**RAM Biomass Conversion Guide**

**Model Fitting Protocol**

There are occasions1 where a total biomass time series is desired, but a stock only has a spawning stock biomass time series available in the assessment. SSB is generally a subset of TB, consisting of only selected age groups and in some cases selected sexes. We address this problem by generating conversion ratios of TB:SSB for each stock (and for each of its assessments) that can be used to convert between SSB and TB. Conversion ratios can only be estimated from assessments that provide both TB and SSB, but once they are estimated, they can be applied to similar stocks that have only SSB available in order to estimate missing TB.

Conversion ratios are estimated using a series of linear mixed-effects regression candidate models that incorporate a variety of potential time series and input parameters as predictor covariates (***Table 1***). Several combinations of covariates and their interaction terms are considered to generate the list of candidate models (***Table 2***), which are then compared on the basis of AICc values across multiple data scenarios. These data scenarios involve using different combinations of data input types to help find a best fit (***Table 3***). From this a hierarchical list of the candidate models is created. Based on which data was available from the assessment, the highest ranking model that fits the data criteria is selected from the list and is used to calculate the biomass conversion value.

Biomass conversions are only conducted in the Extended RAMLDB version (or ‘model-fits’ version), not in the ‘assessment-only’ version.

**Regression Variables (Table 1)**

This table shows the data types used in the biomass conversion procedure.

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| --- | --- | --- |
| **Variable** | **Type** | **Description** |
| TB:SSB ratio | response | Ratio of total biomass to spawning stock biomass |
| taxgroup | predictor | RAM taxonomic group category |
| region | predictor | RAM region category |
| SSBSEX | predictor | Spawning stock biomass sex category (females only, males only, or both) |
| SSBAGE | predictor | Spawning stock biomass ages included |
| mort | predictor | Natural mortality value |
| maxl | predictor | Maximum length value |
| VBK | predictor | Von Bertalanffy growth K value |
| Udivlag | predictor | U/Umsy or U/Utarget time series lagged by 1 year |
| Udivlag2 | predictor | U/Umsy or U/Utarget time series lagged by 2 years |
| Udivlag3 | predictor | U/Umsy or U/Utarget time series lagged by 3 years |

**Candidate Model List (Table 2)**

The table below lists the full set of models that are compared on the basis of AICc values.

