Coral cover simulations

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Introduction

Numerical simulations were based on modelled coral cover representing time-series analysis of a coral reef experiencing a variety of prescribed disturbance histories.

Stable

For sites exhibiting stable coral cover (y_i) in year i, we generated 30 random values about an intercept (b) with variation (w_i), for a thirty-year time-series as follows:

$$
\begin{aligned}
y_i &= b + w_i \\
b &= \mathcal{N}(40, 5) \mid \mathcal{U}(5, 40) \\
\sigma_b &= \mathcal{N}(0.1b, 0.5) \\
w_i &= \mathcal{N}(0, \sigma_b)
\end{aligned}
$$

where σ_b is the standard deviation about b. The intercept b is chosen from either a normal ($\mathcal{N}$) or uniform distribution ($\mathcal{U}$), determined by a fair coin flip.

Phase shift

For sites exhibiting a phase shift, a new intercept (b_{new}) and variation ($w_{i_{new}}$) was selected at a year chosen randomly between year 10 and year 30 (x_{shift}) of a thirty-year time-series as follows:

$$
y_i = \begin{cases} b + w_i & \text{if } x < x_{shift} \\ b_{new} + w_{i_{new}} & \text{if } x \geq x_{shift} \end{cases}
$$

$$
\begin{aligned}
x_{shift} &= \mathcal{U}(10, 30) \\
b_{new} &= \mathcal{U}(1, 0.5b) \\
\sigma_{b_{new}} &= \mathcal{N}(\sigma_b, 0.1) \\
w_{i_{new}} &= \mathcal{N}(0, \sigma_{b_{new}})
\end{aligned}
$$

where $\sigma_{b_{new}}$ is the new standard deviation about b_{new}. The effect of the phase shift is to reduce the coral cover to a value chosen uniformly between 1 and half of the original b.

Linear trend

For sites exhibiting a linear trend in coral cover, a slope (m) was also selected randomly with a thirty-year time series determined by the equation for a line, as follows:

$$
\begin{aligned}
y_i &= mx + b + w_i \\
b &= \mathcal{N}(40, 5) \mid \mathcal{U}(5, 40) \\
\sigma_b &= \mathcal{N}(0.1b, 0.5) \\
w_i &= \mathcal{N}(0, \sigma_b) \\
m &= \mathcal{N}(-0.5, 0.25)
\end{aligned}
$$

where σ_b is the standard deviation about b.

Oscillations

Finally, we used a cosine curve (y = a*cos (bx + c) + w) to simulate oscillations over time, with an amplitude (a) and phase shift (c).