Testing and predicting synergy between multiple stressors

Isabelle M. Côté and Emily S. Darling





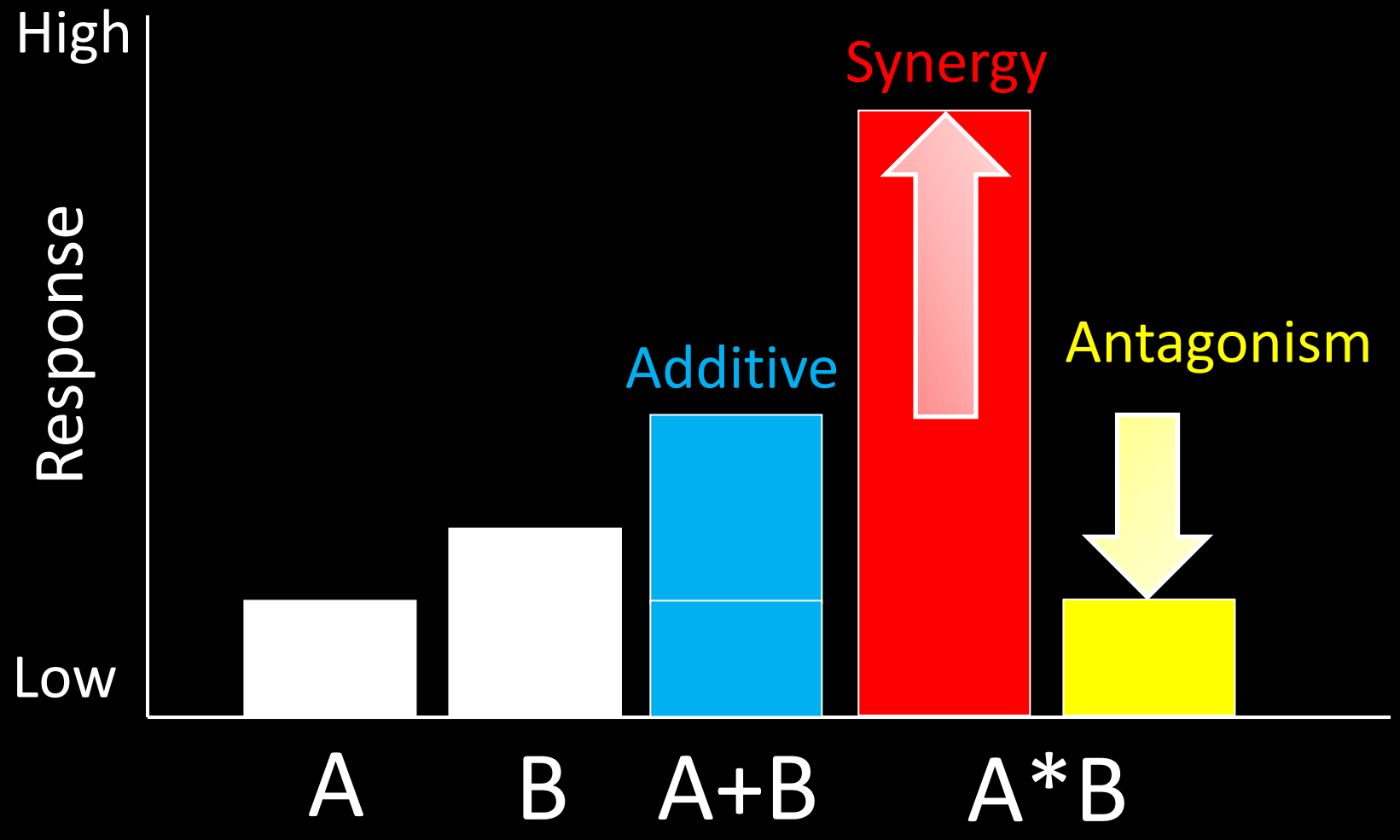





Understanding the role of compounded disturbances will be basic to environmental management decisions in the 21st century

