



Buying Years to Extinction: Is compensatory mitigation for bycatch of seabirds possible?

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About 27.0 million tons of fish are discarded each year in commercial fisheries (5 -80% of the total catch).

Alverson et al. (1994) A global assessment of fisheries bycatch and discards. FAO Fisheries Technical Paper. No. 339. Rome, FAO. 1994.



"With 300,000 seabirds dying annually as bycatch [...] the European Community has the responsibility to put in place effective measures"

Dunn (2007) *A report from BirdLife International's Global Seabird Programme*. BirdLife International, Cambridge, UK.



The most important areas of action of the common fisheries policy are:

- laying down rules to ensure Europe's fisheries are **sustainable** and do not damage the marine environment (see **fishing rules**)

<ul style="list-style-type: none"> ▶ Illegal fishing (IUU) ▶ Fishing rules ▶ The European fisheries fund ▶ Aquaculture ▶ International ▶ Market ▶ Fisheries controls ▶ Fisheries research 	<p><i>Fishermen in Ireland. © Lionel Flageul</i></p> <p>The most important areas of action of the common fisheries policy are:</p> <ul style="list-style-type: none"> • laying down rules to ensure Europe's fisheries are sustainable and do not damage the marine environment (see fishing rules) • providing national authorities with the tools to enforce these rules and punish offenders (see fisheries controls) 	<ul style="list-style-type: none"> • Basic regulation on the common fisheries policy (CFP) • Regulation governing financial interventions under the CFP • Fisheries legislation (EUR-Lex) <p>Summaries of EU legislation:</p> <ul style="list-style-type: none"> • All topics related to EU fisheries policy • The basic regulation on the common fisheries policy • Rights-based management tools in fisheries <p>Facts and figures on the CFP [4 MB] </p>
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The compensatory principle

CONCEPTS AND QUESTIONS

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Compensatory mitigation as a solution to fisheries bycatch–biodiversity conservation conflicts

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In a nutshell:

- Fisheries bycatch is causing serious environmental damage, resulting in social conflict, litigation, and fisheries closures
- We demonstrate that a compensatory mitigation approach, reducing other mortality sources to offset the impact of fisheries bycatch, can yield a conservation return on investment 23 times greater than a fishery closure
- If funded by a fee to fishers for their bycatch, this approach provides an individual incentive that increases with extinction risk, which has been shown to be the best predictor of sustainable fisheries management



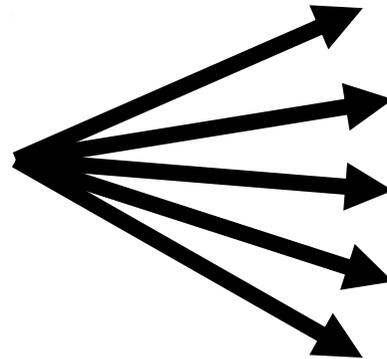
Courtesy of RW Henry



Our problem

The introduced Black rat, *Rattus rattus*, is considered one of the most common threat for many island seabirds populations.

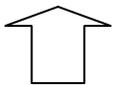
Ruffino L et al. (2009) Biological Invasions in press.



