

Package ‘gadget3’

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Type Package

Title Globally-Applicable Area Disaggregated General Ecosystem Toolbox
V3

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Description A framework to assist creation of marine ecosystem models, generating either 'R' or 'C++' code which can then be optimised using the 'TMB' package and standard 'R' tools. Principally designed to reproduce gadget2 models in 'TMB', but can be extended beyond gadget2's capabilities.

Kasper Kristensen, An-

ders Nielsen, Casper W. Berg, Hans Skaug, Bradley M. Bell (2016) <[doi:10.18637/jss.v070.i05](https://doi.org/10.18637/jss.v070.i05)> ``TMB: Automatic Differentiation and Laplace Approximation.".

Begley, J., & Howell, D. (2004) <<https://core.ac.uk/download/pdf/225936648.pdf>> ``An overview of Gadget, the globally applicable area-disaggregated general ecosystem toolbox. ICES.".

URL <https://gadget-framework.github.io/gadget3/>,
<https://github.com/gadget-framework/gadget3/>

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Description

Produce objects with special meaning to gadget3

Usage

```
g3_native(r, cpp, depends = c())
g3_global_formula(f = ~noop, init_val = NULL)
```

Arguments

r	An R function to decorate with a 'C++' equivalent
cpp	Either: <ol style="list-style-type: none"> 1. A character string containing the 'C++' equivalent as a Lambda function 2. A character string containing 'C++' function template definition, calling the function <code>__fn__</code> 3. A list of type-casts to use when calling an equivalently named native function
depends	A list of string names of dependent functions. The content of this and the initial <code>[]</code> for any Lambda function should match.
f	An optional formula to modify the content of a globally-defined variable
init_val	An optional formula to set the initial value of a globally-defined variable

Details

These functions are generally for gadget3 development, but made available so actions can be produced outside the package.

Value

g3_native: Returns a function that can be used in formulas for both R and TMB-based models.

g3_global_formula: Returns a [formula](#) that will be defined globally, and this can preserve state across timesteps.

Examples

```
# The definition of g3_env$ratio_add_vec looks like:
eg_ratio_add_vec <- g3_native(r = function(orig_vec, orig_amount,
                                         new_vec, new_amount) {
  ((orig_vec * orig_amount + new_vec * new_amount)
   /
   avoid_zero_vec(orig_amount + new_amount))
```

```

}, cpp = '[&avoid_zero_vec](vector<Type> orig_vec, vector<Type> orig_amount,
                        vector<Type> new_vec, vector<Type> new_amount)
                        -> vector<Type> {
    return (orig_vec * orig_amount + new_vec * new_amount)
        /
        avoid_zero_vec(orig_amount + new_amount);
}', depends = c('avoid_zero_vec'))
# eg_ratio_add_vec() can then be used in formulas, both in R & TMB.

# Define a random walk action, using g3_global_formula to keep track of
# previous value. NB: my_randomwalk_prevrec must be unique in a model
random_walk_action <- g3_formula(quote({
  if (cur_time > 0) nll <- nll + dnorm(x, stock__prevrec, 1, 1)
  my_randomwalk_prevrec <- x
}), x = 'TODO', my_randomwalk_prevrec = g3_global_formula(init_val = 0.0))

```

aab_env

Gadget3 global environment

Description

Functions available to any gadget3 model

Details

g3_env is the top-level [environment](#) that any gadget3 model uses, populated with utility functions.

NB: Several functions have `_vec` variants. Due to TMB limitations these should be used when you have a vector not scalar input.

ADREPORT

TMB's ADREPORT function. See [sdreport](#) documentation

as_integer

C++ compatible equivalent to [as.integer](#)

as.numeric

R [as.numeric](#) or TMB `asDouble`

assert_msg

C++/R function that ensures expression is true, or stops model.

```
assert_msg(x > 0, "x must be positive")
```

avoid_zero / avoid_zero_vec

Adds small value to input to ensure output is never zero

bounded / bounded_vec

Ensures x is within limits a & b .

```
bounded_vec(x, 100, 1000)
```

g3_matrix_vec

Apply matrix transformation tf to vector vec , return resultant vector.

```
g3_matrix_vec(tf, vec)
```

lgamma_vec

Vector equivalent of [lgamma](#)

logspace_add / logspace_add_vec

TMB's `logspace_add`, essentially a differentiable version of [pmax](#).

normalize_vec

Divide vector a by it's sum, i.e. so it now sums to 1

nvl

Return first non-null argument. NB: No C++ implementation.

pow_vec

Vector equivalent of [^](#)

print_array

Utility to pretty-print array ar

ratio_add_vec

Sum $orig_vec$ & new_vec according to ratio of $orig_amount$ & new_amount

REPORT

TMB's REPORT function.

REprintf

Equivalent of RCpp [REprintf](#)

Rprintf

Equivalent of RCpp **Rprintf**

Examples

```
# Call g3's avoid_zero_vec directly from R
g3_env$avoid_zero_vec(c(0, 0.001, 1, 100))
```

action_age

Gadget3 age action

Description

Add ageing actions to a g3 model

Usage

```
g3a_age(stock, output_stocks = list(), output_ratios = rep(1/length(output_stocks),
  times = length(output_stocks)), run_f = ~cur_step_final,
  run_at = 12, transition_at = 12)
```

Arguments

stock	g3_stock to age.
output_stocks	List of g3_stocks that oldest specimens in <i>stock</i> should move into.
output_ratios	Vector of proportions for how to distribute into <i>output_stocks</i> , default evenly spread.
run_f	formula specifying a condition for running this action, default is end of model year.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in vignette("model_structure") .
transition_at	Integer order that transition actions will be run within model, see "Ordering of actions" in vignette("model_structure") .

Value

An action (i.e. list of formula objects) that will, for the given *stock*...

1. Move the final age group into temporary storage, `stock__transitioning_num/stock__transitioning_wgt`
2. Move the contents of all other age groups into the age group above
3. Move the contents of the temporary storage into *output_stocks*

If *stock* has only one age, and *output_stocks* has been specified, then the contentes will be moved, if *output_stocks* is empty, then the action will do nothing.

See Also

https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockmature,g3_stock

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock('ling_mat', seq(20, 156, 4)) %>% g3s_age(5, 15)

# Ageing for immature ling
age_action <- g3a_age(ling_imm,
  output_stocks = list(ling_mat))
```

action_grow

Gadget3 growth action

Description

Add growth/maturity actions to a g3 model

Usage

```
g3a_grow_lengthvbssimple(
  linf_f = g3_parameterized('Linf', by_stock = by_stock),
  kappa_f = g3_parameterized('K', by_stock = by_stock, scale = 0.001),
  by_stock = TRUE)

g3a_grow_weightssimple(
  alpha_f = g3_parameterized('walpha', by_stock = by_stock),
  beta_f = g3_parameterized('wbeta', by_stock = by_stock),
  by_stock = TRUE)

g3a_grow_impl_bbinom(
  delta_len_f, delta_wgt_f,
  beta_f = g3_parameterized('bbin', by_stock = by_stock),
  maxlengthgroupgrowth,
  by_stock = TRUE)

g3a_growmature(stock, impl_f, maturity_f = ~0, output_stocks = list(),
  output_ratios = rep(1/length(output_stocks), times = length(output_stocks)),
  transition_f = ~cur_step_final, run_f = ~TRUE, run_at = 5,
  transition_at = 7)
```

Arguments

linf_f	A formula to substitute for L_∞ .
kappa_f	A formula to substitute for κ .
alpha_f	A formula to substitute for α .
beta_f	A formula to substitute for β .
maxlengthgroupgrowth	An integer with the maximum length groups an individual can jump in one step.
stock	g3_stock to grow.
delta_len_f	A formula defining a non-negative vector for mean increase in length for stock for each lengthgroup, as defined by g3a_grow_lengthvbsimple .
delta_wgt_f	A formula defining the corresponding weight increase as a matrix of lengthgroup to lengthgroup delta for stock, as defined by g3a_grow_weightsimple .
by_stock	Change the default parameterisation (e.g. to be by 'species'), see g3_parameterized .
impl_f	A pair of formula objects, as defined by g3a_grow_impl_bbinom . Both define a matrix of length groups i to length group deltas j ($0..maxlengthgroupgrowth$), the values in the first indicate the proportion of individuals moving from i to $i + j$, the values in the second indicate the corresponding weight increase of individuals moving from i to $i + j$.
maturity_f	A maturity formula , as defined by g3a_mature_constant .
output_stocks	List of g3_stocks that maturing <i>stock</i> should move into.
output_ratios	Vector of proportions for how to distribute into <i>output_stocks</i> , summing to 1, default evenly spread.
transition_f	formula specifying a condition for running maturation steps as well as growth, default final step of year.
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .
transition_at	Integer order that transition actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

A model can have any number of `g3a_growmature` actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

`impl_f`'s dependent variables are analysed to see what will affect growth. If nothing but `cur_step_size` will affect growth, then growth will only be recalculated when the step size changes.

Value

`g3a_grow_lengthvbsimple`: Returns a [formula](#) for use as `delta_len_f`:

$$\Delta L_i = (L_\infty - L_i)(1 - e^{-\kappa \Delta t})$$

Where Δt is the length of the current timestep.

g3a_grow_weightsimple: Returns a [formula](#) for use as `delta_wgt_f`:

$$\Delta W_{i,j} = \alpha((L_i + \Delta L_j)^\beta - L_i^\beta)$$

Where Δt is the length of the current timestep, ΔL is all possible length group increases i.e. `0..maxlengthgroupgrowth`.

g3a_grow_impl_bbinom: [formula](#) object converting mean growths using beta-binomial distribution. See <https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#beta-binomial>

g3a_growmature: An action (i.e. list of formula objects) that will, for the given `stock`...

1. Move any maturing individuals into temporary storage, `stock__transitioning_num/stock__transitioning_wgt`
2. Calculate increase in length/weight using `growth_f` and `impl_f`
3. Move the contents of the temporary storage into `output_stocks`

See Also

https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockgrowth,g3_stock

Examples

```
ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4))
ling_mat <- g3_stock(c(species = 'ling', 'mat'), seq(20, 156, 4))

# Growth / maturity for immature ling
growth_action <- g3a_growmature(ling_imm,
  impl_f = g3a_grow_impl_bbinom(
    # Parameters will be ling.Linf, ling.K
    g3a_grow_lengthvbsimple(by_stock = 'species'),
    # Parameters will be ling_imm.walpha, ling_imm.wbeta
    g3a_grow_weightsimple(),
    maxlengthgroupgrowth = 15),
  maturity_f = g3a_mature_constant(
    alpha = g3_parameterized('ling.mat1', scale = 0.001),
    150 = g3_parameterized('ling.mat2')),
  output_stocks = list(ling_mat))
```

action_mature

Gadget3 maturity action

Description

Add maturity actions to a g3 model

Usage

```

g3a_mature_continuous(
  alpha = g3_parameterized('mat.alpha', by_stock = by_stock, scale = 0.001),
  l50 = g3_parameterized('mat.l50', by_stock = by_stock),
  beta = 0,
  a50 = 0,
  by_stock = TRUE)

g3a_mature_constant(alpha = NULL, l50 = NA, beta = NULL, a50 = NA, gamma = NULL,
  k50 = NA)

g3a_mature(stock, maturity_f, output_stocks, output_ratios = rep(1/length(output_stocks),
  times = length(output_stocks)), run_f = ~TRUE, run_at = 5,
  transition_at = 7)

```

Arguments

alpha	A formula to substitute for α .
l50	A formula to substitute for l_{50} . Must be defined if <i>alpha</i> is defined.
beta	A formula to substitute for β .
a50	A formula to substitute for a_{50} . Must be defined if <i>beta</i> is defined.
gamma	A formula to substitute for γ .
k50	A formula to substitute for k_{50} . Must be defined if <i>gamma</i> is defined.
by_stock	Change the default parameterisation (e.g. to be by 'species'), see g3_parameterized .
stock	g3_stock to mature.
maturity_f	A maturity formula , as defined by g3a_mature_constant .
output_stocks	List of g3_stocks that maturing <i>stock</i> should move into.
output_ratios	Vector of proportions for how to distribute into <i>output_stocks</i> , summing to 1, default evenly spread.
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in vignette("model_structure") .
transition_at	Integer order that transition actions will be run within model, see "Ordering of actions" in vignette("model_structure") .

Details

Generally you would use [g3a_growmature](#), which does both growth and maturity at the same time.

A model can have any number of [g3a_mature](#) actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

Value

g3a_mature_continuous: A [formula](#) object representing

$$m_0 * (\alpha \Delta L + \beta \Delta t)^\top$$

m_0 The [g3a_mature_constant](#) formula, as defined below, using parameters supplied to [g3a_mature_continuous](#)

ΔL Vector of all possible changes in length, as per current growth matrix (see [g3a_grow_impl_bbinom](#))

Δt Length of the current timestep

g3a_mature_constant: A [formula](#) object with the following equation

$$\frac{1}{1 + e^{-\alpha(l-l_{50}) - \beta(a-a_{50}) - \gamma(k-k_{50})}}$$

l length of stock

l_{50} length of stock when 50% are mature

a age of stock

a_{50} age of stock when 50% are mature

k weight of stock

k_{50} weight of stock when 50% are mature

g3a_mature: An action (i.e. list of formula objects) that will, for the given *stock*...

1. Move any maturing individuals into temporary storage, `stock__transitioning_num/stock__transitioning_wgt`
2. Move the contents of the temporary storage into `output_stocks`

See Also

<https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockmature>,
[g3a_growmature](#), [g3_stock](#)

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4))
ling_mat <- g3_stock('ling_mat', seq(20, 156, 4))

# Maturity for immature ling
maturity_action <- g3a_mature(ling_imm,
  maturity_f = g3a_mature_continuous(),
  output_stocks = list(ling_mat))
```

action_migrate	<i>Gadget3 migration action</i>
----------------	---------------------------------

Description

Add migration to a g3 model

Usage

```
g3a_migrate_normalize(row_total = 1)

g3a_migrate(stock, migrate_f, normalize_f = g3a_migrate_normalize(),
            run_f = TRUE, run_at = 2)
```

Arguments

row_total	When calculating the proportion of individuals that will stay in place, use this total for what rows are expected to sum to.
stock	The <code>g3_stock</code> that will migrate in this action.
migrate_f	A formula describing the migration in terms of (source) area and dest_area.
normalize_f	Function to normalize a vector of possible destinations, to make sure fish aren't added or destroyed.
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that spawning actions will be run within model, see "Ordering of actions" in vignette("model_structure").

