The use of monitoring data from marine reserves for fishery management: the density ratio control rule

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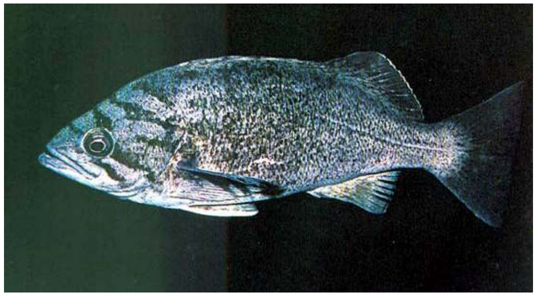
Marine Biology and Fisheries



Outline

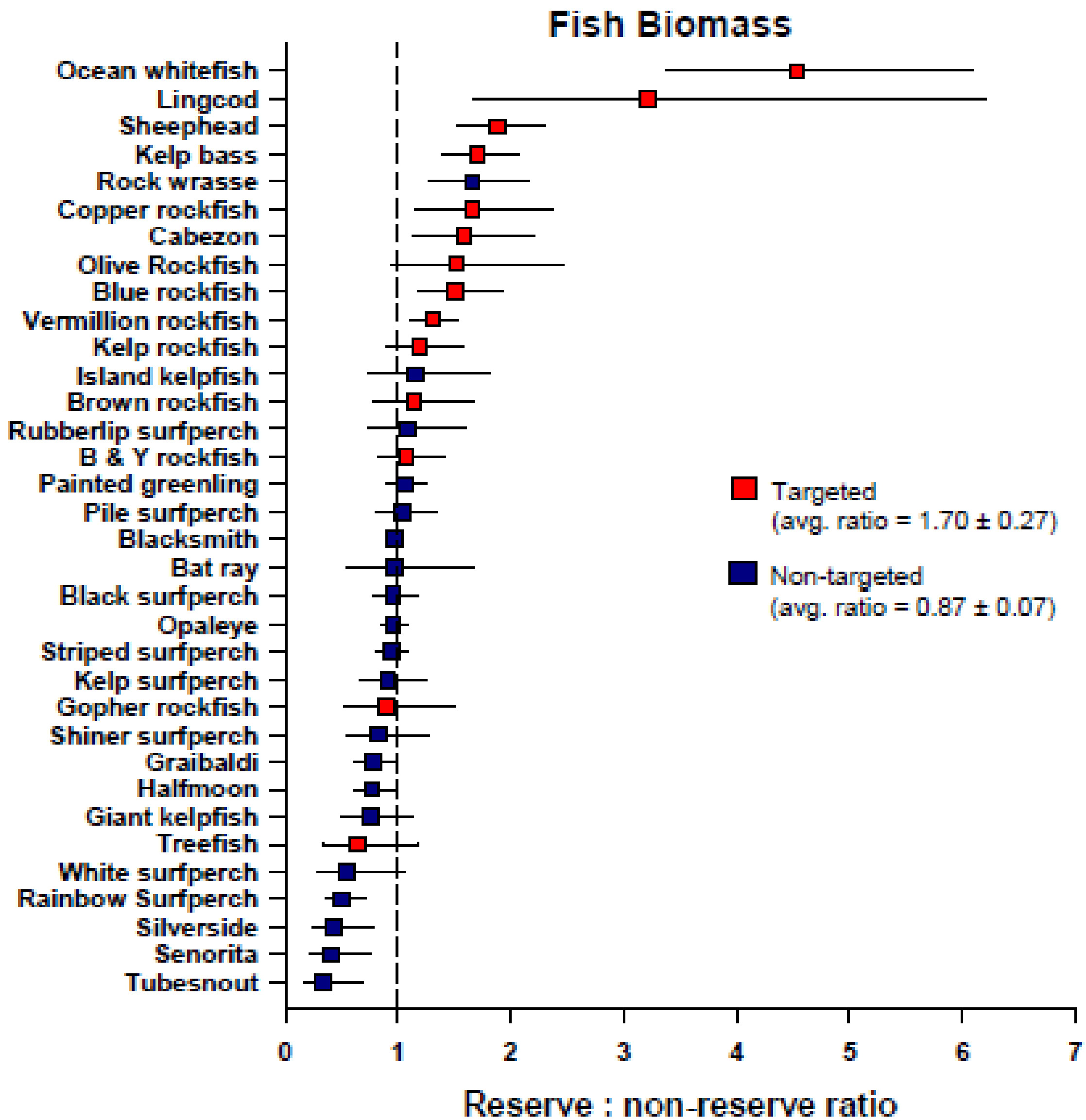
- Density ratio control rule theory
- Simulation tests based on California nearshore fishes
- Thoughts on how to apply a density ratio control rule

