**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.

**Regression Variables (Table 1)**

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

|  |  |  |
| --- | --- | --- |
| **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.

|  |  |  |  |
| --- | --- | --- | --- |
| **Case** | **Data Pool** | **FishBase Data Inclusion** | **Udiv Source** |
| 1 | All data used | FishBase data included | U/Umgt |
| 2 | Only shared data used | FishBase data included | U/Umgt |
| 3 | All data used | FishBase data not included | U/Umgt |
| 4 | Only shared data used | FishBase data not included | U/Umgt |
| 5 | All data used | FishBase data included | U/mean(U) |
| 6 | Only shared data used | FishBase data included | U/mean(U) |
| 7 | All data used | FishBase data not included | U/mean(U) |
| 8 | Only shared data used | FishBase data not included | U/mean(U) |