	Ecology model fitted	Uptake half saturation coefficient	Corpses by birds
bdapar_bird	439	0	Ecology model fitted	Bedding DeAngelis parameter	Birds
ucarn_seal	440	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by pinnipeds
hscarn_seal	441	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by pinnipeds
ubenths_seal	442	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos by pinnipeds
hsbenths_seal	443	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos by pinnipeds
ubenthc_seal	444	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos by pinnipeds
hsbenthc_seal	445	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos by pinnipeds
ufishp_seal	446	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish by pinnipeds
hsfishp_seal	447	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish by pinnipeds
ufishm_seal	448	0	Ecology model fitted	Maximum uptake rate	Migratory fish by pinnipeds
hsfishm_seal	449	0	Ecology model fitted	Uptake half saturation coefficient	Migratory fish by pinnipeds
ufishd_seal	450	0	Ecology model fitted	Maximum uptake rate	Demersal fish by pinnipeds
hsfishd_seal	451	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish by pinnipeds
ubird_seal	452	0	Ecology model fitted	Maximum uptake rate	Birds by pinnipeds
hsbird_seal	453	0	Ecology model fitted	Uptake half saturation coefficient	Birds by pinnipeds
udisc_seal	454	0	Ecology model fitted	Maximum uptake rate	Discards by pinnipeds
hsdisc_seal	455	0	Ecology model fitted	Uptake half saturation coefficient	Discards by pinnipeds
ucorp_seal	456	0	Ecology model fitted	Maximum uptake rate	Corpses by pinnipeds
hscorp_seal	457	0	Ecology model fitted	Uptake half saturation coefficient	Corpses by pinnipeds
bdapar_seal	458	0	Ecology model fitted	Bedding DeAngelis parameter	Pinnipeds
uherb_ceta	459	0	Ecology model fitted	Maximum uptake rate	Omnivorous zooplankton by cetaceans
hsherb_ceta	460	0	Ecology model fitted	Uptake half saturation coefficient	Omnivorous zooplankton by cetaceans
ucarn_ceta	461	0	Ecology model fitted	Maximum uptake rate	Carnivorous zooplankton by cetaceans
hscarn_ceta	462	0	Ecology model fitted	Uptake half saturation coefficient	Carnivorous zooplankton by cetaceans
ubenths_ceta	463	0	Ecology model fitted	Maximum uptake rate	Suspension/deposit feeding benthos by cetaceans
hsbenths_ceta	464	0	Ecology model fitted	Uptake half saturation coefficient	Suspension/deposit feeding benthos by cetaceans
ubenthc_ceta	465	0	Ecology model fitted	Maximum uptake rate	Carnivore/scavenge feeding benthos by cetaceans
hsbenthc_ceta	466	0	Ecology model fitted	Uptake half saturation coefficient	Carnivore/scavenge feeding benthos by cetaceans

