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Methods for evaluating the potential effects of MPAs on adjacent fisheries

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Background

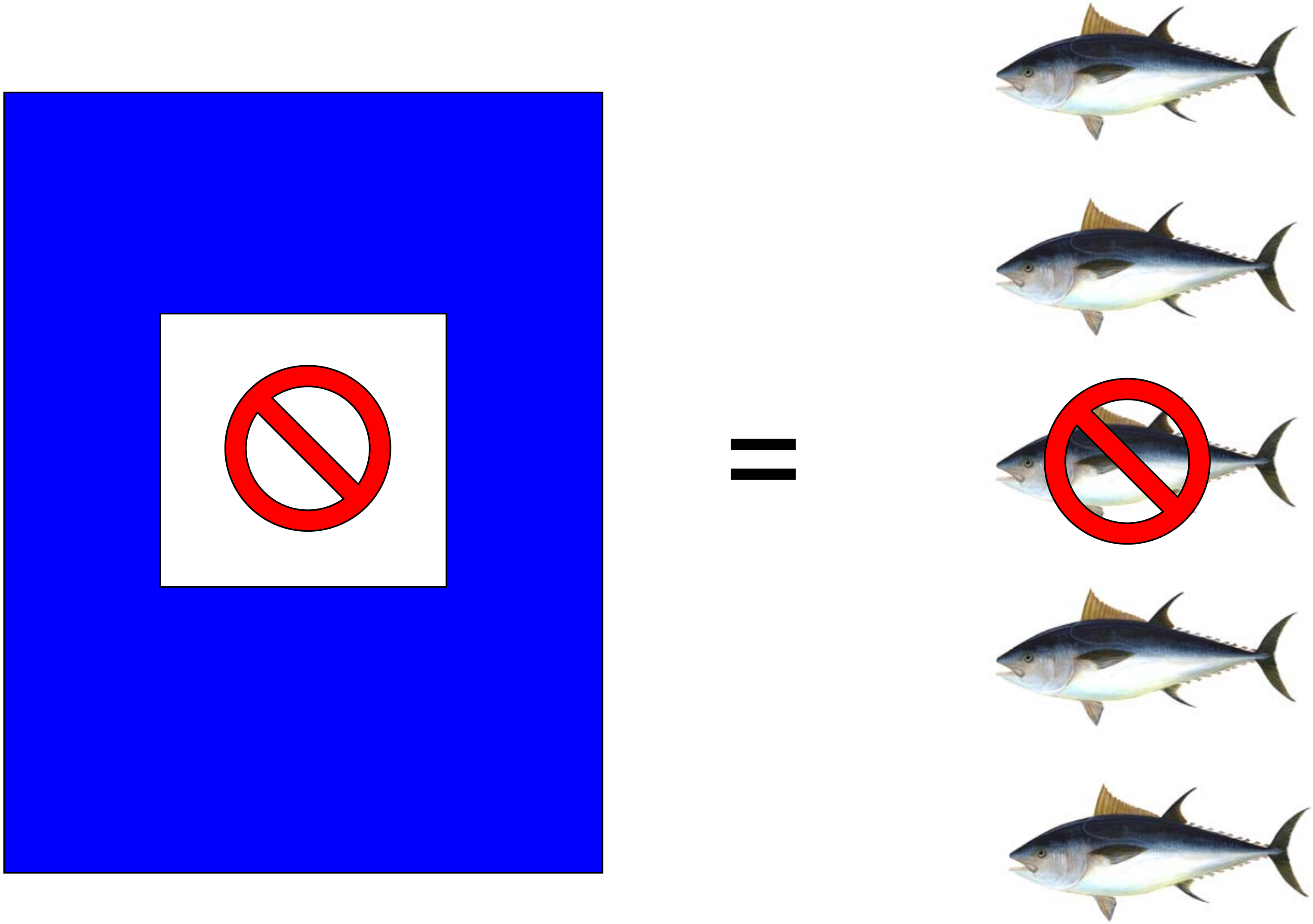
Proposals to establish MPAs are usually opposed by the fishing industry:

If proposals are subject to stakeholder consultation –

What are the industry concerns?

What information is useful in addressing those concerns?

A common fear



MPA and adjacent fisheries management objectives

We assume that the MPA is established for some specific conservation purpose, i.e.

It is not primarily intended as a method for managing the fishery

MPAs are more likely to achieve industry consent if :

> MPAs are placed so that the effects on adjacent fisheries are acceptable, or
>
> reasonable compensation is available

Industry may be prepared to accept small losses,

otherwise …

if compensation is an issue, how much is fair?

One way to address these issues is to use ‘operating models’ for the fishery and for the fish population(s)

The results presented here are for a low productivity fish, e.g. various rockfish species

Project Aims

Develop flexible dynamic spatial models of fisheries and exploited fish populations for use in management strategy evaluation

Use the models to examine which fishery and research data can make useful predictions about the likely effects of proposed MPAs on adjacent fisheries

Rank various types of data by predictive power and explore how well they need to be estimated

The fish models

The fish population models are based on density dependent habitat selection

Fish preferentially occupy favourable habitat – they move into marginal habitat when numbers in favourable habitats approach local carrying capacities

Fish continually explore the surrounding habitat – but tend to remain in those areas that maximise their reproductive output

The fisheries models

The fishery models are based on profit maximisation

Fishing vessels preferentially occupy areas with high catch rates – moving away from areas of low fish abundance and hence profitability

Fishing vessels continually explore the surrounding habitat – but tend to remain in those areas that maximise their profits

An example:

Suppose we have a fishing ground consisting of a single fish concentration

What is the effect on fisheries catch-rates from placing an MPA in various places that include part of the fishing ground?

How important is fish mobility in determining the effects?

How well does it need to be estimated?

Can fishery-derived data predict the effects?

The experiment:

We modelled a single concentration of fish - exploited with constant total effort.

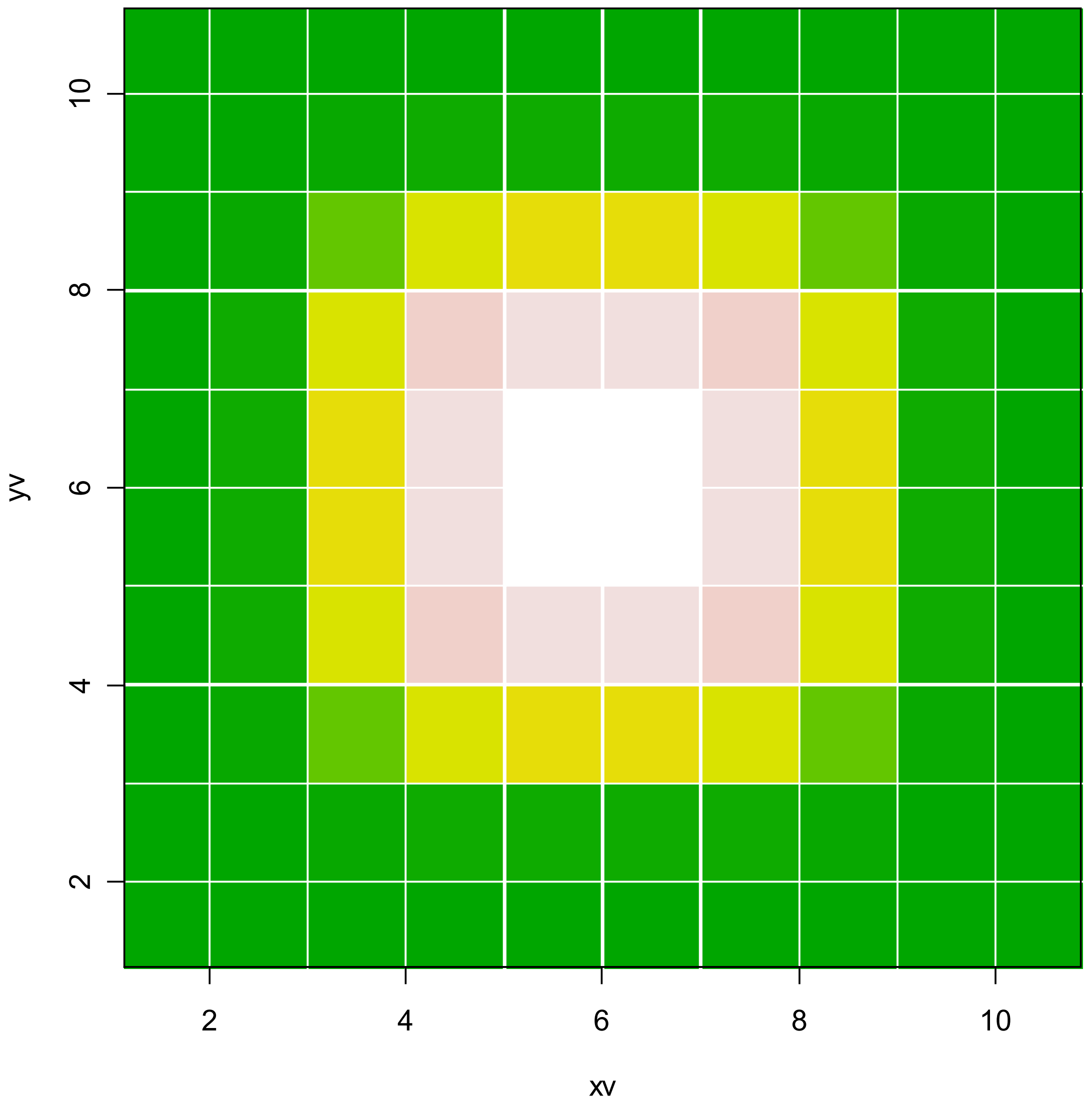
We examined:

7 different MPA placements

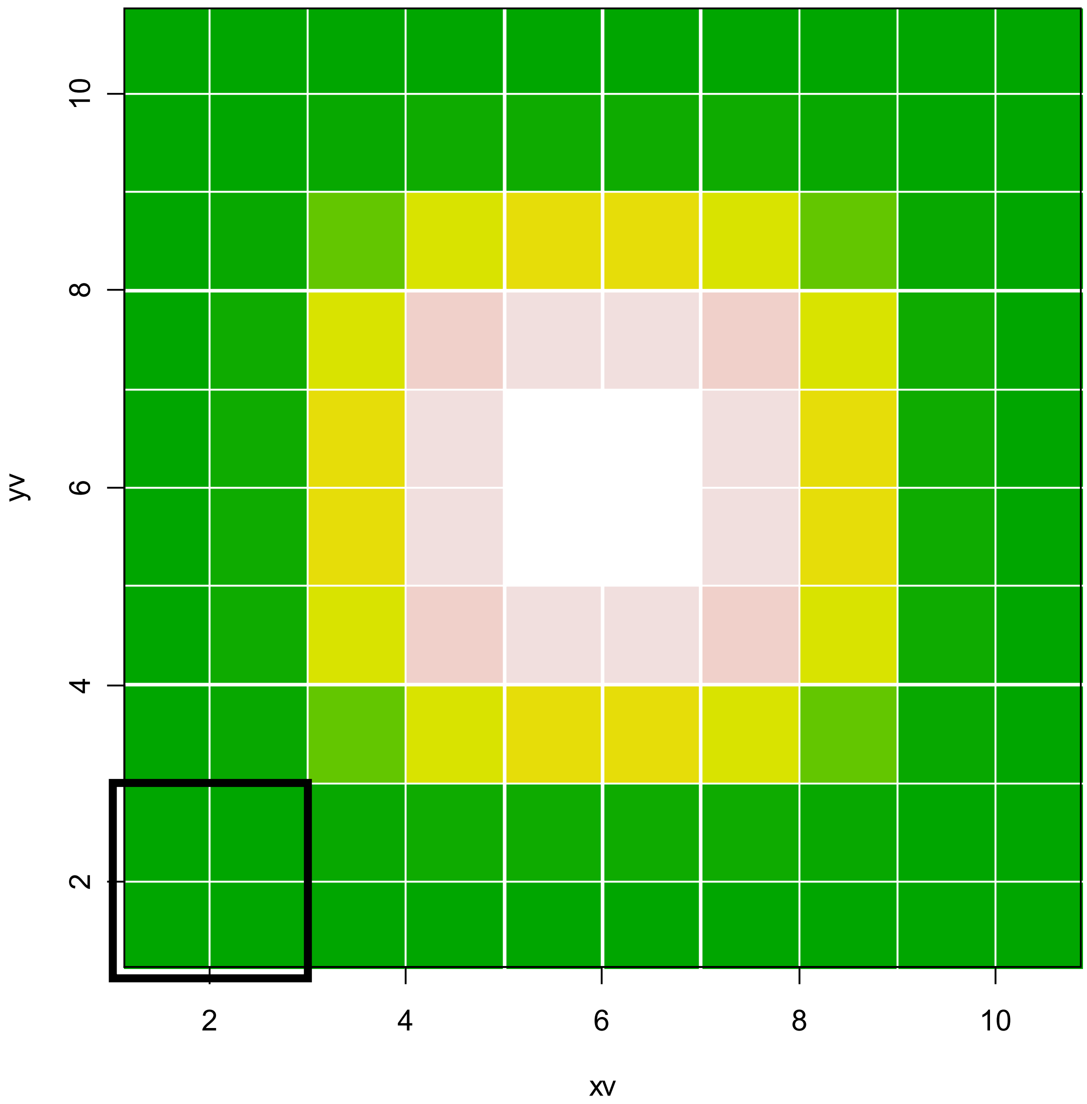
5 levels of fish mobility (none to highly mobile)

3 levels of stock depletion (25%, 50% and 75%)