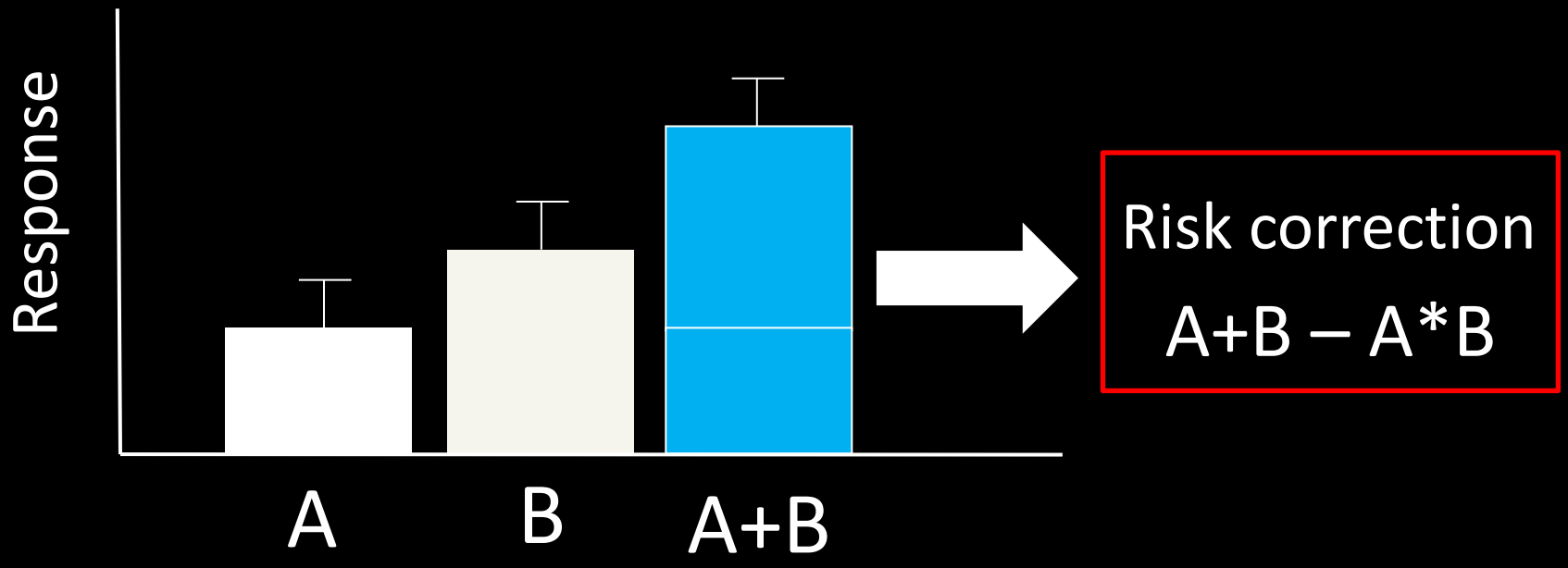
RT Paine 1998

How stressors can interact



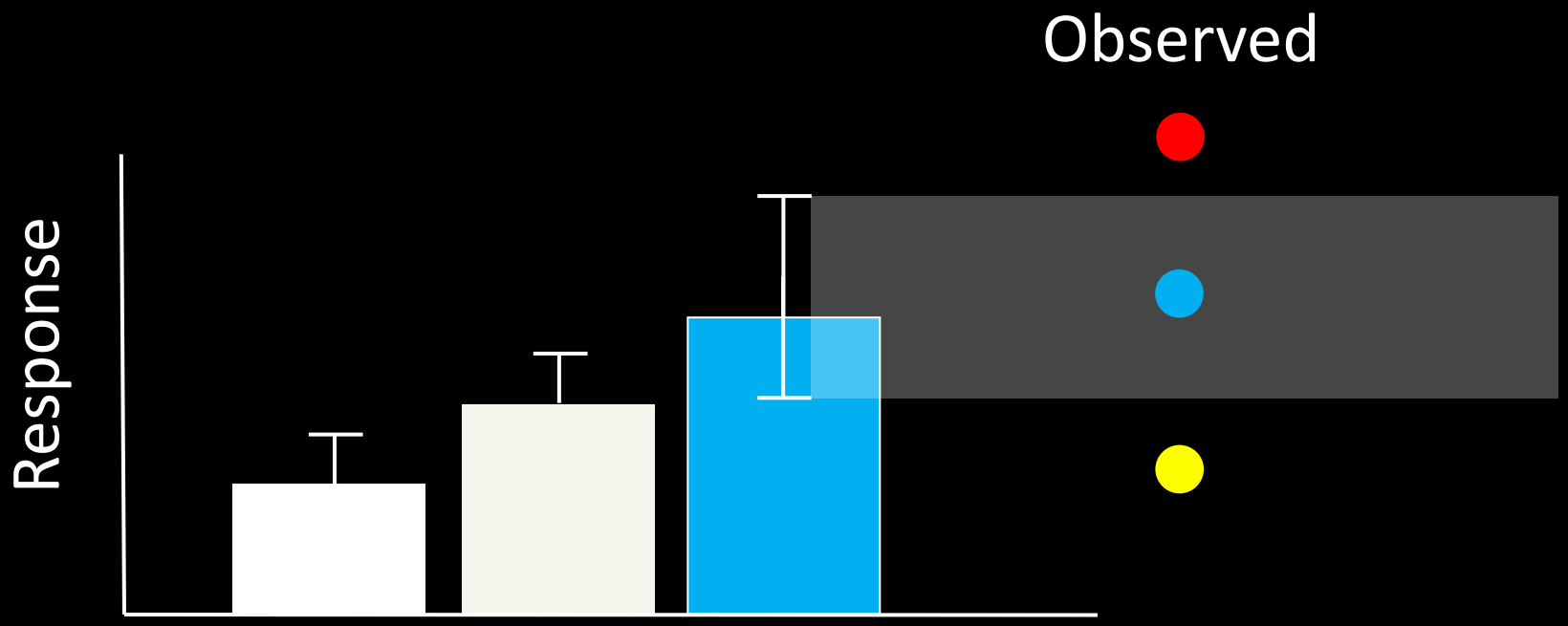
Detecting synergies

1. Compare observed impacts of multiple stressors to additive null model



Detecting synergies

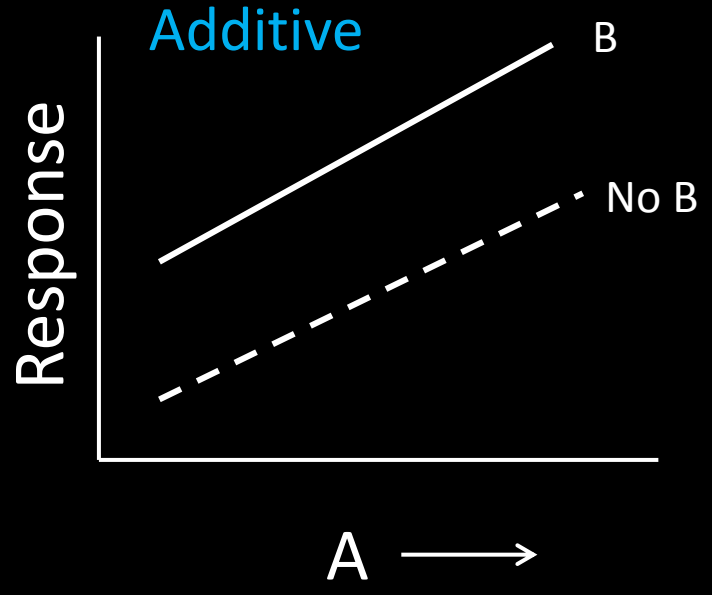
1. Compare observed impacts of multiple stressors to additive null model