|  |  |
| --- | --- |
| **Model** | **Description** |
| 1 | ratio ~ -1 + SSBSEX + (1|taxgroup/species) + (1|region) |
| 2 | ratio ~ -1 + SSBSEX + SSBAGE + (1|taxgroup/species) + (1|region) |
| 3 | ratio ~ -1 + SSBSEX + mort + (1|taxgroup/species) + (1|region) |
| 4 | ratio ~ -1 + SSBSEX + maxl + (1|taxgroup/species) + (1|region) |
| 5 | ratio ~ -1 + SSBSEX + VBK + (1|taxgroup/species) + (1|region) |
| 6 | ratio ~ -1 + SSBSEX + mort + maxl + (1|taxgroup/species) + (1|region) |
| 7 | ratio ~ -1 + SSBSEX + mort + VBK + (1|taxgroup/species) + (1|region) |
| 8 | ratio ~ -1 + SSBSEX + maxl + VBK + (1|taxgroup/species) + (1|region) |
| 9 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + (1|taxgroup/species) + (1|region) |
| 10 | ratio ~ -1 + SSBSEX + SSBAGE + mort + (1|taxgroup/species) + (1|region) |
| 11 | ratio ~ -1 + SSBSEX + SSBAGE + maxl + (1|taxgroup/species) + (1|region) |
| 12 | ratio ~ -1 + SSBSEX + SSBAGE + VBK + (1|taxgroup/species) + (1|region) |
| 13 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + (1|taxgroup/species) + (1|region) |
| 14 | ratio ~ -1 + SSBSEX + SSBAGE + mort + VBK + (1|taxgroup/species) + (1|region) |
| 15 | ratio ~ -1 + SSBSEX + SSBAGE + maxl + VBK + (1|taxgroup/species) + (1|region) |
| 16 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + (1|taxgroup/species) + (1|region) |
| 17 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 18 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 19 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 20 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 21 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 22 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 23 | ratio ~ -1 + SSBSEX + SSBAGE + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 24 | ratio ~ -1 + SSBSEX + SSBAGE + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 25 | ratio ~ -1 + SSBSEX + SSBAGE + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 26 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 27 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 28 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 29 | ratio ~ -1 + SSBSEX + SSBAGE + maxl + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 30 | ratio ~ -1 + SSBSEX + SSBAGE + maxl + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 31 | ratio ~ -1 + SSBSEX + SSBAGE + maxl + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 32 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 33 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 34 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 35 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + (1|taxgroup/species) + (1|region) |
| 36 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + Udivlag2 + (1|taxgroup/species) + (1|region) |
| 37 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + Udivlag2 + Udivlag3 + (1|taxgroup/species) + (1|region) |
| 38 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + mort:Udivlag1 + (1|taxgroup/species) + (1|region) |
| 39 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + Udivlag2 + mort:Udivlag1 + mort:Udivlag2 + (1|taxgroup/species) + (1|region) |
| 40 | ratio ~ -1 + SSBSEX + mort + maxl + Udivlag1 + Udivlag2 + Udivlag3 + mort:Udivlag1 + mort:Udivlag2 + mort:Udivlag3 + (1|taxgroup/species) + (1|region) |
| 41 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + mort:Udivlag1 + (1|taxgroup/species) + (1|region) |
| 42 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + Udivlag2 + mort:Udivlag1 + mort:Udivlag2 + (1|taxgroup/species) + (1|region) |
| 43 | ratio ~ -1 + SSBSEX + mort + maxl + VBK + Udivlag1 + Udivlag2 + Udivlag3 + mort:Udivlag1 + mort:Udivlag2 + mort:Udivlag3 + (1|taxgroup/species) + (1|region) |
| 44 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + mort:Udivlag1 + (1|taxgroup/species) + (1|region) |
| 45 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + Udivlag2 + mort:Udivlag1 + mort:Udivlag2 + (1|taxgroup/species) + (1|region) |
| 46 | ratio ~ -1 + SSBSEX + SSBAGE + mort + Udivlag1 + Udivlag2 + Udivlag3 + mort:Udivlag1 + mort:Udivlag2 + mort:Udivlag3 + (1|taxgroup/species) + (1|region) |
| 47 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + mort:Udivlag1 + (1|taxgroup/species) + (1|region) |
| 48 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + Udivlag2 + mort:Udivlag1 + mort:Udivlag2 + (1|taxgroup/species) + (1|region) |
| 49 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + Udivlag1 + Udivlag2 + Udivlag3 + mort:Udivlag1 + mort:Udivlag2 + mort:Udivlag3 + (1|taxgroup/species) + (1|region) |
| 50 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + mort:Udivlag1 + (1|taxgroup/species) + (1|region) |
| 51 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + Udivlag2 + mort:Udivlag1 + mort:Udivlag2 + (1|taxgroup/species) + (1|region) |
| 52 | ratio ~ -1 + SSBSEX + SSBAGE + mort + maxl + VBK + Udivlag1 + Udivlag2 + Udivlag3 + mort:Udivlag1 + mort:Udivlag2 + mort:Udivlag3 + (1|taxgroup/species) + (1|region) |

Notes:

* ‘-1’ indicates removal of a single overall intercept; instead, separate intercepts are estimated for each level of SSBSEX (females only, males only, both).
* Interactions are specified with ‘:’.
* Terms in parentheses specify random effect terms, which represent intercept offsets. In all models, species are nested within ‘taxgroup’ taxonomic groups. There is additionally a regional random effect crossed with the taxonomic random effect.

**Model Cases (Table 3)**

The below model cases show which factors determine the data used in the model. The **Data Pool** column indicates if all available data is used, or if only stocks are used that share the same data. Since not all stocks have all the available parameters, the *“Only shared data used”* set of data scenarios results in a much smaller pool of stocks. The **Udiv Source** column indicates which time series type was used for the *Udivlag* terms. Similar to the previous set of scenarios, since not all stocks have a U management target reference point, the “*U/mean(U)*” data scenario allows for a greater pool of stocks to be used.

|  |  |  |
| --- | --- | --- |
| **Case** | **Data Pool** | **Udiv Source** |
| 1 | All data used | U/Umgt |
| 2 | Only shared data used | U/Umgt |
| 3 | All data used | U/mean(U) |
| 4 | Only shared data used | U/mean(U) |