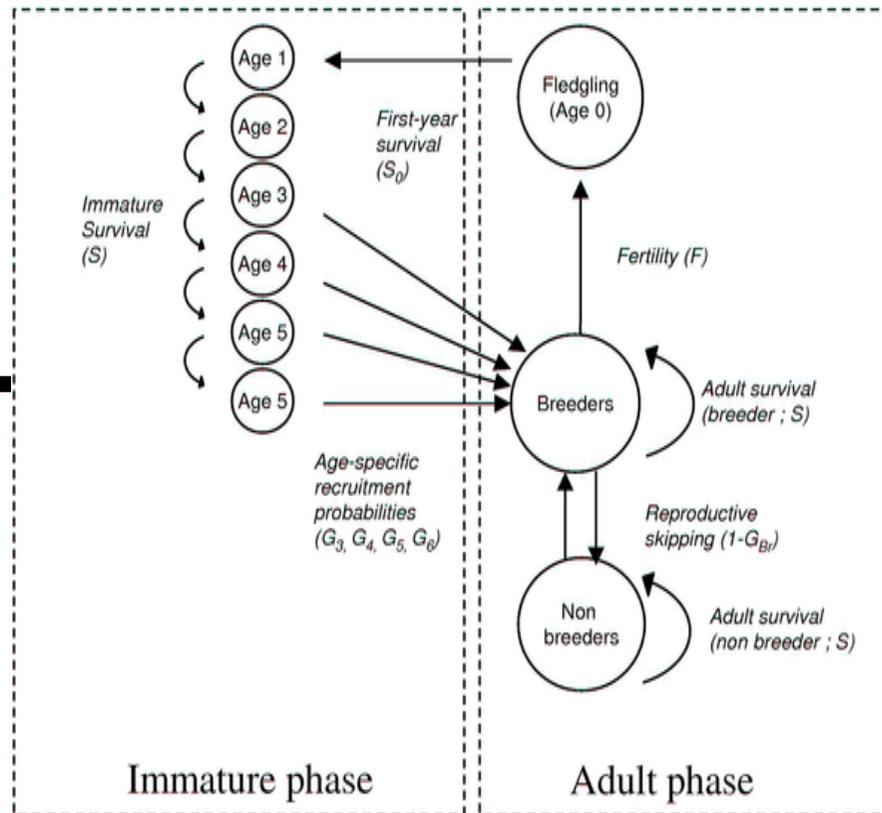
Will compensation work ?



Rat predation



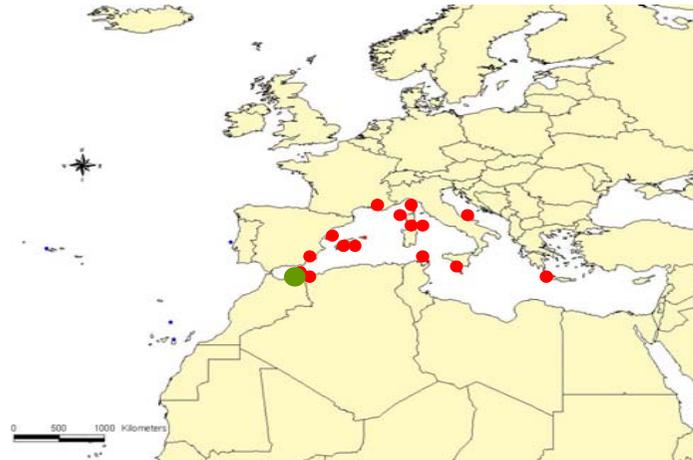
Mortality due to fishery



Perturbation analysis



Cory's shearwaters, rats and fishery



Eradication campaign began in 1997. In parallel rat abundance, R , monitored and individual based information collected

