Abundance-driven vs. observed change
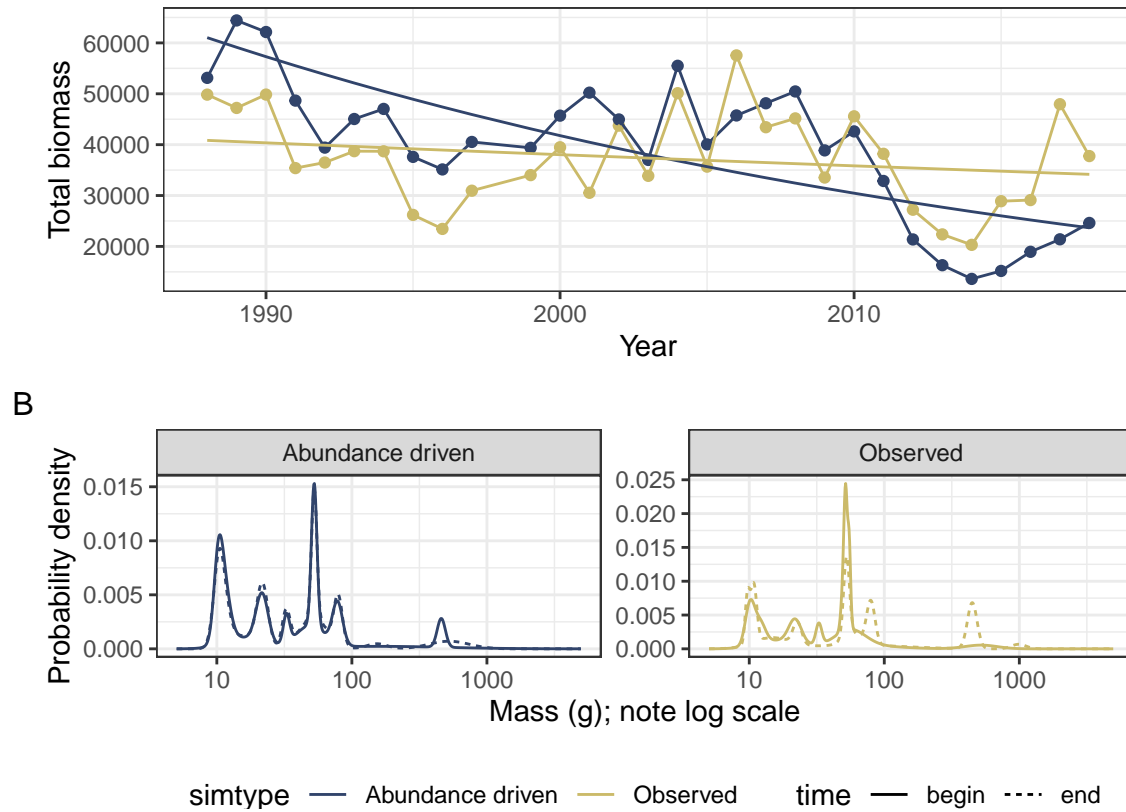

Figure 1. Illustration of abundance-driven (null model) dynamics as compared to observed dynamics (A), and the underlying dynamics of the ISD (B) for a sample route (LINDBROOK, Alberta). **A. Dynamics of total biomass.** The orange points show the true values for total biomass in each year, and the purple points show the values for total biomass simulated from a null model that incorporates change in total abundance, but assumes no change in the size structure, over time. The smooth lines show the predicted values from a Gamma (log-link) linear model of the form `total_biomass ~ year * simtype`. For this route, change in the individual size distribution has decoupled the dynamics of biomass from those that would occur due only to changes in abundance. The slope for abundance-driven dynamics is significantly more negative than for the observed dynamics (interaction term p = 0.0013), which do not have a slope significantly different from zero (slope term p = .27). **B. Underlying changes in the ISD.** The individual size distributions for the first 5 years (solid lines) and last 5 years (dashed lines) of the timeseries. The x-axis is body size (as mass in grams; note log scale) and the y-axis is probability density from a Gaussian mixture model fit to a vector of simulated individual masses for all individuals observed in the years in questions, standardized to sum to 1. For the abundance-driven (purple) scenario, individuals' species identities (which determine their body size estimates) are re-assigned at random weighte by each species' mean relative abundance throughout the timeseries, resulting in a consistent individual size distribution over time. For the observed (orange) scenario, individuals' body sizes are estimated based on their actual species identities. For this route, species composition has shifted over time, resulting in distinct ISDs for the "begin" and "end" time periods. Specifically, the "end" ISD has peaks at larger body sizes (ca. 90g and 500g) not present in the "begin" ISD. This redistribution of density towards larger body sizes results in an overall increase in body size community wise, which partially offsets declines in total biomass from those expected given change in abundance alone.

