Standardisation of CPUE data to account for variations in targeting in a mixed species linefishery: Illustrative example

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Example simulation for the two-habitat-four species scenarios

This document provides an illustrative example of the performance of the 'Direct Principal Component' method (DPC) based on the two-habitat-four species scenarios H2.S4.PC1.R4E$_1$ and H2.S4.PC1.R4E$_2$. This mixed-fishery scenario is illustrated in Fig. 1.
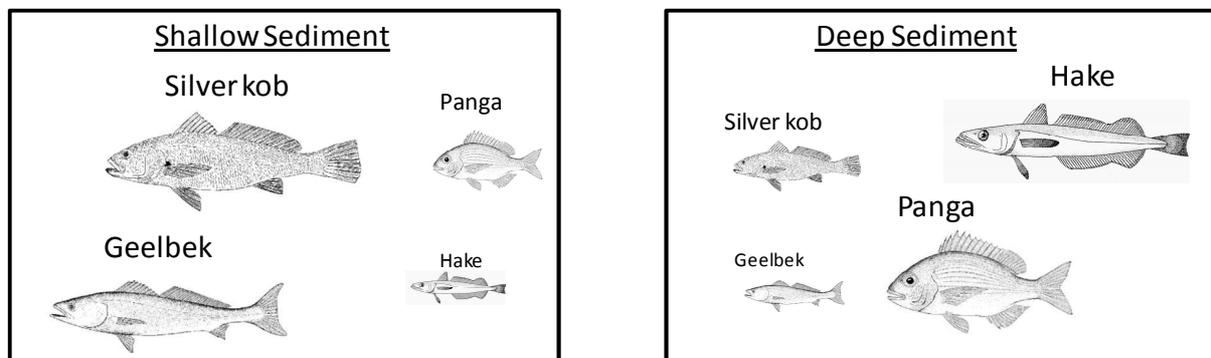

Fig.1 illustrates the mixed-fishery scenario for four target species that are unevenly distributed across two different habitat-types that are targeted by the fishery (H2.S4 scenario)

For the purpose of this simulation example, values for $B_{i,1}$ and r_i were arbitrarily specified as follows: silver kob $B_{1,1} = 10000$ and $r_i = 0.1$; geelbek $B_{2,1} = 18000$ and $r_i = -0.07$; hake $B_{3,1} = 40000$ and $r_i = -0.05$; and panga $B_{4,1} = 80000$ and $r_i = 0.04$. The resulting 'true' biomass trends for species i in year y is illustrated over a period of 20 years in Fig. 2.
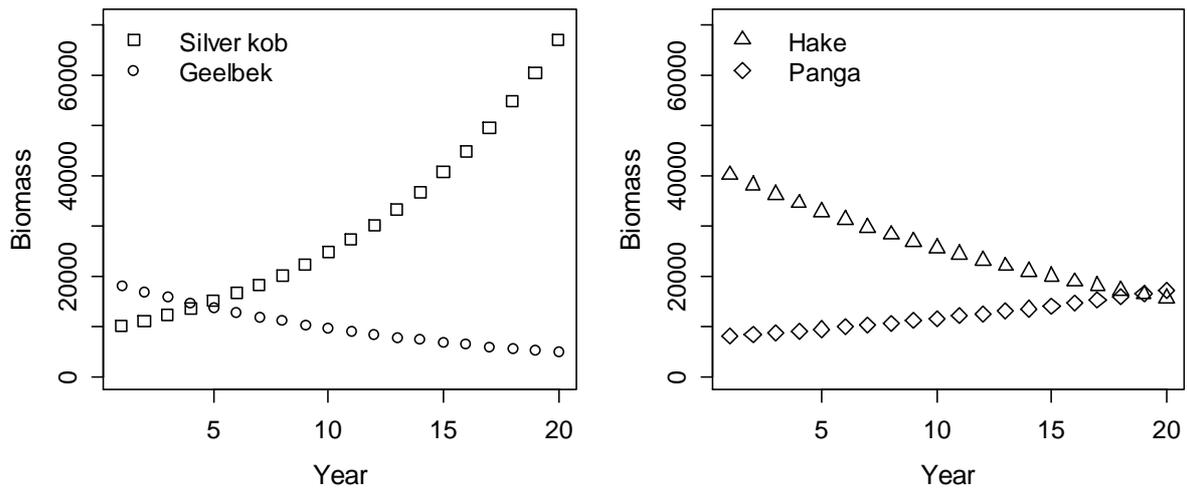
Fig. 2 Simulated biomass trends for silver kob, gelbeek, hake and panga