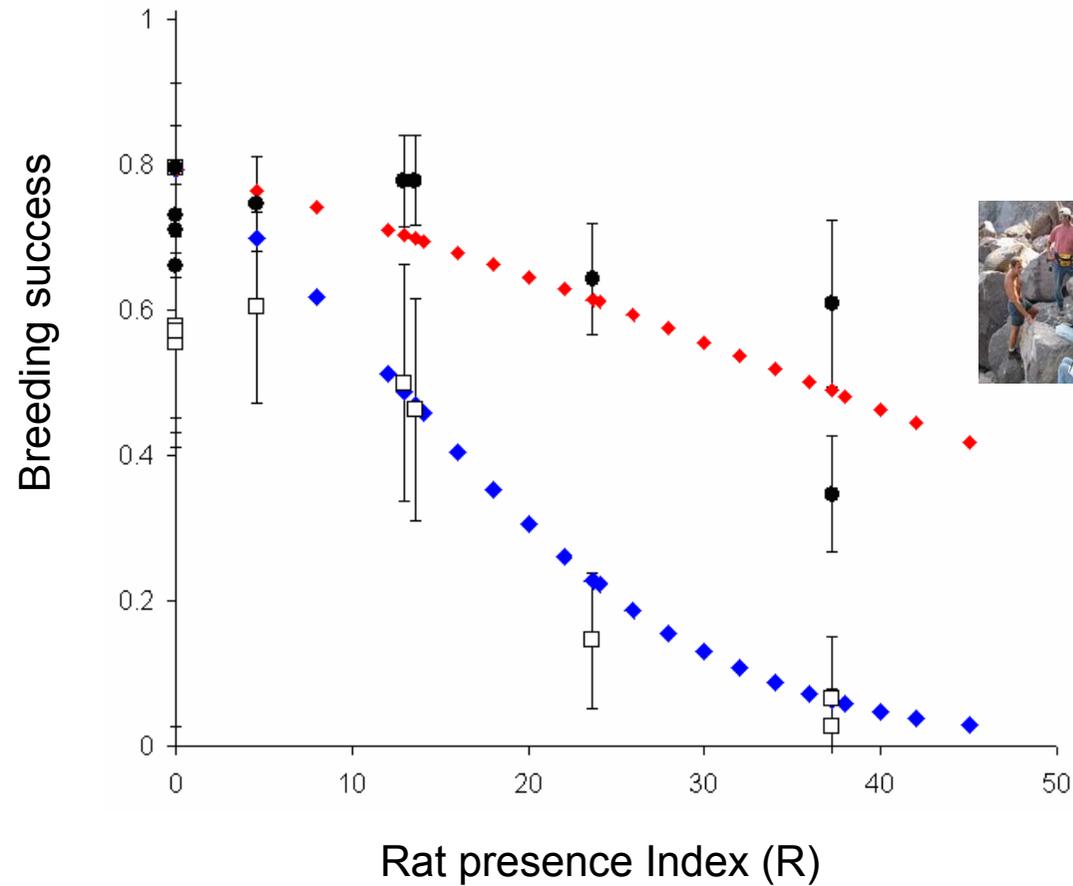
Rats predation depends on nest characteristics (i.e. accessibility). Habitat variables reduced (CatPCA) into an index of habitat structure,

H . Igual et al. (2006). *Animal Conservation* 9: 59–65.

Cory's shearwaters and rats

Model	Notation	Estimates	se	Z	p
1	Intercept	0.668	0.147	4.544	<0.001
	R	-0.651	0.090	-7.225	<0.001
	H	0.4182	0.139	2.999	<0.01
	R×H	0.3710	0.098	3.779	<0.001
2	Intercept	0.661	0.147	4.495	<0.001
	R	-0.653	0.090	-7.232	<0.001
	R×H	0.405	0.083	4.886	<0.001

The effect of rat abundance (R), habitat structure (H) and their statistical interaction (R×H) on shearwater breeding success has been modelled through logistic regressions using the breeding output of 101 nests monitored from 1997 to 2007. The nest identity was taken as a random effect to account for multiple entries from the same nest. doi:10.1371/journal.pone.0004826.t001