Detecting synergies

2. Test for interaction in a statistical model

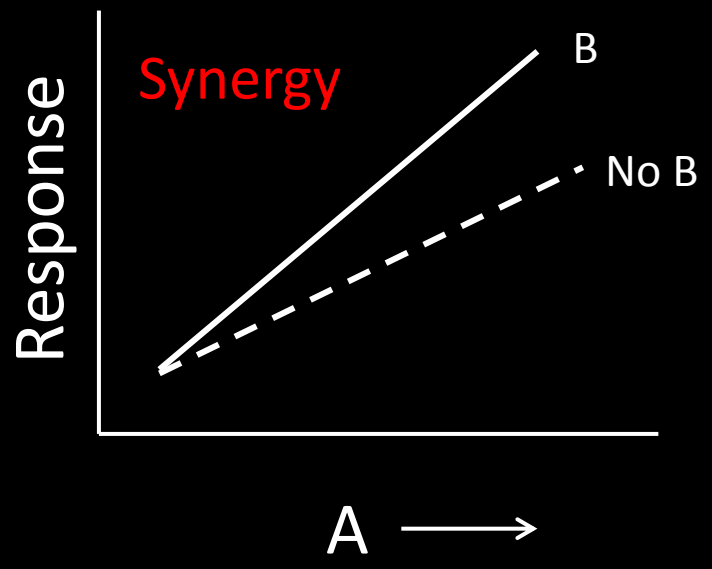
Effect	df	F	p
A			*
B			*
A*B			NS



Detecting synergies

2. Test for interaction in a statistical model

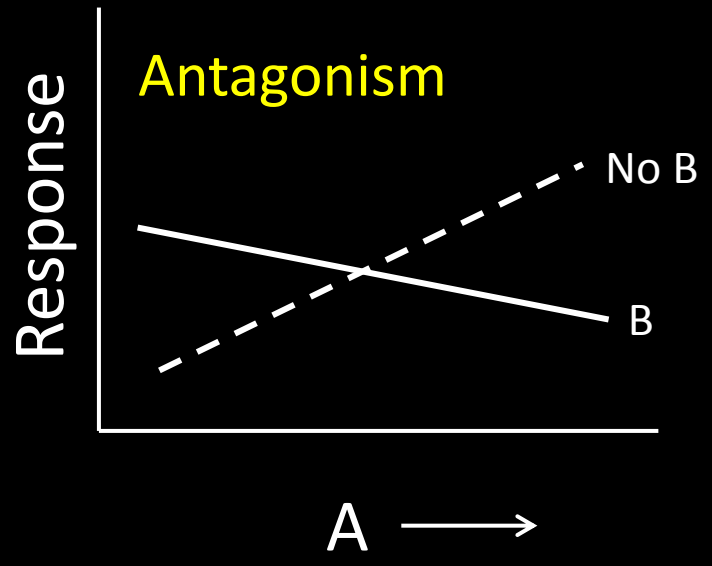
Effect	df	F	p
A			
B			
A*B			**



Detecting synergies

2. Test for interaction in a statistical model

Effect	df	F	p
A			
B			
A*B			**

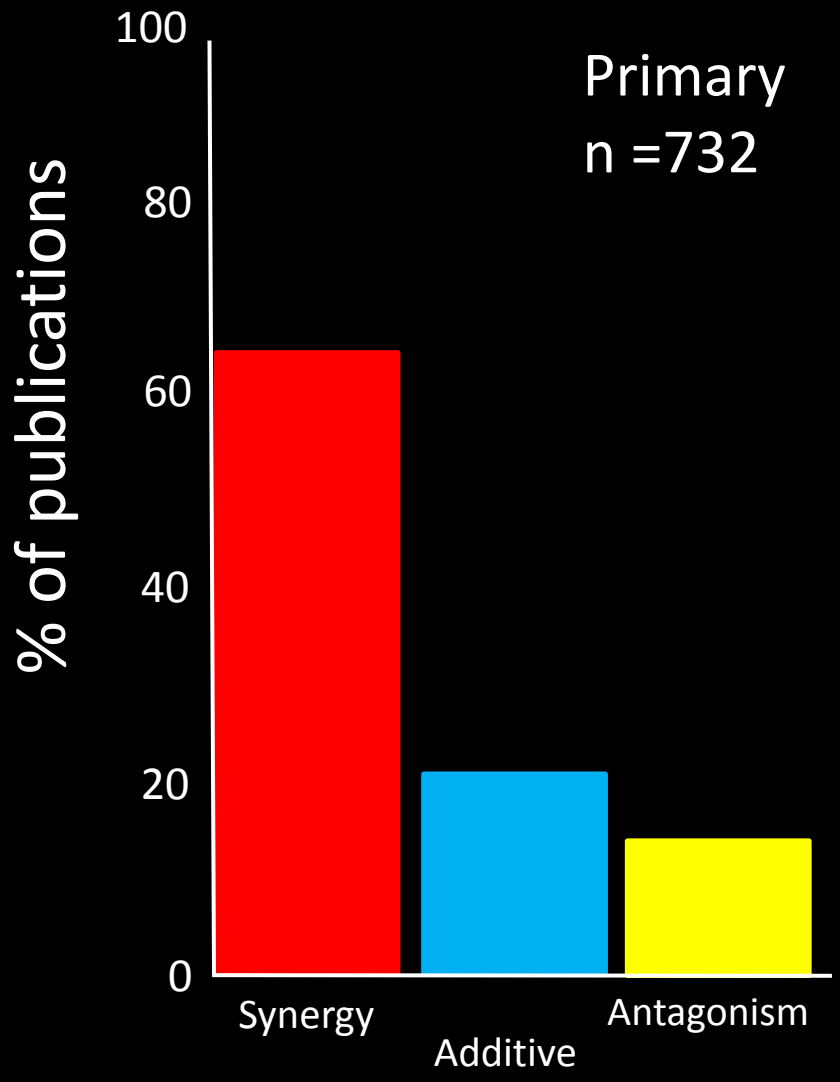


Detecting synergies

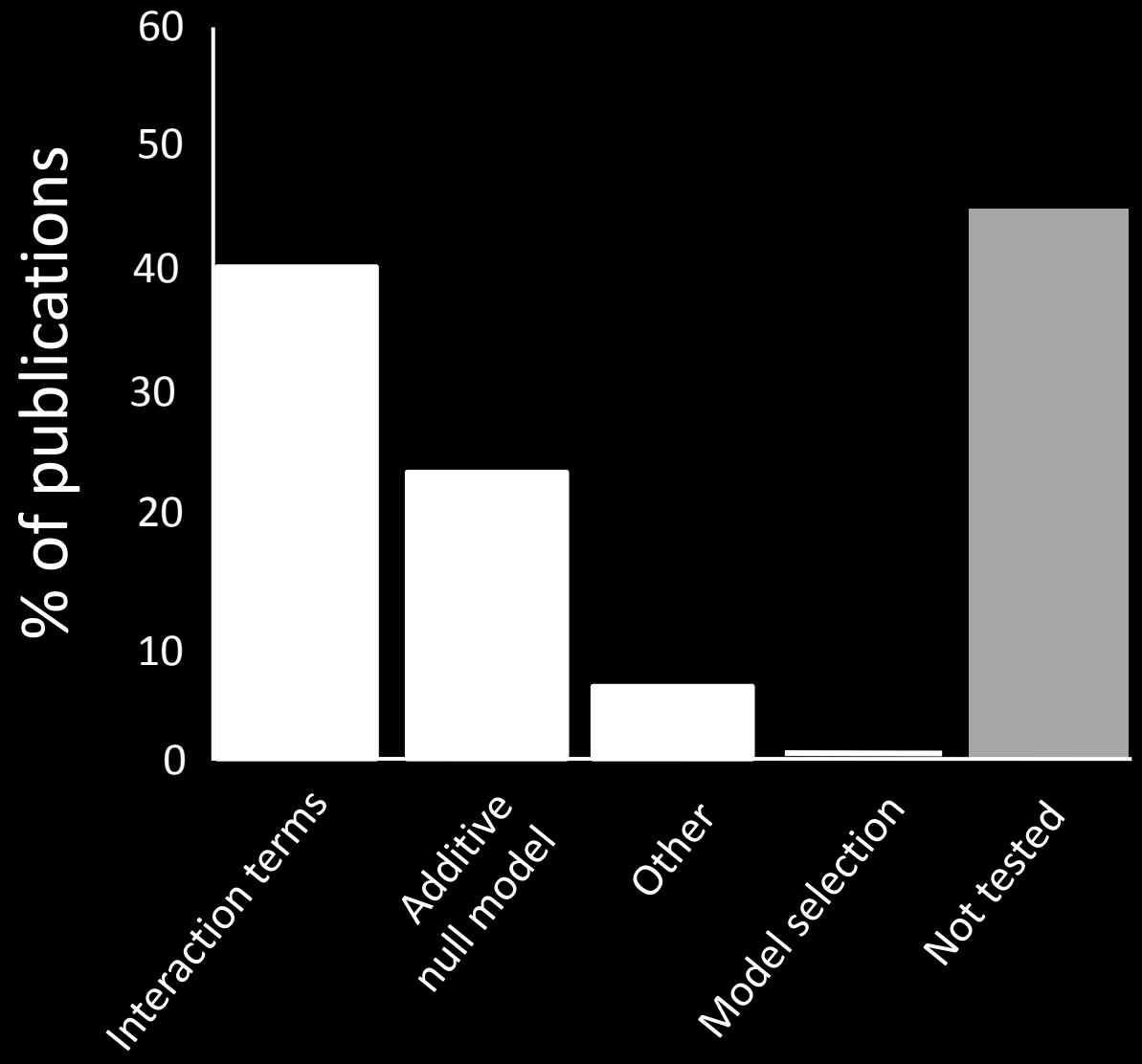
2. Test for interaction in a statistical model

Model	K	ΔAIC	wAIC
1. A		10	0.01
2. B		10	0.01
3. A + B		7	0.03
4. A + B + A*B		0	0.96

How prevalent are synergies?

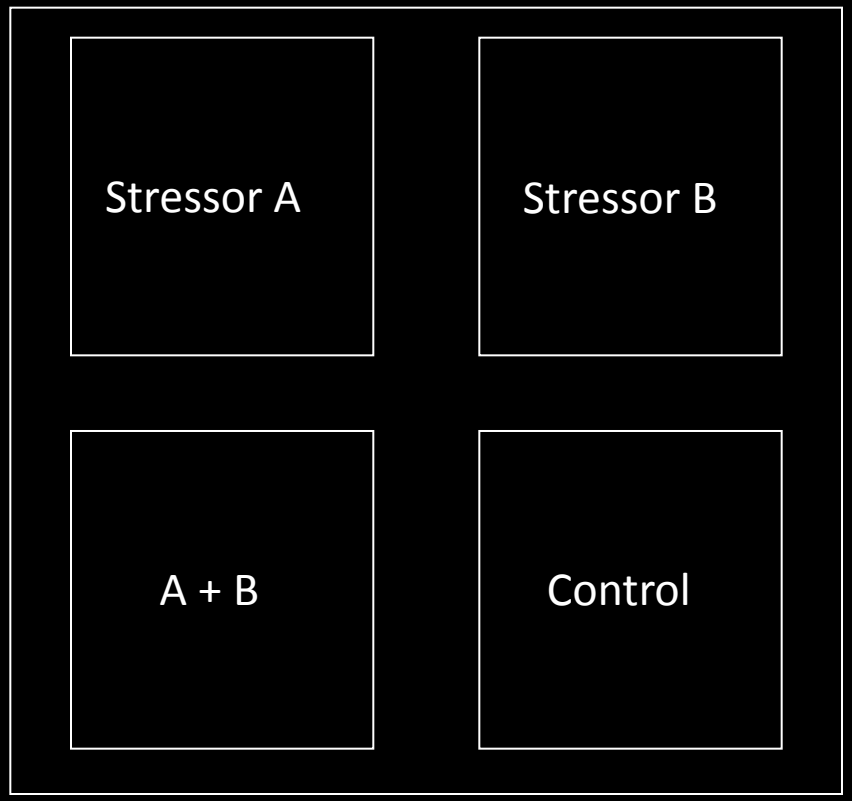


How prevalent are synergies?



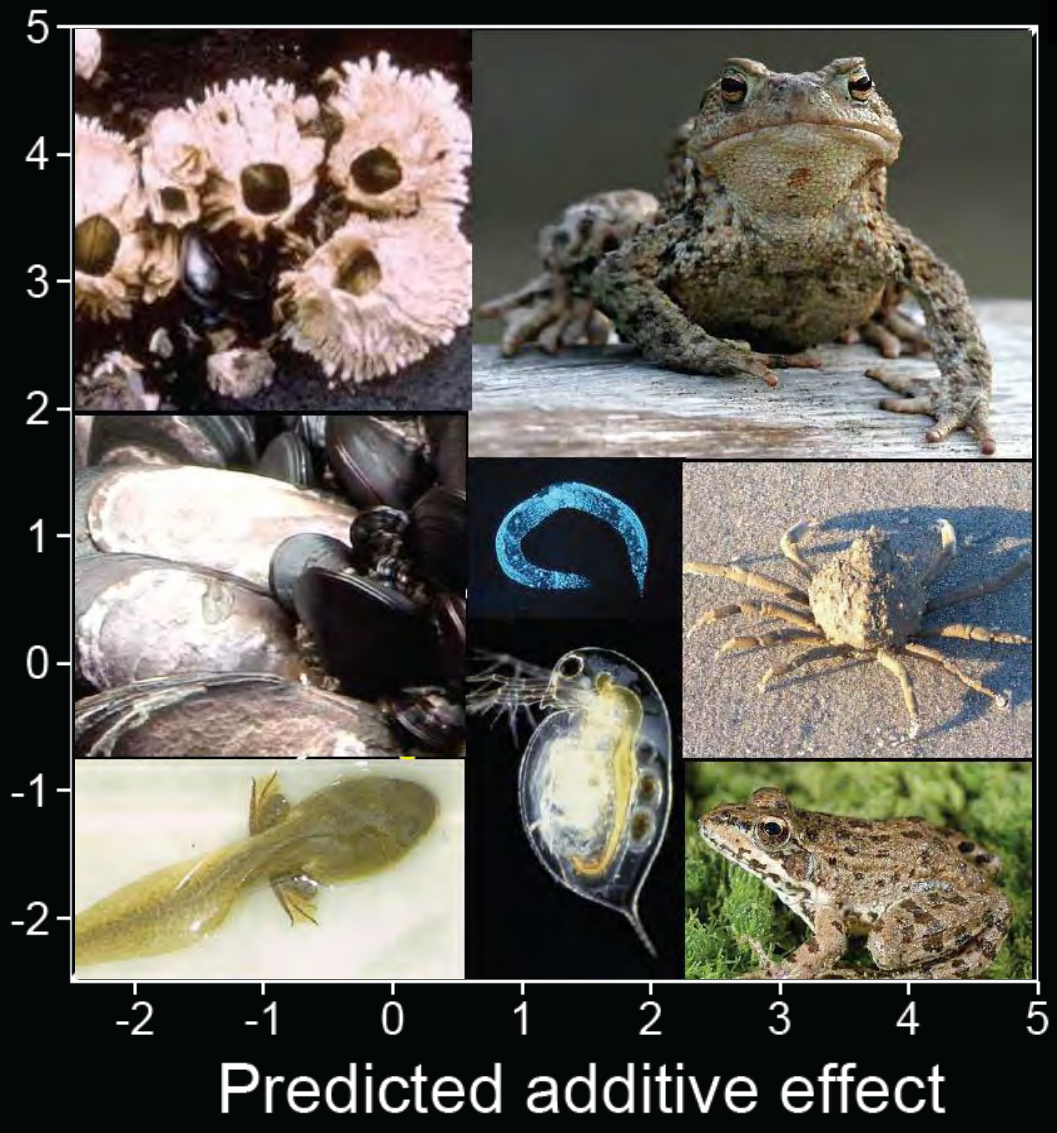
How prevalent are synergies?