The two alternative effort scenarios used for simulating the distribution of fishing effort across habitats are illustrated in Fig.3. The distribution of effort allocations across the two habitats is determined as the probability that habitat j is targeted in year y, $e_{j,y}$. The first effort scenario (E_1) simulates time-invariant probabilities $e_{j,y}$ and acts as a 'control' (Fig. 3a), while the second effort (E_2) scenario simulates a linear increase in $e_{j,y}$ for one habitat and a linear decrease for the other habitat (Fig. 3b).
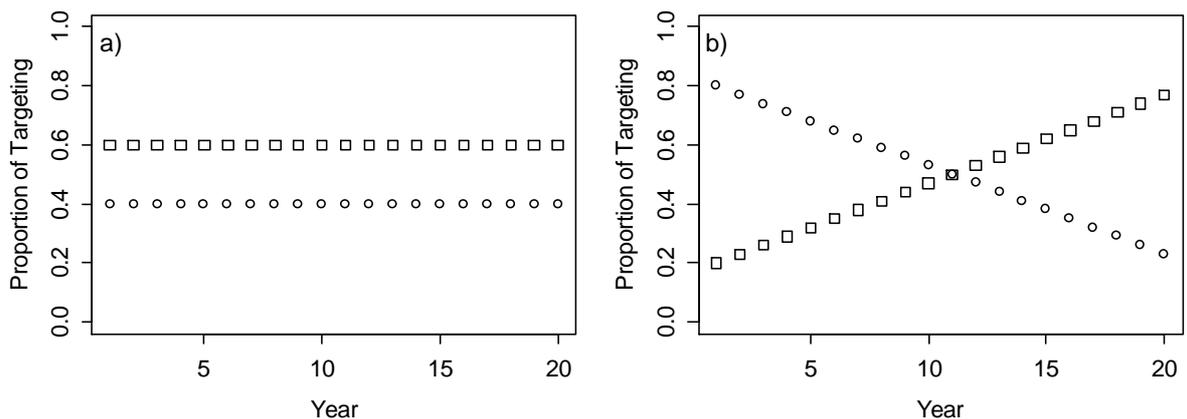

Fig. 3 Two effort allocation scenarios, E_1 and E_2 for H2.S4 models. Each symbol represents a particular habitat and the y-axes denote the probably that this habitat is targeted for any given year.

The performance of DPC method is illustrated by comparing standardized CPUE indices and the nominal CPUE indices (PC0 models) to the 'true' biomass trends. The performance of the DPC standardization models was evaluated in terms of the ability to accurately estimate r_i in comparison to the nominal CPUE indices. Estimates $\hat{r}_i$ were obtained from a simple linear regression of the form:

$$\ln(\overline{CPUE}_{i,y}) = \alpha + \hat{r}_i y \qquad\qquad y = 1, 2,\ldots, 20,$$

where $\ln(\overline{CPUE}_{i,y})$ expected standardized CPUE for species i and year i and a is the intercept. The relative abundance trend for each species i is then given by the bias-corrected estimate:

$$CPUE^r_{i,y} = \exp(\ln(\hat{\alpha}_i + \hat{r}_i y) + \frac{\sigma^2}{2}).$$

To facilitate graphical comparisons of abundance trends, the 'true' abundance $B_{i,y}$ and the estimated relative abundance trends $CPUE^r_{i,y}$ were normalized by:

$$B^{Norm}_{i,y} = \frac{B_{i,y}}{\exp(\frac{1}{20}\sum_y \ln(B_{i,y}))}$$

and

$$CPUE^{Norm}_{i,y} = \frac{CPUE^r_{i,y\,i,y}}{\exp(\frac{1}{20}\sum_y \ln(CPUE^r_{i,y}))}.$$

Summary of results

Comparisons of between $B^{Norm}_{i,y}$ and $CPUE^{Norm}_{i,y}$ indicate that only minimal bias is introduced by the DPC method in the case of the control scenario H2.S4.R4.PC1.E$_1$ (Fig. 4). The normalized trends for scenario H2.S4.R4.PC1.E$_2$ illustrate the ability of DPC method to