California: Channel Islands Marine Reserves

Protected Since 2004

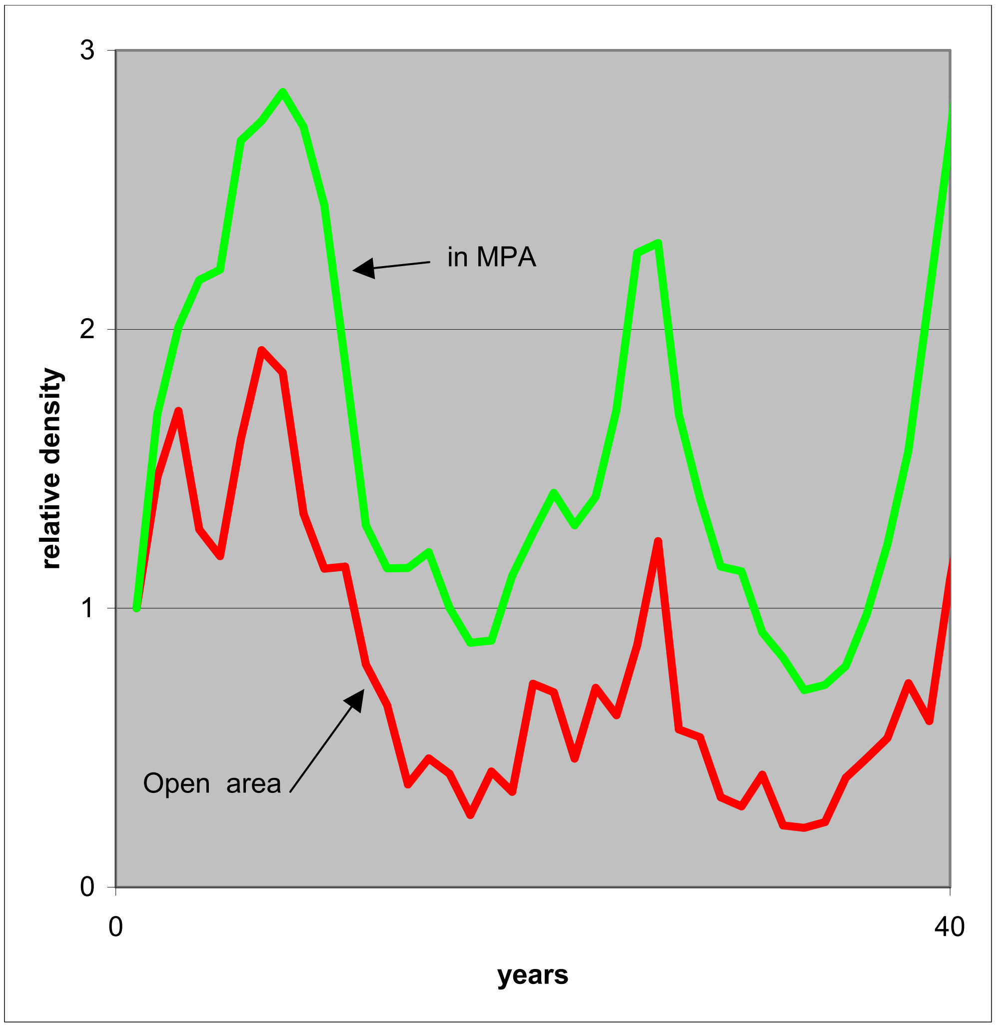
www.piscoweb.org

Change in biomass after 5 years



Jenn Caselle, PISCO-UCSB

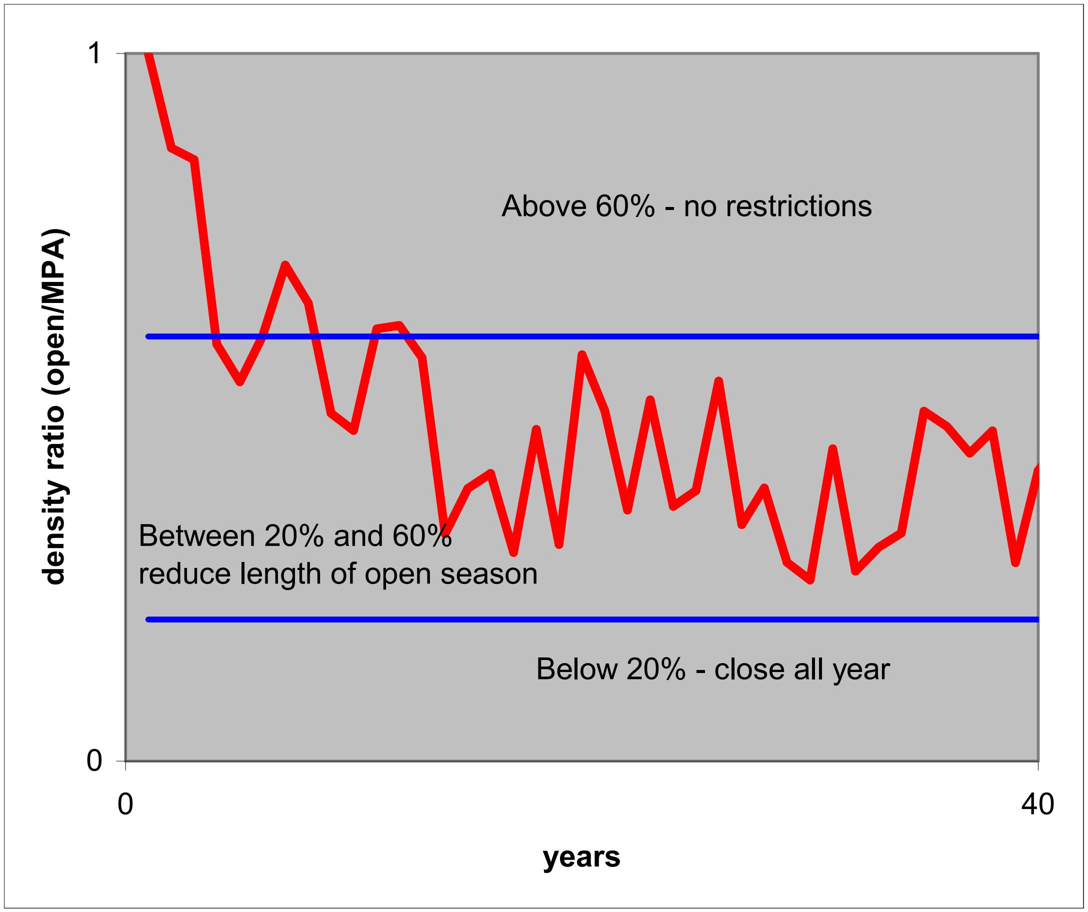
Density in a reserve and in a fished area



- Use fish densities in MPAs as an index of potential unfished levels
- Compare with fish densities in fished areas
- Restrict fishing season progressively as fish densities in the open areas decline relative to protected areas