Meta-analysis of fully factorial experiments
n = 112

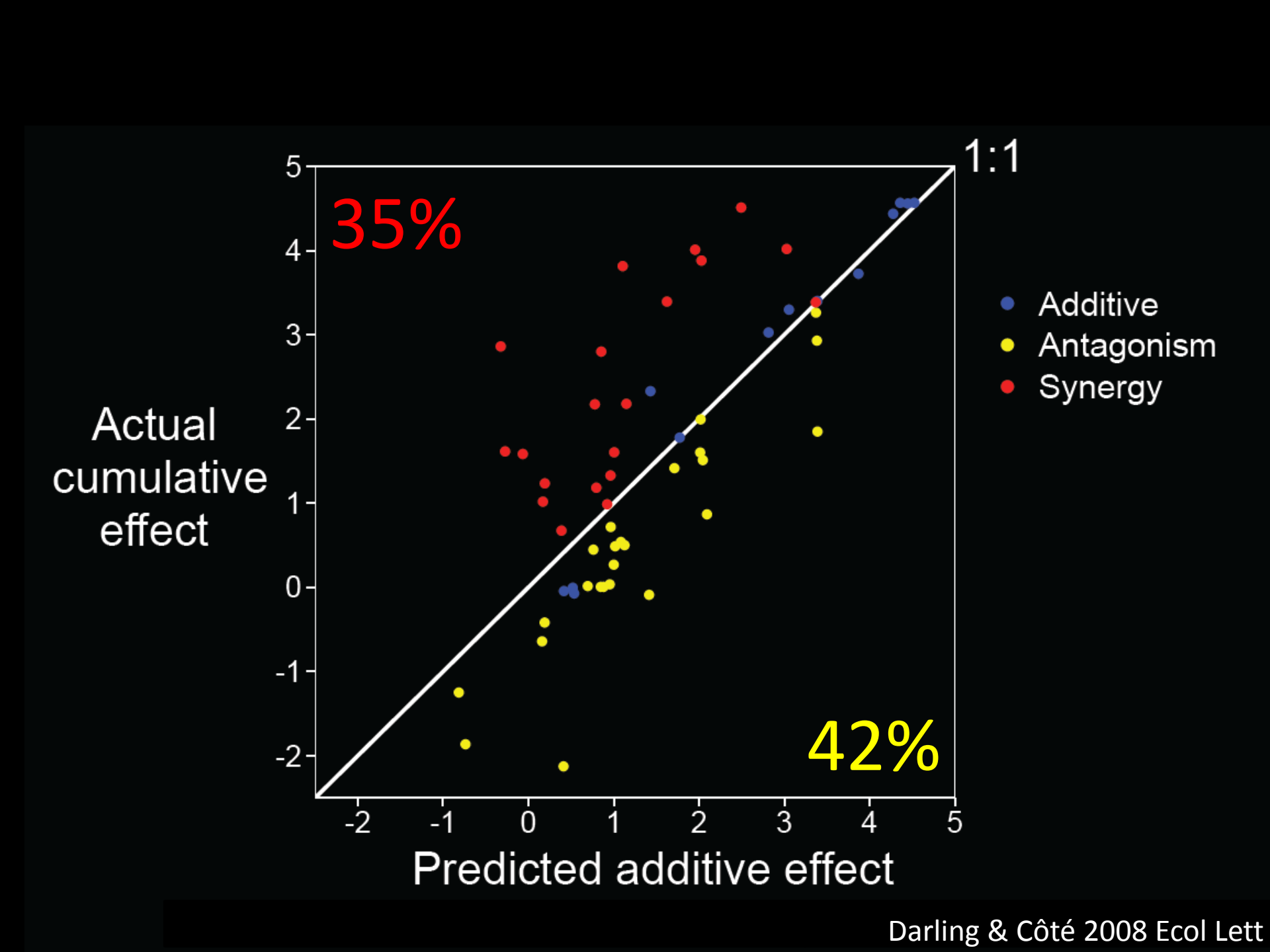


Response ratio

$$= \ln \left(\frac{\text{mortality}_{\text{stressor}}}{\text{mortality}_{\text{control}}} \right)$$