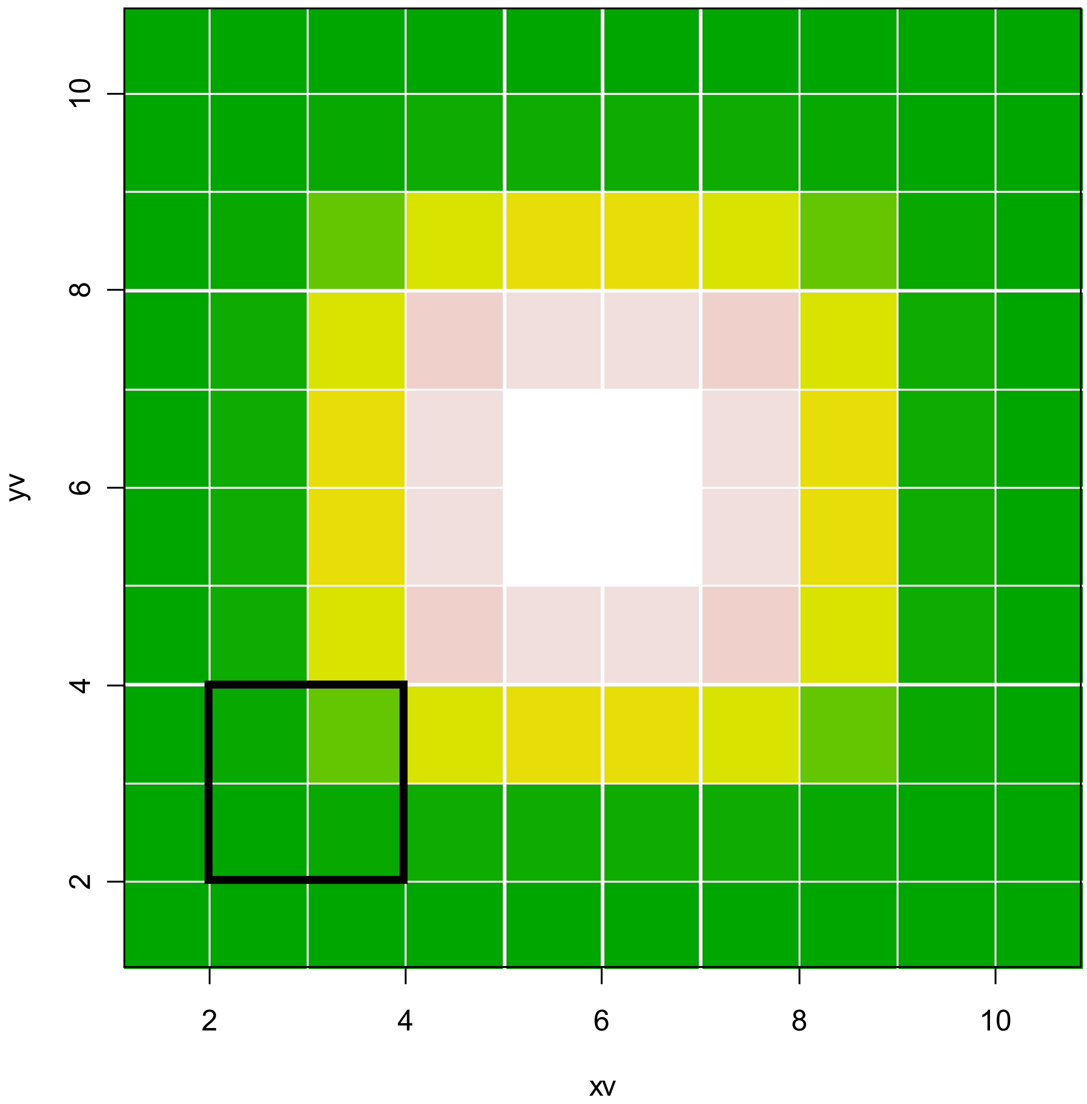
The fish concentration



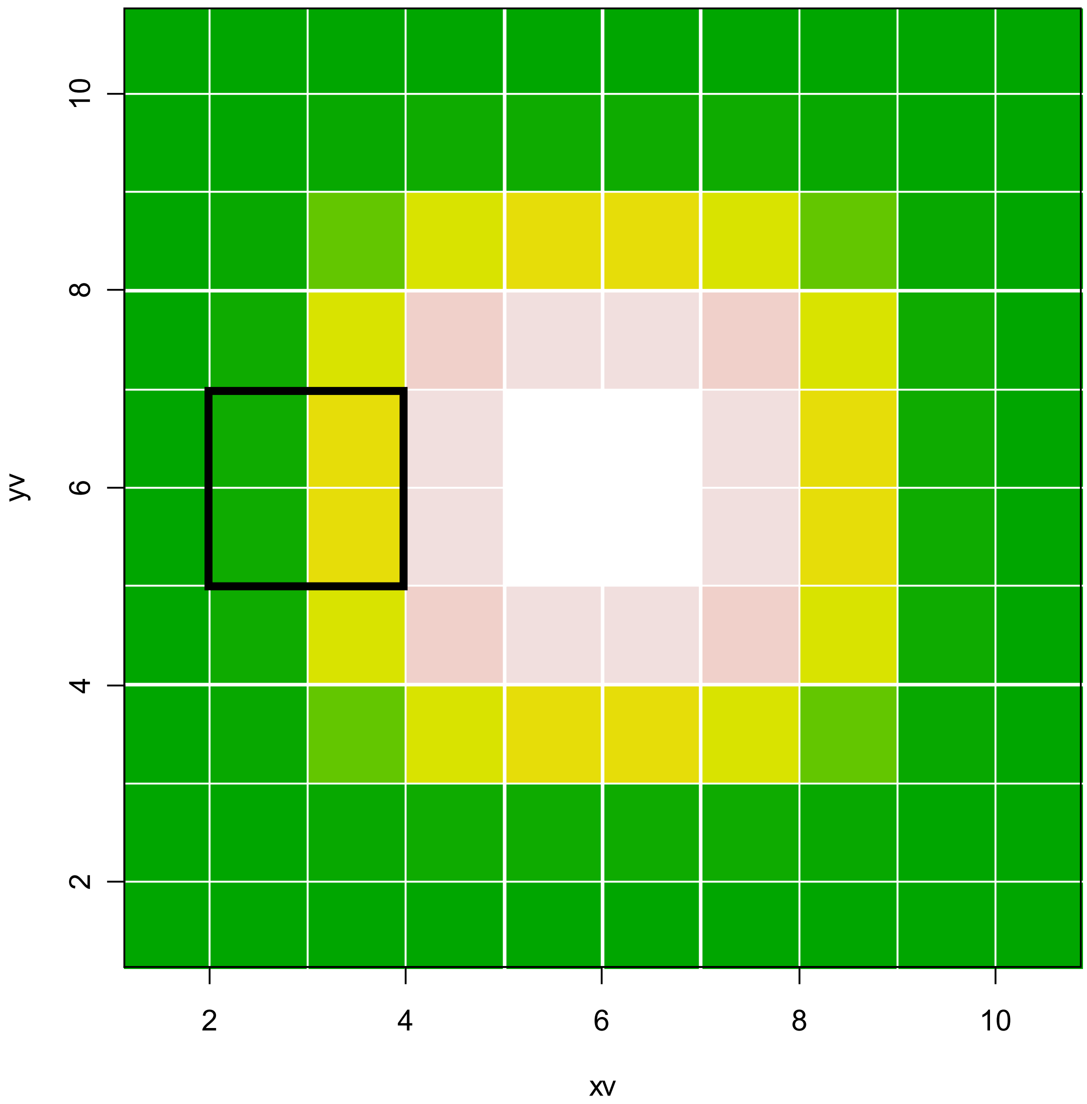
Outside



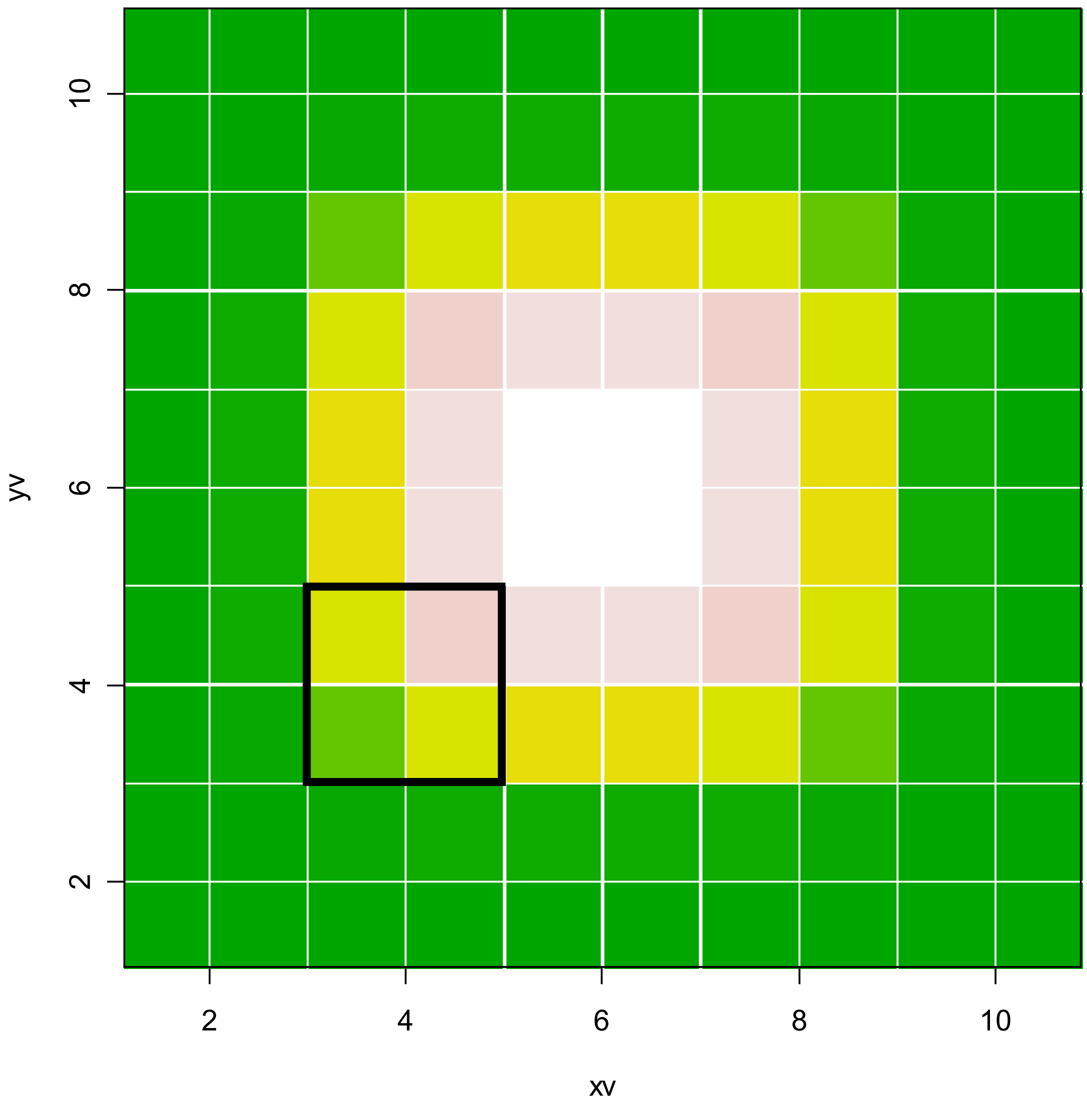
Touching



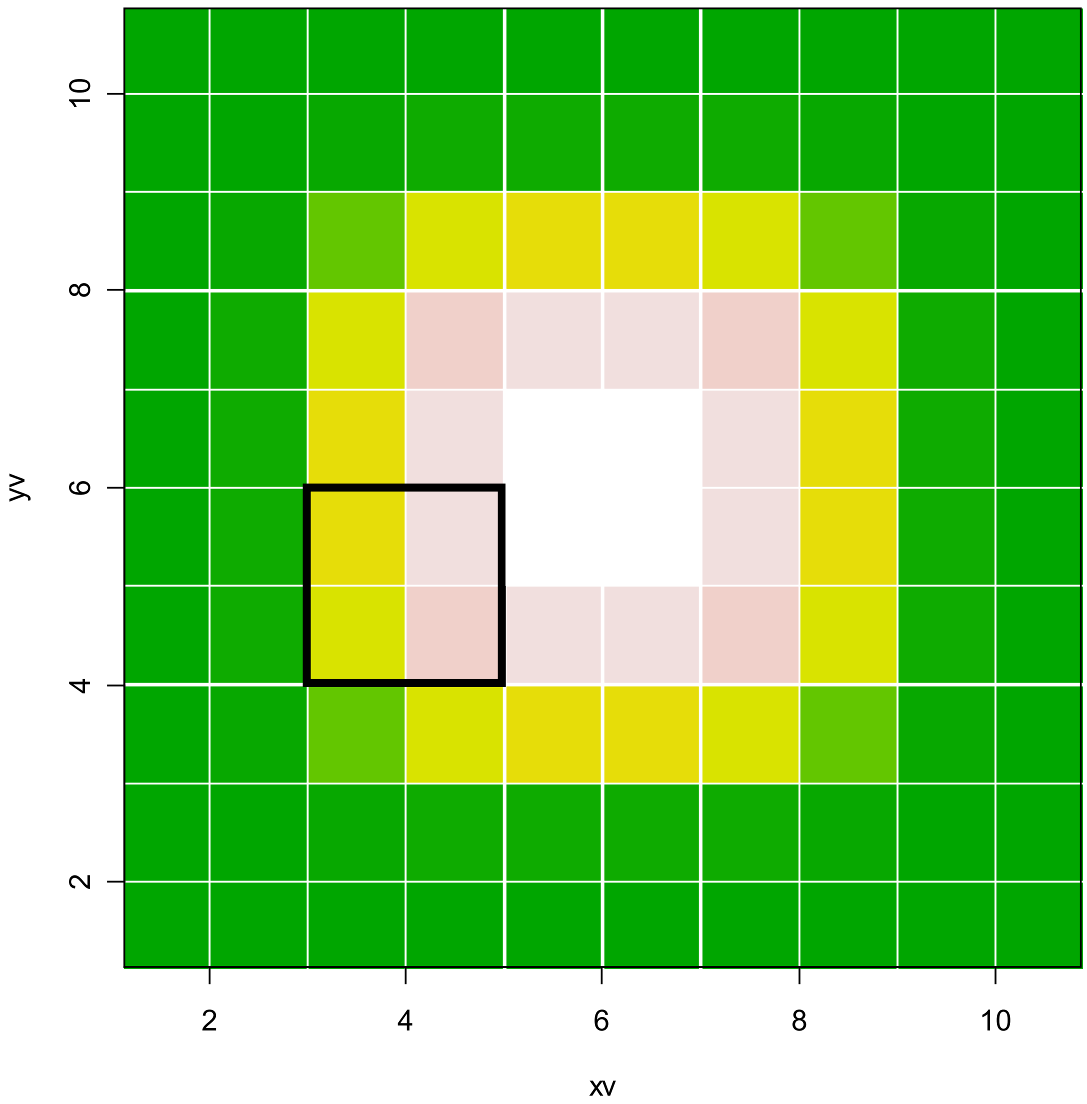
Fringe