Alec MacCall

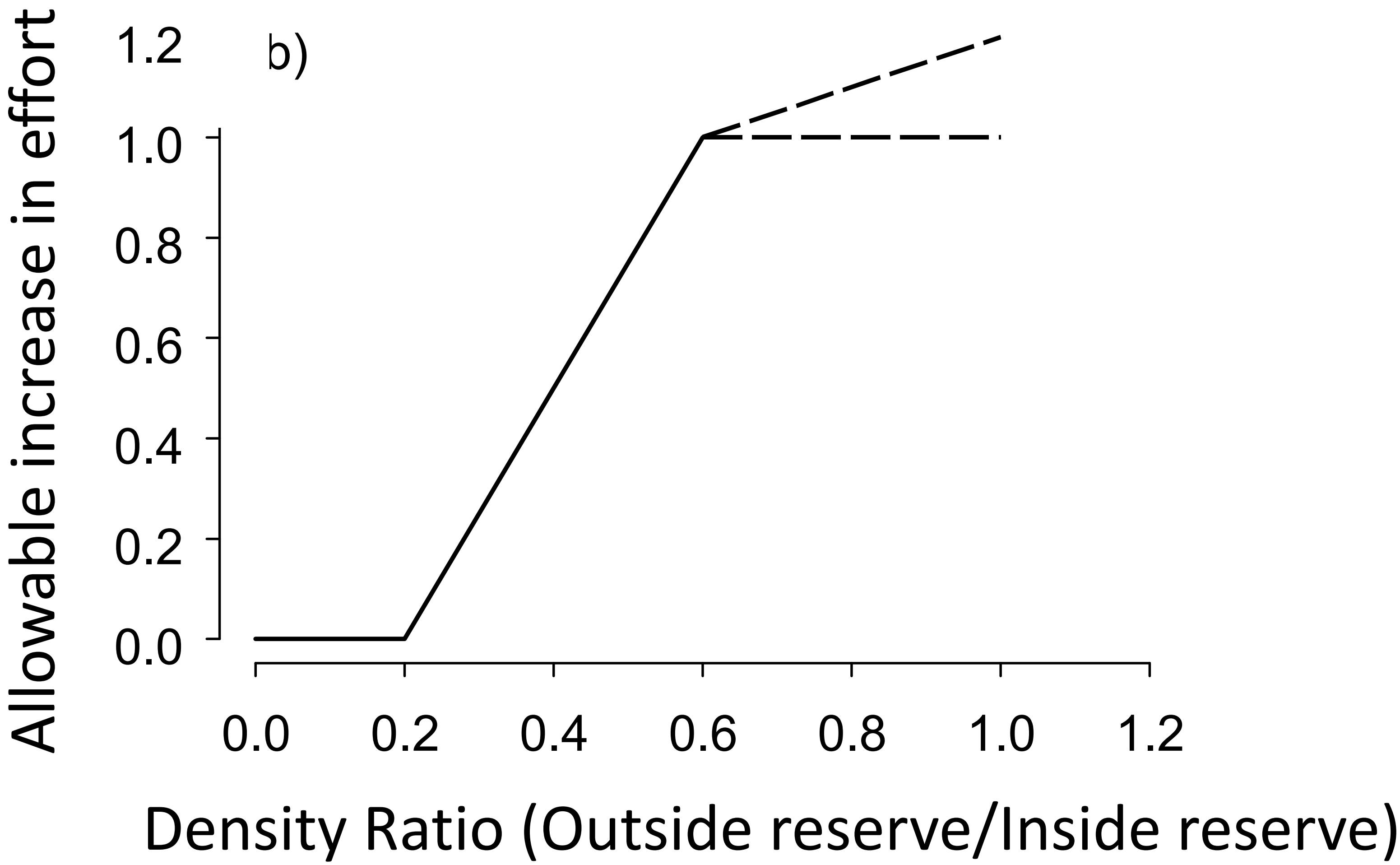
Density ratio control rule (DRCR)



- Ratio of density inside/density outside
- Can be function of density ratio of multiple species (e.g. geometric mean, d.r of weakest species)

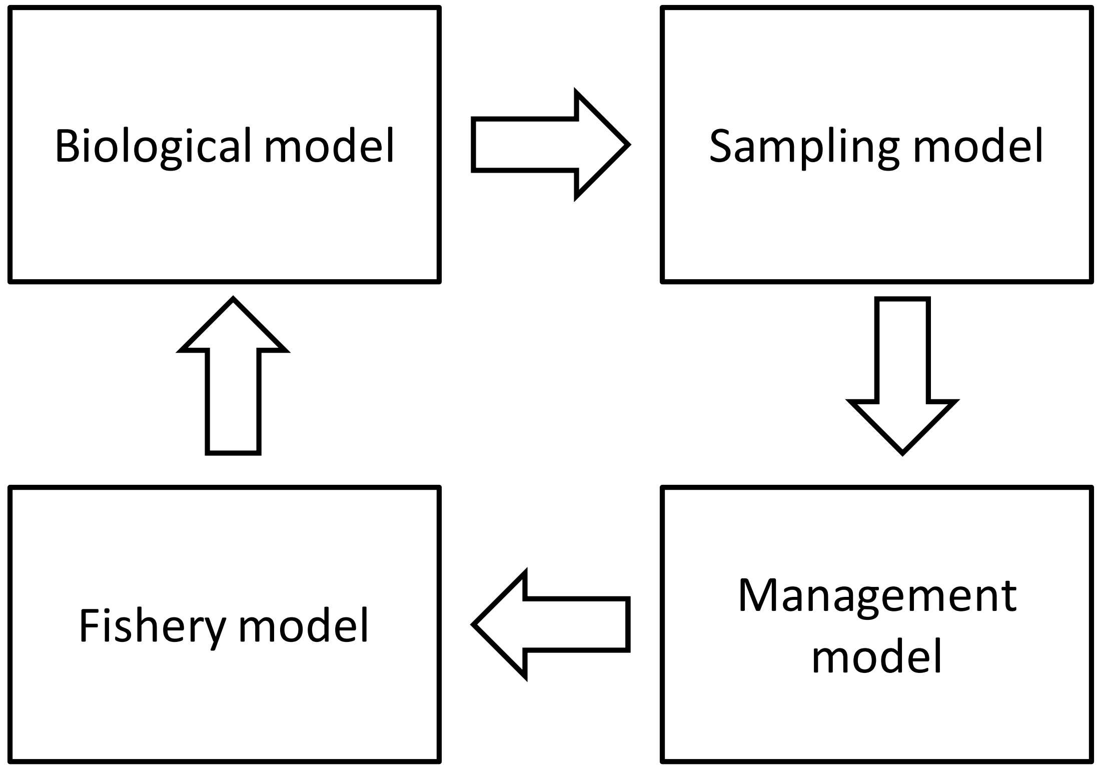
Alec MacCall

Density ratio control rule (DRCR)