Darling & Côté 2008 Ecol Lett



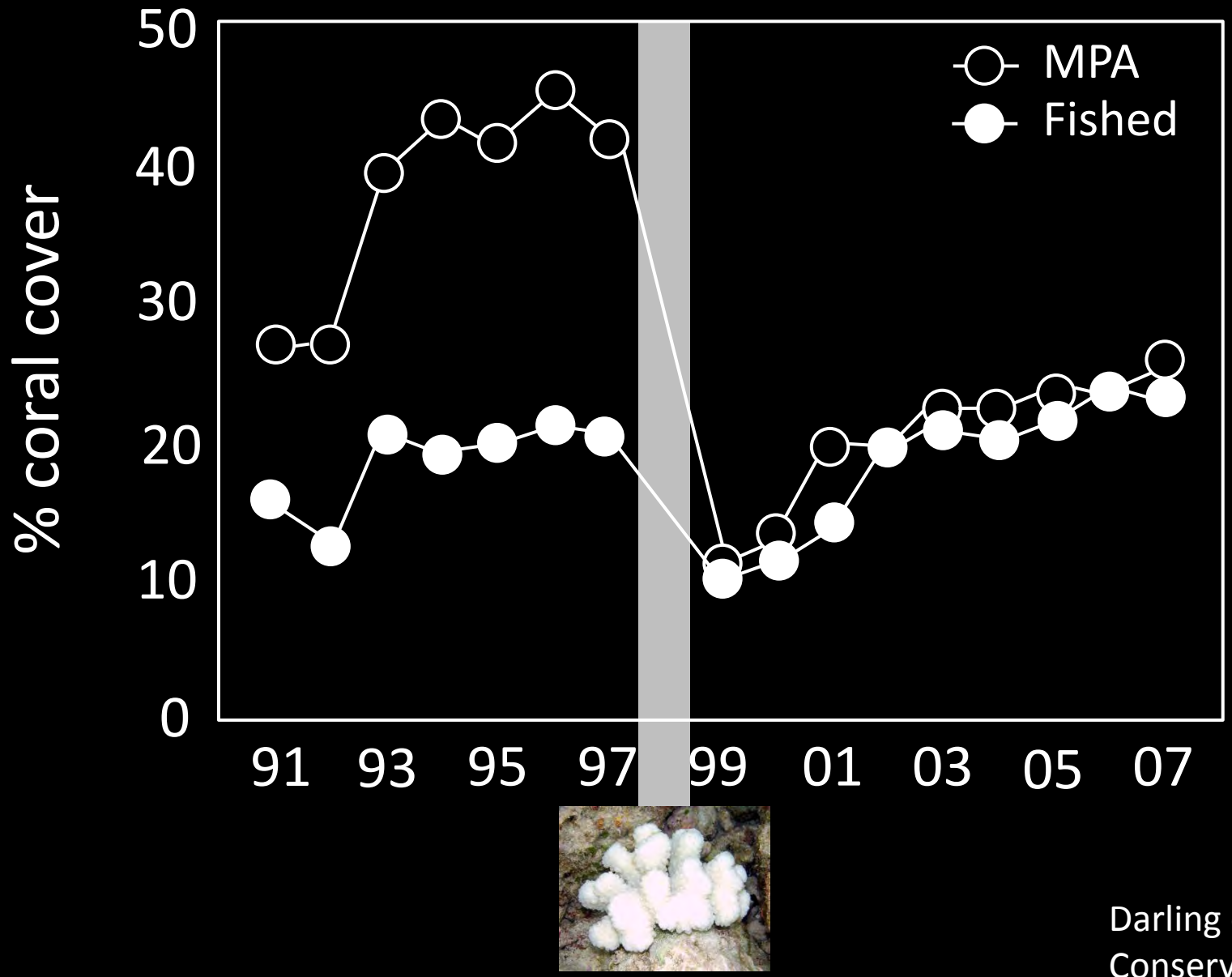
Darling & Côté 2008 Ecol Lett

Looking for synergies in the wild

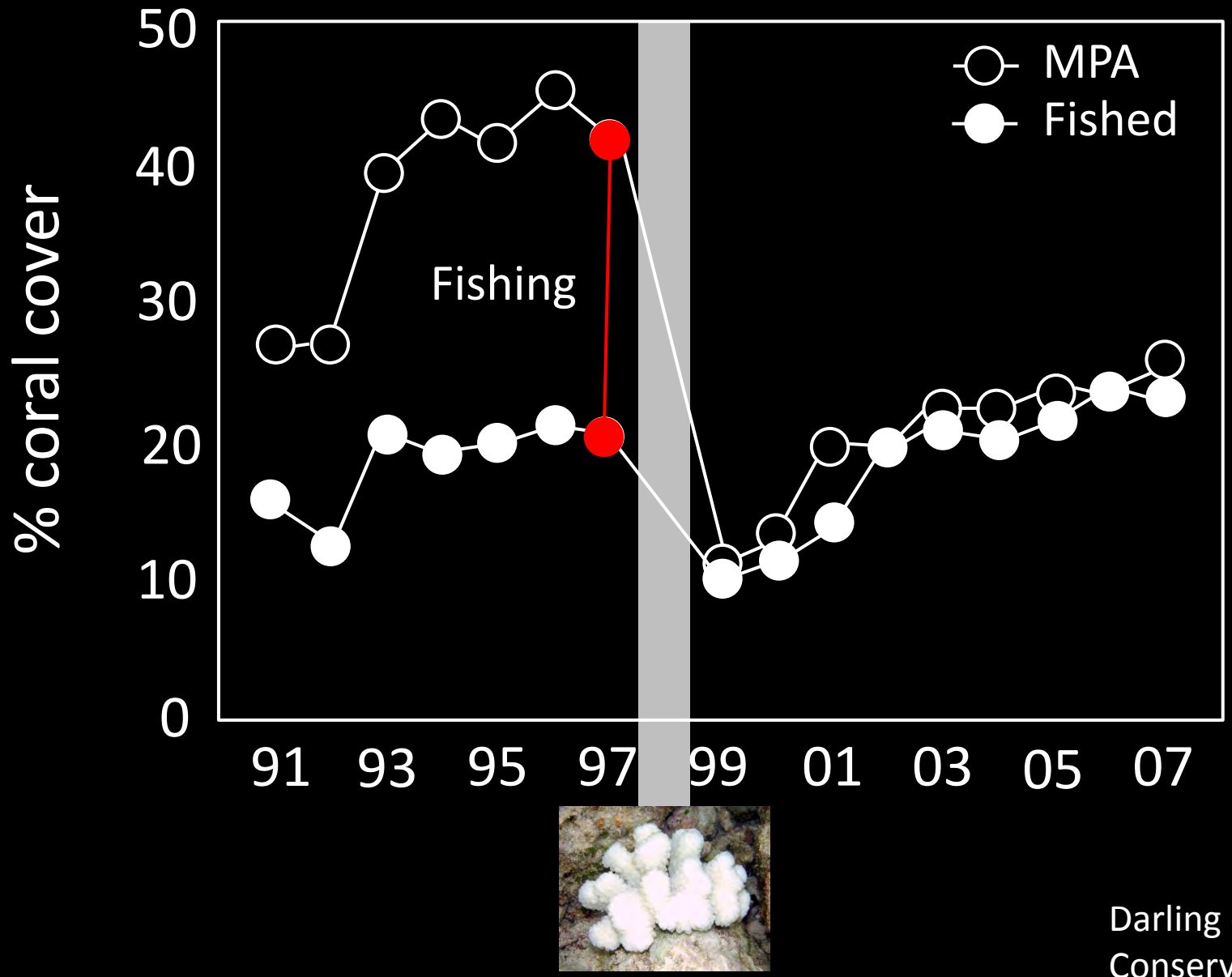
Kenyan coral reefs

Climate change

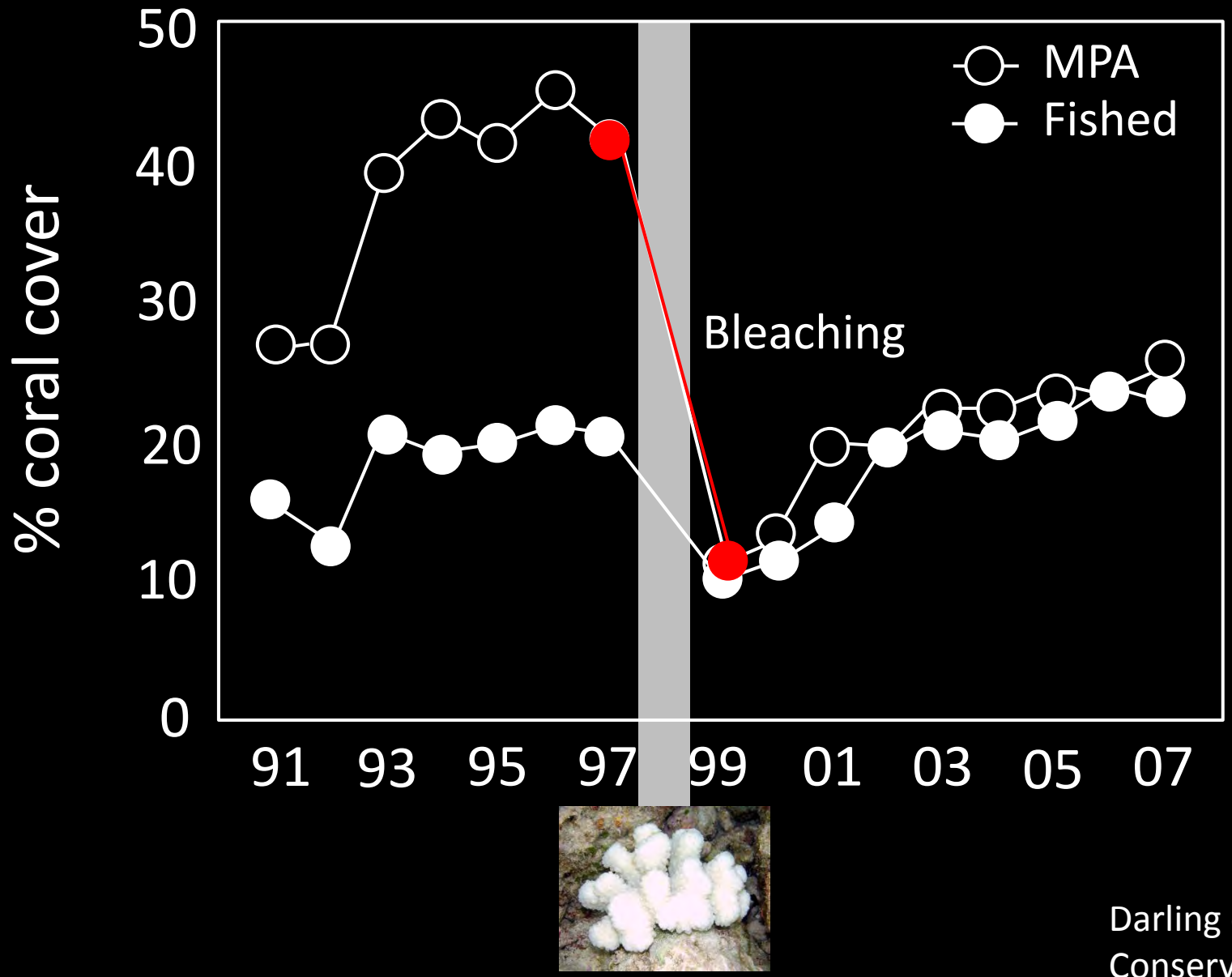
Fishing



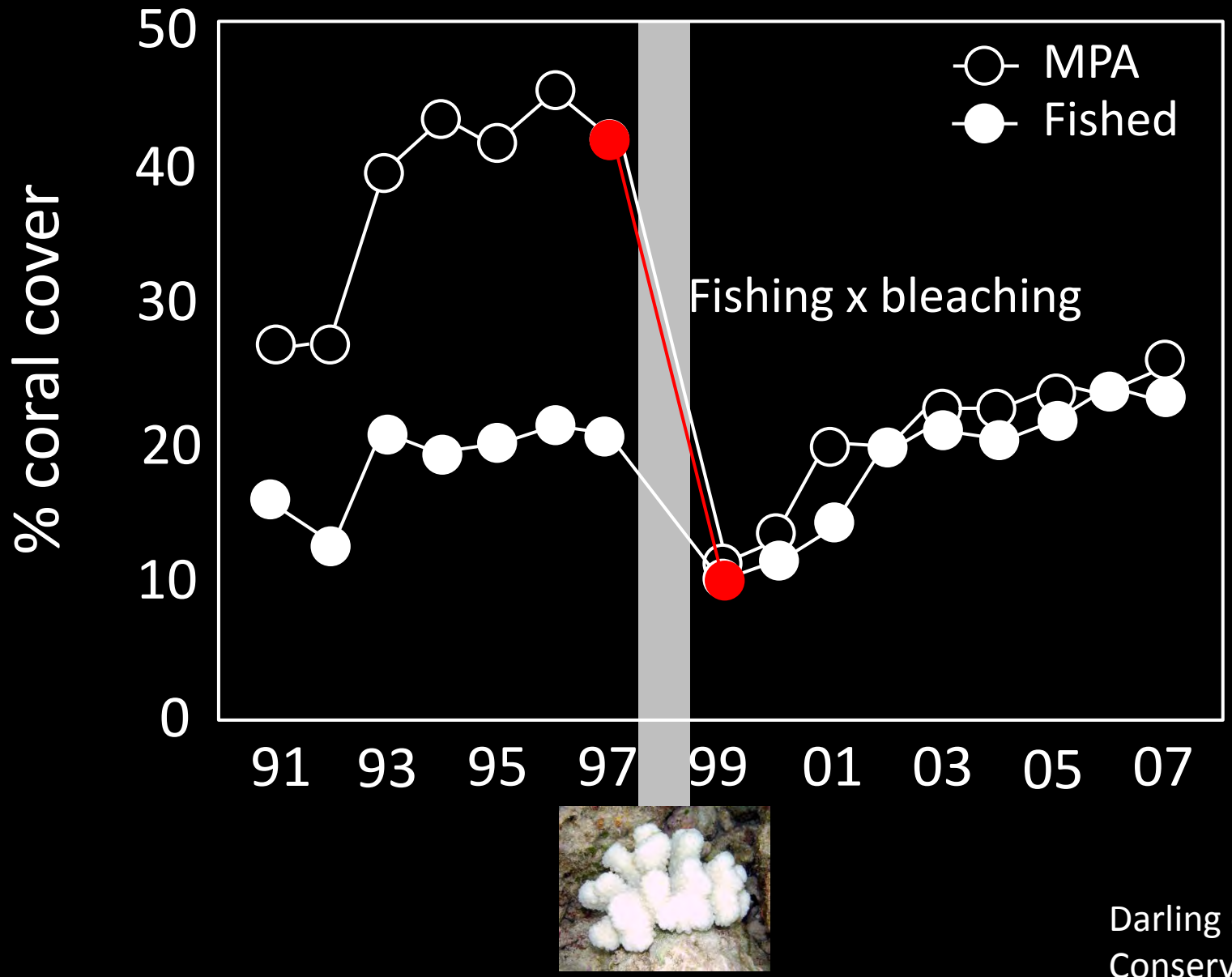
Darling et al. 2010
Conservation Lett