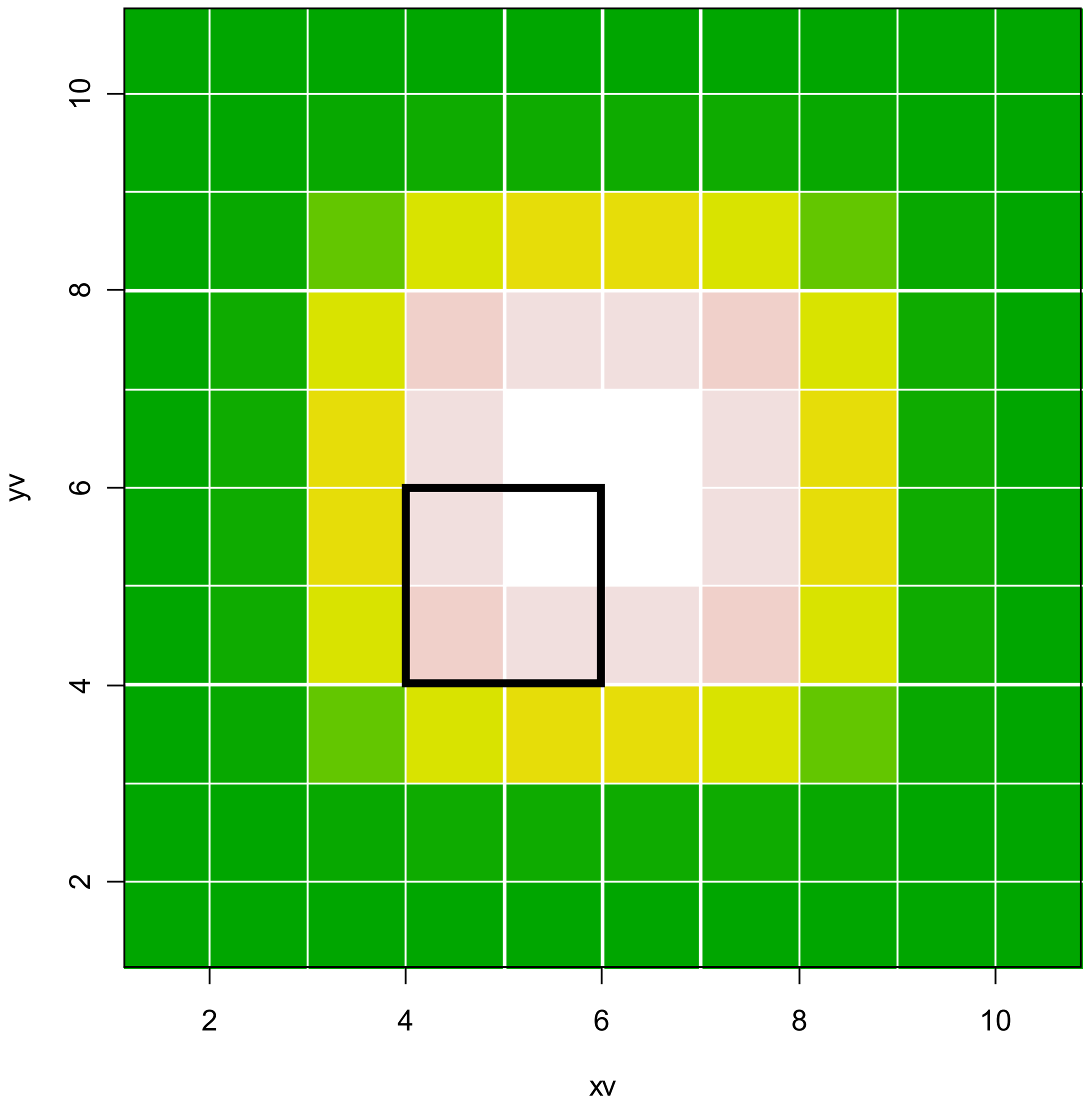
Marginal



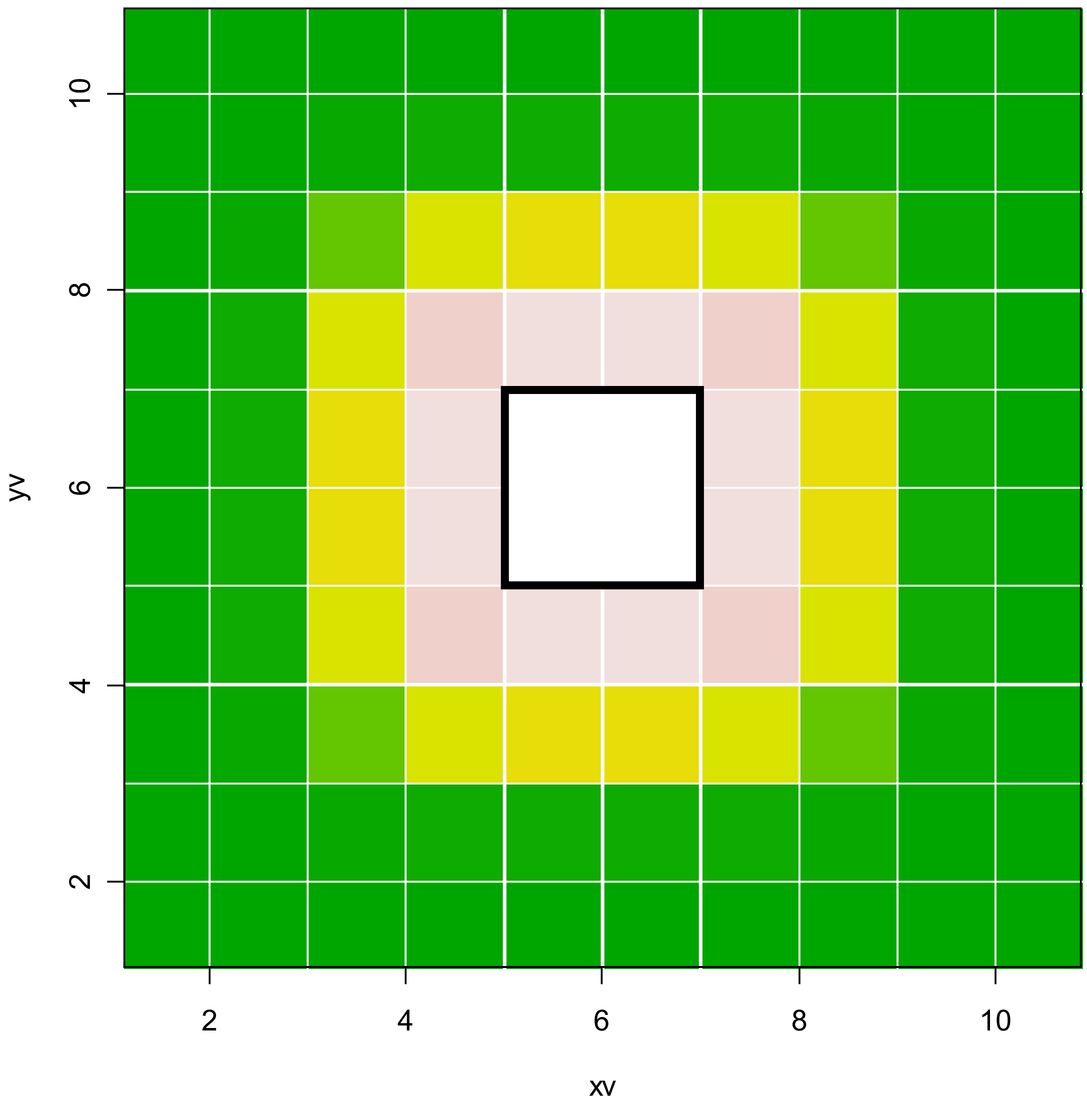
Transitional



Encroaching



Core

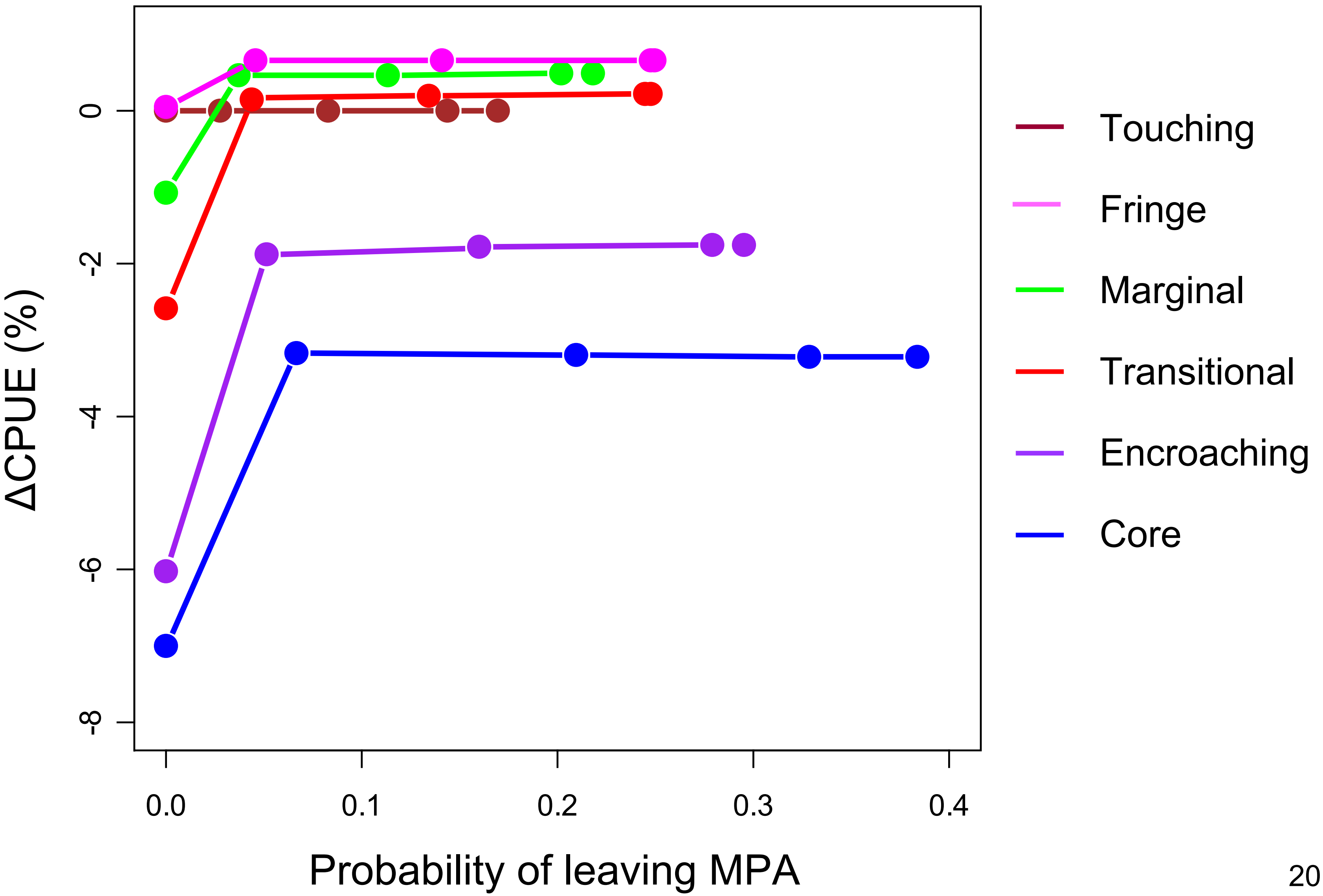


We collected the following data from the model system:

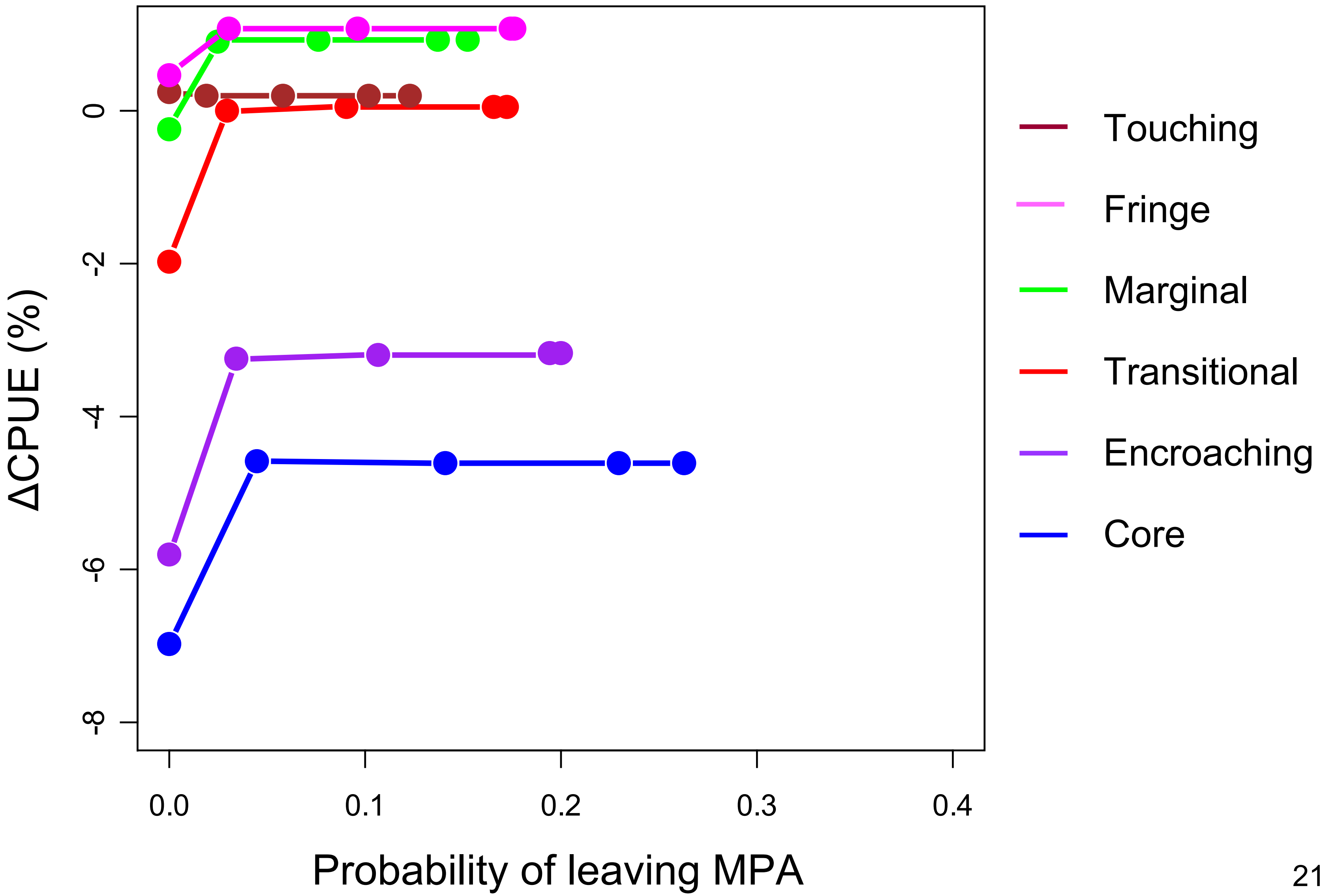
- The percentage change in catch rate (ΔCPUE) over a ten year period following the introduction of the MPA
- The probability that a fish in the future MPA one day would be found outside it the next day
- The catch and effort in each grid square prior to introducing the MPA

We considered ΔCPUE as the performance indicator of primary interest to the fishing industry

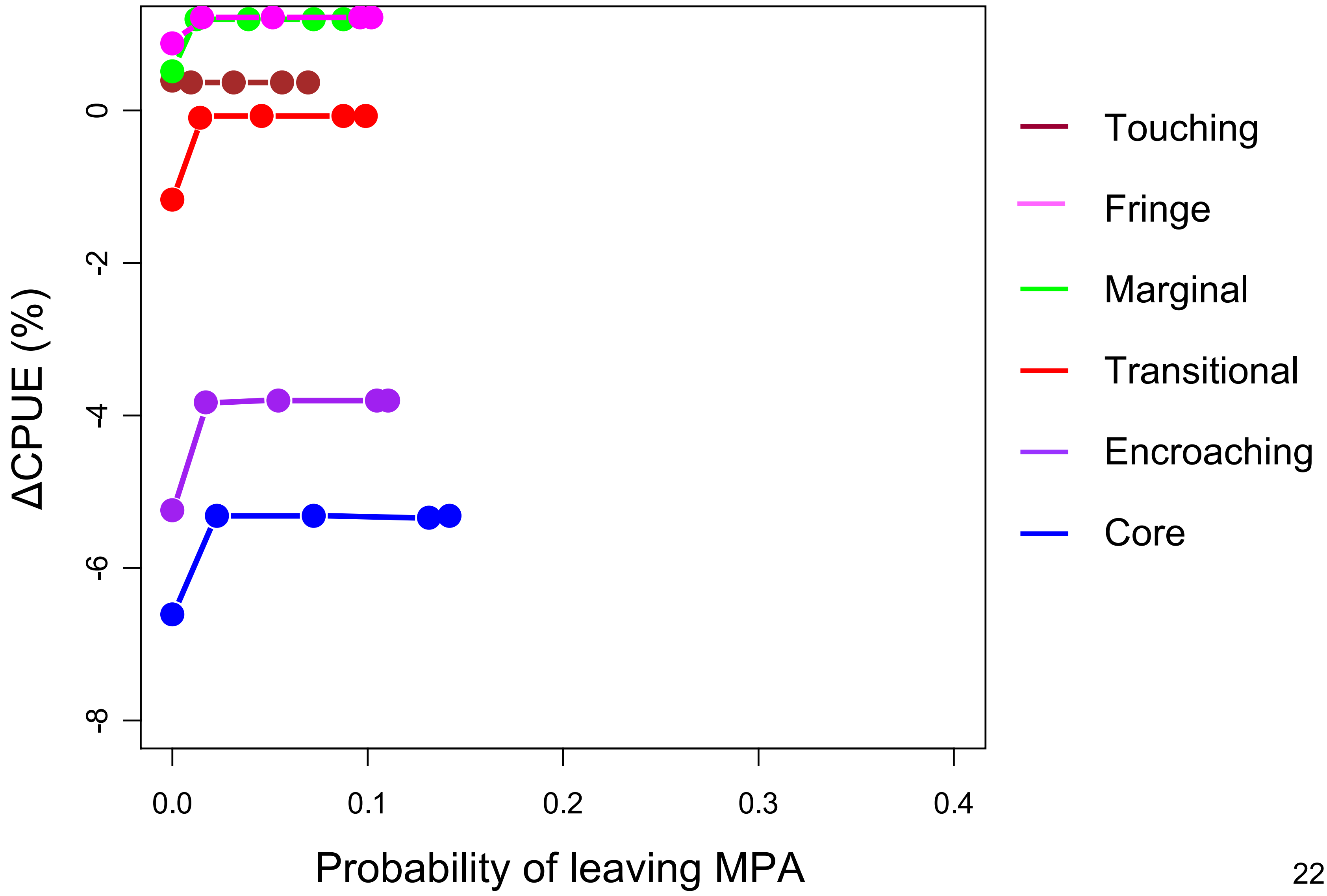
Change in CPUE vs fish movement for different MPA placements:
depletion to 25% of unfished abundance



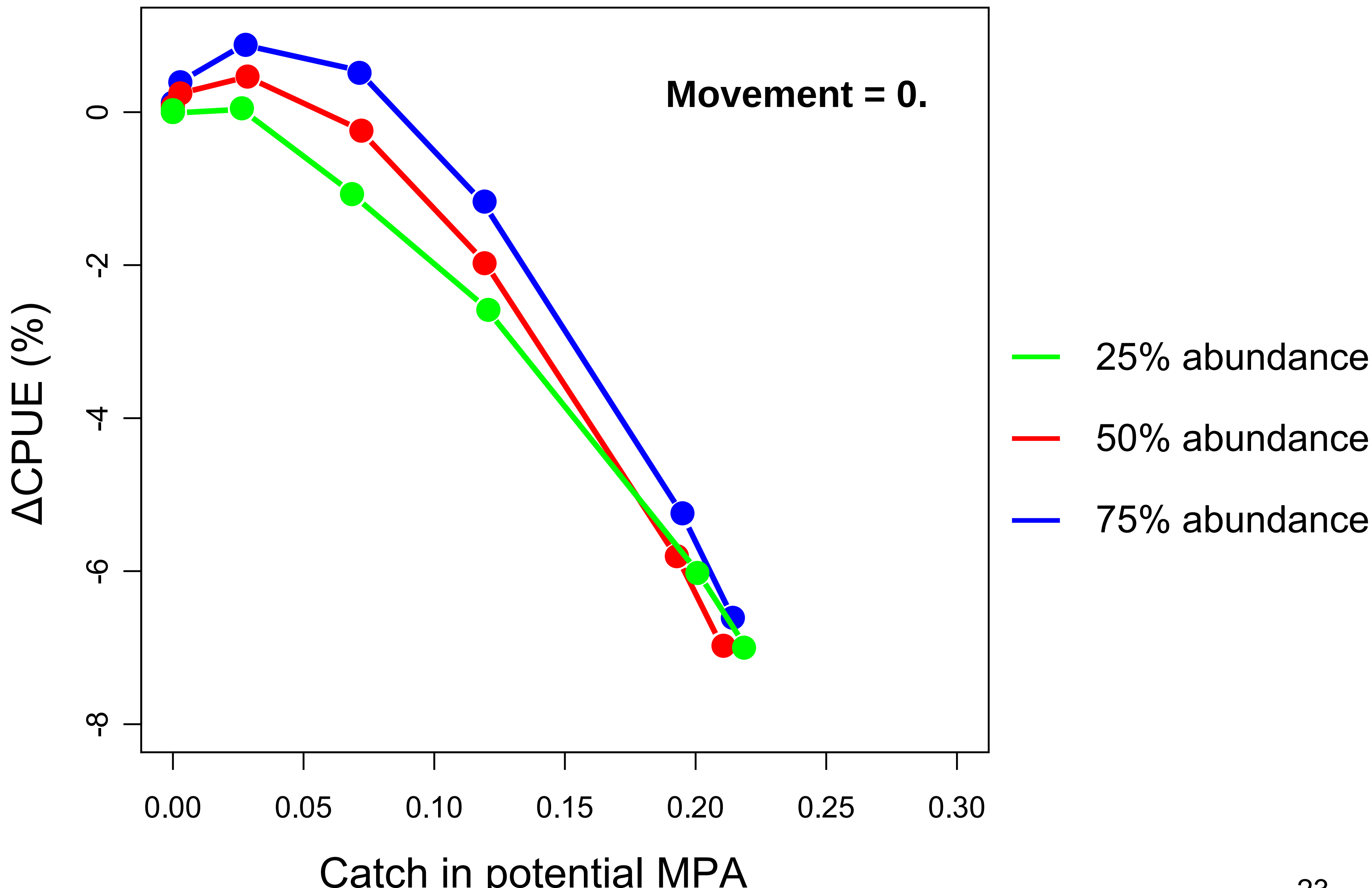
Change in CPUE vs fish movement for different MPA placements: *depletion to 50% of unfished abundance*