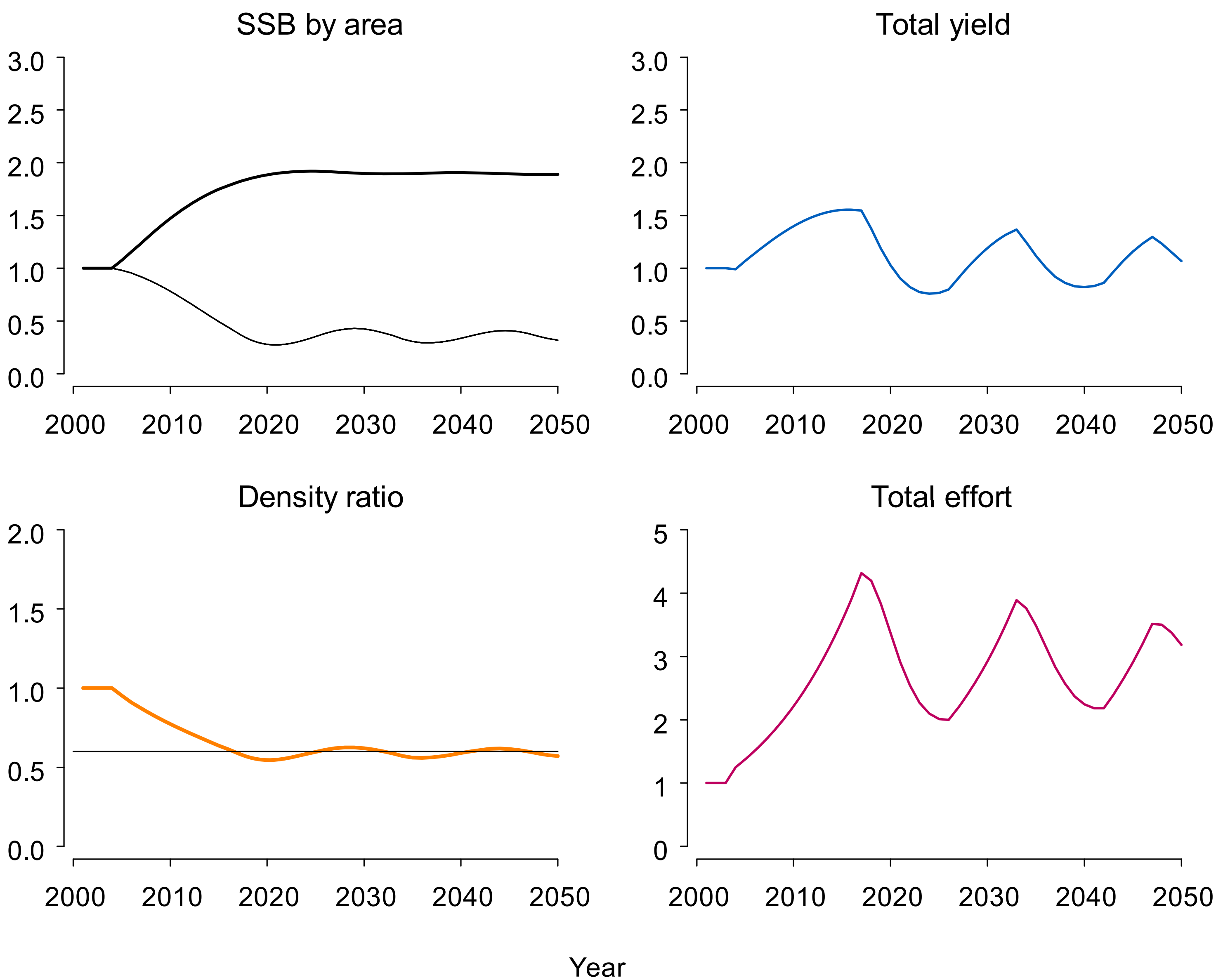
Simulation testing (Management Strategy Evaluation)

- What is best DRCR?
- How does DRCR compare to constant F strategies?