Details

To restrict movement to a particular step in a year, or a particular area, use `run_f`. For example:

```
cur_step == 1 Migration will happen on first step of every year
cur_step == 1 && cur_year >= 1990 Migration will happen on first step of every year after 1990
cur_step == 2 && area = 1 Migration will happen on second step of every year, in the first area
```

Multiple migration actions can be added, for a separate spring and autumn migration, for instance.

The action will define the following stock instance variables for each given `stock`:

`stock__migratematrix` $a \times a$ array, containing proportion of (stock) moved from one area to another.
If NaN, no movement has occurred

Value

g3a_migrate_normalize: A formula transforming `stock__migratematrix[,stock__area_idx]` (i.e. all possible destinations from a given area) by:

1. Squaring so values are all positive
2. Altering the proportion of static individuals so a row sums to *row_total*
3. Dividing by *row_total* so a row sums to 1

g3a_migrate: An action (i.e. list of formula objects) that will, for the given *stock...*

1. Fill in *stock__migratematrix* using *migrate_f* and *normalize_f*
2. Apply movement to *stock*

See Also

[g3_stock](#)

Examples

```
areas <- list(a=1, b=2, c=3, d=4)

# NB: stock doesn't live in b, so won't figure in stock_acd__migratematrix
stock_acd <- (g3_stock('stock_acd', seq(10, 40, 10))
  %>% g3s_livesonareas(areas[c('a', 'c', 'd')]))

movement_action <- list(
  g3a_migrate(
    stock_acd,
    # In spring, individuals in area 'a' will migrate to 'd'.
    ~if (area == area_a && dest_area == area_d) 0.8 else 0,
    run_f = ~cur_step == 2),
  g3a_migrate(
    stock_acd,
    # In autumn, individuals in all areas will migrate to 'a'
    ~if (dest_area == area_a) 0.8 else 0,
    run_f = ~cur_step == 4),
  list())
```

action_naturalmortality

Gadget3 natural mortality action

Description

Add natural mortality to a g3 model

Usage

```
g3a_naturalmortality_exp(
  param_f = g3_parameterized('M', by_stock = by_stock, by_age = by_age),
  by_stock = TRUE,
  by_age = FALSE,
  action_step_size_f = ~cur_step_size)

g3a_naturalmortality(stock, mortality_f, run_f = TRUE, run_at = 4)
```

Arguments

param_f	A formula to substitute for <i>m</i> .
action_step_size_f	How much model time passes in between runs of action? defaults to ~cur_step_size, i.e. every step. Use action_step_size_f = 1 if action only runs yearly.
by_stock	Change the default parameterisation (e.g. to be by 'species'), see g3_parameterized .
by_age	Change the default parameterisation to be per stock age, see g3_parameterized .
stock	g3_stock mortality applies to.
mortality_f	A mortality formula , as defined by g3a_naturalmortality_exp .
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

A model can have any number of `g3a_naturalmortality` actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

Value

g3a_naturalmortality_exp: A [formula](#) object with the following equation

$$e^{-m\Delta t}$$

Δt length of current timestep

g3a_naturalmortality: An action (i.e. list of formula objects) that will, for the given *stock*...

1. Remove a proportion of each stock group as calculated by the mortality formula `mortality_f`

See Also

<https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stocknatmort>, [g3a_growmature](#), [g3_stock](#)

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)

# Natural mortality for immature ling
naturalmortality_action <- g3a_naturalmortality(ling_imm,
  g3a_naturalmortality_exp())
```

action_predate	<i>Gadget3 predation actions</i>
----------------	----------------------------------

Description

Add predation to a g3 model

Usage

```
g3a_predate_catchability_totalfleet(E)

g3a_predate_catchability_numberfleet(E)

g3a_predate_catchability_linearfleet(E)

g3a_predate_catchability_effortfleet(catchability_fs, E)

g3a_predate_catchability_quotafleet(quota_table, E,
  sum_stocks = list(),
  recalc_f = NULL)

g3a_predate_fleet(fleet_stock, prey_stocks, suitabilities, catchability_f,
  overconsumption_f = quote(
    logspace_add_vec(stock__consratio * -1e3, 0.95 * -1e3) / -1e3 ),
  run_f = ~TRUE, run_at = 3)

# NB: Deprecated interface, use g3a_predate_fleet with g3a_predate_catchability_totalfleet
g3a_predate_totalfleet(fleet_stock, prey_stocks, suitabilities, amount_f,
  overconsumption_f = quote(
    logspace_add_vec(stock__consratio * -1e3, 0.95 * -1e3) / -1e3 ),
  run_f = ~TRUE, run_at = 3)
```

Arguments

fleet_stock	g3_stock that describes the harvesting fleet.
prey_stocks	List of g3_stocks that maturing <i>stock</i> should move into.
suitabilities	Either a list of stock names to formula objects, with an optional unnamed default option, or a formula object (which is always used). Each formula should define suitability of a stock, for example by using g3_suitability_exponential15

catchability_f	A formula generated by e.g. <code>g3a_preadate_catchability_totalfleet</code> expressing the catchability (i.e. total biomass) for that fleet.
E	A formula that returns the total biomass a stock can harvest in the current time/area, generally defined by a <code>g3_timeareadata</code> table.
catchability_fs	Either a list of stock names to formula objects, with an optional unnamed default option, or a formula object (which is always used).
quota_table	A data.frame with 'biomass' and 'quota' columns, where 'biomass' corresponds to total biomass of <code>sum_stocks</code> stocks, the final value always being Inf. A quota is chosen by the largest 'biomass' value less than the current total biomass amount. For example, <code>data.frame(biomass = c(100, Inf), quota = I(list(~g3_param('quota.low', ~g3_param('quota.high'))))</code>
sum_stocks	Either a list of <code>g3_stock</code> objects to sum when choosing a value from <code>quote_table</code> , or NULL, in which case choose the quota based on the current prey.
recalc_f	A formula denoting when to recalculate the current quota. For example <code>~cur_step == 1</code> will ensure the quota is only recalculated at the beginning of the year.
amount_f	Equivalent to <code>E</code> passed to <code>g3a_preadate_catchability_totalfleet</code> .
overconsumption_f	Overconsumption rule, a formula that should cap all values in <code>stock__constratio</code> to <code><= 95</code>
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The actions will define the following stock instance variables for each given `fleet_stock` and `prey_stock`:

`prey_stock__suit_fleet_stock` Suitability of (`prey_stock`) for (`fleet_stock`), in a prey array. i.e. the result of calculating the formula in `suitabilities` for the current state of the prey

`prey_stock__predby_fleet_stock` Biomass of (`prey_stock`) caught by (`fleet_stock`), in a prey array

`fleet_stock__catch` Biomass of all prey caught by (`fleet stock`), in a fleet array

`prey_stock__totalpredate` Biomass of total consumed (`prey_stock`), in a prey array

`prey_stock__constratio` Ratio of `prey_stock__totalpredate` / (current biomass), capped by `overconsumption_f`

A model can have any number of `g3a_preadate_*` actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

Value

g3a_preadate_catchability_totalfleet: A **formula** object:

$$\frac{EN_{sl}W_{sl}}{\sum_{stocks} \sum_{lengths} N_{sl}W_{sl}}$$

E E argument, biomass caught by fleet

N Number of stock in length cell

W Mean weight of stock in length cell

g3a_predate_catchability_numberfleet: A [formula](#) object:

$$\frac{EN_{sl}}{\sum_{stocks} \sum_{lengths} N_{sl}}$$

E E argument, numbers caught by fleet

N Number of stock in length cell

g3a_predate_catchability_linearfleet: A [formula](#) object:

$$E\Delta t N_{sl} W_{sl}$$

E E argument, numbers caught by fleet

Δt length of current timestep

N Number of stock in length cell

W Mean weight of stock in length cell

g3a_predate_catchability_effortfleet: A [formula](#) object:

$$EN_{sl} W_{sl} C_s$$

E E argument, numbers caught by fleet

c_s *catchability_fs* argument for the current stock

N Number of stock in length cell

W Mean weight of stock in length cell

g3a_predate_catchability_quotafleet: A [formula](#) object:

$$qE\Delta t N_{sl} W_{sl}$$

q quota chosen from *quota_table*, corresponding to the total biomass of *sum_stocks*

E E argument, numbers caught by fleet

Δt length of current timestep

N Number of stock in length cell

W Mean weight of stock in length cell

...if *recalc_f* is set, this will only be recalculated when true. Any other step will use the previous value.

g3a_predate_fleet: An action (i.e. list of formula objects) that will...

1. Zero fleet and prey catch counters
2. For each prey, collect maximum desired by fleet for all prey, into a *prey_stock__predby_fleet_stock* variable
3. After all fleet consumption is done, scale consumption using *catchability_f*, sum into *prey_stock__totalpredate*
4. After all consumption is done, temporarily convert *prey_stock__predby_fleet_stock* to a proportion of *prey_stock__totalpredate*
5. Calculate *prey_stock__consratio* (ratio of consumed to available), capping using *overconsumption_f*. Update *prey_stock__num*
6. Recalculate *prey_stock__predby_fleet_stock*, *fleet_stock__catch*, post-overconsumption

See Also

https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockpredator,g3_stock

Examples

```
areas <- c(a = 1, b = 2)
ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock(c(species = 'ling', 'mat'), seq(20, 156, 4)) %>% g3s_age(5, 15)
lln <- g3_fleet('lln') %>% g3s_livesonareas(areas[c('a', 'b')])

# Invent a lln_landings table
# NB: Generally use mfdb::mfdb_sample_totalweight() to do this for you
lln_landings <- list(expand.grid(
  year = 1999:2000,
  step = c(1, 2),
  area = areas[c('a', 'b')]))
lln_landings[[1]]$total_weight <- floor(runif(nrow(lln_landings[[1]]), min=100, max=999))

predate_action <- g3a_predate_fleet(
  lln,
  list(ling_imm, ling_mat),
  suitabilityes = list(
    ling_imm = g3_suitability_exponential150(
      g3_parameterized('lln.alpha', by_stock = 'species'),
      g3_parameterized('lln.l50', by_stock = 'species')),
    ling_mat = g3_suitability_exponential150(
      g3_parameterized('lln.alpha', by_stock = 'species'),
      g3_parameterized('lln.l50', by_stock = 'species')),
    catchability_f = g3a_predate_catchability_totalfleet(
      g3_timeareadata('lln_landings', lln_landings[[1]])))
```

action_renewal

Gadget3 renewal actions

Description

Add renewal / initialconditions to a g3 model

Usage

```
g3a_renewal_vonb(
  Linf = g3_parameterized('Linf', by_stock = by_stock),
  K = g3_parameterized('K', by_stock = by_stock, scale = 0.001),
  recl = g3_parameterized('recl', by_stock = by_stock),
  recage = g3_parameterized('recage', by_stock = FALSE, optimise = FALSE),
  by_stock = TRUE)
```