ufishp_ceta	467	0	Ecology model fitted	Maximum uptake rate	Planktivorous fish by cetaceans
hsfishp_ceta	468	0	Ecology model fitted	Uptake half saturation coefficient	Planktivorous fish by cetaceans
ufishm_ceta	469	0	Ecology model fitted	Maximum uptake rate	Migratory fish by cetaceans
hsfishm_ceta	470	0	Ecology model fitted	Uptake half saturation coefficient	Migratory fish by cetaceans
ufishd_ceta	471	0	Ecology model fitted	Maximum uptake rate	Demersal fish by cetaceans
hsfishd_ceta	472	0	Ecology model fitted	Uptake half saturation coefficient	Demersal fish by cetaceans
ubird_ceta	473	0	Ecology model fitted	Maximum uptake rate	Birds by cetaceans
hsbird_ceta	474	0	Ecology model fitted	Uptake half saturation coefficient	Birds by cetaceans
useal_ceta	475	0	Ecology model fitted	Maximum uptake rate	Pinnipeds by cetaceans
hsseal_ceta	476	0	Ecology model fitted	Uptake half saturation coefficient	Pinnipeds by cetaceans
udisc_ceta	477	0	Ecology model fitted	Maximum uptake rate	Discards by cetaceans
hsdisc_ceta	478	0	Ecology model fitted	Uptake half saturation coefficient	Discards by cetaceans
bdapar_ceta	479	0	Ecology model fitted	Bedding DeAngelis parameter	Cetaceans
aH	480	1	Ecology model fixed	Assimilation efficiency	Omnivorous zooplankton
aC	481	1	Ecology model fixed	Assimilation efficiency	Carnivorous zooplankton
aBslar	482	1	Ecology model fixed	Assimilation efficiency	Suspension/deposit feeding benthos larvae
aBclar	483	1	Ecology model fixed	Assimilation efficiency	Carnivore/scavenge feeding benthos larvae
aBs	484	1	Ecology model fixed	Assimilation efficiency	Suspension/deposit feeding benthos
aBc	485	1	Ecology model fixed	Assimilation efficiency	Carnivore/scavenge feeding benthos
aFplar	486	1	Ecology model fixed	Assimilation efficiency	Planktivorous fish larvae
aFdlar	487	1	Ecology model fixed	Assimilation efficiency	Demersal fish lavae
aFp	488	1	Ecology model fixed	Assimilation efficiency	Planktivorous fish
aFm	489	1	Ecology model fixed	Assimilation efficiency	Migratory fish
aFd	490	1	Ecology model fixed	Assimilation efficiency	Demersal fish
abird	491	1	Ecology model fixed	Assimilation efficiency	Birds
aseal	492	1	Ecology model fixed	Assimilation efficiency	Pinnipeds
aceta	493	1	Ecology model fixed	Assimilation efficiency	Cetaceans
eHt	494	1	Ecology model fixed	Background metabolic rate coefficient	Omnivorous fish
eCt	495	1	Ecology model fixed	Background metabolic rate coefficient	Carnivorous zooplankton
eBslart	496	1	Ecology model fixed	Background metabolic rate coefficient	Suspension/deposit feeding benthos larvae
eBclart	497	1	Ecology model fixed	Background metabolic rate coefficient	Carnivore/scavenge feeding benthos larvae
eBst	498	1	Ecology model fixed	Background metabolic rate coefficient	Suspension/deposit feeding benthos
eBct	499	1	Ecology model fixed	Background metabolic rate coefficient	Carnivore/scavenge feeding benthos
eFplart	500	1	Ecology model fixed	Background metabolic rate coefficient	Planktivorous fish larvae
eFdlart	501	1	Ecology model fixed	Background metabolic rate coefficient	Demersal fish larvae
eFpt	502	1	Ecology model fixed	Background metabolic rate coefficient	Planktivorous fish
eFmt	503	1	Ecology model fixed	Background metabolic rate coefficient	Migratory fish
eFdt	504	1	Ecology model fixed	Background metabolic rate coefficient	Demersal fish
ebirdt	505	1	Ecology model fixed	Background metabolic rate coefficient	Birds
esealt	506	1	Ecology model fixed	Background metabolic rate coefficient	Pinnipeds
ecetat	507	1	Ecology model fixed	Background metabolic rate coefficient	Cetaceans