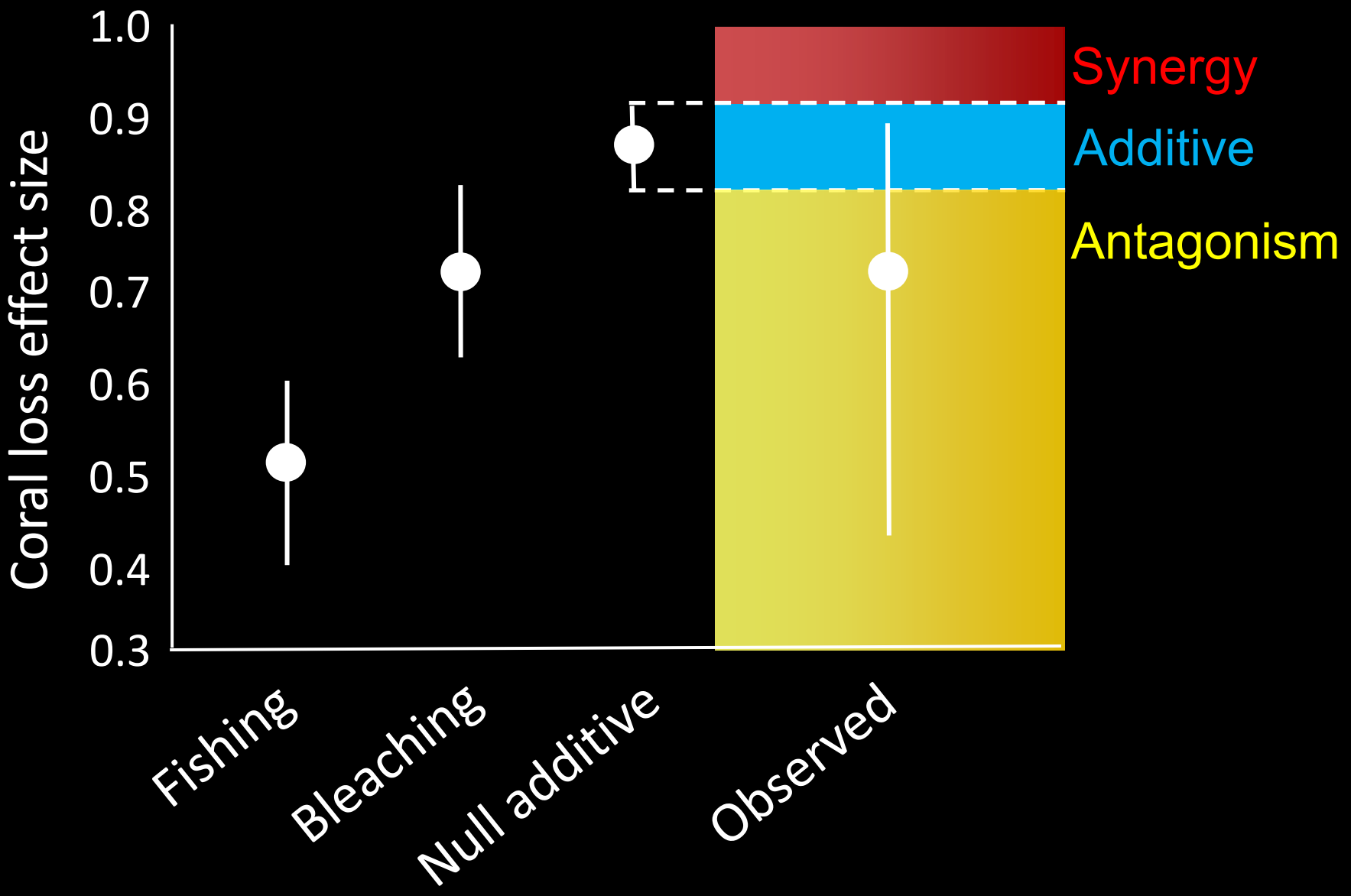
Darling et al. 2010
Conservation Lett



Darling et al. 2010
Conservation Lett

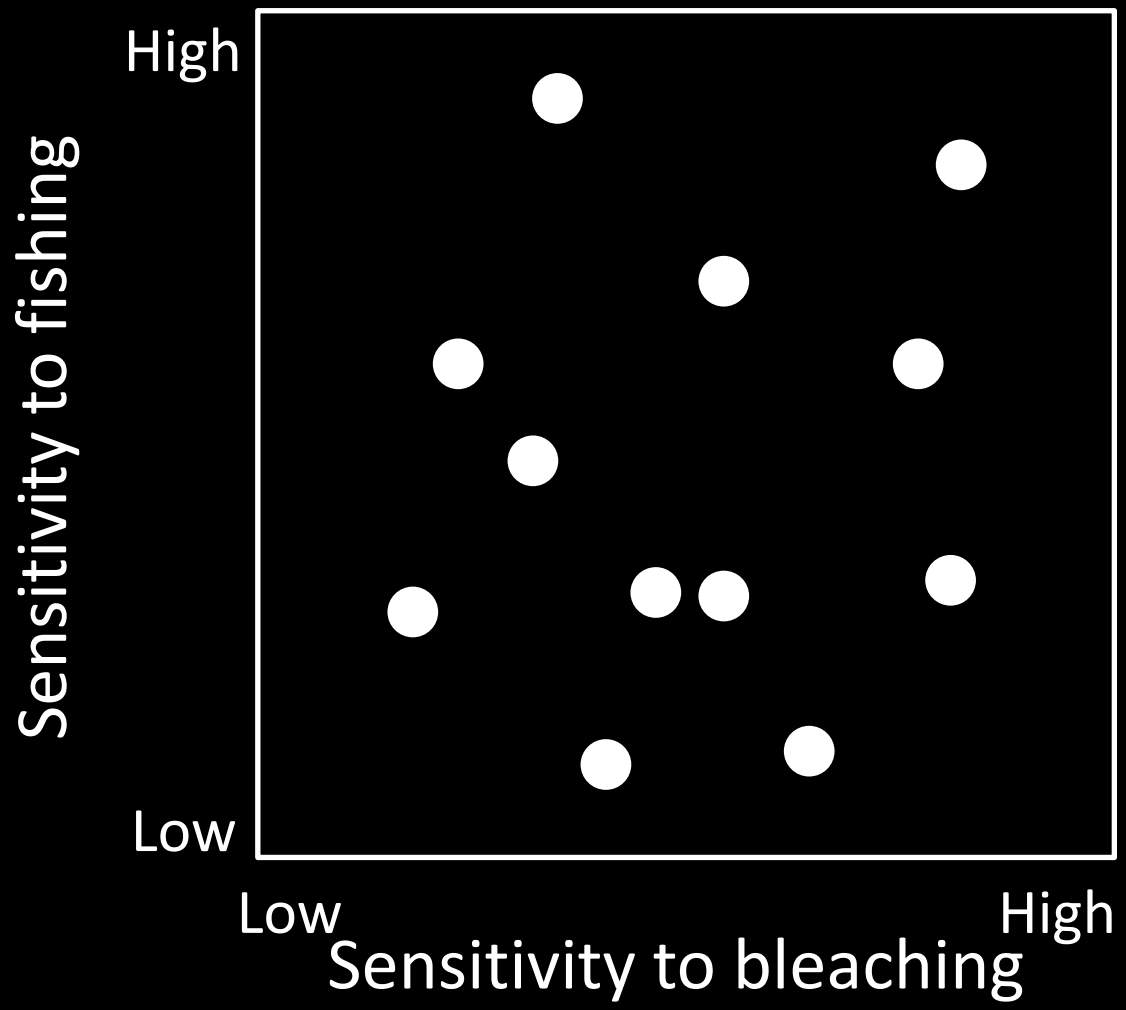


Darling et al. 2010
Conservation Lett



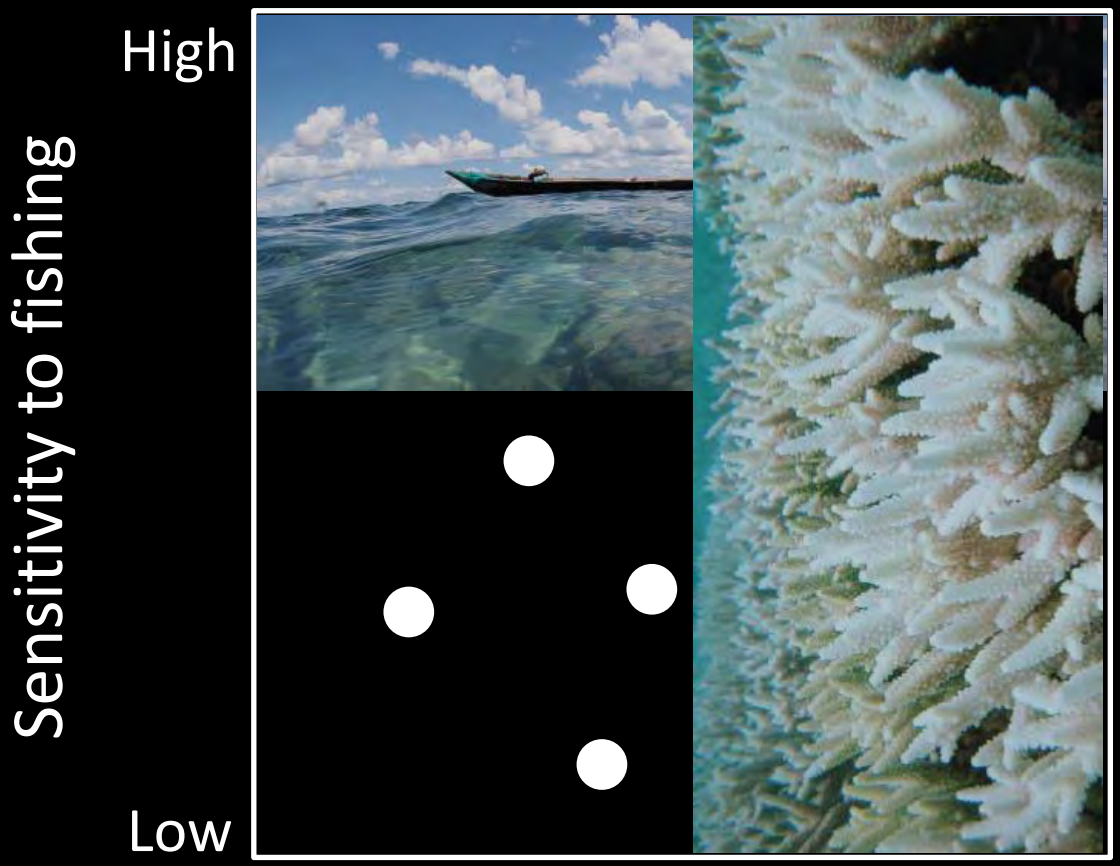
Darling et al. 2010
Conservation Lett

Co-tolerance: the key to predicting interaction type?