```

g3a_renewal_initabund(
  scalar = g3_parameterized('init.scalar', by_stock = by_stock),
  init = g3_parameterized('init', by_stock = by_stock, by_age = TRUE),
  M = g3_parameterized('M', by_stock = by_stock),
  init_F = g3_parameterized('init.F', by_stock = by_stock_f),
  recage = g3_parameterized('recage', by_stock = FALSE, optimise = FALSE),
  proportion_f = ~1,
  by_stock = TRUE,
  by_stock_f = FALSE)

g3a_initialconditions(stock, num_f, wgt_f, run_f = ~cur_time == 0L, run_at = 0)

g3a_initialconditions_normalparam(
  stock,
  factor_f = g3a_renewal_initabund(by_stock = by_stock),
  mean_f = g3a_renewal_vonb(by_stock = by_stock),
  stddev_f = g3_parameterized('init.sd', by_stock = by_stock, by_age = by_age),
  alpha_f = g3_parameterized('walpha', by_stock = wgt_by_stock),
  beta_f = g3_parameterized('wbeta', by_stock = wgt_by_stock),
  by_stock = TRUE,
  by_age = FALSE,
  wgt_by_stock = TRUE,
  run_f = ~cur_time == 0L,
  run_at = 0)

g3a_renewal(stock, num_f, wgt_f, run_f = ~TRUE, run_at = 8)

g3a_renewal_normalparam(
  stock,
  factor_f,
  mean_f,
  stddev_f = g3_parameterized('rec.sd', by_stock = by_stock, by_age = by_age),
  alpha_f = g3_parameterized('walpha', by_stock = wgt_by_stock),
  beta_f = g3_parameterized('wbeta', by_stock = wgt_by_stock),
  by_stock = TRUE,
  by_age = FALSE,
  wgt_by_stock = TRUE,
  run_f = ~TRUE,
  run_at = 8)

```

Arguments

stock	The g3_stock to apply to
num_f	formula that produces a lengthgroup vector of number of individuals for the current age/area/... length group.
wgt_f	formula that produces a lengthgroup vector of mean weight for the current age/area/... length group.

run_at	Integer order that actions will be run within model, see "Ordering of actions" in vignette("model_structure").
factor_f	formula substituted into normalparam calculations, see below.
mean_f	formula substituted into normalparam calculations, see below.
stddev_f	formula substituted into normalparam calculations, see below.
alpha_f	formula substituted into normalparam calculations, see below.
beta_f	formula substituted into normalparam calculations, see below.
run_f	formula specifying a condition for running this action, default always runs for renewal, first timestep for initialconditions.
Lin_f	formula substituted into vonb calculations, see below.
K	formula substituted into vonb calculations, see below.
recl	formula substituted into vonb calculations, see below.
recage	formula substituted into initial abundance and vonb calculations, see below.
proportion_f	formula substituted into initial abundance calculations, see below.
scalar	formula substituted into initial abundance calculations, see below.
init	formula substituted into initial abundance calculations, see below.
M	formula substituted into initial abundance calculations, see below.
init_F	formula substituted into initial abundance calculations, see below.
by_stock	Controls how parameters are grouped, see g3_parameterized
wgt_by_stock	Controls how parameters are grouped, see g3_parameterized
by_stock_f	Controls how parameters are grouped, see g3_parameterized
by_age	Controls how parameters are grouped, see g3_parameterized

Details

A model can have any number of `g3a_renewal_*` actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

The `g3a_renewal_*` actions will define the following stock instance variables for `stock`:

`stock__renewalnum` Extra individuals added to the stock

`stock__renewalwgt` Mean weight of added individuals

Value

g3a_renewal_vonb: A [formula](#) object representing

$$L_{\infty} * 1 - e^{-1 * \kappa * (a - (a_0 + \frac{\log(1 - L_0 / L_{\infty})}{\kappa}))}$$

g3a_renewal_initabund: A [formula](#) object representing

$$scalar * init * e^{-1 * (M + F_0) * (a - a_0)} * proportion_a$$

g3a_initialconditions / g3a_renewal: An action (i.e. list of formula objects) that will, for the given *stock*, iterate over each area/age/etc. combination, and generate a lengthgroup vector of new individuals and weights using *num_f* and *wgt_f*.

renewal will add fish to the existing collection, whereas initialconditions will assume the stock is currently empty.

g3a_initialconditions_normalparam / g3a_renewal_normalparam: As [g3a_initialconditions / g3a_renewal](#), but the following formulae are used to calculate num/wgt:

$$n = e^{-\left(\frac{L-\mu}{\sigma}\right)^2/2}$$

$$N = F10000 \frac{n}{\sum n}$$

$$W = \alpha L^\beta$$

L Midlength of length groups for current area/age/...

F Substituted for *factor_f*

μ Substituted for *mean_f*

σ Substituted for *stddev_f*

α Substituted for *alpha_f*

β Substituted for *beta_f*

See Also

<https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockinitial>,
<https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stockrenew>,
[g3_stock](#)

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)

initialconditions_action <- g3a_initialconditions_normalparam(
  ling_imm,
  by_age = TRUE) # per-age init.sd parameters
renewal_action <- g3a_renewal_normalparam(
  ling_imm,
  factor_f = g3_parameterized(
    'rec',
    by_stock = ling_imm,
    by_year = TRUE,
    ifmissing = NaN),
  mean_f = g3a_renewal_vonb(),
  run_f = ~cur_step == 1 && age == stock__minage && !cur_year_projection)
```

 action_report

Gadget3 report actions

Description

Add report to a g3 model

Usage

```
g3a_report_stock(report_stock, input_stock, report_f,
  include_adreport = FALSE,
  run_f = TRUE, run_at = 11)
```

```
g3a_report_history(
  actions,
  var_re = "__num$|__wgt$",
  out_prefix = "hist_",
  run_f = TRUE,
  run_at = 11)
```

```
g3a_report_detail(actions,
  run_f = quote( g3_param('report_detail', optimise = FALSE, value = 0L) == 1 ),
  abundance_run_at = 1,
  run_at = 11)
```

Arguments

report_stock	The g3_stock to aggregate into
input_stock	The g3_stock that will be aggregated
report_f	formula specifying what to collect, for instance <code>g3_formula(stock_ss(input_stock__num))</code> or <code>g3_formula(stock_ss(input_stock__wgt))</code> .
actions	List of actions that model will consist of.
var_re	Regular expression specifying variables to log history for.
out_prefix	Prefix to add to history report output, e.g. <code>hist_ling_imm__num</code> .
include_adreport	Should the aggregated value get ADREPORT'ed?
abundance_run_at	Integer order that abundance will be collected within the model. Note that by default it's collected at the start, not the end
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The actions will define the following variables in your model:

report_stock__instance_name Results of collating *input_stock__instance_name*, where *instance_name* is defined by the first instance variable in *report_f*. For example, if *report_f* is `~input_stock__num`, then we will report `report_stock__num`.

A model can have any number of `g3a_report_*` actions, so long as the calling arguments are different. For instance, `run_f = ~age == 5` and `run_f = ~age == 7`.

Value

g3a_report_stock: An action (i.e. list of formula objects) that will...

1. Iterate over *input_stock*, collecting data into *report_stock*
2. Add the contents of *report_stock__instance_name* to the model report

g3a_report_history: An action (i.e. list of formula objects) that will store the current state of each variable found matching *var_re*.

g3a_report_detailed: Uses [g3a_report_history](#) to generate detailed reports suitable for use in `g3_fit`.

See Also

[g3_stock](#)

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)

# Report that aggregates ages together
agg_report <- g3_stock('agg_report', c(1)) %>%
  g3s_agegroup(list(young = 1:3, old = 4:5)) %>%
  g3s_time(year = 2000:2002)
# Generate dissaggregated report by cloning the source stock, adding time
raw_report <- g3s_clone(ling_imm, 'raw_report') %>%
  g3s_time(year = 2000:2002)

actions <- list(
  g3a_age(ling_imm),
  g3a_report_stock(agg_report, ling_imm, g3_formula( stock_ss(ling_imm__num) ),
    include_adreport = TRUE),
  g3a_report_stock(raw_report, ling_imm, g3_formula( stock_ss(ling_imm__num) )))
# "raw_report__num" and "agg_report__num" will be available in the model report
# In addition, agg_report__num will be included in TMB::sdreport() output

# Report history of all "__num" and "__wgt" variables
actions <- c(actions, list(g3a_report_history(actions)))

# Report history of just "ling_imm__num"
```

```
actions <- c(actions, list(g3a_report_history(actions, "^ling_imm_num$")))

# Add a detail report suitable for g3_fit
actions <- c(actions, list(g3a_report_detail(actions)))
```

action_spawn	<i>Gadget3 spawning action</i>
--------------	--------------------------------

Description

Add spawning to a g3 model

Usage

```
g3a_spawn_recruitment_fecundity(p0, p1, p2, p3, p4)

g3a_spawn_recruitment_simplessb(mu)

g3a_spawn_recruitment_ricker(mu, lambda)

g3a_spawn_recruitment_bevertonholt(mu, lambda)

g3a_spawn_recruitment_hockeystick(r0, blim)

g3a_spawn(stock, recruitment_f, proportion_f = 1, mortality_f = 0,
  weightloss_f = 0, output_stocks = list(),
  output_ratios = rep(1/length(output_stocks), times = length(output_stocks)),
  mean_f, stddev_f, alpha_f, beta_f, run_f = ~TRUE, run_at = 6,
  recruit_at = 8)
```

Arguments

p0	Substituted into <code>g3a_spawn_recruitment_fecundity</code> formula, see below.
p1	Substituted into <code>g3a_spawn_recruitment_fecundity</code> formula, see below.
p2	Substituted into <code>g3a_spawn_recruitment_fecundity</code> formula, see below.
p3	Substituted into <code>g3a_spawn_recruitment_fecundity</code> formula, see below.
p4	Substituted into <code>g3a_spawn_recruitment_fecundity</code> formula, see below.
mu	Substituted into <code>g3a_spawn_recruitment_*</code> formula, see below.
lambda	Substituted into <code>g3a_spawn_recruitment_*</code> formula, see below.
r0	Substituted into <code>g3a_spawn_recruitment_*</code> formula, see below.
blim	Substituted into <code>g3a_spawn_recruitment_*</code> formula, see below.
stock	The mature g3_stock that will spawn in this action.
recruitment_f	A list of formula generated by one of the <code>g3a_spawn_recruitment_*</code> functions, containing

	s Formula run for each subset of stock
	r Final formula for calculating number of recruits for spawning action
proportion_f	formula generated by one of the g3_suitability_* functions, describing the proportion of stock that will spawn at this timestep.
mortality_f	formula generated by one of the g3_suitability_* functions, describing the proportion of spawning stock that will die during spawning.
weightloss_f	formula generated by one of the g3_suitability_* functions, describing the overall weight loss during spawning.
output_stocks	List of g3_stocks that will be spawned into.
output_ratios	Vector of proportions for how to distribute into <i>output_stocks</i> , summing to 1, default evenly spread.
mean_f	formula substituted into stock structure calculations, see g3a_renewal_normalparam for details.
stddev_f	formula substituted into stock structure calculations, see g3a_renewal_normalparam for details.
alpha_f	formula substituted into stock structure calculations, see g3a_renewal_normalparam for details.
beta_f	formula substituted into stock structure calculations, see g3a_renewal_normalparam for details.
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that spawning actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .
recruit_at	Integer order that recruitment from spawning will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

To restrict spawning to a particular step in a year, or a particular area, use *run_f*. For example:

`cur_step == 1` Spawning will happen on first step of every year

`cur_step == 1 && cur_year >= 1990` Spawning will happen on first step of every year after 1990

`cur_step == 2 && area = 1` Spawning will happen on second step of every year, in the first area

The action will define the following stock instance variables for each given *stock* and *output_stock*:

stock__spawnprop Proportion of (stock) that are spawning in this spawning event

stock__spawningnum Numbers of (stock) that are spawning in this spawning event

output_stock__spawnednum Numbers of (output_stock) that will be produced in this spawning event

Value

g3a_spawn_recruitment_fecundity: A pair of **formula** objects:

$$S = l^{p_1} a^{p_2} (p N_{al})^{p_3} W_{al}^{p_4}$$

$$R = p_0 S$$

N_{al} Number of parent stock

W_{al} Weight of parent stock

p Proportion of parent stock spawning, from *proportion_f*

$p_{0..4}$ Arguments provided to function

g3a_spawn_recruitment_simplessb: A pair of **formula** objects:

$$S = N_{al} p W_{al}$$

$$R = \mu S$$

N_{al} Number of parent stock

W_{al} Weight of parent stock

p Proportion of parent stock spawning, from *proportion_f*

μ Argument provided to function

g3a_spawn_recruitment_ricker: A pair of **formula** objects:

$$S = N_{al} p W_{al}$$

$$R = \mu S e^{-\lambda S}$$

N_{al} Number of parent stock

W_{al} Weight of parent stock

p Proportion of parent stock spawning, from *proportion_f*

μ Argument provided to function

λ Argument provided to function

g3a_spawn_recruitment_bevertonholt: A pair of **formula** objects:

$$S = N_{al} p W_{al}$$

$$R = \frac{\mu S}{\lambda + S}$$

N_{al} Number of parent stock

W_{al} Weight of parent stock

p Proportion of parent stock spawning, from *proportion_f*

μ Argument provided to function

λ Argument provided to function

g3a_spawn_recruitment_hockeystick: A pair of **formula** objects:

$$S = N_{al} p W_{al}$$

$$R = R_0 \min(S/B_{lim}, 1)$$

N_{al} Number of parent stock
 W_{al} Weight of parent stock
 p Proportion of parent stock spawning, from *proportion_f*
 R_0 Argument r_0 provided to function
 B_{lim} Argument $blim$ provided to function

NB: This formula is differentiable, despite using `min()` in the definition above.

g3a_spawn: An action (i.e. list of formula objects) that will, for the given *stock*...

1. Use *proportion_f* to calculate the total parent stock that will spawn
2. Use *recruitment_f* to derive the total newly spawned stock
3. Apply *weightloss_f* and *mortality_f* to the parent stock

... then, at recruitment stage ...

1. Recruit evenly into *output_stocks*, using *mean_f*, *stddev_f*, *alpha_f*, *beta_f* as-per [g3a_renewal_normalparam](#)

See Also

https://gadget-framework.github.io/gadget2/userguide/chap-stock.html#sec:stocknatmort,g3a_naturalmortality,g3_stock

Examples

```

ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock('ling_mat', seq(20, 156, 4)) %>% g3s_age(3, 10)

spawn_action <- g3a_spawn(
  # Spawn from ling_mat
  ling_mat,
  # Use Ricker Recruitment Function to calculate # of recruits from total biomass
  recruitment_f = g3a_spawn_recruitment_ricker(
    g3_parameterized("ricker.mu"),
    g3_parameterized("ricker.lambda")),
  # Proportion of ling_mat spawning exponential relationship based on length
  proportion_f = g3_suitability_exponential150(
    alpha = g3_parameterized("spawn.prop.alpha", scale = -1),
    150 = g3_parameterized("spawn.prop.150")),
  # Proportion of ling_mat dying during spawning linear relationship to length
  mortality_f = g3_suitability_straightline(
    alpha = g3_parameterized("spawn.mort.alpha"),
    beta = g3_parameterized("spawn.mort.beta")),
  # Weightloss of ling_mat during spawning a constant
  weightloss_f = g3_parameterized("spawn.weightloss"),
  # Spawn into ling_imm
  output_stocks = list(ling_imm),
  # Spawned stock structure, as-per g3a_renewal_normalparam()
  mean_f = 50,
  stddev_f = 0.9,
  alpha_f = 1,
  beta_f = 1,

```