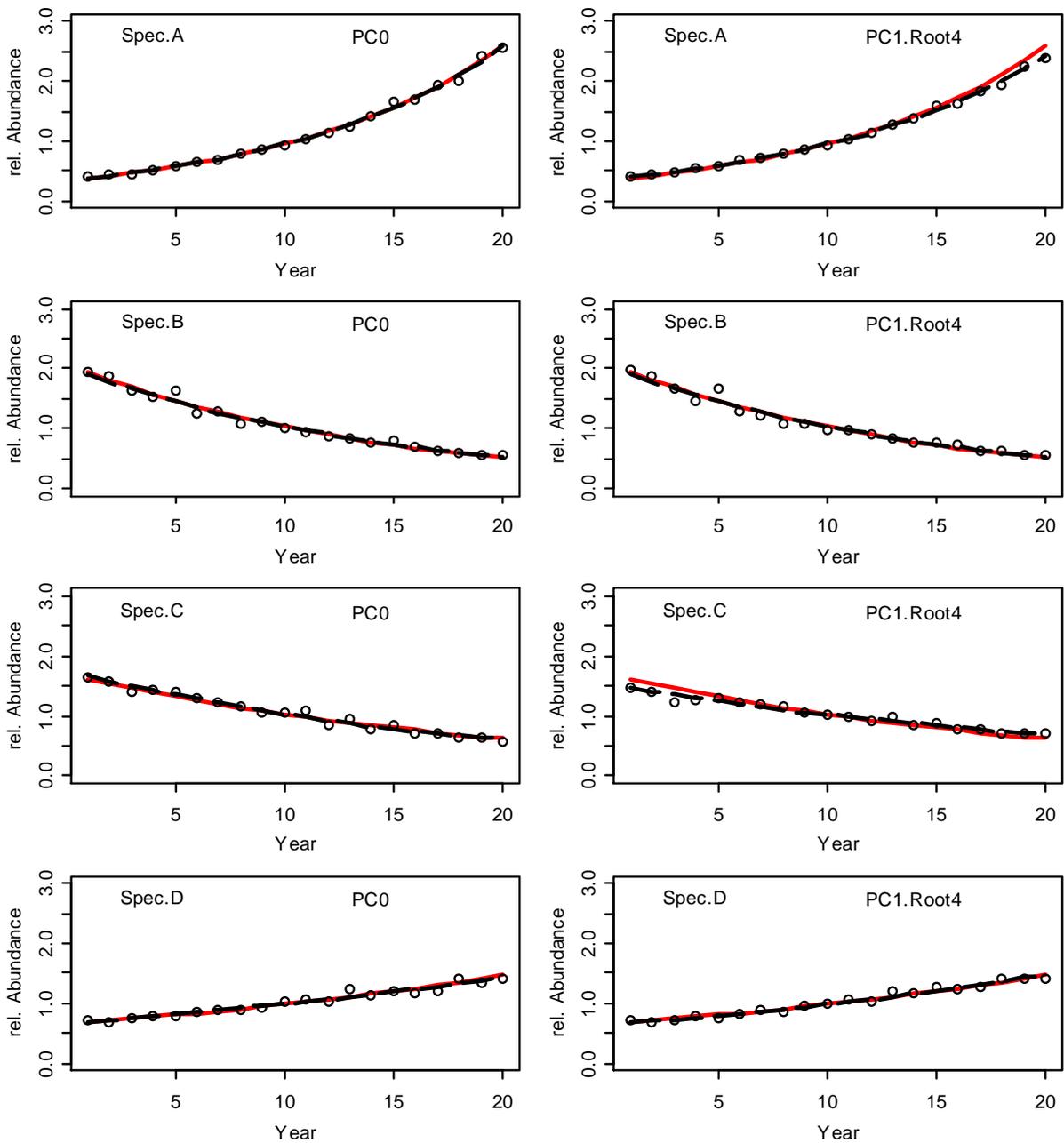remove the effect of time-varying effort allocation between habitats in comparison to the PC0 models (Fig. 5).