mt	508	0	Ecology model fitted	Mineralisation rate coefficient	Suspended detritus
nst	509	0	Ecology model fitted	Nitrification rate coefficient	Upper layer ammonia
dst	510	0	Ecology model fitted	Denitrification rate coefficient	Upper layer nitrate
ndt	511	0	Ecology model fitted	Nitrification rate coefficient	Lower layer ammonia
ddt	512	0	Ecology model fitted	Denitrification rate coefficient	Lower layer nitrate
qs_p1	513	0	Ecology model fitted	Conversion rate coefficient	Labile to refractory sediment detritus
qs_p2	514	0	Ecology model fitted	Mineralistation rate scaling parameter	Refractory sediment detritus
qs_p3	515	0	Ecology model fitted	Remobilisation parameter	Refractory to labile sediment detritus
msedt	516	0	Ecology model fitted	Mineralisation rate coefficient	Labile sediment detritus
msens	517	0	Ecology model fitted	Mineralisation rate sensitivity to grain size	Labile sediment detritus
nsedt	518	0	Ecology model fitted	Nitrification rate coefficient	Sediment porewater ammonia
nsens	519	0	Ecology model fitted	Nitrification rate sensitivity to grain size	Sediment porewater ammonia
dsedt	520	0	Ecology model fitted	Denitrification rate coefficient	Sediment porewater nitrate
dsens	521	0	Ecology model fitted	Denitrification rate sensitivity to grain size	Sediment porewater nitrate
xwave_kelp	522	0	Ecology model fitted	Wave height dependent conversion rate	Macrophytes to macrophyte debris
xst	523	0	Ecology model fitted	Density dependent mortality coefficient	Phytoplankton upper layer
xdt	524	0	Ecology model fitted	Density dependent mortality coefficient	Phytoplankton lower layer
xherb	525	0	Ecology model fitted	Density dependent mortality coefficient	Omnivorous zooplankton
xcarn	526	0	Ecology model fitted	Density dependent mortality coefficient	Carnivorous zooplankton
xbenthslar	527	0	Ecology model fitted	Density dependent mortality coefficient	Suspension/deposit feeding benthos larvae
xbenthclar	528	0	Ecology model fitted	Density dependent mortality coefficient	Carnivore/scavenge feeding benthos larvae
xbenths	529	0	Ecology model fitted	Density dependent mortality coefficient	Suspension/deposit feeding benthos
xbenthc	530	0	Ecology model fitted	Density dependent mortality coefficient	Carnivore/scavenge feeding benthos
xpfishlar	531	0	Ecology model fitted	Density dependent mortality coefficient	Planktivorous fish larvae
xdfishlar	532	0	Ecology model fitted	Density dependent mortality coefficient	Demersal fish larvae
xpfish	533	0	Ecology model fitted	Density dependent mortality coefficient	Planktivorous fish
xmfish	534	0	Ecology model fitted	Density dependent mortality coefficient	Migratory fish
xdfish	535	0	Ecology model fitted	Density dependent mortality coefficient	Demersal fish
xbird	536	0	Ecology model fitted	Density dependent mortality coefficient	Birds
xseal	537	0	Ecology model fitted	Density dependent mortality coefficient	Pinnipeds
xceta	538	0	Ecology model fitted	Density dependent mortality coefficient	Cetaceans
kelpdebris_det	539	0	Ecology model fitted	Disintigration rate	Macrophyte debris to detritus
corp_det	540	0	Ecology model fitted	Conversion rate coefficient	Corpses to labile sediment detritus
disc_corp	541	0	Ecology model fitted	Conversion rate coefficient	Discards to corpses
dsink_s	542	0	Ecology model fitted	Sinking rate coefficient	Upper layer suspended detritus
dsink_d_	543	0	Ecology model fitted	Sinking rate coefficient	Lower layer suspended detritus
dfdp	544	0	Ecology model fitted	Scaling parameter	Linking demersal fish survey and model abundance
pfish_migcoef	545	0	Ecology model fitted	Active migration coefficient	Planktivorous fish
mfish_migcoef	546	0	Ecology model fitted	Active migration coefficient	Migratory fish
dfish_migcoef	547	0	Ecology model fitted	Active migration coefficient	Demersal fish

bird_migcoef	548	0	Ecology model fitted	Active migration coefficient	Birds
seal_migcoef	549	0	Ecology model fitted	Active migration coefficient	Pinnipeds
ceta_migcoef	550	0	Ecology model fitted	Active migration coefficient	Cetaceans
protect_PF_o	551	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Planktivorous fish offshore
protect_DF_o	552	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Demersal fish offshore
protect_MF_o	553	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Migratory fish offshore
protect_SB_o	554	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Suspension/deposit feeding benthos offshore
protect_CB_o	555	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Carnivore/scavenge feeding benthos offshore
protect_CZ_o	556	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Carnivorous zooplankton offshore
protect_BD_o	557	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Birds offshore
protect_SL_o	558	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Pinnipeds offshore
protect_CT_o	559	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Cetaceans offshore
protect_PF_i	560	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Planktivorous fish inshore
protect_DF_i	561	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Demersal fish inshore
protect_MF_i	562	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Migratory fish inshore
protect_SB_i	563	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Suspension/deposit feeding benthos inshore
protect_CB_i	564	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Carnivore/scavenge feeding benthos inshore
protect_CZ_i	565	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Carnivorous zooplankton inshore
protect_BD_i	566	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Birds inshore
protect_SL_i	567	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Pinnipeds inshore
protect_CT_i	568	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Cetaceans inshore
protect_KP_i	569	0	Ecology model fitted	Threshold biomass for zero exploitable stock remaining	Macrophytes inshore
max_exploitable_f_PF	570	1	Ecology model fixed	Maximum exploitable fraction of stock	Planktivorous fish