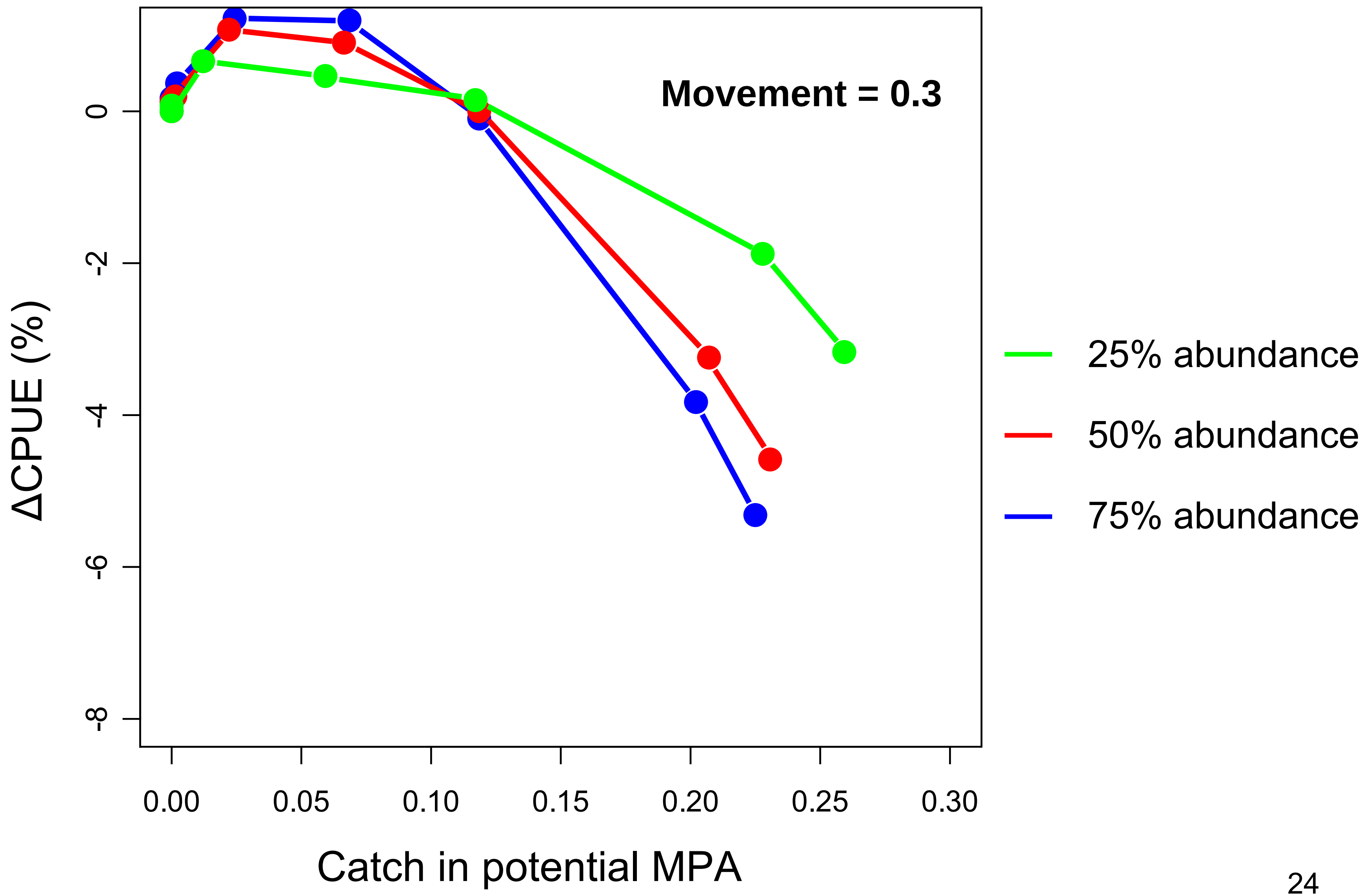
Change in CPUE vs fish movement for different MPA placements:
depletion to 75% of unfished abundance



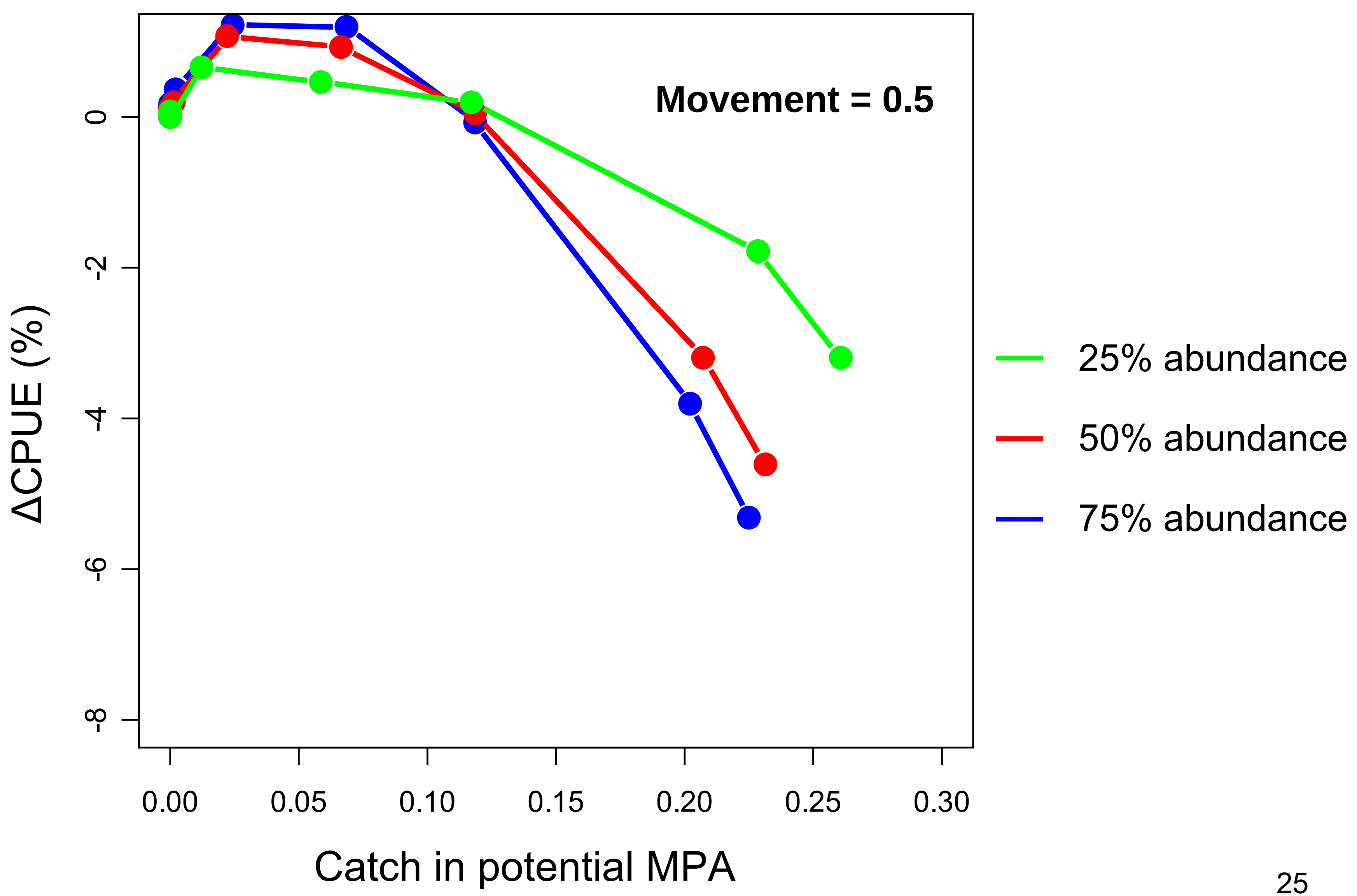
Change in CPUE vs proportion of catch in potential MPA