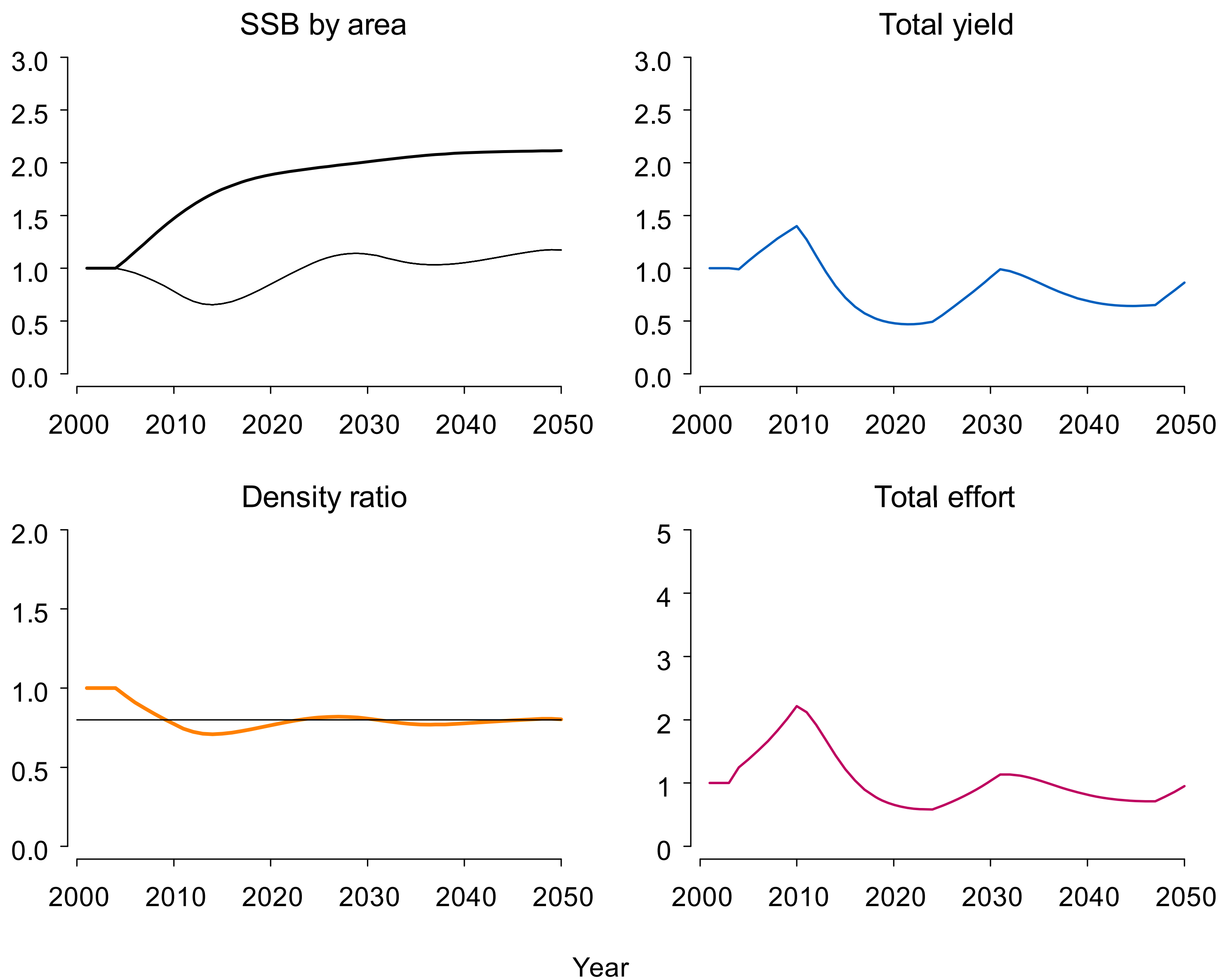


Babcock and MacCall 2011. Canadian Journal of Fisheries and Aquatic Sciences

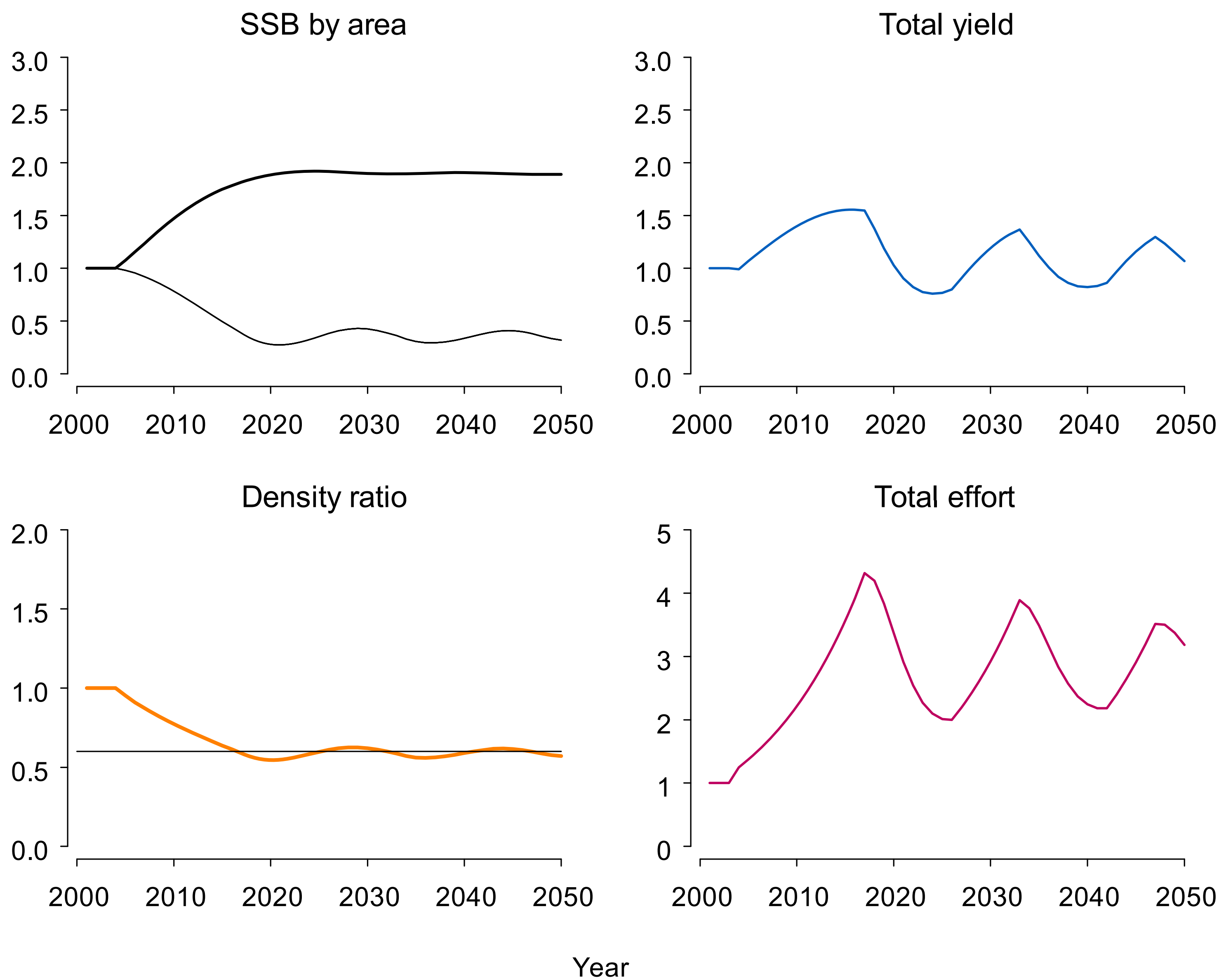
Blue rockfish: DR target is 60%. No migration