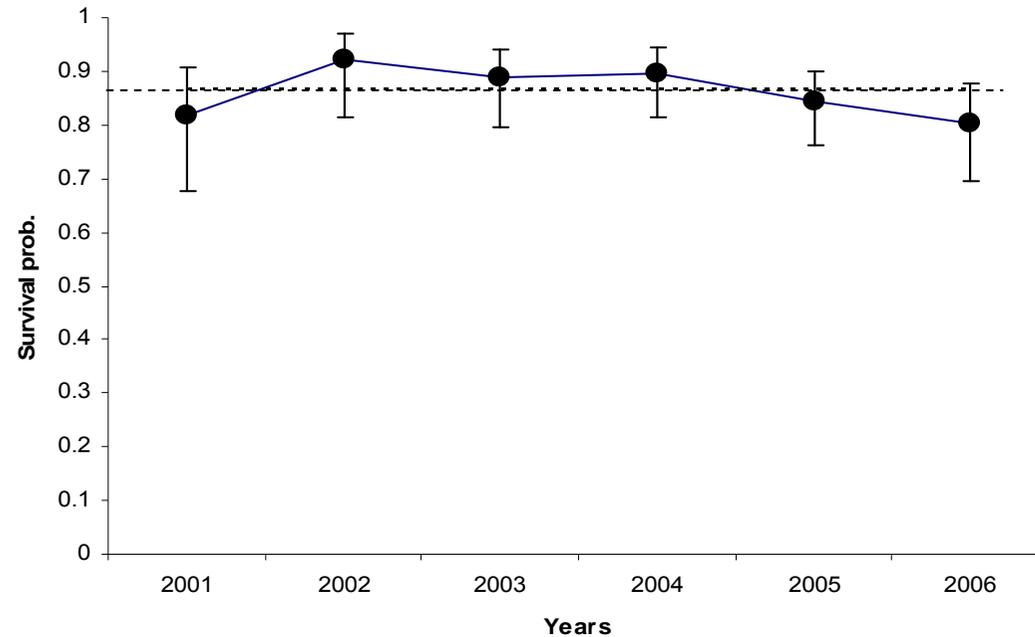


Cory's shearwaters and rats

ANODEV

Covariate Model: {S(R) p(.)}

Source	df	Dev	Mean Dev	F	P
Uncorrected Total	7	101.523			
Grand Mean	2	95.082			
Corrected Total	5	6.441			
Total Covariate	1	0.652	0.652	0.4504	0.5389
Error	4	5.789	1.447		



Rats influence breeding success but not adult survival



Cory's shearwaters and fishery



Hazard rate, z

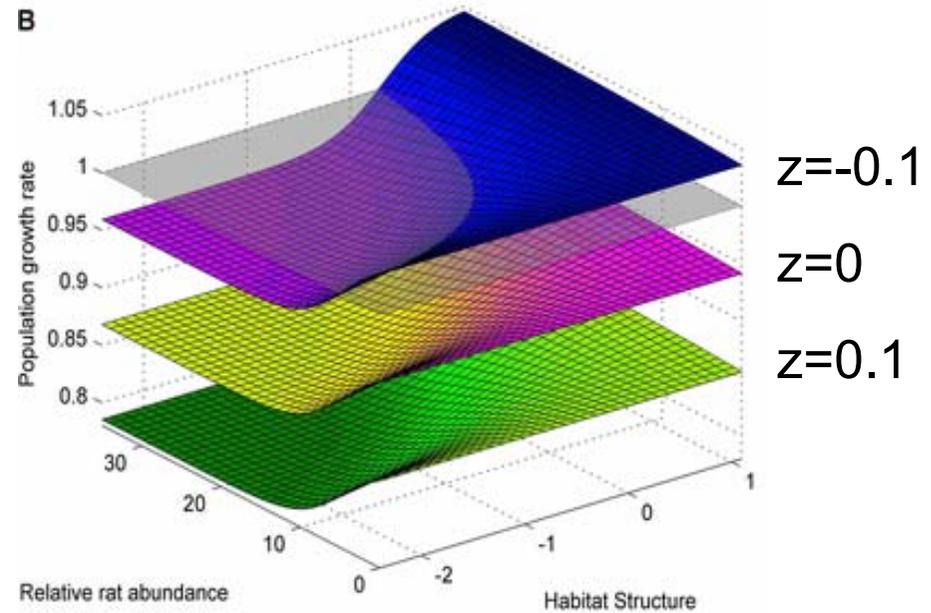
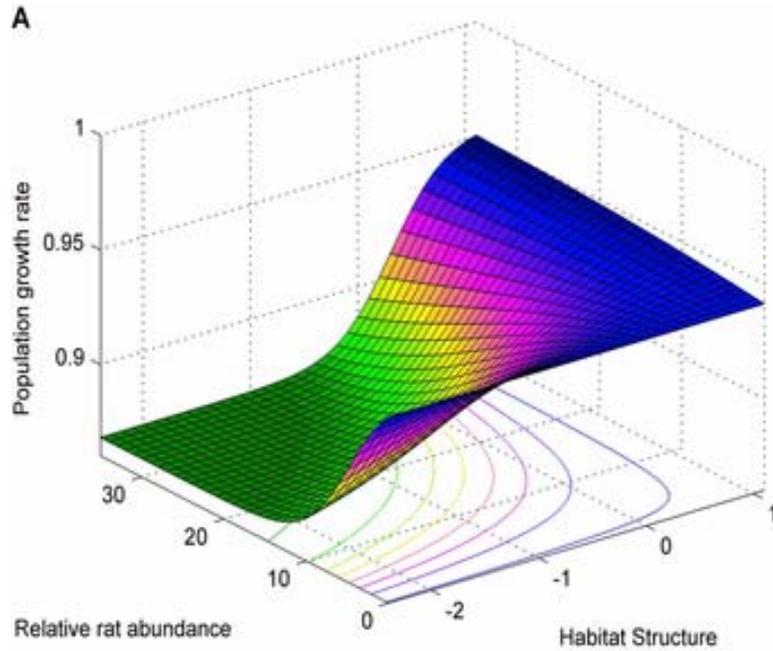
Hunter CM, Caswell H (2005) *Journal of Animal Ecology* 74:589-600