Fig. 4 Normalized 'true' biomass ($B_{i,y}^{Norm}$) (red line), normalized CPUE indices (open circles) and the predicted CPUE trends as a function of $\hat{r}_i$ ($CPUE_{i,y}^{Norm}$) (dashed line) for the models H2.S4.P0.E$_1$ and H2.S4.P1.R4.E$_1$.
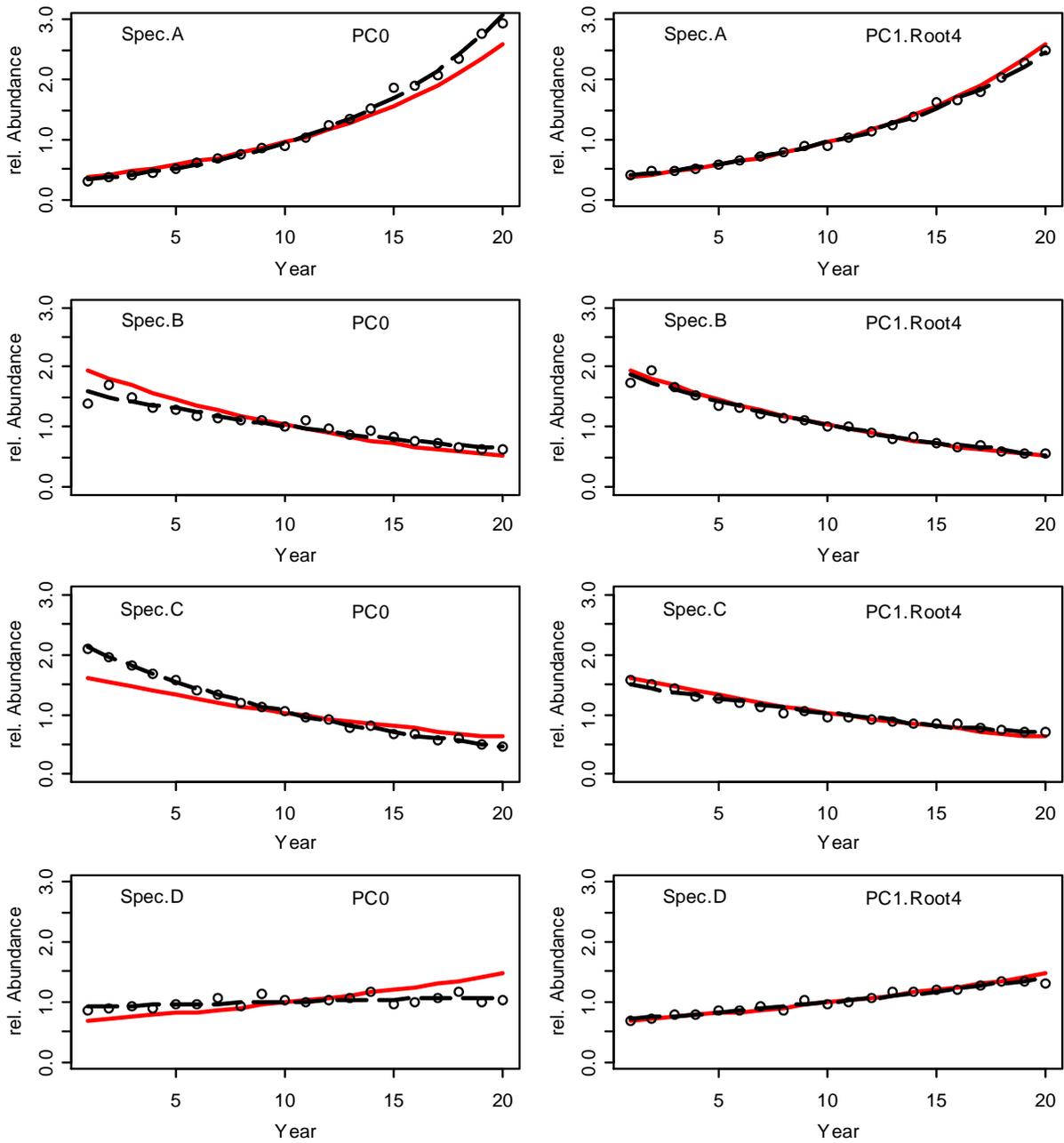
Fig. 5 Normalized 'true' biomass ($B_{i,y}^{Norm}$) (red line), normalized CPUE indices (open circles) and the predicted CPUE trends as a function of $\hat{r}_i$ ($CPUE_{i,y}^{Norm}$) (dashed line) for the models H2.S4.P0.E$_2$ and H2.S4.P1.R4.E$_2$.