All the models you are working with in Fish 507 are MARSS models: Multivariate AR State-Space

a type of linear dynamical model

$$\mathbf{x}_t = \mathbf{B}\mathbf{x}_{t-1} + \mathbf{u} + \mathbf{C}\mathbf{c}_t + \mathbf{w}_t \quad \text{where} \quad \mathbf{w}_t \sim \text{MVN}(0, \mathbf{Q})$$

$$\mathbf{y}_t = \mathbf{Z}\mathbf{x}_t + \mathbf{a} + \mathbf{D}\mathbf{d}_t + \mathbf{v}_t \quad \text{where} \quad \mathbf{v}_t \sim \text{MVN}(0, \mathbf{R})$$

MVN (multivariate normal) can be relaxed

	Population model; no interactions	Population model; with interactions	DFA	DLM
x	Hidden true population size	Hidden true population size	Hidden trend that the data can be decomposed into (linearly)	Time-varying effect sizes (alpha, betas in lm)
Z	Identity or design if mult ts	Identity or design if mult ts	Estimated loadings for the trends (x's)	Explanatory variables (for which you are estimating effects)
B	Identity (dens ind) Diagonal (dens dep)	Unconstrained with diagonal and non-diagonal elements	Fixed identity matrix	Estimated (or fixed) Identity (rand walk) Diagonal (mean-reverting)
Q	Estimated (or fixed) process variance	Estimated (or fixed) process variance	Fixed identity matrix	Estimated process variance
R	Estimated (or fixed) observation variance	Estimated (or fixed) observation variance	Estimated observation variance	Estimated observation variance
A	Estimated if states have > 1 ts	Estimated if states have > 1 ts	Fixed at zero	Fixed at zero (typically)
U	Trend if B identity Level if B diagonal	Level Often will need to be fixed for B estimation	Fixed at zero	Trend in effect sizes Fixed at zero typically, but could be estimated
x0	Hidden initial state tinitx=0 (default) typically works best if B identity	Hidden initial state Often will need to be set to tinitx=1 for numerical reasons	Fixed at zero	Hidden initial effects tinitx=0 (default) typically works best if B identity
C	Covariates for population change	Covariates for pop change Z-scored for numerical reasons	Fixed at zero	Covariates for temporal change in effect sizes (x's)
D	Covariates for obs error	Covariates for obs error Z-scored for numerical reasons	Covariates for obs error	Covariates for obs error