```
# Spawning should happen on the first step of every year
run_f = ~cur_step==1)
```

action_tagging *Gadget3 tag-release action*

Description

Add tag-release to a g3 model

Usage

```
g3a_predate_tagrelease(
  fleet_stock, prey_stocks, suitabilities, catchability_f,
  output_tag_f, mortality_f = 0, run_f = ~TRUE, run_at = 3, ...)
```

```
g3a_tag_shedding(stocks, tagshed_f, run_f = ~TRUE, run_at = 9)
```

Arguments

fleet_stock	Tagging fleet, see g3a_predate_fleet
prey_stocks	Stocks fleet harvests, see g3a_predate_fleet
suitabilities	See g3a_predate_fleet
catchability_f	See g3a_predate_fleet
output_tag_f	formula specifying which numeric tag (see g3s_tag) stock will be released into. Implemented with a g3_timeareadata table, e.g.
mortality_f	formula generated by one of the g3_suitability_* functions, describing the proportion of tagged stock that will die during tagging.
stocks	Stocks that will shed tags
tagshed_f	formula for proportion that will shed tags at this point
run_f	formula specifying a condition for running this action, default always runs.
run_at	Integer order that spawning actions will be run within model, see "Ordering of actions" in vignette("model_structure").
...	Any further options for g3a_predate_fleet

Value

g3a_predate_tagrelease: An action (i.e. list of formula objects) that will...

1. Harvest as-per [g3a_predate_fleet](#)
2. Use *mortality_f* to apply tagging mortality to harvested stock
3. Use *output_tag_f* to decide what tag should be applied to harvested stock
4. Put harvested stock back into general circulation

g3a_tag_shedding: An action (i.e. list of formula objects) that will...

1. For each *stock*, move the proportion *tagshed_f* back to the "untagged" tag

See Also

[g3a_predate_fleet](#), [g3s_tag](#)

Examples

```
tags <- c('H1-00', 'H1-01')
tags <- structure(seq_along(tags), names = tags)

prey_a <- g3_stock('prey_a', seq(1, 10)) %>% g3s_tag(tags)
fleet_a <- g3_fleet('fleet_a')

actions <- list(
  # NB: If g3_tag() is used in the stock, initialconditions/renewal
  # will only renew into tag == 0 (i.e. untagged)
  g3a_predate_tagrelease(
    # Setup as-per g3a_predate_fleet
    fleet_a,
    list(pre_y_a),
    suitability_f = list(pre_y_a = 1),
    catchability_f = g3a_predate_catchability_numberfleet(~100),

    # Optional tag mortality suitability
    mortality_f = g3_suitability_straightline(
      g3_parameterized('mort_alpha'),
      g3_parameterized('mort_beta')),

    # Formula to decide which tag to output into, generate table
    # with one tag per year
    output_tag_f = g3_timeareadata('fleet_a_tags', data.frame(
      year = 2000:2001,
      tag = tags[c('H1-00', 'H1-01')],
      stringsAsFactors = FALSE), value_field = "tag"),

    # Experiment only happens in spring
    run_f = ~cur_step == 2),

  g3a_tag_shedding(
    list(pre_y_a),
    # i.e. 0.125 will lose their tag each step
    tagshed_f = log(8))
```

action_time

Gadget3 timekeeping actions

Description

Add timekeeping to a g3 model

Usage

```
g3a_time(start_year, end_year, step_lengths = as.array(c(12)),
         final_year_steps = quote( length(step_lengths) ),
         project_years = ~g3_param('project_years', default = 0, optimise = FALSE),
         retro_years = ~g3_param('retro_years', default = 0, optimise = FALSE),
         run_at = 0)
```

Arguments

start_year	Year model run will start.
end_year	After this year, model run will stop.
step_lengths	Either an MFDB time grouping, e.g. <code>mfdm::mfdm_timestep_quarterly</code> , or a vector of step lengths which should sum to 12, for example, <code>c(3, 3, 3, 3)</code> for quarterly steps within a year.
final_year_steps	Number of steps of final year to include. Either as an integer or quoted code, in which case it will be calculated when the model runs. For example: 0 Model stops before the start of <i>end_year</i> (it is exclusive) <code>length(step_lengths)</code> Model stops at the end of <i>end_year</i> (it is inclusive) 2 Model stops at the second step of <i>end_year</i> , mid-year if <i>step_lengths</i> is quarterly
project_years	Number of years to continue running after the "end" of the model. Must be ≥ 0 . Defaults to an unoptimized <code>project_years</code> parameter, set to 0 (i.e. no projection). Generally, you would change this parameter in the parameter template, rather than changing here.
retro_years	Adjust <i>end_year</i> to finish model early. Must be ≥ 0 . Can be used in conjunction with <i>project_years</i> to project instead. The true end year of the model will be $end_year - retro_years + project_years$. Defaults to an unoptimized <code>retro_years</code> parameter, set to 0. Generally, you would change this parameter in the parameter template, rather than changing here.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The actions will define the following variables in your model:

cur_time Current iteration of model, starts at 0 and increments until finished

cur_step Current step within individual year

cur_step_size Proportion of year this step contains, e.g. quarterly = 3/12

cur_year Current year

cur_step_final TRUE iff this is the final step of the year

cur_year_projection TRUE iff we are currently projecting past *end_year*
total_steps Total # of iterations (including projection) before model stops
total_years Total # of years (including projection) before model stops

Value

g3a_time: An action (i.e. list of formula objects) that will...

1. Define *cur_** variables listed above
2. If we've reached the end of the model, return *null*

Examples

```
# Run model 2000..2004, in quarterly steps
time_action <- g3a_time(
  start_year = 2000,
  end_year = 2004,
  c(3, 3, 3, 3))
```

eval

Evaluate G3 formulas

Description

Evaluate G3 formulas / code outside a model

Usage

```
g3_eval(f, ...)
```

Arguments

<i>f</i>	A formula object or quoted code to be evaluated
<i>...</i>	Named items to add to the formula's environment, or a single list / environment to use.

Details

Allows snippets of gadget3 code to be run outside a model. This could be done with regular [eval](#), however, `g3_eval` does a number of things first:

1. The global `g3_env` is in the environment, so functions such as `avoid_zero` can be used
2. If substituting a `g3_stock`, all definitions such as `stock__minlen` will also be substituted
3. `g3_param('x')` will pull `param.x` from the environment

Value

Result of evaluating f .

Examples

```
# Evaluate suitability function for given stocks
g3_eval(
  g3_suitability_andersen(0,1,2,3,4),
  pred_stock = g3_stock('pred', 11:20),
  stock = g3_stock('prey', 1:10))

# Parameters can be filled in with "param." items in environment
g3_eval(quote( g3_param('x') ), param.x = 88)
g3_eval(
  g3_parameterized('lln.alpha', by_stock = TRUE, value = 99),
  stock = g3_stock("fish", 1:10),
  param.fish.lln.alpha = 123)

# Graph gadget3's built-in logspace_add()
if (interactive()) {
  curve(g3_eval(quote( logspace_add(a, 10) ), a = x), 0, 50)
}
```

 formula_utils

Gadget3 formula helpers

Description

Tools to create R formulas

Usage

```
g3_formula(code, ...)
```

Arguments

code	Unevaluated code to be turned into a formula
...	Named items to add to the formula's environment, or a single list / environment to use.

Details

When using `~`, the local environment is attached to the code. This can leak unwanted variables into a model. This allows you to avoid the problem without resorting to [local](#).

Value

A [formula](#) object, with environment created from Can then be used anywhere in gadget3 that accepts a [formula](#).

Examples

```
# g3_formula is identical to defining a formula within local():
stopifnot(all.equal(
  g3_formula(x + 1, z = 44),
  local({ z = 44; ~x + 1 })
))

# If the code is destined for CRAN, you need to quote() to avoid check errors:
stopifnot(all.equal(
  g3_formula(quote( x + 1 ), z = 44),
  local({ z = 44; ~x + 1 })
))
```

language

G3 language extensions to R

Description

Additional meta-functions available for use in G3 formula.

Details

Whilst used as functions, these functions alter the code output of the model, rather than appearing directly.

g3_idx

Adds a - 1 to the supplied expression, but only in C++ (which has 0-based indexes). Under R the expression is passed through unchanged.

Note: This is generally for internal use, as `[]` will do this automatically for you.

For example, `g3_idx(a)` will be replaced with `a` in R output and `a - 1` in C++ output.

g3_param

Reference a scalar parameter by name. Arguments:

name Variable name for parameter. Required

value Initial value in model parameter_template. Default 0

optimise Initial optimise setting in parameter_template. Default TRUE

random Initial random setting in parameter_template. Default FALSE

lower Initial lower setting in parameter_template. Default NA

upper Initial upper setting in parameter_template. Default NA

For example, `g3_param("ling.Linf")` will register a scalar parameter called *ling.Linf*, available in the model parameter template, and be replaced by a reference to that parameter.

`g3_param("ling.Linf")` can be used multiple times, to refer to the same value.

g3_param_vector

Reference a vector parameter by name. Arguments:

name Variable name for parameter. Required

value Initial value for use in model parameter_template. Default 0

Same as `g3_param`, but the parameter will be expected to be a vector. You can then dereference with `[[`.

For example, `g3_param_vector("lingimm.M")[[age - 3 + 1]]`.

g3_param_table

Reference a lookup-table of parameters.

name Variable name for parameter. Required

table A data.frame, one column for each variable to check, one row for possible values. Required

value Initial value for use in model parameter_template. Default 0

optimise Initial optimise setting in parameter_template. Default TRUE

random Initial random setting in parameter_template. Default FALSE

lower Initial lower setting in parameter_template. Default NA

upper Initial upper setting in parameter_template. Default NA

ifmissing Value to return when outside of table bounds. Default NaN with warning if a value is missing

This is similar to providing a vector, but can use values in the model to provide bounds-checking.

The function takes 2 arguments, a prefix for the generated parameters, and a data.frame of variables to possible values. `expand.grid` can be used to produce a cross product of all provided variables.

Note: The variables referenced will need to be integer variables, most likely iteration variables such as `cur_year`, `age`, `area`...

For example, the following: `g3_param_table('lingimm.M', expand.grid(age = seq(ling_imm__minage, ling_imm__maxage)))` will generate parameters *lingimm.M.3..lingimm.M.10*, assuming that `ling_imm` has ages 3..10.

The call to `g3_param_table` will be replaced with `param[[paste("lingimm.M", age, sep = ".")]]`, or equivalent code in C++.

g3_report_all

Report all non-constant variables from a model.

Any variable that gets assigned to in the course of the model will be reported. If a variable doesn't change (i.e. data/params/constant), then there shouldn't be any point reporting.

Note: This is added by default in `g3a_time()`, so shouldn't be used manually unless re-implementing.

g3_with

`g3_with(var1 := val1, var2 := val2, { x <- val1 * val2 })` is equivalent to `local({var1 <- val1, var2 <- val2, { x <<- val1 * val2 } })`

However, we don't make a new environment for the code block in R, only in C++.

likelihood_catchdistribution
Gadget3 likelihood actions

Description

Gather nll in a g3 model

Usage

```
g3l_distribution_sumofsquares(over = c("area"))
g3l_distribution_multinomial(epsilon = 10)
g3l_distribution_multivariate(rho_f, sigma_f, over = c("area"))
g3l_distribution_surveyindices_log(alpha = NULL, beta = NULL)
g3l_distribution_surveyindices_linear(alpha = NULL, beta = NULL)

g3l_abundancedistribution(
  nll_name,
  obs_data,
  fleets = list(),
  stocks,
  function_f,
  transform_fs = list(),
  missing_val = 0,
  area_group = NULL,
  report = FALSE,
  nll_breakdown = FALSE,
  weight = substitute(
    g3_param(n, optimise = FALSE, value = 1),
```