Vinebrooke et al. 2004 Oikos

Co-tolerance



Additive

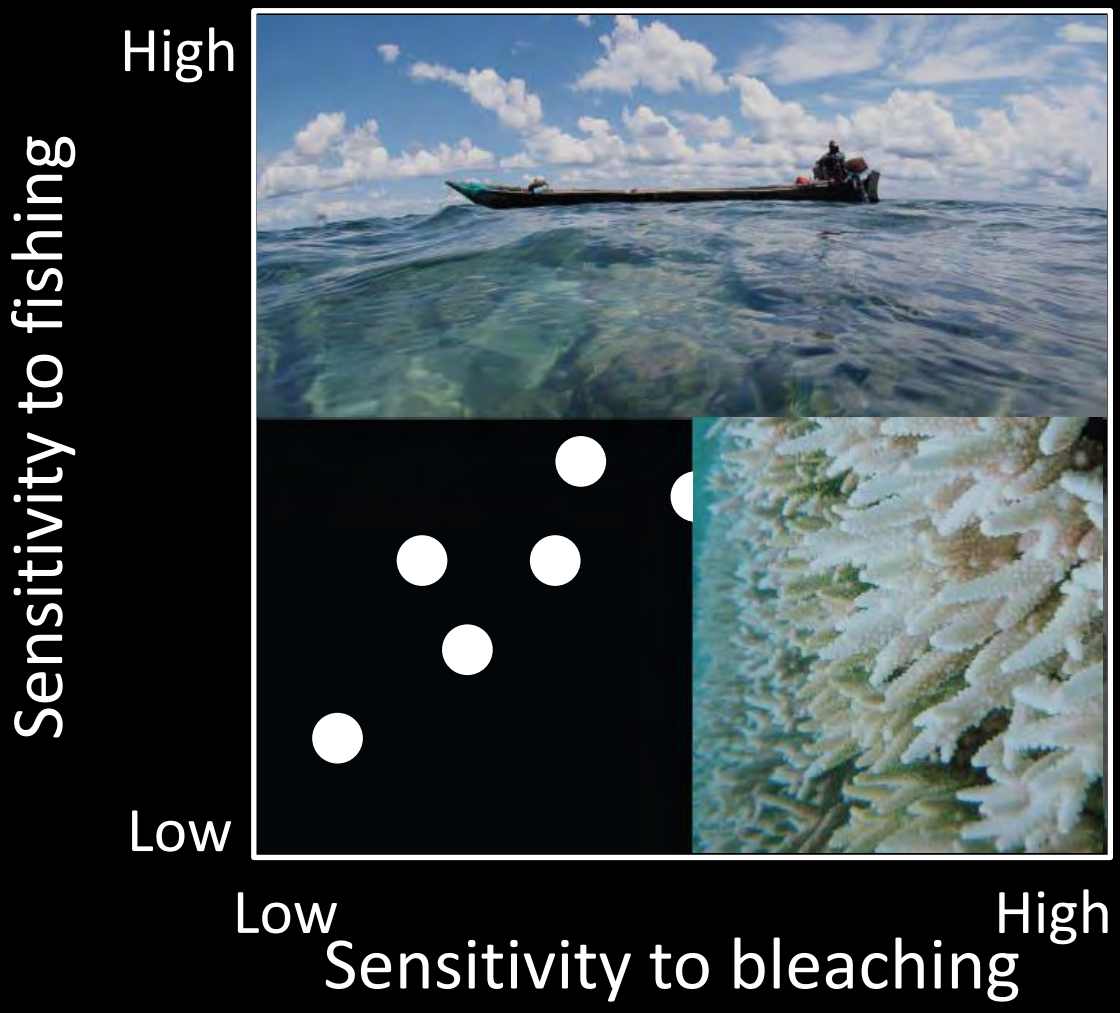
Vinebrooke et al. 2004 Oikos

Co-tolerance

Synergy

Vinebrooke et al. 2004 Oikos

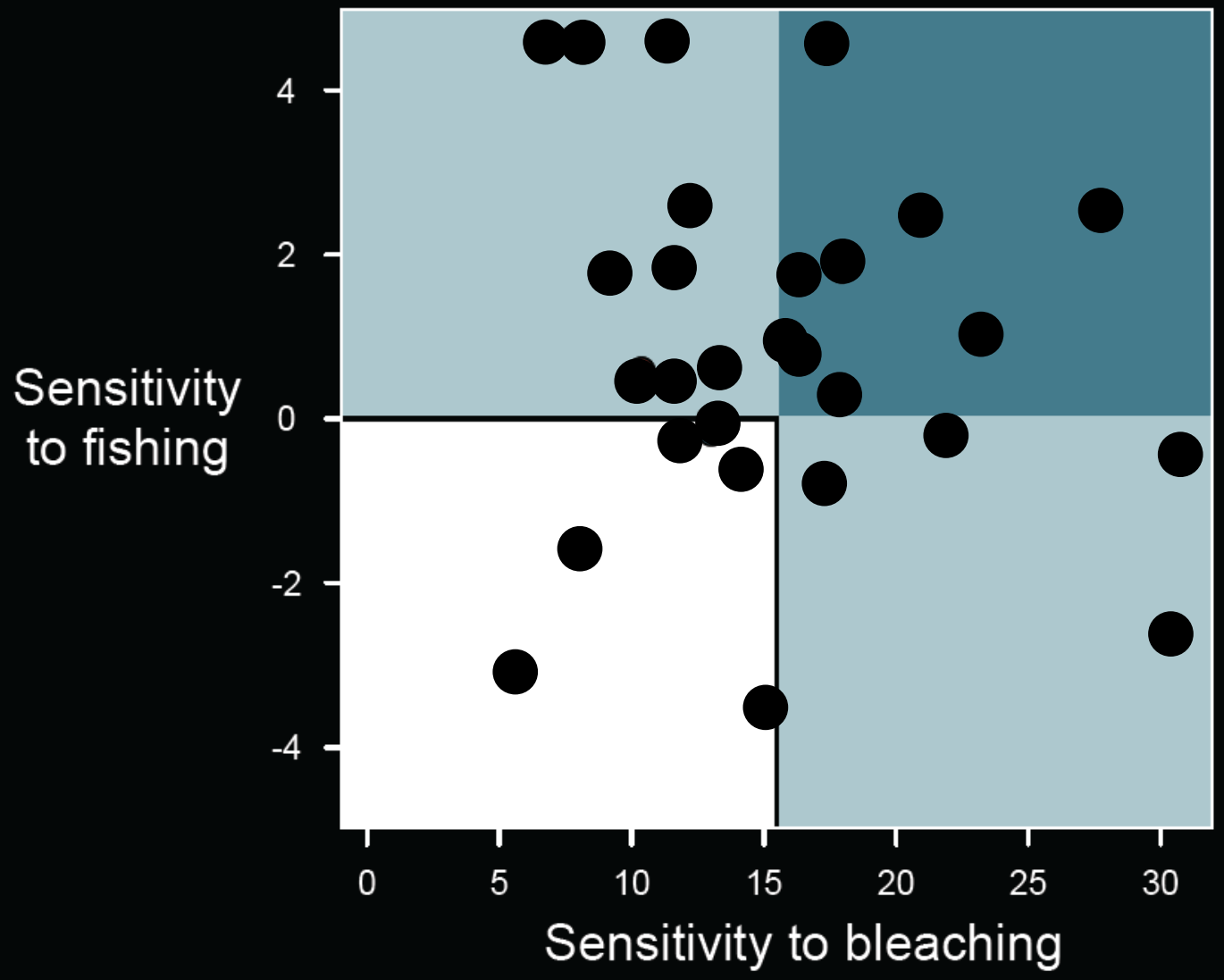
Co-tolerance



Antagonism

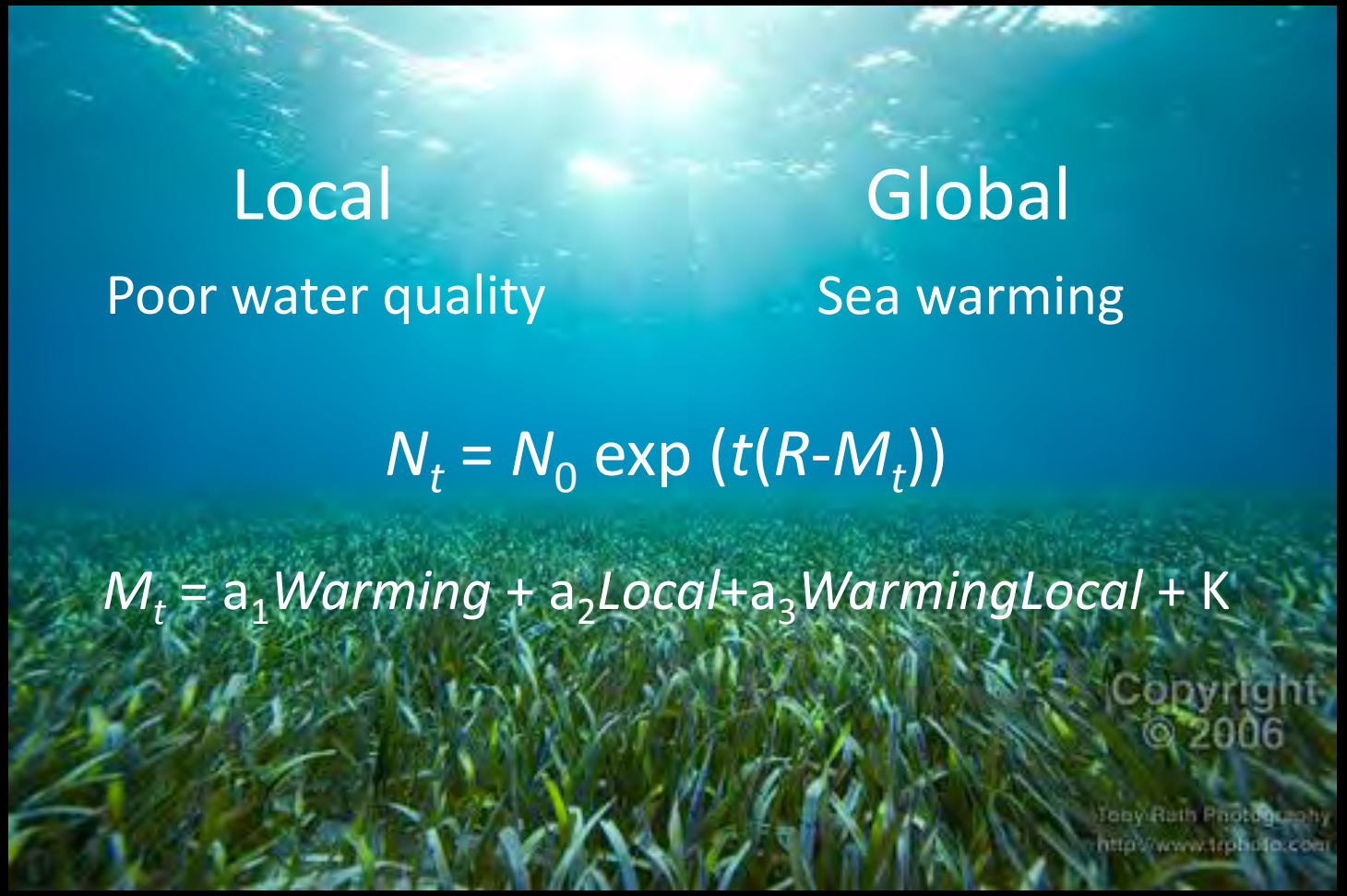
Vinebrooke et al. 2004 Oikos

Co-tolerance in Kenyan corals



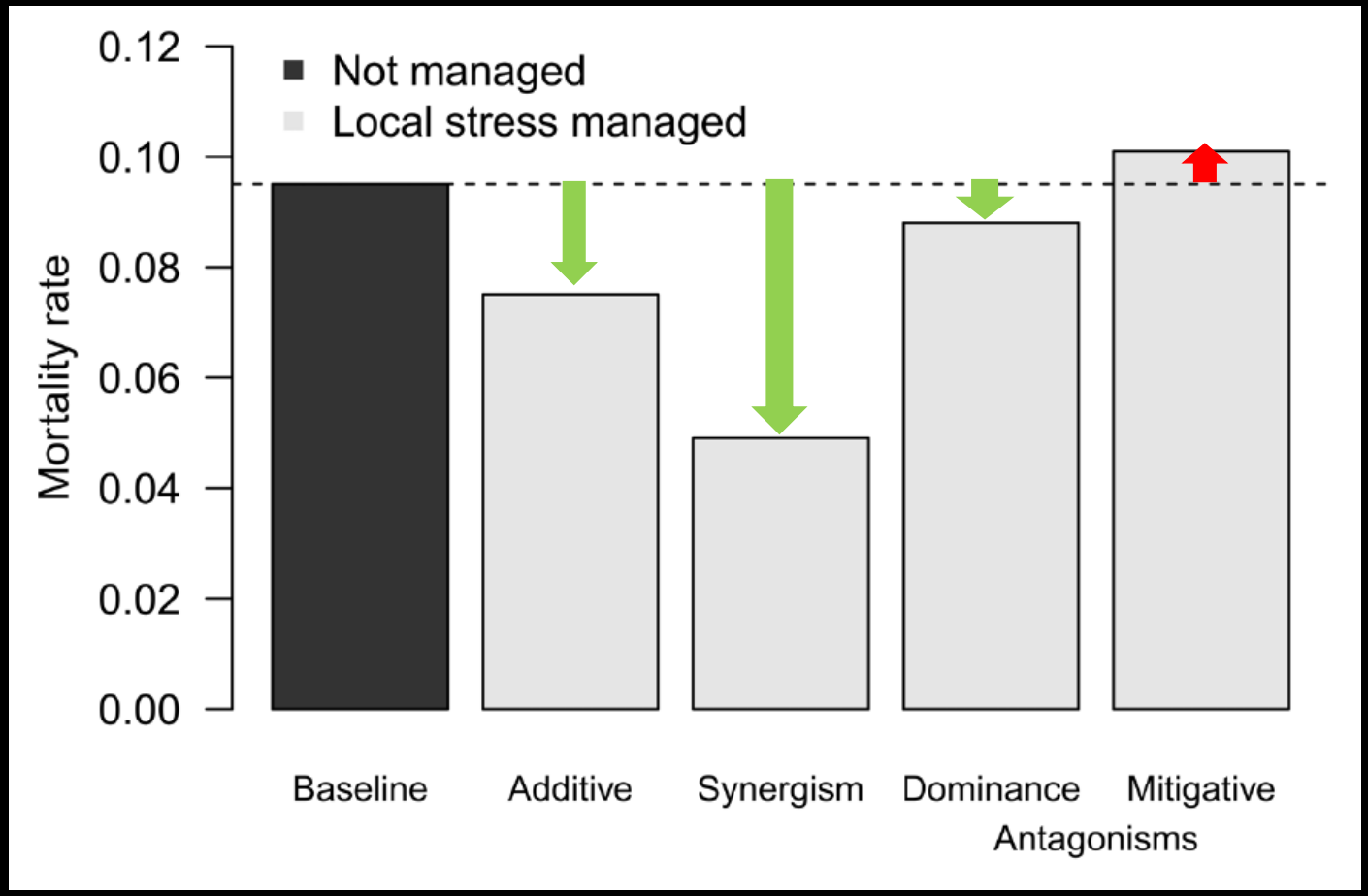