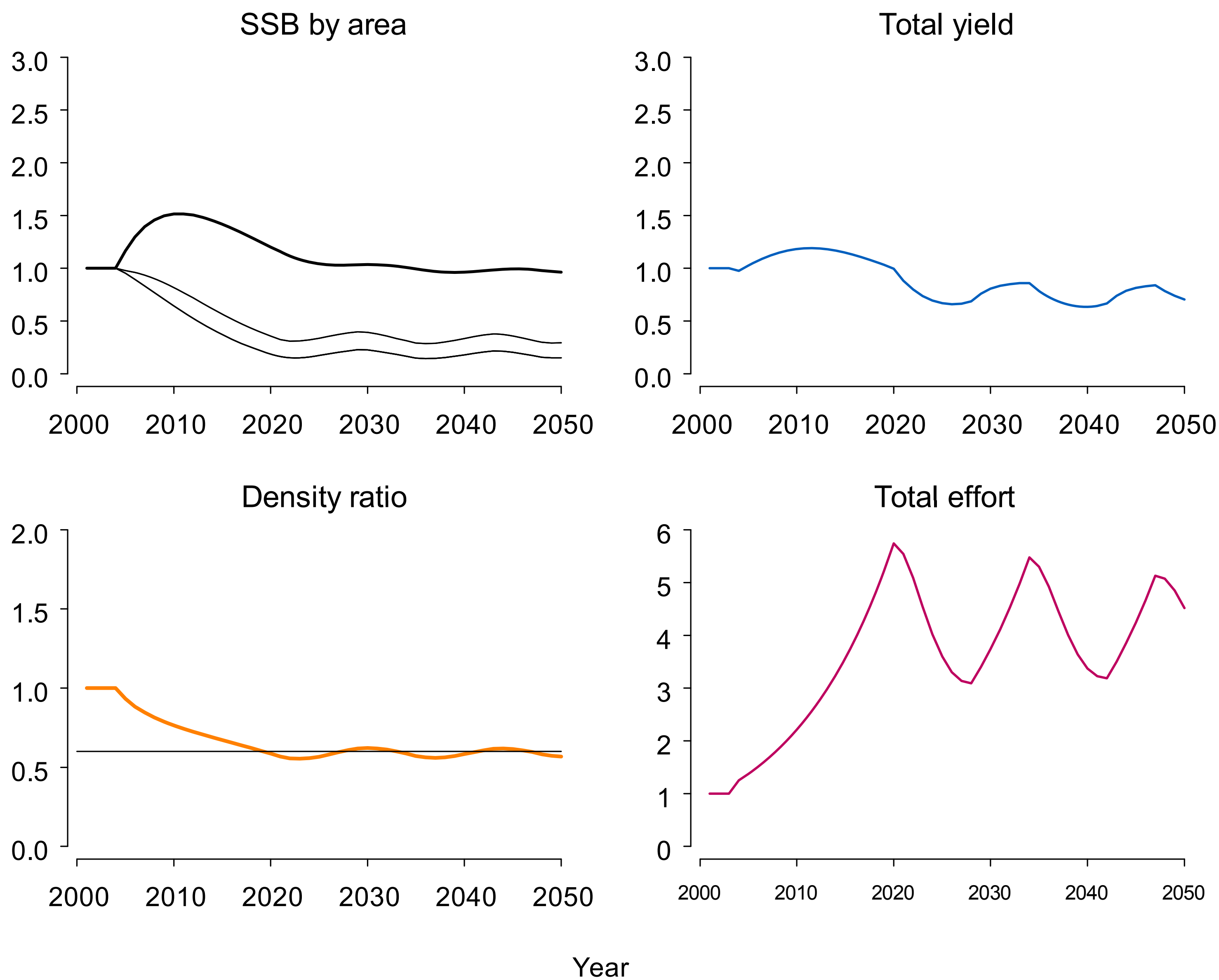
Blue rockfish: DR target is 80%. No migration



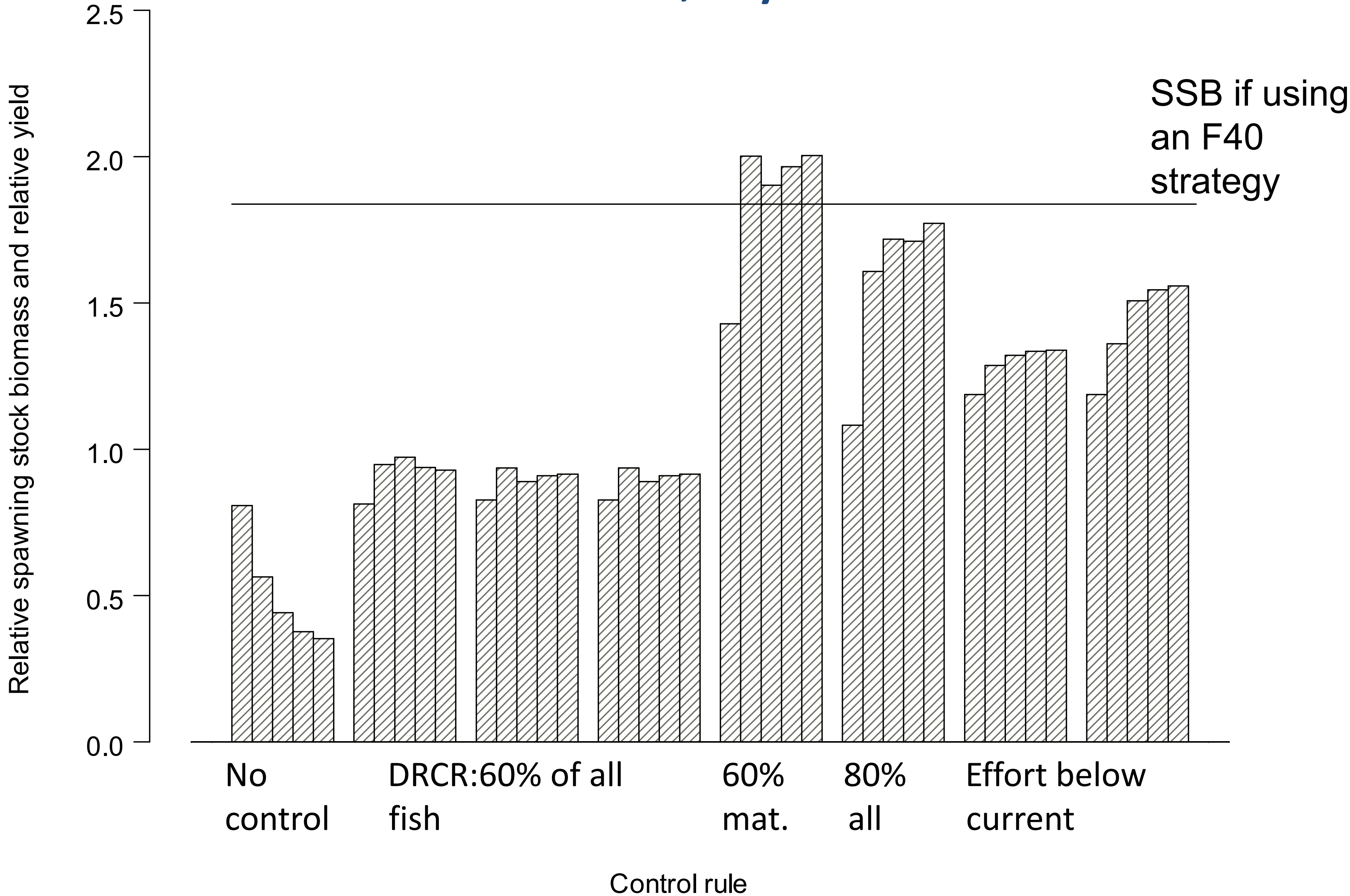
Blue rockfish: DR target is 60%. No migration