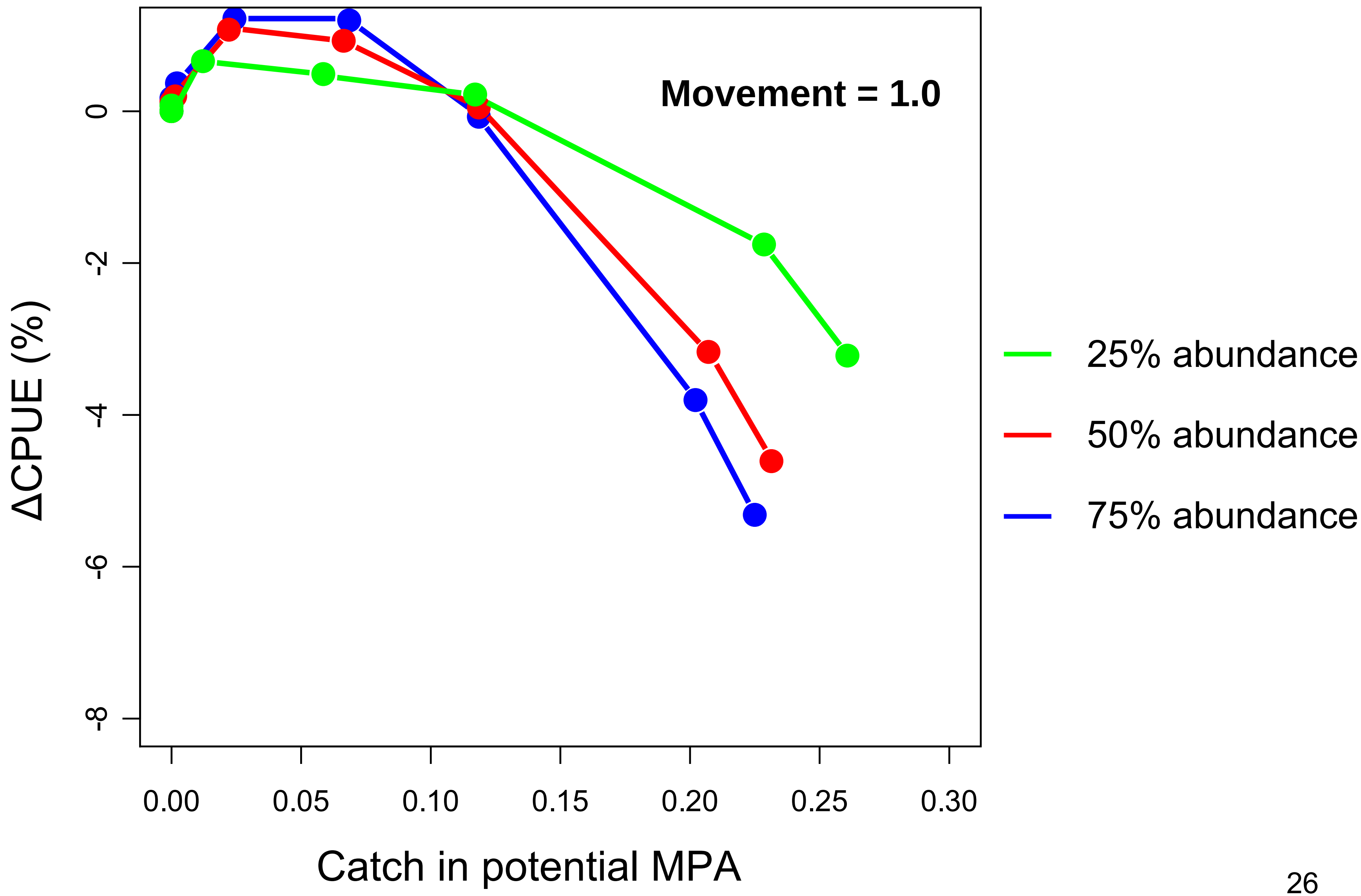
Change in CPUE vs proportion of catch from potential MPA



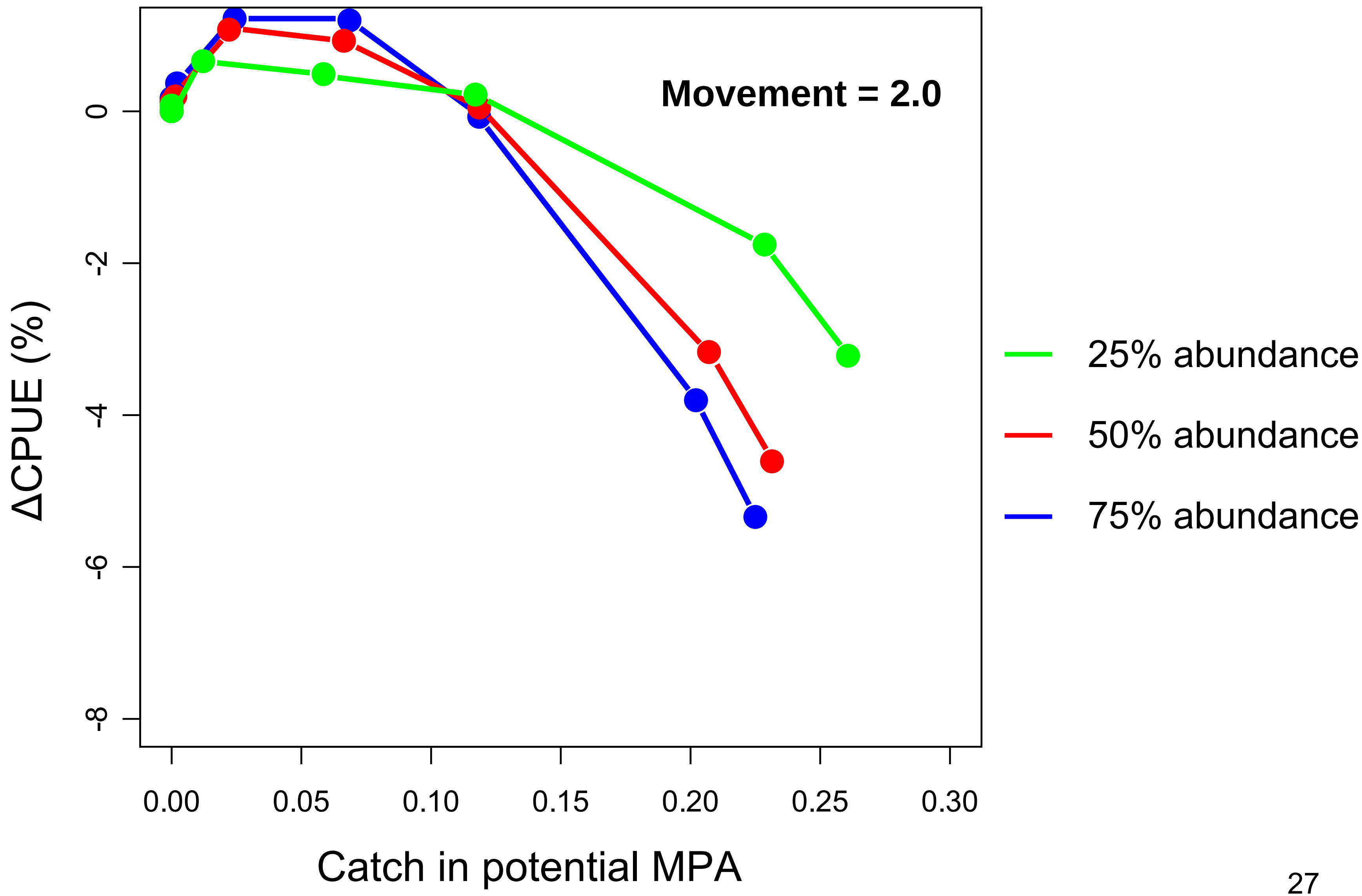
Change in CPUE vs proportion of catch from potential MPA



Change in CPUE vs proportion of catch from potential MPA



Change in CPUE vs proportion of catch from potential MPA



Predicting change in CPUE from pre-MPA data

A crude way of predicting the effect of an MPA is to set the future effort in the potential MPA to zero

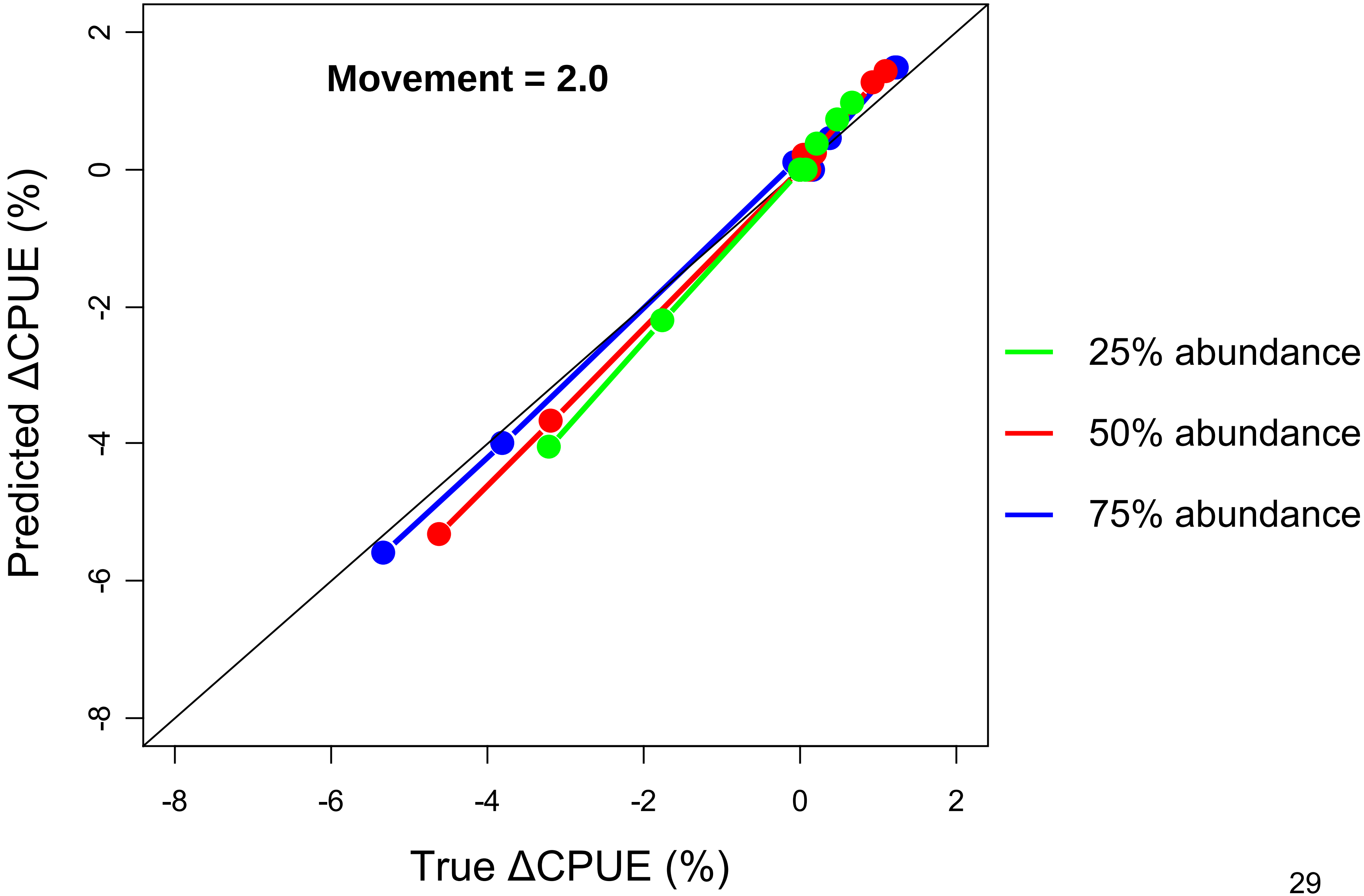
Reallocate that effort to other areas by simply re-scaling their effort to give the same total effort