```

        list(n = paste0(nll_name, "_weight"))),
run_at = 10)

g3l_catchdistribution(
  nll_name,
  obs_data,
  fleets = list(),
  stocks,
  function_f,
  transform_fs = list(),
  missing_val = 0,
  area_group = NULL,
  report = FALSE,
  nll_breakdown = FALSE,
  weight = substitute(
    g3_param(n, optimise = FALSE, value = 1),
    list(n = paste0(nll_name, "_weight"))),
run_at = 10)

g3l_distribution_sumofsquaredlogratios(epsilon = 10)

```

Arguments

over	When comparing proportions of lengthgroups, specifies the dimensions that define the total. For example the default "area" means the proportion of the current lengthgroup to all individuals in that area.
rho_f	formula substituted into multivariate calculations, see below.
sigma_f	formula substituted into multivariate calculations, see below.
epsilon	Value to be used whenever the calculated probability is very unlikely. Default 10.
alpha	formula substituted into surveyindices calculations to fix intercept of linear regression, or NULL if not fixed. See below.
beta	formula substituted into surveyindices calculations to fix slope of linear regression, or NULL if not fixed. See below.
nll_name	Character string, used to define the variable name for <i>obsstock</i> and <i>modelstock</i> .
obs_data	Data.frame of observation data, for example the results of mfdb_sample_count . Should at least have a year column, and a length or weight column. For more information, see "obs_data and data aggregation" below.
fleets	A list of g3_stock objects to collect catch data for. If empty, will collect abundance data for <i>stocks</i> instead.
stocks	A list of g3_stock objects to collect catch or abundance data for, depending if <i>stocks</i> were provided.
function_f	A formula to compare <i>obsstock__x</i> to <i>modelstock__x</i> and generate nll, defined by one of the <i>g3l_distribution_*</i> functions.

	This will be adapted to compare either number (<i>modelstock__num</i>) or weight (<i>modelstock__wgt</i>) depending on what columns <i>obs_data</i> has.
<code>transform_fs</code>	A list of dimension name to formula to apply to model data before collating. See examples.
<code>missing_val</code>	Where there are missing values in the incoming data, value to replace them with.
<code>area_group</code>	mfdb_group or list mapping area names used in <i>obs_data</i> to integer model areas, see "obs_data and data aggregation" below.
<code>report</code>	If TRUE, add model and observation arrays to the model report, called <code>cdist_nll_name_model__num/wgt</code> and <code>cdist_nll_name_obs__num/wgt</code> respectively
<code>nll_breakdown</code>	Should the nll report be broken down by time? TRUE / FALSE
<code>weight</code>	Weighting applied to this likelihood component. Default is a <code>g3_param</code> that defaults to 1, allowing weights to be altered without recompiling.
<code>run_at</code>	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The actions will define the following variables in your model:

`obsstock__num/wgt` A `g3_stock` instance that contains all observations in an array

`modelstock__num/wgt` A `g3_stock` instance that groups in an identical fashion to `obsstock`, that will be filled with the model's predicted values

The model report will contain `nll_cdist_nll_name__num` and/or `nll_cdist_nll_name__wgt`, depending on the columns in *obs_data* (a number column will compare by individuals, and produce a corresponding num report). If `nll_breakdown` is TRUE, this will be an array with one entry per timestep.

`g3l_abundancedistribution` compares abundance of stocks, `g3l_catchdistribution` compares fleet catch. Thus providing fleets is mandatory for `g3l_catchdistribution`, and an error for `g3l_abundancedistribution`.

obs_data and data aggregation: The *obs_data* data.frame, as well as providing the observation data to compare the model data against, controls the grouping of model data to compare to the observation data, by inspecting the MFDB column attributes produced by e.g. [mfdb_sample_count](#). Metadata columns describe the observation datapoint in that row. The columns should be from this list:

year Required. Year for the data point. Gaps in years will result in no comparison for that year

step Optional. If there is no step column, then the data is assumed to be yearly, and the model data for all timesteps will be summed before comparing.

Model timestep for the data point. Gaps in steps will result in no comparison for that year/step.

length Optional. If missing all lengthgroups in the model will be summed to compare to the data. If `open_ended = c('lower', 'upper')` was used when querying MFDB for the data, then the bottom/top length groups will be modified to start from zero or be infinite respectively. Any missing lengthgroups (when there is otherwise data for that year/step) will be compared to zero.

- age** Optional. If missing all age-groups (if any) in the model will be summed to compare to the data.
 Model ages will be grouped by the same groupings as MFDB used, thus if the data was formed with a query `age = mfdb_group(young = 1:3, old = 4:5)`, then the model data will similarly have 2 groups in it.
 Any missing ages (when there is otherwise data for that year/step) will be compared to zero.
- stock** Optional. If this and `stock_re` are missing all stocks in `stocks` will be summed to compare to the data.
 The values in the `stocks` column should match the names of the stocks given in the `stocks` parameter. This column can be factor or character.
 Any missing stocks (when there is otherwise data for that year/step) will be compared to zero.
- stock_re** Optional. If this and `stock` are missing all stocks in `stocks` will be summed to compare to the data.
 The values in the `stocks` column will be used as regular expressions to match the names of the stocks given in the `stocks` parameter. For example, `'_mat_'` will match both `'ghd_mat_f'` and `'ghd_mat_m'` and will be compared against the sum of the 2 stocks.
 Any missing stocks (when there is otherwise data for that year/step) will be compared to zero.
- fleet** Optional. If this and `fleet_re` are missing all fleets in `fleets` will be summed to compare to the data.
 The values in the `fleets` column should match the names of the fleets given in the `fleets` parameter. This column can be factor or character.
 Any missing fleets (when there is otherwise data for that year/step) will be compared to zero.
- fleet_re** Optional. If this and `fleet` are missing all fleets in `fleets` will be summed to compare to the data.
 The values in the `fleets` column will be used as regular expressions to match the names of the fleets given in the `fleets` parameter. For example, `'_trawl_'` will match both `'fleet_trawl_is'` and `'fleet_trawl_no'` and will be compared against the sum of the 2 fleets.
 Any missing fleets (when there is otherwise data for that year/step) will be compared to zero.
- area** Optional. If missing all areas in the model will be summed to compare to the data.
 Unlike other columns, the MFDB grouping here is ignored (the areas it is grouping over aren't integer model areas). Instead, the `area_group` parameter should describe how to map from the area names used in the table to integer model areas.
 For example, if `area_group = list(north=1:2, south=3:5)`, then the `area` column of `obs_data` should contain either "north" or "south", and corresponding model data will be summed from integer model areas 1,2 and 3,4,5 respectively.
 If `area_group` is not supplied, then we assume that `obs_data` `area` column will contain model area integers.
 Any missing areas (when there is otherwise data for that year/step) will be compared to zero.
- Data columns contain the observation data to compare. There should be at least one of:
- number** If a number column appears in `obs_data`, then the stock abundance by individuals will be aggregated and compared to the `obs_data` number column.
- weight** If a weight column appears in `obs_data`, then the total biomass of the stock will be aggregated and compared to the `obs_data` number column.

Value

g3l_distribution_sumofsquares: Returns a [formula](#) for use as `function_f`:

$$\sum_{lengths} \left(\frac{N_{tral}}{N_{tr}} - \frac{\nu_{tral}}{\nu_{tr}} \right)^2$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

N_{tr} Total observation sample size for current time/area (or dimensions set in *over*)

ν_{tr} Total model sample size for current time/area (or dimensions set in *over*)

g3l_distribution_multinomial: Returns a [formula](#) for use as *function_f*:

$$2 \left(\sum_{lengths} \log N_{tral}! - \log \left(\sum_{lengths} N_{tral} \right)! - \sum_{lengths} \left(N_{tral} \log \min \left(\frac{\nu_{tral}}{\sum_{lengths} \nu_{tral}}, \frac{1}{l\epsilon} \right) \right) \right)$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

l Number of lengthgroups in sample

ϵ *epsilon* parameter

g3l_distribution_multivariate: Returns a [formula](#) for use as *function_f*, which calls TMB's SCALE(AR1(rho), sigma)(x), where *rho* and *sigma* are parameters, and x is defined as:

$$\frac{N_{tral}}{N_{tr}} - \frac{\nu_{tral}}{\nu_{tr}}$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

N_{tr} Total observation sample size for current time/area (or dimensions set in *over*)

ν_{tr} Total model sample size for current time/area (or dimensions set in *over*)

For more information, see [Autoregressive processes](#) in the TMB book.

g3l_distribution_surveyindices_log: Returns a [formula](#) for use as *function_f*:

$$\sum_{time} (\alpha + \beta \log N_{tral} - \log \nu_{tral})^2$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

α *alpha* parameter

β *beta* parameter

If *alpha* or *beta* is not provided, then linear regression is performed on N , ν over time for each area/age/length combination. The used values will be stored in a `cdist_nll_name_model__param` array and reported after model run, whether calculated or hard-coded.

g3l_distribution_surveyindices_linear: Returns a [formula](#) for use as *function_f*:

$$\sum_{lengths} (\alpha + \beta N_{tral} - \nu_{tral})^2$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

α *alpha* parameter

β *beta* parameter

If *alpha* or *beta* is not provided, then linear regression is performed on N , ν over time for each area/age/length combination. The used values will be stored in a `cdist_nll_name_model__param` array and reported after model run, whether calculated or hard-coded.

g3l_*distribution: Assuming *fleets* is empty, an action (i.e. list of formula objects) that will...

1. For all *stocks*, collect catch data into `modelstock__num` or `modelstock__wgt`, depending on the columns provided in `obs_data`
2. Compare `modelstock__num/wgt` with `obsstock__num/wgt`, using `function_f`

The output of `function_f` is summed over all stock dimensions (age/area) and time and added to `nll`.

g3l_catchdistribution: An action (i.e. list of formula objects) that will...

1. For all *fleets* and *stocks* combinations, collect catch data into `modelstock__num` or `modelstock__wgt`, depending on the columns provided in `obs_data`
2. Compare `modelstock__num/wgt` with `obsstock__num/wgt`, using `function_f`

The output of `function_f` is summed over all stock dimensions (age/area) and time and added to `nll`.

g3l_distribution_sumofsquaredlogratios: The equivalent of `gadget2`'s `catchinkilos`.

Returns a [formula](#) for use as `function_f`:

$$\sum_{lengths} (\log(N_{tral} + \epsilon) - \log(\nu_{tral} + \epsilon))^2$$

N_{tral} Observation sample size for current time/area/age/length combination

ν_{tral} Model sample size for current time/area/age/length combination

ϵ *epsilon* parameter

See Also

<https://gadget-framework.github.io/gadget2/userguide/chap-like.html>, [g3_stock](#)

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock('ling_mat', seq(20, 156, 4)) %>% g3s_age(5, 15)
lln <- g3_fleet('lln')
```

```
# Invent a ldist.lln table for our tests
# NB: Generally one would use mfdb::mfdb_sample_count() to do this for you
ldist.lln <- list(expand.grid(
  year = 1999:2000,
  step = c(1, 2),
```

```

    age = c(5,6,7,8)))
ldist.lln[[1]]$number <- floor(runif(nrow(ldist.lln[[1]]), min=100, max=999))

likelihood_actions <- list(
  g3l_catchdistribution(
    'ldist_lln',
    ldist.lln[[1]],
    fleets = list(lln),
    stocks = list(ling_imm, ling_mat),
    g3l_distribution_sumofsquares())

# Apply age-reading error matrix to model data
more_likelihood_actions <- list(
  g3l_catchdistribution(
    'ldist_lln_readerror',
    ldist.lln[[1]],
    fleets = list(lln),
    stocks = list(ling_imm, ling_mat),
    transform_fs = list(age = g3_formula(
      g3_param_array('reader1matrix', value = diag(5))[g3_idx(preage), g3_idx(age)]
    )),
    g3l_distribution_sumofsquares())

# Apply per-stock age-reading error matrix to model data
more_likelihood_actions <- list(
  g3l_catchdistribution(
    'ldist_lln_readerror',
    ldist.lln[[1]],
    fleets = list(lln),
    stocks = list(ling_imm, ling_mat),
    transform_fs = list(age = g3_formula(stock_switch(stock,
      ling_imm = g3_param_array('imm_readermatrix',
        value = diag(ling_imm__maxage - ling_imm__minage + 1)
      )[ling_imm__preage_idx, ling_imm__age_idx],
      ling_mat = g3_param_array('mat_readermatrix',
        value = diag(ling_mat__maxage - ling_mat__minage + 1)
      )[ling_mat__preage_idx, ling_mat__age_idx],
      unused = 0))),
    g3l_distribution_sumofsquares())

```

likelihood_random

Gadget3 random effects likelihood actions

Description

Add likelihood components for random effects

Usage

```
g3l_random_dnorm(
```

```

nll_name,
param_f,
mean_f = 0,
sigma_f = 1,
log_f = TRUE,
weight = if (log_f) -1.0 else 1.0,
run_at = 10)

g3l_random_walk(
  nll_name,
  param_f,
  sigma_f = 1,
  log_f = TRUE,
  period = 'year',
  nll_breakdown = FALSE,
  weight = if (log_f) -1.0 else 1.0,
  run_at = 10)

```

Arguments

param_f	A formula representing the value to apply <code>dnorm</code> to. Invariably a <code>g3_param</code> for <code>g3l_random_dnorm</code> , a <code>g3_param_table</code> with <code>cur_year</code> for <code>g3l_random_walk</code> .
mean_f	A formula representing <i>mean</i> in <code>dnorm</code> .
sigma_f	A formula representing <i>sigma</i> in <code>dnorm</code> .
log_f	A formula representing <i>log</i> in <code>dnorm</code> .
period	When <code>dnorm</code> should be recalculated. Once per year or every step.
nll_name	Character string, used to define the variable name for <code>dnorm</code> output.
nll_breakdown	Should the nll report be broken down by time? TRUE / FALSE
weight	Weighting applied to this likelihood component.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The model report will contain `nll_random_dnorm_dnorm_lin__dnorm`, the results of applying `dnorm`. If `nll_breakdown` is TRUE, this will be an array with one entry per timestep.

Value

g3l_random_dnorm: An action (i.e. list of formula objects) that will...

1. On the final model step, calculate `dnorm(param_f, mean_f, sigma_f)` & add to nll

g3l_random_walk: An action (i.e. list of formula objects) that will...