Darling et al. 2013
Glob Change Biol

Implications for management

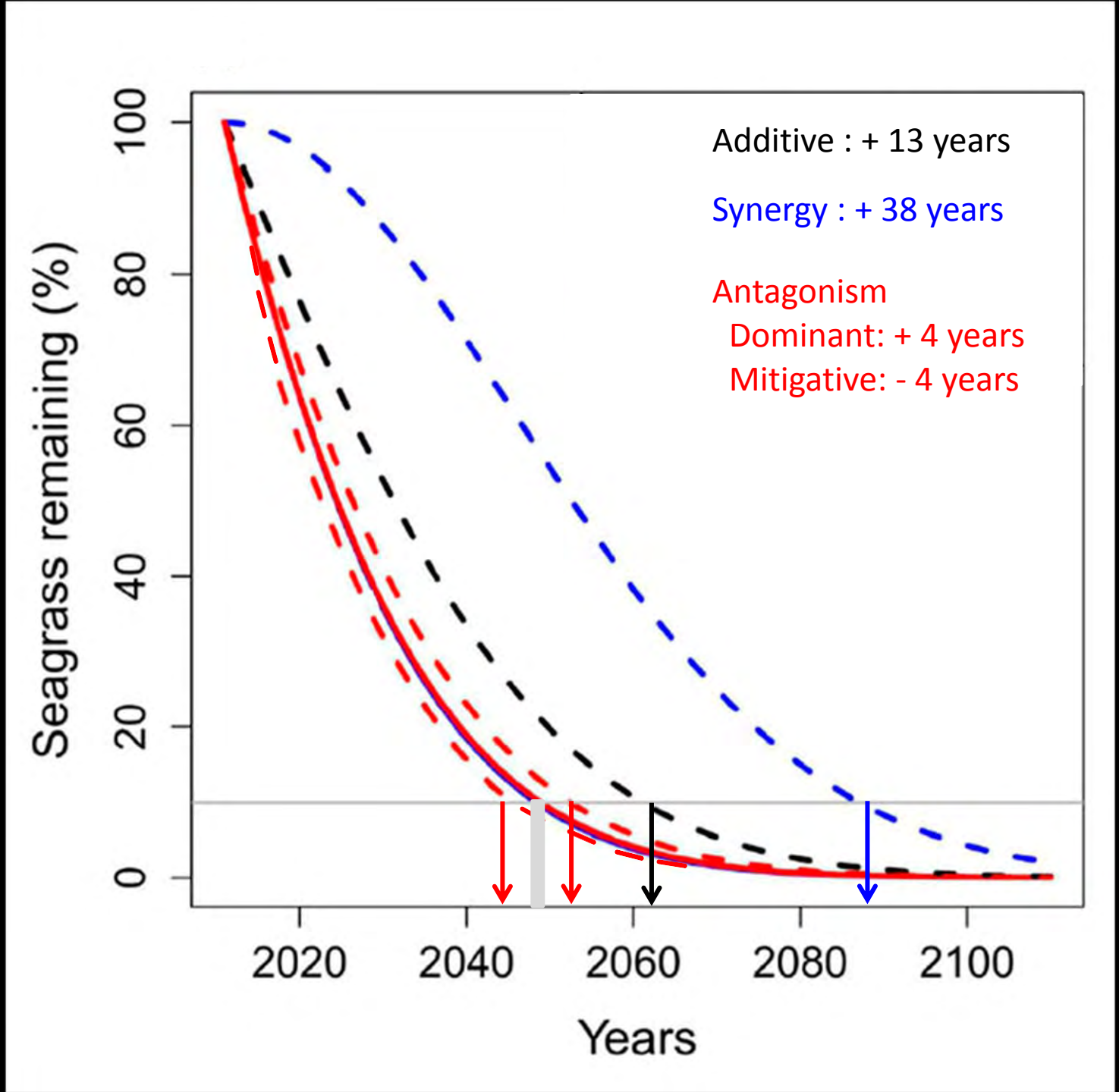


Brown et al. 2013 PLOS One

Implications for management



Brown et al. 2013 PLOS One



Brown et al. 2013 PLOS One

Conclusions

- Synergies are not the only option
- Interaction type matters
- Co-tolerance pattern might predict interaction type
- We have much left to learn