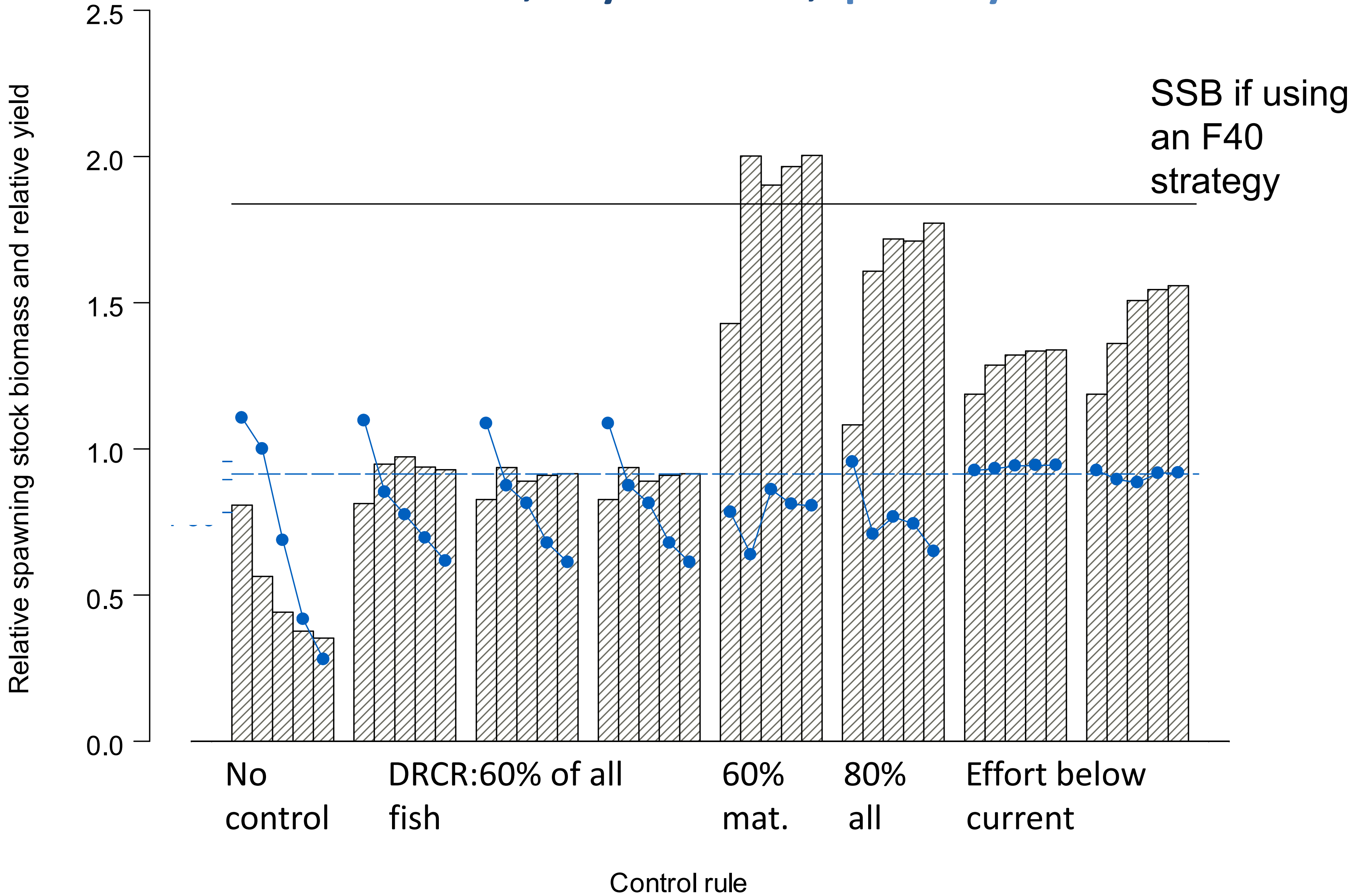
Blue rockfish: DR target is 60%, migration