1. Calculate `dnorm(param_f, previous param_f, sigma_f)` (at final year if `period = year`)
2. Add to nll.

Examples

```
likelihood_actions <- list(
  # Calculate dnorm() for the dnorm_log parameter
  g3l_random_dnorm('dnorm_log',
    g3_parameterized('dnorm_log', value = 0, random = TRUE),
    mean_f = 0),

  # Treat the walk_year.xxxx parameters as a random walk
  g3l_random_walk('walk_year',
    g3_parameterized('walk_year', by_year = TRUE, value = 0, random = TRUE))
)
```

likelihood_tagging_ckmr

Gadget3 CKMR likelihood

Description

Experimental CKMR tagging likelihood

Usage

```
g3l_tagging_ckmr(
  nll_name,
  obs_data,
  fleets,
  parent_stocks,
  offspring_stocks,
  weight = substitute(
    g3_param(n, optimise = FALSE, value = 1),
    list(n = paste0(nll_name, "_weight"))),
  run_at = 10)
```

Arguments

nll_name	Character string, used to define the variable name for <i>obsstock</i> and <i>modelstock</i> .
obs_data	Data.frame of observed mother-offspring pairs with columns year / parent_age / offspring_age / mo_pairs
fleets	A list of g3_stock objects to collect catch data for.
parent_stocks	A list of g3_stock objects that are parents in a g3a_spawn action
offspring_stocks	A list of g3_stock objects that are output_stocks in a g3a_spawn action
weight	Weighting applied to this likelihood component. Default is a g3_param that defaults to 1, allowing weights to be altered without recompiling.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

Implementation of CKMR based on *Bravington, M.V., Skaug, H.J., & Anderson, E.C. (2016). Close-Kin Mark-Recapture. Statistical Science, 31, 259-274.*

Only one kinship probability is implemented, mother-offspring with lethal sampling, i.e. (3.2) in the paper. This is then used as a pseudo-likelihood as per (4.1).

obs_data: The *obs_data* data.frame provides observed pairs. Unlike other likelihood methods, it has a fixed structure:

year Year of observation for the data point.

parent_age Age of the parent in an observed parent-offspring pair.

offspring_age Age of the offspring in an observed parent-offspring pair.

mo_pairs Number of pairs observed with these ages.

Value

g3l_tagging_ckmr: An action (i.e. list of formula objects) that will...

1. For all *parent_stocks* and *offspring_stocks*, collect spawning rate into *modelhist__spawning* and *modelhist__spawned*, total number of parents and total number of spawned offspring respectively
2. For all *fleets*, collect catch data into *modelhist__catch*
3. For any observed pairs that year, include the probability of that event happening into *nll*

See Also

Bravington, M.V., Skaug, H.J., & Anderson, E.C. (2016). Close-Kin Mark-Recapture. Statistical Science, 31, 259-274. [g3_stock](#)

likelihood_understocking

Gadget3 likelihood understocking action

Description

Add rates of understocking in a g3 model to *nll*

Usage

```
g3l_understocking(pre_y_stocks, power_f = ~2, nll_breakdown = FALSE, weight = 1,
  run_at = 10)
```

Arguments

prey_stocks	A list of <code>g3_stock</code> objects to collect catch data for
power_f	A <code>formula</code> representing power coefficient p to use.
nll_breakdown	Should the nll report be broken down by time? TRUE / FALSE
weight	Weighting applied to this likelihood component.
run_at	Integer order that actions will be run within model, see "Ordering of actions" in <code>vignette("model_structure")</code> .

Details

The model report will contain `nll_understocking__wgt`, the results of the formula below. If `nll_breakdown` is TRUE, this will be an array with one entry per timestep.

Value

g3l_distribution_understocking: An action (i.e. list of formula objects) that will...

1. Sum the total biomass adjustment due to overstocking for each prey according to the formula

$$\ell = \sum_{time} \sum_{areas} \left(\sum_{prey_stocks} U_{trs} \right)^p$$

Where p is the power coefficient from `power_f`, U_{trs} is the total biomass adjustment to predator consumption due to overconsumption.

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock('ling_mat', seq(20, 156, 4)) %>% g3s_age(5, 15)
lln <- g3_fleet('lln')

likelihood_actions <- list(
  g3l_understocking(list(ling_imm, ling_mat)))
```

 params

Gadget3 parameter helpers

Description

Shortcuts to parameterise a model with `g3_param`

Usage

```
g3_parameterized(
  name,
  by_stock = FALSE,
  by_year = FALSE,
  by_age = FALSE,
  exponentiate = FALSE,
  avoid_zero = FALSE,
  scale = 1,
  offset = 0,
  ...)
```

Arguments

name	Suffix for parameter name.
by_stock	Should there be individual parameters per-stock? FALSE No TRUE Produce a "stock_name.name" parameter character vector Select the stock name_part(s) to use, e.g. to produce "stock_species.name" parameter with "species" List of g3_stock objects Produce a parameter that applies to all given stocks
by_year	Should there be individual parameters per model year? FALSE No TRUE Produce a "name.1998" parameter for each year the model runs
by_age	Should there be individual parameters per stock age? FALSE No TRUE Produce a "name.4" parameter for each age of the stock(s) in <i>by_stock</i>
exponentiate	Use $\exp(\text{value})$ instead of the raw parameter value. Will add "_exp" to the parameter name.
avoid_zero	If TRUE, wrap parameter with <code>avoid_zero</code>
scale	Use $\text{scale} * \text{value}$ instead of the raw parameter value. Either a numeric constant or character. If character, add another parameter for scale, using the same <i>by_stock</i> value.
offset	Use $\text{value} + \text{offset}$ instead of the raw parameter value Either a numeric constant or character. If character, add another parameter for offset, using the same <i>by_stock</i> value.
...	Additional parameters passed through to <code>g3_param</code> , e.g. <i>optimise</i> , <i>random</i> , ...

Details

The function provides shortcuts to common formulas used when parameterising a model.

Value

A [formula](#) object defining the given parameters

See Also

[g3_param](#), [g3_param_table](#), [stock_param](#), [stock_param_table](#)

Examples

```
stock_a <- g3_stock(c(species = 'stock', 'aaa'), seq(10, 35, 5)) %>% g3s_age(1, 10)
stock_b <- g3_stock(c(species = 'stock', 'bbb'), seq(10, 35, 5)) %>% g3s_age(1, 10)

# Not by anything, so just a regular parameter
g3_parameterized('K')

# by_stock, so will use stock_param() to rename variables
g3_parameterized('K', by_stock = TRUE)

# Adding by_year or by_age turns it into a table
g3_parameterized('K', by_stock = TRUE, by_year = TRUE, by_age = TRUE)

# Can specify the name parts you want
g3_parameterized('K', by_stock = 'species', by_year = TRUE)

# Can give a list of stocks, in which case it works out name parts for you
g3_parameterized('K', by_stock = list(stock_a, stock_b))
g3_parameterized('K', by_stock = list(stock_a, stock_b), by_age = TRUE)
```

run_desc

Gadget3 actions into R code

Description

Convert g3 actions into a character vector describing the model

Usage

```
g3_to_desc(actions, minor_steps = FALSE)
```

Arguments

actions	A list of actions (i.e. list of formula objects), as produced by <i>g3a_*</i> functions.
minor_steps	Include minor steps (e.g. zeroing cumulative arrays)? TRUE / FALSE

Value

Character vector describing each step in the model. An action in a model may have generated multiple steps (e.g. select each prey stock, scale total amount, apply overstocking), and there will be a line in here for each.

Examples

```

ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)

initialconditions_action <- g3a_initialconditions_normalparam(
  ling_imm,
  by_age = TRUE)

# Timekeeping action
time_action <- g3a_time(
  start_year = 2000,
  end_year = 2004,
  c(3, 3, 3, 3))

# Generate a list outlining the steps the model uses
as.list(g3_to_desc(list(initialconditions_action, time_action)))

```

run_r

Gadget3 actions into R code

Description

Convert g3 actions into an R function that can then be executed

Usage

```
g3_to_r(actions, trace = FALSE, strict = FALSE)
```

Arguments

actions	A list of actions (i.e. list of formula objects), as produced by <i>g3a_*</i> functions.
trace	If TRUE, turn all comments into print statements.
strict	If TRUE, enable extra sanity checking in actions. Any invalid conditions (e.g. more/less fish after growth) will result in a warning.

Value

A function that takes a *params* variable, that defines all *g3_params* required by the model. The following attributes will be set:

actions The original *actions* list given to the function

parameter_template A list of all parameters expected by the model, to fill in

Use e.g. `attr(fn, 'parameter_template')` to retrieve them.

Invariant model data will be stored as a closure, i.e. in `environment(fn)`. This can be fetched with `environment(fn)$cdist_sumofsquares_ldist_gil_obs__num`.

The function will return *nll* produced by the model. You can also use `attributes(nll)` to get any report variables from the model.

Examples

```

ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4)) %>% g3s_age(3, 10)

initialconditions_action <- g3a_initialconditions_normalparam(
  ling_imm,
  factor_f = g3a_renewal_initabund(by_stock_f = 'species'),
  by_stock = 'species',
  by_age = TRUE)

# Timekeeping action
time_action <- g3a_time(
  start_year = 2000,
  end_year = 2004,
  c(3, 3, 3, 3))

# Generate a model from the above 2 actions
# NB: Obviously in reality we'd need more actions
fn <- g3_to_r(list(initialconditions_action, time_action))

if (interactive()) {
  # Edit the resulting function
  fn <- edit(fn)
}

param <- attr(fn, 'parameter_template')
param$project_years <- 0
param$ling.init.F <- 0.4
param$ling.Linf <- 160
param$ling.K <- 90
param$ling.recl <- 12
param$recage <- g3_stock_def(ling_imm, 'minage')
param[grepl('^ling.init.sd.', names(param))] <- 50.527220
param[grepl('^ling_imm.init.\\d+', names(param))] <- 1
param$ling_imm.init.scalar <- 200
param$ling_imm.walpha <- 2.27567436711055e-06
param$ling_imm.wbeta <- 3.20200445996187
param$ling_imm.M <- 0.15

# Run the model with the provided parameters
nll <- fn(param)

# Get the report from the last model run
report <- attributes(nll)

# Fetch a value from the model data
environment(fn)$ling_imm__midlen

```

Description

Turn g3 actions into CPP code that can be compiled using TMB

Usage

```
g3_to_tmb(actions, trace = FALSE, strict = FALSE, adreport_re = '^$')

g3_tmb_adfun(cpp_code, parameters = attr(cpp_code, "parameter_template"),
  compile_flags =
    if (.Platform$OS.type == "windows") c("-O1", "-march=native")
    else c("-O3", "-flto", "-march=native"),
  work_dir = tempdir(),
  output_script = FALSE, ...)

g3_tmb_par(parameters, include_random = TRUE)

g3_tmb_lower(parameters)

g3_tmb_upper(parameters)

g3_tmb_parscale(parameters)

g3_tmb_relist(parameters, par)
```

Arguments

actions	A list of actions (i.e. list of formula objects), as produced by <i>g3a_*</i> functions.
trace	If TRUE, turn all comments into print statements.
strict	If TRUE, enable extra sanity checking in actions. Any invalid conditions (e.g. more/less fish after growth) will result in a warning.
adreport_re	Regular expression, variables that match this will be added to the ADREPORT, for use with sdreport . The default '^\$', doesn't match anything so no variables will be ADREPORTed.
cpp_code	cpp_code as produced by <i>g3_to_tmb</i> .
parameters	Parameter table as produced by <code>attr(g3_to_tmb(...), 'parameter_template')</code> , modified to provide initial conditions, etc.
par	Parameter vector, as produced by one of <ol style="list-style-type: none"> <code>nlminb(...)\$par</code> <code>obj.fun\$env\$last.par</code> <code>g3_tmb_par()</code> The first will not include random parameters by default, the others will.
include_random	Should random parameters assumed to be part of par? Should be TRUE if using <code>obj.fun\$fn</code> , <code>obj.fun\$report</code> directly, e.g. <code>obj.fun\$fn(g3_tmb_par(param_tbl))</code> . In other cases, FALSE.

compile_flags	List of extra flags to compile with, use e.g. "-g" to enable debugging output.
work_dir	Directory to write and compile .cpp files in. Defaults to R's current temporary directory
output_script	If TRUE, create a temporary R script that runs MakeADFun , and return the location. This can then be directly used with gdbsource or <code>callr::rscript</code> .
...	Any other options handed directly to MakeADFun

Details

g3_tmb_adfun: [g3_tmb_adfun](#) will do both the [compile](#) and [MakeADFun](#) steps of making a model. If the code is identical to an already-loaded model then it won't be recompiled, so repeated calls to [g3_tmb_adfun](#) to change *parameters* are fast.

If [MakeADFun](#) is crashing your R session, then you can use *output_script* to run in a separate R session. Use this with [gdbsource](#) to debug your model.

Value

g3_to_tmb: A string of C++ code that can be used as an input to [g3_tmb_adfun](#), with the following attributes:

actions The original *actions* list given to the function

model_data An environment containing data attached to the model

parameter_template A data.frame to be filled in and used as *parameters* in the other [g3_tmb_*](#) functions

Use e.g. `attr(cpp_code, 'parameter_template')` to retrieve them.

g3_tmb_adfun: An ADFun as produced by TMB's [MakeADFun](#), or location of temporary script if *output_script* is TRUE

g3_tmb_par: Values extracted from *parameters* table converted into a vector of values for `obj$fn(par)` or `nlminb`

g3_tmb_lower: Lower bounds extracted from *parameters* table converted into a vector of values for `nlminb`. Random parameters are always excluded

g3_tmb_upper: Lower bounds extracted from *parameters* table converted into a vector of values for `nlminb`. Random parameters are always excluded

g3_tmb_parscale: Parscale extracted from *parameters* table, converted into a vector of values for `nlminb`. Random parameters are always excluded

g3_tmb_relist: The *parameters* table value column, but with optimised values replaced with contents of *par* vector. i.e. the inverse operation to [g3_tmb_par](#). *par* can either include or discount random variables.

Examples

```

ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4)) %>% g3s_age(3, 10)

initialconditions_action <- g3a_initialconditions_normalparam(
  ling_imm,
  factor_f = g3a_renewal_initabund(by_stock_f = 'species'),
  by_stock = 'species',
  by_age = TRUE)

abundance_action <- g3l_abundancedistribution(
  'abundance',
  data.frame(year = 2000:2004, number = 100),
  stocks = list(ling_imm),
  function_f = g3l_distribution_sumofsquares())