$$S = \phi \exp(-z)$$

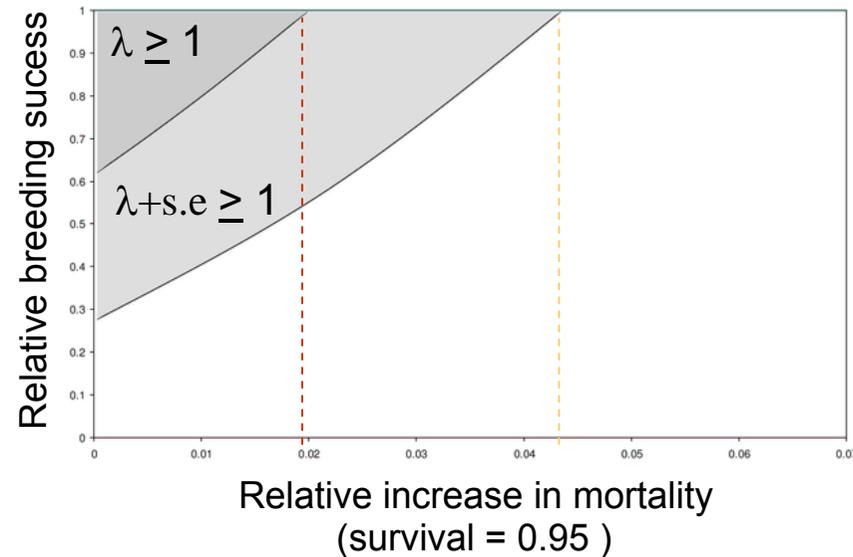
Positive values of z mimic an increase in the harvesting rate by fisheries. We considered a range of adult survival variations between 0.96 and 0.78 ($z = -0.1, -0.05, 0, 0.05$ and 0.1). Jenouvrier S et al. (2008). *Global Change Biology* 15: 268–279.



Perturbations and scenarios



Perturbations and scenarios



By using demographic invariants :

$$\Delta F/F \approx TK$$

where $\Delta F/F$ is the relative change in fecundity needed to compensate a change K in relative mortality for a species with the generation time T . Lebreton J-D (2008) Australian and New Zealand Journal of Statistics 47: 49–63.

The max increase in breeding success observed at Chafarinas Islands was of 40%, which suggests a theoretical additional mortality of maximum 2%.

Conclusions

At Chafarinas islands, rat eradication would postpone extinction of c. 30 years (25% of the time predicted), **but will not change the fate of the population.** Compensatory mitigation appears a temporary but insufficient measure

To meet the expected increase in the average per capita consumption in 2030 [..] the net supply of fishery will have to increase by 1.6 million tonnes (Mt)

Failler, P. (2007). Future prospects for fish and fishery products. 4. Fish consumption in the European Union in 2015 and 2030. *FAO Fisheries Circular*. No. 972/4, Part 1. Rome, FAO.