max_exploitable_f_DF	571	1	Ecology model fixed	Maximum exploitable fraction of stock	Demersal fish
max_exploitable_f_MF	572	1	Ecology model fixed	Maximum exploitable fraction of stock	Migratory fish
max_exploitable_f_SB	573	1	Ecology model fixed	Maximum exploitable fraction of stock	Suspension/deposit feeding benthos
max_exploitable_f_CB	574	1	Ecology model fixed	Maximum exploitable fraction of stock	Carnivore/scavenge feeding benthos
max_exploitable_f_CZ	575	1	Ecology model fixed	Maximum exploitable fraction of stock	Carnivorous zooplankton
max_exploitable_f_BD	576	1	Ecology model fixed	Maximum exploitable fraction of stock	Birds
max_exploitable_f_SL	577	1	Ecology model fixed	Maximum exploitable fraction of stock	Pinnipeds
max_exploitable_f_CT	578	1	Ecology model fixed	Maximum exploitable fraction of stock	Cetaceans
max_exploitable_f_KP	579	1	Ecology model fixed	Maximum exploitable fraction of stock	Macrophytes
PF_fec	580	1	Ecology model fixed	Annual fecundity	Planktivorous fish
DF_fec	581	1	Ecology model fixed	Annual fecundity	Demersal fish
BS_fec	582	1	Ecology model fixed	Annual fecundity	Suspension/deposit feeding benthos
BC_fec	583	1	Ecology model fixed	Annual fecundity	Carnivore/scavenge feeding benthos
CZ_inedible_biomass_o	584	1	Ecology model fixed	Inedible biomass offshore	Carnivorous zooplankton
CZ_inedible_biomass_i	585	1	Ecology model fixed	Inedible biomass inshore	Carnivorous zooplankton
fdriversslight	1001	4	Environmental driver	Sea surface irradiance	Inshore and offshore zones
fdriverso_logespm	1002	4	Environmental driver	Suspended particulate matter	Offshore zone
fdriversi_logespm	1003	4	Environmental driver	Suspended particulate matter	Inshore zone
fdriverso_temp	1004	4	Environmental driver	Temperature	Offshore zone upper layer
fdriverd_temp	1005	4	Environmental driver	Temperature	Lower layer offshore
fdriversi_temp	1006	4	Environmental driver	Temperature	Inshore zone
fdriverv_dif	1007	4	Environmental driver	Vertical diffusion rate	Offshore zone
fdriverso_inflow	1008	4	Environmental driver	Boundary volume inflow rate	Inshore zone
fdriverd_inflow	1009	4	Environmental driver	Boundary volume inflow rate	Lower layer offshore
fdriversi_inflow	1010	4	Environmental driver	Boundary volume inflow rate	Inshore zone
fdriverso_outflow	1011	4	Environmental driver	Volumne outflow rate	Offshore surface
fdriverd_outflow	1012	4	Environmental driver	Volume outflow rate	Lower layer offshore
fdriversi_outflow	1013	4	Environmental driver	Volume outflow rate	Inshore zone
fdriverso_si_flow	1014	4	Environmental driver	Volume exchange rate	Offshore to inshore zone
fdriversi_so_flow	1015	4	Environmental driver	Volume exchange rate	Inshore to offshore zone
fdrivers_upwell	1016	4	Environmental driver	Upwelling rate	Offshore zone
fdriverriver	1017	4	Environmental driver	River volume inflow rate	Inshore zone
fdriverboundso_det	1018	4	Environmental driver	Boundary concentration	Upper layer offshore detritus
fdriverboundd_det	1019	4	Environmental driver	Boundary concentration	Lower layer detritus
fdriverboundsi_det	1020	4	Environmental driver	Boundary concentration	Inshore detritus
fdriverboundso_amm	1021	4	Environmental driver	Boundary concentration	Upper layer offshore ammonia
fdriverboundd_amm	1022	4	Environmental driver	Boundary concentration	Lower layer ammonia
fdriverboundsi_amm	1023	4	Environmental driver	Boundary concentration	Inshore ammonia
fdriverboundso_nit	1024	4	Environmental driver	Boundary concentration	Upper layer offshore nitrate
fdriverboundd_nit	1025	4	Environmental driver	Boundary concentration	Lower layer nitrate
fdriverboundsi_nit	1026	4	Environmental driver	Boundary concentration	Inshore nitrate