Slopes

A

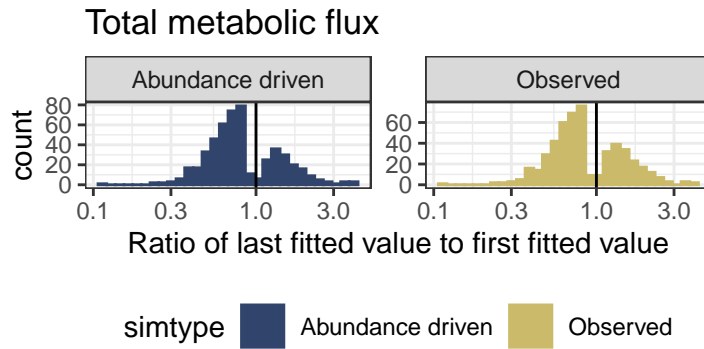### Total biomass

B

Total metabolic flux
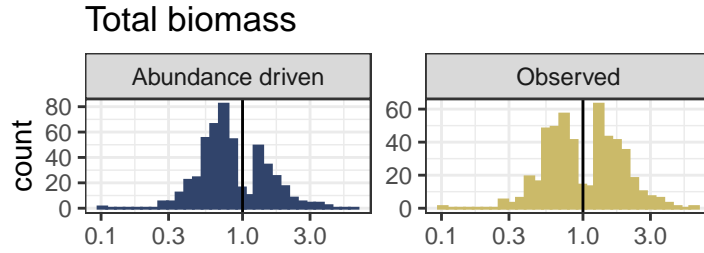
Figure 2. Long-term trends in total biomass and energy use Histograms showing the direction and magnitude of change over time for the abundance-driven (left) and observed (right) changes in biomass (A) and energy use (B), for communities with a significant slope and/or interaction term (for biomass, 500/739 routes; for energy use, 506/739 routes). Change is summarized as the ratio of the fitted value for the last year in the time series to the fitted value for the first year in the timeseries from the best-fitting model for that community. Values greater than 1 (vertical black line) indicate increases in total energy or biomass over time, and less than 1 indicate decreases. The abundance-driven dynamics (left) reflect the trends fit for the null model, while the observed dynamics (right) reflect trends incorporating both change in total abundance and change in the size structure over time. For communities with no significant interaction term in the best-fitting model, the "abundance-driven" and "observed" ratios will be the same; interaction terms will result in different ratios for "abundance-driven" and "observed" dynamics.

Abundance-driven dynamics are dominated by decreases. For biomass, observed dynamics are balanced evenly between increases and decreases - indicating that changes in the size structure produce qualitatively different long-term trends for biomass than would be expected given abundance changes alone. However, trends for energy use (which scales nonlinearly with biomass) are dominated by decreases, more closely mirroring the trends expected given changes in abundance.

Model outcomes

Biomass

Overall proportion of routes with winning models:

model_family	model_formula	n	prop
Gamma	1	239	0.3234100
Gamma	timeperiod	351	0.4749662
Gamma	timeperiod * source	149	0.2016238

Of models with slope term, the proportion for which abundance and biomass are increasing:

abundance_increasing	n	prop
FALSE	335	0.67
TRUE	165	0.33

biomass_increasing	n	prop
FALSE	256	0.512
TRUE	244	0.488

Metabolic flux

Overall proportion of routes with winning models:

model_family	model_formula	n	prop
Gamma	1	230	0.3112314
Gamma	timeperiod	456	0.6170501
Gamma	timeperiod * source	53	0.0717185