# Timekeeping action
time_action <- g3a_time(
  start_year = 2000,
  end_year = 2004,
  c(3, 3, 3, 3))

# Generate a model from the above 2 actions
# NB: Obviously in reality we'd need more actions
cpp <- g3_to_tmb(list(initialconditions_action, abundance_action, time_action))

if (interactive()) {
  # Edit the resulting code
  cpp <- edit(cpp)
}

# Set initial conditions for parameters
tmb_param <- attr(cpp, 'parameter_template')
tmb_param$value$project_years <- 0
tmb_param$value$ling.init.F <- 0.4
tmb_param$value$ling.Linf <- 160
tmb_param$value$ling.K <- 90
tmb_param$value$ling.recl <- 12
tmb_param$recage <- g3_stock_def(ling_imm, 'minage')
tmb_param[grepl('^ling.init.sd.', rownames(tmb_param)), 'value'] <- 50.527220
tmb_param[grepl('^ling_imm.init.\\d+', rownames(tmb_param)), 'value'] <- 1
tmb_param$value$ling_imm.init.scalar <- 200
tmb_param$value$ling_imm.walpha <- 2.27567436711055e-06
tmb_param$value$ling_imm.wbeta <- 3.20200445996187
tmb_param$value$ling_imm.M <- 0.15

# We can set lower/upper bounds for multiple properties at once with grepl()
tmb_param[grepl('.', rownames(tmb_param)), 'lower'] <- -1000
tmb_param[grepl('.', rownames(tmb_param)), 'upper'] <- 1000

# parscale gives optim() a relative scale of parameters
tmb_param['parscale'] <- 1

```

```

# Compile to a TMB ADFun
tmb <- g3_tmb_adfun(cpp, tmb_param)

# Build the model in an isolated R session w/debugger
writeLines(TMB::gdbsource(g3_tmb_adfun(cpp, compile_flags = "-g", output_script = TRUE)))

# Perform a single run, using values in table
result <- tmb$fn(g3_tmb_par(tmb_param))

# perform optimisation using upper/lower/parscale from table
fit <- optim(tmb$par, tmb$fn, tmb$gr,
  method = "L-BFGS-B",
  upper = g3_tmb_upper(tmb_param),
  lower = g3_tmb_lower(tmb_param),
  control = list(maxit=10, parscale=g3_tmb_parscale(tmb_param)))

# perform optimisation without bounds
fit <- optim(tmb$par, tmb$fn, tmb$gr)

# Go back to a list of parameters, suitable for the R version
# NB: This will not set the values for random parameters
param_list <- g3_tmb_relist(tmb_param, fit$par)

# Update parameters with values from last run, *including* random parameters.
param_list <- g3_tmb_relist(tmb_param, tmb$env$last.par)

# Rebuild, only including "Fun" (i.e. without auto-differentiation)
# Result will only work for tmb$report
tmb <- g3_tmb_adfun(cpp, tmb_param, type = "Fun")
result <- tmb$report(g3_tmb_par(tmb_param))

```

step

G3 stock_ transformation functions*

Description

Additional meta-functions to help manage writing stock-handling actions.

Usage

```
g3_step(step_f, recursing = FALSE, orig_env = environment(step_f))
```

Arguments

step_f	Input formula containing references to functions below
recursing	Only use default value
orig_env	Only use default value

Details

All action producing functions will run their output through `g3_step`. This means that the functions described here will be available in any `gadget3` code.

They handle translation of stock instance naming, so code can refer to e.g. `stock__num` without having to translate naming to the final stock name, and iterating over stock dimensions.

Value

`g3_step`: A [formula](#) object with references to above functions replaced.

`debug_label`

Add a comment to the code to act as a label for that step, when producing an outline of the model. There shouldn't be more than one `debug_label` call in a step.

Models compiled with `trace = TRUE` will print the resultant string to `stdout`.

Arguments: Any number of character strings, or [g3_stock](#) variables. The latter will be replaced with the final name.

`debug_trace`

Identical to [debug_label](#), but not considered a "label", just a code comment, so any number of calls can be added.

`stock_assert`

```
stock_assert(expression, message, message/stock-var, ...)
```

Assert that *expression* is true, if not abort with a message.

`stock_reshape`

```
stock_reshape(dest_stock, expression)
```

Output *expression* with it's length structure reshaped to match *dest_stock*. The source stock is considered to be the first one found in *expression*

How this is achieved depends on the difference. If the source and destination match then this is a no-op. Otherwise a transformation matrix is generated and included into the model.

`stock_ss`

```
stock_ss(stock_var, [ dimname = override, dimname = override, ... ])
```

Subsets *stock_var* to get a length vector for the current iteration of [stock_iterate\(\)](#). If *dimnames* are supplied, then these dimensions overwritten with the supplied override, which could be a missing value, to preserve a dimension. See final example.

Length is a missing value by default, i.e. we return length groups. To avoid this happening, set `length = default` to iterate over length too.

stock_ssinv

```
stock_ssinv(stock_var, [ dimname, dimname, ... ])
```

like [stock_ss\(\)](#), but subset only the mentioned *dimnames*.

stock_switch

```
stock_ss(stock, stock_name1 = expr, stock_name2 = expr, ... [ default ])
```

Switch based on name of *stock*, returning the relevant *expr* or *default*. If no default supplied, then an unknown stock is an error.

expr is implicitly wrapped with [stock_with](#)(*stock*, ...), so any references to the stock variable will work. If only default is provided, then this is identical to calling [stock_with](#).

stock_with

```
stock_with(stock, expr)
```

Replaced with *expr* but with all stock variables of *stock* renamed with their final name. This is generally needed when not iterating over a stock, but e.g. zeroing or summing the whole thing.

stock_iterate

```
stock_iterate(stock, expr)
```

Wrap *expr* with the code to iterate over vector dimensions in *stock*, accessed using [stock_ss](#)(*stock*).

Which dimensions are iterated over is decided based on the call to [stock_ss](#)(*stock*). By default, [stock_ss](#) leaves length blank so will iterate over a length vector for each dimension.

You can iterate over each value individually with the following: [stock_iterate](#)(*stock*, [stock_ss](#)(*stock*, length = default))

Current values for each dimension will be available as variables, e.g. *area*, *age*, and can be used in formulae.

stock_intersect

```
stock_intersect(stock, expr)
```

Wrap *expr* with the code to intersect all dimensions with the dimensions of an outer [stock_iterate](#)().

stock_interact

```
stock_interact(stock, expr, prefix = prefix)
```

Wrap *expr* with the code to interact with the dimensions of an outer [stock_iterate](#)(). Interact means to intersect over area, but try the combinatorial explosion of all other dimensions, i.e. what would make most sense when 2 stocks interact in a predator-prey relationship.

Additional variables will be prefixed with *prefix*.

stock_param

```
stock_param(stock, name, name_part = NULL, ...)
```

Convert to a call to [g3_param](#), prefixing the *name* with the stock name. If *name_part* given, only use given part(s) of the stock name.

All other args passed through to [g3_param](#).

stock_param_table

```
stock_param_table(stock, name, name_part = NULL, table_defn, ...)
```

Convert to a call to [g3_param_table](#), prefixing the *name* with the stock name. If *name_part* given, only use given part(s) of the stock name.

The *table_defn* will have any instances of *stock* replaced using [stock_with](#)().

All other args passed through to [g3_param_table](#).

Examples

```
### debug_label
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10)
prey_stock <- g3_stock('herring', 1:3) %>% g3s_age(1,3)
g3_step(~debug_trace("Zero ", stock, "-", prey_stock, " biomass-consuming counter"))

### stock_assert
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10)
g3_step(~stock_assert(stock_with(stock, all(is.finite(stock__num))), stock, "__num became NaN/Inf"))

### stock_reshape
imm_stock <- g3_stock('halibut.imm', 1:5) %>% g3s_age(1,3)
g3_step(~stock_reshape(stock, stock_ss(imm_stock__transitioning_num)))

### stock_ss
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10) %>% g3s_livesonareas(1)
stock__num <- g3_stock_instance(stock)
g3_step(~stock_iterate(stock, { x <- x + stock_ss(stock__num) }))
g3_step(~stock_ss(stock__num, area = 5))
g3_step(~stock_ss(stock__num, age = i + 1))
g3_step(~stock_ss(stock__num, area = , age = j))

### stock_ssinv
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10) %>% g3s_livesonareas(1)
g3_step(~g3_step(~stock_ssinv(stock, 'age')))
g3_step(~g3_step(~stock_ssinv(stock, 'area')))

### stock_switch
stock <- g3_stock('halibut', 1:10) ; fleet_stock <- g3_fleet('igfs')
g3_step(~stock_switch(stock, halibut = 2, herring = 3, -1))
g3_step(~stock_switch(fleet_stock, halibut = 2, herring = 3, -1))
g3_step(~stock_switch(stock, halibut = stock__midlen, -1))

### stock_with
```

```

stock <- g3_stock('halibut', 1:10)
g3_step(~stock_with(stock, sum(stock__num)))

### stock_iterate
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10)
g3_step(~stock_iterate(stock, x <- x + stock_ss(stock__num)))

### stock_intersect
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10)
prey_stock <- g3_stock('herring', 1:3) %>% g3s_age(1,3)
g3_step(~stock_iterate(stock, stock_intersect(pre_y_stock, {
  x <- x + stock_ss(stock__num) + stock_ss(pre_y_stock__num)
})))

### stock_interact
stock <- g3_stock('halibut', 1:10) %>% g3s_age(1,10)
prey_stock <- g3_stock('herring', 1:3) %>% g3s_age(1,3)
g3_step(~stock_iterate(stock, stock_interact(pre_y_stock, {
  x <- x + stock_ss(stock__num) + stock_ss(pre_y_stock__num)
}, prefix = "prey" )))

### stock_param
stock <- g3_stock(c(species = 'halibut', sex = 'm', 'imm'), 1:10) %>% g3s_age(1,10)
g3_step(~stock_param(stock, 'K'))
g3_step(~stock_param(stock, 'K', name_part = 'species'))
g3_step(~stock_param(stock, 'K', name_part = c('species', 'sex'))))

### stock_param_table
stock <- g3_stock(c(species = 'halibut', 'imm'), 1:10) %>% g3s_age(1,10)
g3_step(~stock_param_table(stock, 'K', expand.grid(year = 2000:2004)))
g3_step(~stock_param_table(stock, 'K', expand.grid(age = seq(stock__minage, stock__maxage))))

```

stock

Gadget3 stock storage

Description

Define multi-dimensional storage for use in models, mostly to contain state about stocks.

Usage

```

g3_stock(var_name, lengthgroups, open_ended = TRUE)

g3_stock_instance(stock, init_value = NA, desc = "")

g3_fleet(var_name)

g3_stock_def(stock, name)

```

```
g3s_clone(inner_stock, var_name)
```

```
g3_is_stock(stock)
```

Arguments

var_name	Prefix used for all instance variables of this stock. Can have multiple parts that will be concatenated together, see example.
lengthgroups	Vector defining length groups, each entry defining the minimum value.
open_ended	If TRUE, final <i>lengthgroups</i> value defines a group $x:Inf$. If FALSE, final <i>lengthgroups</i> value is the upper bound for the previous group.
inner_stock	A g3_stock or g3_fleet object to clone.
stock	A g3_stock or g3_fleet .
init_value	Initially the array will be filled with this constant, e.g. 1, 0 or NaN
desc	Description of the array that will be included in models
name	Name of definition to extract, e.g. "minlen".

Value

g3_stock: A [g3_stock](#) with length groups

g3_stock_instance: An array with dimensions matching the stock.

g3_fleet: A [g3_stock](#) without length groups

g3s_clone: A [g3_stock](#) with identical dimensions to *inner_stock* but with a new name.

g3_is_stock: TRUE iff *stock* is a [g3_stock](#) object.

Examples

```
# Define a stock with 3 lengthgroups
stock <- g3_stock('name', c(1, 10, 100))

# Define a stock with a multi-part name. We can then dig out species name
stock <- g3_stock(c(species = 'ling', 'imm'), c(1, 10, 100))
stopifnot( stock$name == 'ling_imm' )
stopifnot( stock$name_parts[['species']] == 'ling' )

# Use stock_instance define storage for mean weight of stock,
# has dimensions matching what was defined above.
g3_stock_instance(stock, 1, "Mean weight")

# Retrieve the upperlen for the stock
g3_stock_def(stock, 'upperlen')
```

```
# Define a stock, not-open-ended. Now only 2 groups long
stock <- g3_stock('name', c(1, 10, 100), open_ended = FALSE)

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)

# Fleets don't have lengthgroups
stock <- g3_fleet('name') %>% g3s_livesonareas(1)

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)
```

stock_age	<i>Gadget3 stock age dimensions</i>
-----------	-------------------------------------

Description

Add age dimensions to `g3_stock` classes

Usage

```
g3s_age(inner_stock, minage, maxage)

g3s_agegroup(inner_stock, agegroups)
```

Arguments

<code>inner_stock</code>	A <code>g3_stock</code> that we extend with an age dimension
<code>minage</code>	Minimum age to store, integer.
<code>maxage</code>	Maximum age to store, integer.
<code>agegroups</code>	(optionally named) list of vectors of ages, grouping them together.

Value

g3s_age: A `g3_stock` with an additional 'age' dimension.

When iterating over the stock, iterate over each age in turn, `age` will be set to the current integer age.

When intersecting with another stock, only do anything if `age` is between `minage` and `maxage`.

If an age dimension already exists, it is redefined with new parameters.

g3s_agegroup: A `g3_stock` with an additional 'age' dimension.

When iterating over the stock, iterate over each agegroup in turn, `age` will be set to the first age in the group.

When intersecting with another stock, only do anything if `age` is part of one of the groups.

Examples

```
# Define a stock with 3 lengthgroups and 3 ages
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_age(5, 10)

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)