Predict the post MPA catch by pro-rating with the new effort

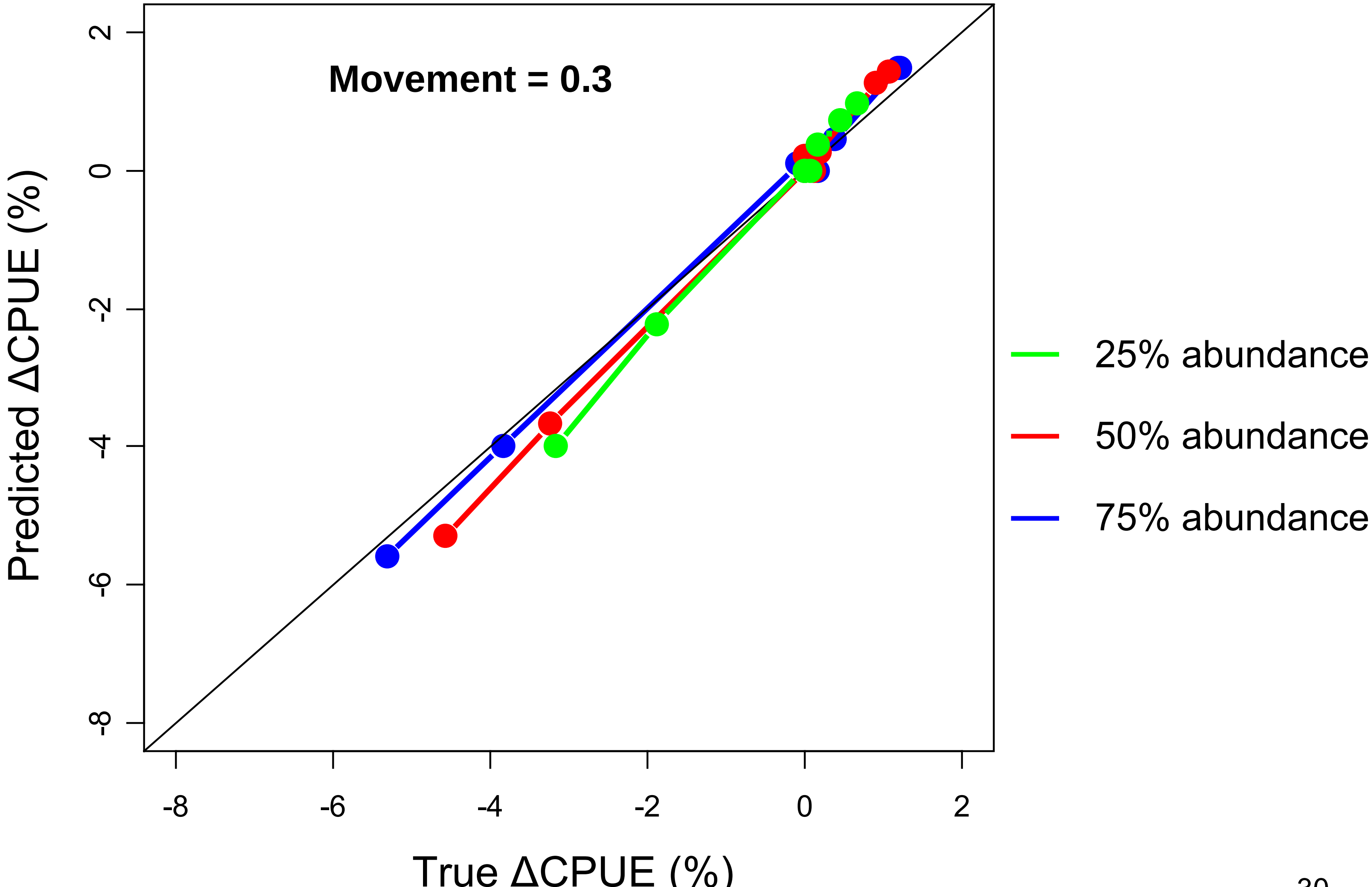
(assumes that the extra effort in each area does not change the abundance of fish there)

This requires spatially resolved catch and effort data

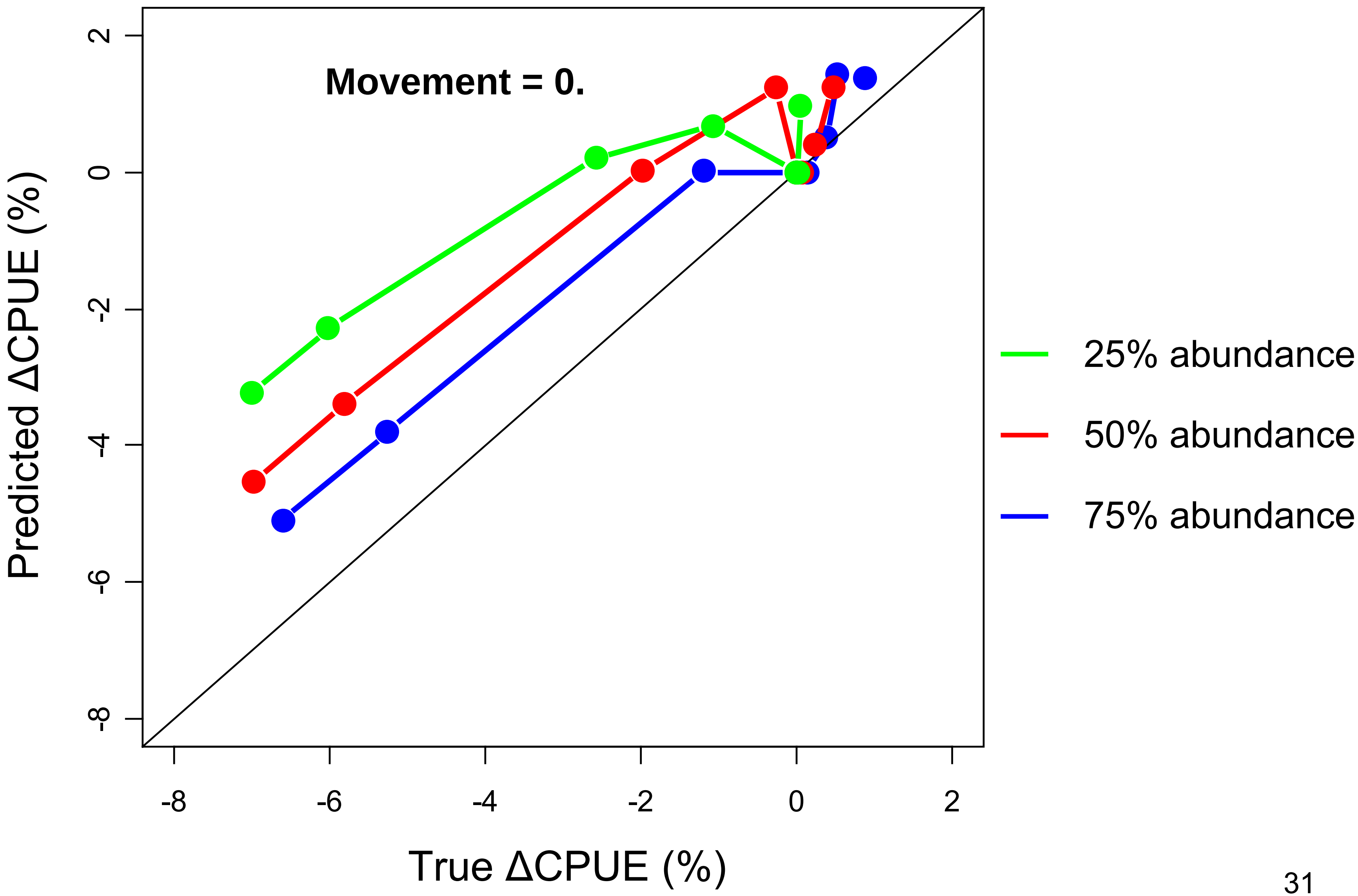
Comparison of predicted vs true change in CPUE



Comparison of predicted vs true change in CPUE



Comparison of predicted vs true change in CPUE



Ranking of the predictors

Analysis of Variance Table

Dependent variable: ΔCPUE

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
MPA catch	1	356.14	356.14	579.1051	< 2.2e-16 ***
Pred cpue	1	104.43	104.43	169.8128	< 2.2e-16 ***
P leave	1	4.64	4.64	7.5375	0.007178 **
Depletion	2	1.18	0.59	0.9579	0.387215
Residuals	99	60.88	0.61		

Conclusions

Not surprisingly, the proportion of the catch taken in the potential MPA is the most important predictor

The crude CPUE estimator is also a useful predictor – at least in this case where harvest rates are low (3% – 8%)

Fish movement adds something to the prediction, but only so far as it is above a low threshold – low precision estimates of fish movement are likely to be sufficient

Depletion of the stock does not appear to be an important predictor