Of models with slope term, the proportion for which abundance and biomass are increasing:
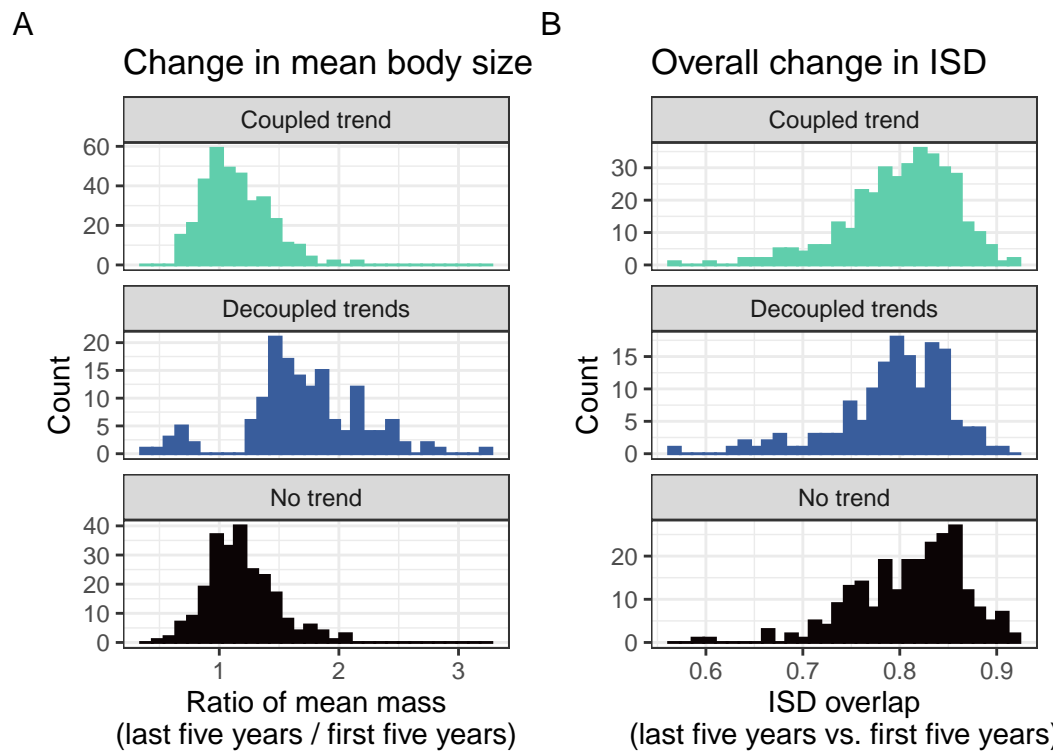
abundance_increasing	n	prop
FALSE	355	0.697446
TRUE	154	0.302554

energy_increasing	n	prop
FALSE	329	0.6463654
TRUE	180	0.3536346

Visualizing decoupling
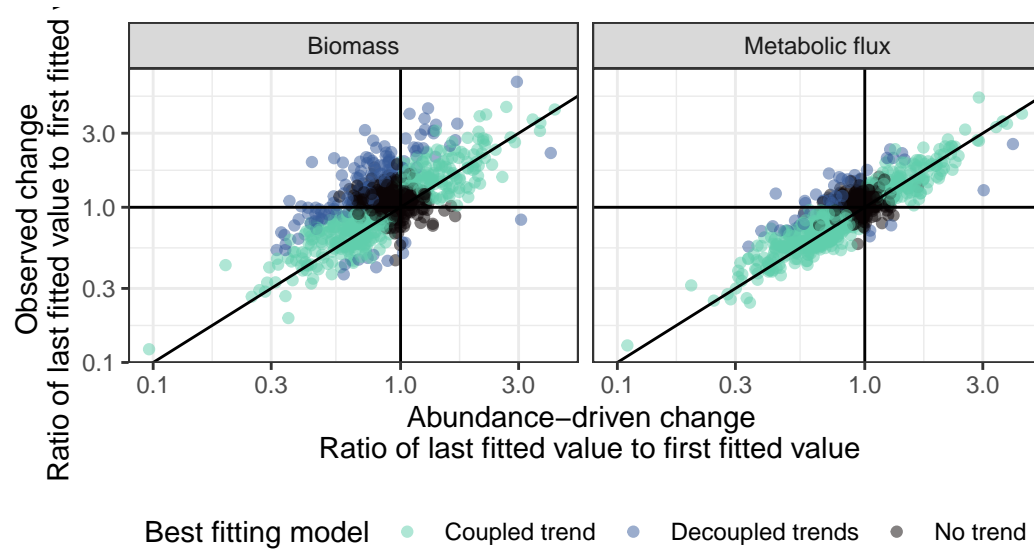
How the ISD contributes to decoupling

R2 of binomial GLM `overlap ~ model_formula` (which does not beat a `overlap ~ 1` via AIC, FYI)

References