# Define a stock that groups age into "young" and "old"
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_agegroup(list(
    young = 5:7,
    old = 8:10))

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)
```

stock_areas

Gadget3 stock area dimensions

Description

Add area dimensions to `g3_stock` classes

Usage

```
g3s_livesonareas(inner_stock, areas)

g3s_areagroup(inner_stock, areagroups)
```

Arguments

<code>inner_stock</code>	A g3_stock that we extend with an area dimension
<code>areas</code>	A vector of numeric areas that the stock is part of
<code>areagroups</code>	A list mapping names to vectors of numeric areas the stock is part of

Details

Each area will be defined as a variable in your model as `area_x`, allowing you to use names in formulas, e.g. `run_f = quote(area == area_x)`.

Value

g3s_livesonareas: A `g3_stock` with an additional 'area' dimension.

When iterating over the stock, iterate over each area in turn, *area* will be set to the current integer area.

When intersecting with another stock, only do anything if *area* is also part of our list of areas.

g3s_areagroup: A `g3_stock` with an additional 'area' dimension.

When iterating over the stock, iterate over each areagroup in turn, *area* will be set to the first area in the group.

When intersecting with another stock, only do anything if *area* is part of one of the groups.

Examples

```
# Make a lookup so we can refer to areas by name
areas <- c(a=1, b=2, c=3, d=4, e=5)

# Define a stock with 3 lengthgroups and 3 areas
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_livesonareas(areas[c('a', 'b', 'c')])

# Area variables will be defined, so you can refer to them in formulas:
g3a_migrate(stock, g3_parameterized("migrate_spring"),
  run_f = ~area == area_b && cur_step == 2)

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)

# Define a stock that groups areas into "north" and "south"
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_areagroup(list(
    north = areas[c('a', 'b', 'c')],
    south = areas[c('d', 'e')]))

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)
```

stock_tag

Gadget3 tag dimension

Description

Add tag dimensions to `g3_stock` classes

Usage

```
g3s_tag(inner_stock, tag_ids, force_untagged = TRUE)
```

Arguments

`inner_stock` A `g3_stock` that we extend with an area dimension

`tag_ids` A vector of numeric tags the stock can have, generated by `seq_along`, e.g. Tag ID 0 is considered to be "untagged".

`force_untagged` If TRUE, if "untagged" tag 0 isn't present it will be added.

Value

g3s_tag: A `g3_stock` with an additional 'tag' dimension.

When iterating over the stock, iterate over each tag in turn, `tag` will be set to the current integer area.

When interacting with another stock, iterate over each tag in turn, the variable name will depend on the scenario, e.g. `prey_tag`.

Examples

```
# Make a lookup of text names to integers
tags <- c('H1-00', 'H1-01')
tags <- structure(seq_along(tags), names = tags)

# prey_a can have any of these tags
prey_a <- g3_stock('prey_a', seq(1, 10)) %>% g3s_tag(tags)

# Use stock_instance to see what the array would look like
g3_stock_instance(prey_a)
```

stock_time	<i>Gadget3 stock time dimensions</i>
------------	--------------------------------------

Description

Add time dimensions to `g3_stock` classes

Usage

```
g3s_time_convert(year, step = NULL)

g3s_time(inner_stock, times, year = NULL, step = NULL)
```

Arguments

`year` Vector of years, used to generate *times* if provided.

`step` Vector of steps, used to generate *times* if provided.

`inner_stock` A `g3_stock` that we extend with a time dimension

`times` A vector of year/step integers as generated by `g3s_time_convert`

Value

g3s_time_convert: A single integer vector representing *year* and *step*.

If *step* is NULL, returns *year*, otherwise $year * 1000 + step$.

g3s_time: A *g3_stock* with an additional 'time' dimension.

If *year/step* provided, time is defined by those, otherwise *times*.

The *g3_stock* will not support iterating, only intersecting.

When intersecting with another stock, only do anything if *cur_year* and *cur_step* matches a time stored in the vector

Examples

```
# Define a stock with 3 lengthgroups and 3 years, not continuous
# When used, all steps within a year will be aggregated, year 2002 will be ignored.
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_time(year = c(2000, 2001, 2003))

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)

# Define a stock with 3 lengthgroups and 3 years, 2 steps
# The dimension will have 6 entries, 2000.1, 2000.2, 2001.1, 2001.2, 2002.1, 2002.2
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_time(year = c(2000, 2001, 2002), step = 1:2)

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)

# g3s_time_convert is best used with a data.frame
data <- read.table(header = TRUE, text = '
year step
2001 1
2001 2
# NB: No "2002 1"
2002 2
')
stock <- g3_stock('name', c(1, 10, 100)) %>%
  g3s_time(times = g3s_time_convert(data$year, data$step))

# Use stock_instance to see what the array would look like
g3_stock_instance(stock)
```

Description

Formula-returning functions describing length suitability relationships.

Usage

```
g3_suitability_exponential150(alpha, 150)
```

```
g3_suitability_andersen(p0, p1, p2, p3 = p4, p4, p5 = ~pred_stock__midlen)
```

```
g3_suitability_andersenfleet(
  p0 = g3_parameterized('andersen.p0', by_stock = by_stock, value = 0,
    optimise = FALSE),
  p1 = g3_parameterized('andersen.p1', by_stock = by_stock, value = log(2)),
  p2 = g3_parameterized('andersen.p2', by_stock = by_stock, value = 1,
    optimise = FALSE),
  p3 = g3_parameterized('andersen.p3', by_stock = by_stock, value = 0.1,
    exponentiate = exponentiate),
  p4 = g3_parameterized('andersen.p4', by_stock = by_stock, value = 0.1,
    exponentiate = exponentiate),
  p5 = quote( stock__maxmidlen ),
  by_stock = TRUE,
  exponentiate = TRUE)
```

```
g3_suitability_gamma(alpha, beta, gamma)
```

```
g3_suitability_exponential(alpha, beta, gamma, delta)
```

```
g3_suitability_straightline(alpha, beta)
```

```
g3_suitability_constant(alpha)
```

```
g3_suitability_richards(p0, p1, p2, p3, p4)
```

Arguments

alpha	formula substituted into calculations, see below.
150	formula substituted into calculations, see below.
p0	formula substituted into calculations, see below.
p1	formula substituted into calculations, see below.
p2	formula substituted into calculations, see below.
p3	formula substituted into calculations, see below.
p4	formula substituted into calculations, see below.
p5	formula substituted into calculations, see below.
beta	formula substituted into calculations, see below.
gamma	formula substituted into calculations, see below.

delta	formula substituted into calculations, see below.
by_stock	Change the default parameterisation (e.g. to be by 'species'), passed through to default calls to g3_parameterized .
exponentiate	Exponentiate parameters, passed through to default calls to g3_parameterized .

Details

When using these to describe a predator/prey relationship, the stock midlength l will refer to the prey midlength.

Value

g3_suitability_exponential50: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\frac{1}{1 + e^{-\alpha(l-l_{50})}}$$

l Vector of stock midlength for each lengthgroup

l_{50} Length of the stock with a 50% probability of predation, from parameter $l50$

g3_suitability_andersen: Returns a [formula](#) for use in predation function's *suitabilities* argument.

If $p_3 = p_4$:

$$p_0 + p_2 e^{-\frac{(x-p_1)^2}{p_4}}$$

Otherwise:

$$p_0 + p_2 e^{-\frac{(x-p_1)^2}{p_4}} * \min(\max(p_1 - x, 0), 1) + p_2 e^{-\frac{(x-p_1)^2}{p_3}} * \min(\max(x, 0), 1)$$

...i.e if $\log \frac{L}{l} \leq p_1$ then p_3 used in place of p_4 .

$x \log \frac{p_5}{l}$

L Vector of predator midlength for each lengthgroup

l Vector of stock midlength for each lengthgroup

$p_0 .. p_4$ Function parameter $p0 .. p4$

p_5 Function parameter $p5$, if unspecified uses L , Vector of predator midlength for each lengthgroup.

NB: Specifying p_5 is equivalent to using the `andersenfleet` function in `gadget2`.

g3_suitability_andersenfleet: A simplified version of [g3_suitability_andersen](#), suitable for predation by fleets, as the defaults do not rely on the predator's length.

g3_suitability_gamma: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\left(\frac{l}{(\alpha - 1)\beta\gamma}\right)^{(\alpha-1)} e^{\alpha-1 - \frac{1}{\beta\gamma}}$$

l Vector of stock midlength for each lengthgroup

α Function parameter *alpha*

β Function parameter *beta*

γ Function parameter *gamma*

This is a suitability function that is more suitable for use when considering the predation by a fleet, where the parameter γ would represent the size of the mesh used by the fleet (specified in centimetres).

g3_suitability_exponential: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\frac{\delta}{1 + e^{-\alpha - \beta l - \gamma L}}$$

L Vector of predator midlength for each lengthgroup

l Vector of stock midlength for each lengthgroup

α Function parameter *alpha*

β Function parameter *beta*

γ Function parameter *gamma*

δ Function parameter *delta*

g3_suitability_straightline: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\alpha + \beta l$$

l Vector of stock midlength for each lengthgroup

α Function parameter *alpha*

β Function parameter *beta*

g3_suitability_constant: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\alpha$$

α Function parameter *alpha*

g3_suitability_richards: Returns a [formula](#) for use in predation function's *suitabilities* argument:

$$\left(\frac{p_3}{1 + e^{-p_0 - p_1 l - p_2 L}} \right)^{\frac{1}{p_4}}$$

L Vector of predator midlength for each lengthgroup

l Vector of stock midlength for each lengthgroup

$p_0 \dots p_4$ Function parameter $p_0 \dots p_4$

This is an extension to [g3_suitability_exponential](#).

Examples

```

ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock(c(species = 'ling', 'mat'), seq(20, 156, 4)) %>% g3s_age(5, 15)
igfs <- g3_fleet('igfs')

igfs_landings <-
  structure(expand.grid(year=1990:1994, step=2, area=1, total_weight=1),
            area_group = list(`1` = 1))

# Generate a fleet predation action using g3_suitability_exponential150
predate_action <- g3a_predate_fleet(
  igfs,
  list(ling_imm, ling_mat),
  suitabilities = list(
    ling_imm = g3_suitability_exponential150(
      g3_parameterized('ln.alpha', by_stock = 'species'),
      g3_parameterized('ln.l50', by_stock = 'species')),
    ling_mat = g3_suitability_exponential150(
      g3_parameterized('ln.alpha', by_stock = 'species'),
      g3_parameterized('ln.l50', by_stock = 'species'))),
  catchability = g3a_predate_catchability_totalfleet(
    g3_timeareadata('igfs_landings', igfs_landings)))

```

 timedata

Gadget3 time-based data

Description

Convert time-based data into a formula to lookup values

Usage

```
g3_timeareadata(lookup_name, df, value_field = "total_weight", areas = NULL)
```

Arguments

lookup_name	A unique name for this lookup, e.g. "igfs_landings".
df	A data.frame with any of columns out of age, area, year and step, finally <i>value_field</i> .
value_field	Column name that contains output value.
areas	Named integer vector of area names to integer values. See g3s_livesonareas .

Value

A [formula](#) object that looks up *value_field* for the current values of age, area, cur_year and cur_step, depending on the columns in *df*. If there's no match, return 0.

Examples

```

ling_imm <- g3_stock(c(species = 'ling', 'imm'), seq(20, 156, 4)) %>% g3s_age(3, 10)
ling_mat <- g3_stock(c(species = 'ling', 'mat'), seq(20, 156, 4)) %>% g3s_age(5, 15)
igfs <- g3_fleet('igfs')

igfs_landings <-
  structure(expand.grid(year=1990:1994, step=2, area=1, total_weight=1),
            area_group = list(`1` = 1))

# Generate a fleet predation action, use g3_timeareadata to supply landings
# NB: Since igfs_landings only contains values for step=2, there will be no
#     predation on other steps (since g3_timeareadata will return 0).
predate_action <- g3a_predate_fleet(
  igfs,
  list(ling_imm, ling_mat),
  suitabilities = list(
    ling_imm = g3_suitability_exponential150(
      g3_parameterized('lln.alpha', by_stock = 'species'),
      g3_parameterized('lln.150', by_stock = 'species')),
    ling_mat = g3_suitability_exponential150(
      g3_parameterized('lln.alpha', by_stock = 'species'),
      g3_parameterized('lln.150', by_stock = 'species'))),
  catchability = g3a_predate_catchability_totalfleet(
    g3_timeareadata('igfs_landings', igfs_landings)))

```

timevariable

Gadget3 time-based formulas

Description

Switch formula based on current time step

Usage

```
g3_timevariable(lookup_name, fs)
```

Arguments

lookup_name	A unique name for this lookup, e.g. "igfs_landings".
fs	A list of formula objects, named with either "init", "(year)" or "(year)-(step)". When the matching time step is reached, the value of the lookup will be changed.

Details

This is mostly for backwards compatibility with `gadget2`, before using this, consider other simpler options, e.g. [g3_timeareadata](#) or the `by_year` option in [g3_parameterized](#).

Value

A [formula](#) object that will switch values at the given time points.

Examples

```
ling_imm <- g3_stock('ling_imm', seq(20, 156, 4)) %>% g3s_age(3, 10)

naturalmortality_action <- g3a_naturalmortality(ling_imm,
  g3a_naturalmortality_exp( g3_timevariable("lingimm.M", list(
    # Start off using lingimm.M.early
    "init" = g3_parameterized("lingimm.M.early"),
    # At 2005 step 2, switch to lingimm.M.mid
    "2005-02" = g3_parameterized("lingimm.M.mid"),
    # At 2010 step 1, switch to lingimm.M.late
    "2010" = g3_parameterized("lingimm.M.late")))))
```

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