fdriverboundso_phyt	1027	4	Environmental driver	Boundary concentration	Upper layer offshore phytoplankton
fdriverboundd_phyt	1028	4	Environmental driver	Boundary concentration	Lower layer phytoplankton
fdriverboundsi_phyt	1029	4	Environmental driver	Boundary concentration	Inshore phytoplankton
fdriverboundriv_amm	1030	4	Environmental driver	Boundary concentration	River ammonia
fdriverboundriv_nit	1031	4	Environmental driver	Boundary concentration	River nitrate
fdriverboundriv_det	1032	4	Environmental driver	Boundary concentration	River detritus
fdriverso_atm_amm	1033	4	Environmental driver	Atmospheric deposition rate	Offshore ammonia
fdriverso_atm_nit	1034	4	Environmental driver	Atmospheric deposition rate	Offshore nitrate
fdriversi_atm_amm	1035	4	Environmental driver	Atmospheric deposition rate	Inshore ammonia
fdriversi_atm_nit	1036	4	Environmental driver	Atmospheric deposition rate	Inshore nitrate
fdriver_s1_erosion	1037	4	Environmental driver	Natural disturbance rate	Inshore muddy sediments
fdriver_s2_erosion	1038	4	Environmental driver	Natural disturbance rate	Inshore sandy sediments
fdriver_s3_erosion	1039	4	Environmental driver	Natural disturbance rate	Inshore coarse sediments
fdriver_d1_erosion	1040	4	Environmental driver	Natural disturbance rate	Offshore muddy sediments
fdriver_d2_erosion	1041	4	Environmental driver	Natural disturbance rate	Offshore sandy sediments
fdriver_d3_erosion	1042	4	Environmental driver	Natural disturbance rate	Offshore coarse sediments
fdriver_s_wave	1043	4	Environmental driver	Significant wave height	Inshore zone
fdriverpfish_sp	1044	4	Biological event driver	Spawning rate	Planktivorous fish
fdriverpfish_rec	1045	4	Biological event driver	Recruitment rate	Planktivorous fish
fdriverdfish_sp	1046	4	Biological event driver	Spawning rate	Demersal fish
fdriverdfish_rec	1047	4	Biological event driver	Recruitment rate	Demersal fish
fdriverbs_sp	1048	4	Biological event driver	Spawning rate	Suspension/deposit feeding benthos
fdriverbs_rec	1049	4	Biological event driver	Recruitment rate	Suspension/deposit feeding benthos
fdriverbc_sp	1050	4	Biological event driver	Spawning rate	Carnivore/scavenge feeding benthos
fdriverbc_rec	1051	4	Biological event driver	Recruitment rate	Carnivore/scavenge feeding benthos
fdrivermfish_im	1052	4	Biological event driver	Immigration rate	Migratory fish
fdrivermfish_em	1053	4	Biological event driver	Emigration rate	Migratory fish

OUTPUTS FROM MONTE CARLO ANALYSIS

The function e2e_run_mc() carries out a Monte Carlo analysis to estimate credible intervals of model outputs given uncertainty in the fitted values of the ecology model parameters.

The computation begins with a parent parameter set (θ) loaded by the e2e_read() function, which should be the maximum-likelihood set produced by the simulated annealing scheme. From this parent set, a series of child-sets (θ^*_k , $1 \le k \le r$, r = e.g. 1000), is generated by applying a separate random increment to each of the parameters; $\theta^*_k = \theta + \delta[k]$ where $\delta[k]$ is a vector of random values from a uniform (rather than a gaussian) distribution of mean 0 and given range.

For each of the parameter sets, the likelihood of the observed annual target data (in the file */Target_data/ annual_target_data*.csv*) $P(observations|\theta^*_k)$ is calculated following a run of the model to stationary state, and all the raw and derived outputs from the final, stationary year of each run is saved (here k = 0 to r, where k = 0 corresponds to the maximum likelihood (parent) parameter set).

To calculate the credible interval for any direct or derived model output variable (e.g. annual average mass density of a state variable, or the mass density on a given day in the final year), the values from the individual model runs (V_k) and the associated likelihoods (P_k) are assembled as a list of $(r + 1; k = 0$ to $r)$ pairs ($a_k = (V_k,P_k)$). The list is then sorted by ascending values of V ($a_j ; j = 1$ to $(r + 1)$ such that $V_j \ge V_{(j - 1)}$). The vector of cumulative likelihoods is then calculated as follows:

$C_j = (P_{j=1}, \sum_{j=1}^{j=2} P_j , \sum_{j=1}^{j=3} P_j , \sum_{j=1}^{j=4} P_j \ \dots \ \sum_{j=1}^{j=(r+1)} P_j)$

and the proportions of maximum cumulative likelihood as $Q_j = C_j/C_{(r+1)}$

Finally, values of V corresponding to discrete values of Q = {0.005, 0.25, 0.5, 0.75, 0.995} are extracted by interpolation. These values span the 0.5% and 99.5% credible intervals of the model output given uncertainty in the fitted ecology parameters. Note that uncertainties in the fixed ecology parameters, fishing fleet parameters, and environmental driving data are not reflected in these credible intervals.

The function generates two types of outputs. First is an accumulation of the run-by-run output from all of the simulations exectuted by the function call (Table 57). Second is outputs from processing of the accumulated run data to generate the credible intervals of each of the state variable and derived outputs (Table 58).

The e2e_run_mc() function is computationally intensive, so arguments are include to enable the task to be shared across multiple processor/machines and for the results to be merged afterwards.

Table 57. File names and details for each of the accumulated sets of run-by-run output from the e2e_run_mc()function.

File-name	Description
CredInt_cumulative_parameters-,csv*	Accumulated sets of ecology model parameters for each run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. . The remaining data on each row are a "column to row" transformation of most of the values in the output structure *results$build$model.parameters* from each model run (see Table 38).
CredInt_cumulative_lastyear-,csv*	Accumulated final year on daily outputs from each model run. Succesive blocks of 361 rows represent the the last 361 rows of the output structures *results$output* (Table 39) and *results$aggregates* (Table 40) from each model run. Two additional column provide the interation number and the likelihood of the target data given the parameter set respectively. This file can accumulate to several Gb in size.
CredInt_cumulative_monthly-,csv*	Accumulated final year data on monthly averaged output from each model run. Succesive blocks of 12 rows (1 per month) represent the individual model runs. The first 9 columns are "column to row" transformation of the values in the output structure *results$final.year.outputs$monthly.averages* from each model run (Table 43). Columns 10, 11 and 12 provide the month, interation number and the likelihood of the target data given the parameter set respectively.
CredInt_cumulative_targetresults-,csv*	Accumulated outputs of final-year simulated annual target data for each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$opt_results$Model_data* from each model run (see Table 48).
CredInt_cumulative_offshoreaamass-,csv*	Accumulated outputs of final year annual averaged state variable mass data for the offshore zone of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$mass_results_offshore$Model_annual_mean* from each model run. This includes the volumetric and layer thickness data required to convert mass into concentrations or area-densities (see Table 44).
CredInt_cumulative_inshoreaamass-,csv*	Accumulated outputs of final year annual averaged state variable mass data for the inshore zone of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$mass_results_inshore$Model_annual_mean* from each model run. This includes the volumetric and layer thickness data required to convert mass into concentrations or area-densities (see Table 44).
CredInt_cumulative_wholeaamass-,csv*	Accumulated outputs of final year annual averaged state variable mass data for the whole domain of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a

	"column to row" transformation of the values in the output structure *results$final.year.outputs$mass_results_wholedomain$Model_annual_mean* from each model run. This includes the volumetric and layer thickness data required to convert mass into concentrations or area-densities (see Table 44).
CredInt_cumulative_offshoreannualflux-,csv*	Accumulated outputs of final year annual flux data for the offshore zone of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$annual_flux_results_offshore$Model_annual_flux* from each model run. This includes the volumetric and layer thickness data required to convert mass fluxes into volume or area flux-densities (see Table 45).
CredInt_cumulative_inshoreannualflux-,csv*	Accumulated outputs of final year annual flux data for the inshore zone of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$annual_flux_results_inshore$Model_annual_flux* from each model run. This includes the volumetric and layer thickness data required to convert mass fluxes into volume or area flux-densities (see Table 45).
CredInt_cumulative_wholeannualflux-,csv*	Accumulated outputs of final year annual flux data for the whole domain of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$annual_flux_results_wholedomain$Model_annual_flux* from each model run. This includes the volumetric and layer thickness data required to convert mass fluxes into volume or area flux-densities (see Table 45).
CredInt_cumulative_network-,csv*	Accumulated outputs of final year annual network index data for the whole domain of each model run. Rows represent individual model runs. Columns 1 and 2 provide the interation number and the likelihood of the target data given the parameter set. The remaining data on each row are a "column to row" transformation of the values in the output structure *results$final.year.outputs$NetworkIndexResults$NetworkData* from each model run (see Table 47).

Table 58. File names and details for each of the post-processed outputs from the e2e_run_mc() or the e2e_process_sens_mc(selection="MC") function.

File-name	Description
CredInt_processeed_parameters-,csv*	Likelihood thresholds of each parameter relative to the maximum likelihood value (level_value/max.likelihood_value) – 1

CredInt_processed_daily_mass-,csv*	Likelihood threshold values of each of the final year daily variable outputs from the model (in blocks of 6 rows for each variable). Columns are the values for each day of the year.
CredInt_ processed _monthly_mass-,csv*	Likelihood threshold values of each of the final year monthly averaged variable outputs from the model (in blocks of 6 rows for each variable). Columns are the values for each month of the year.
CredInt_ processed _targetresults-,csv*	Likelihood threshold values of each of the simulated target data outputs from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables.
CredInt_ processed _AAMresults_offshore-,csv*	Likelihood threshold values of the annual averaged mass-densities ($mMN.m^{-2}$) of state variables in the offshore zone from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables.
CredInt_ processed _AAMresults_inshore-,csv*	Likelihood threshold values of the annual averaged mass-densities ($mMN.m^{-2}$) of state variables in the inshore zone from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables.
CredInt_ processed _AAMresults_whole-,csv*	Likelihood threshold values of the annual averaged mass-densities ($mMN.m^{-2}$) of state variables in the whole domain from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables.
CredInt_ processed _annualflux_offshore-,csv*	Likelihood threshold values of the annual integrated fluxes ($mMN.m^{-2}.y^{-1}$) of state variables in the offshore zone from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables.
CredInt_ processed _annualflux_inshore-,csv*	Likelihood threshold values of the annual integrated fluxes ($mMN.m^{-2}.y^{-1}$) of state variables in the inshore zone from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables
CredInt_ processed _annualflux_whole-,csv*	Likelihood threshold values of the annual integrated fluxes ($mMN.m^{-2}.y^{-1}$) of state variables in the whole domain from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables
CredInt_ processed _daily_fluxes-,csv*	Likelihood threshold values of various daily fluxes ($mMN.m^{-2}.d^{-1}$) of state variables in the inshore zone from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables
CredInt_ processed _daily_migrations,csv*	Likelihood threshold values of the daily net migration fluxes ($mMN.m^{-2}.d^{-1}$) between ofshoire and inshore zones (+ve indicates offshore to inshore and vice versa) of the three fish guilds, birds, pinnipeds and cetaceans from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables
CredInt_ processed _networkresults-,csv*	Likelihood threshold values of the annual network indices in the whole domain from the final years of each of the model runs. Rows are the 6 threshold levels, columns are the variables

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