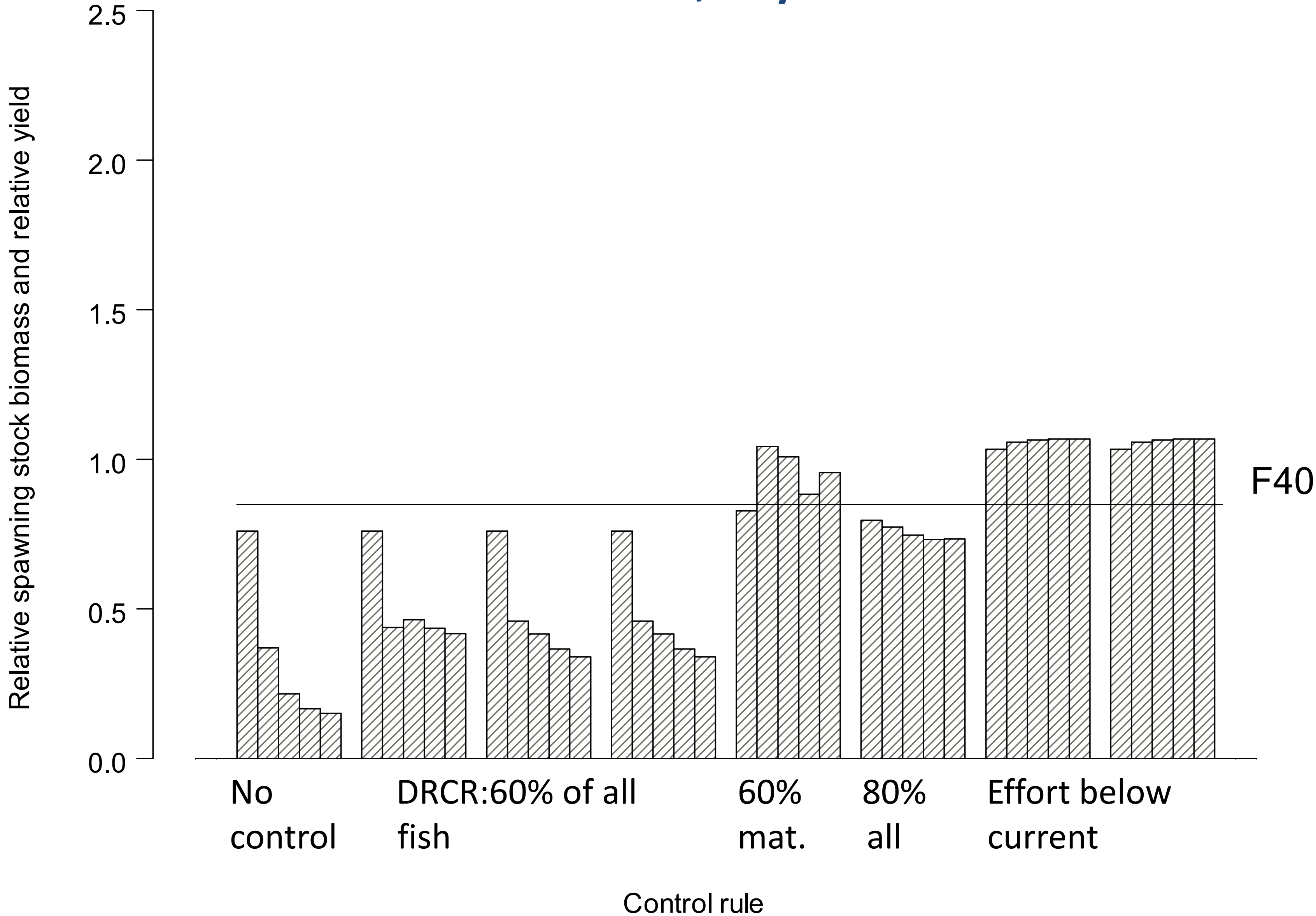
Blue rockfish spawning stock biomass in each decade, by DRCR



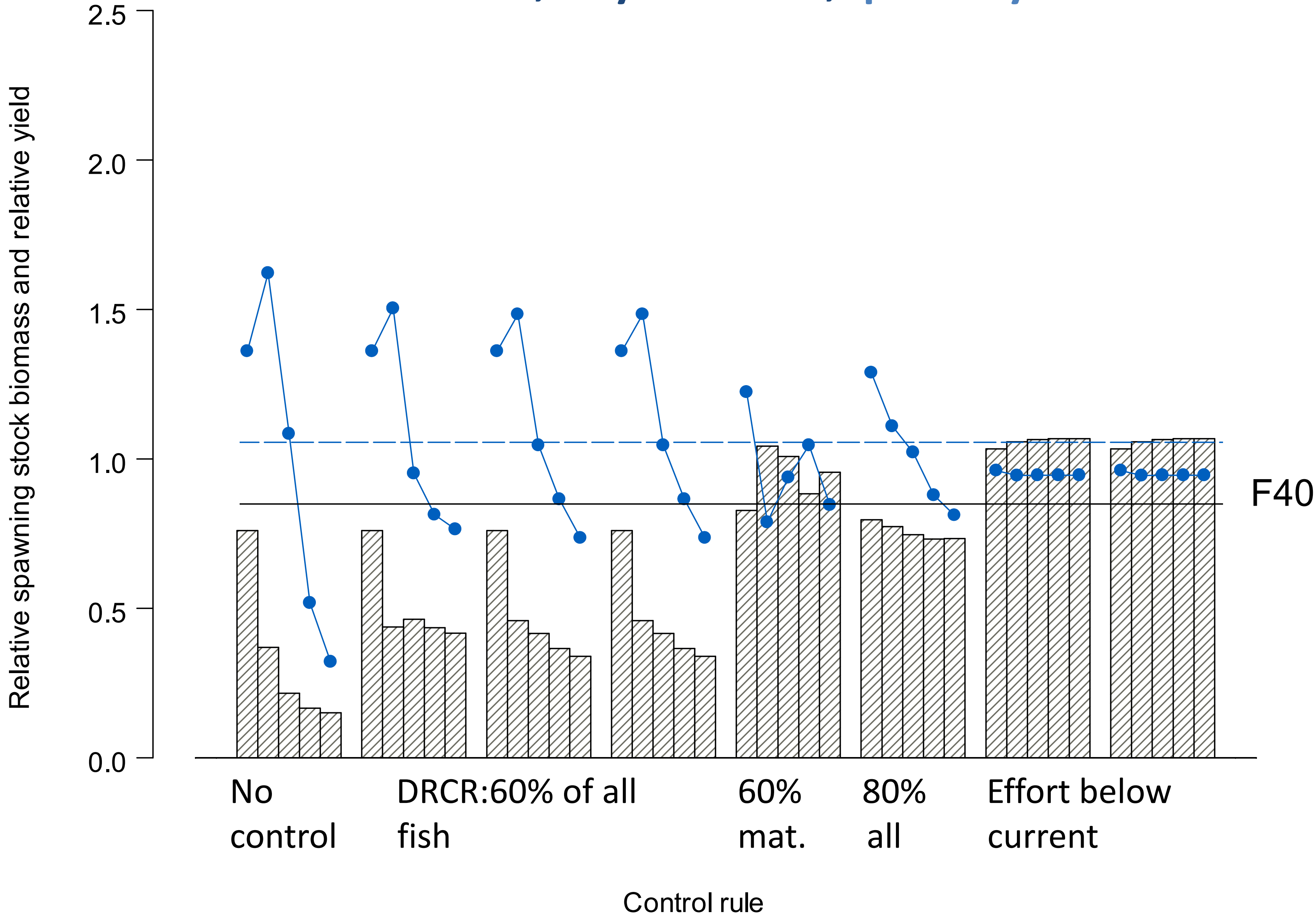
Blue rockfish spawning stock biomass in each decade, by DRCR, plus yield



Black rockfish spawning stock biomass in each decade, by DRCR



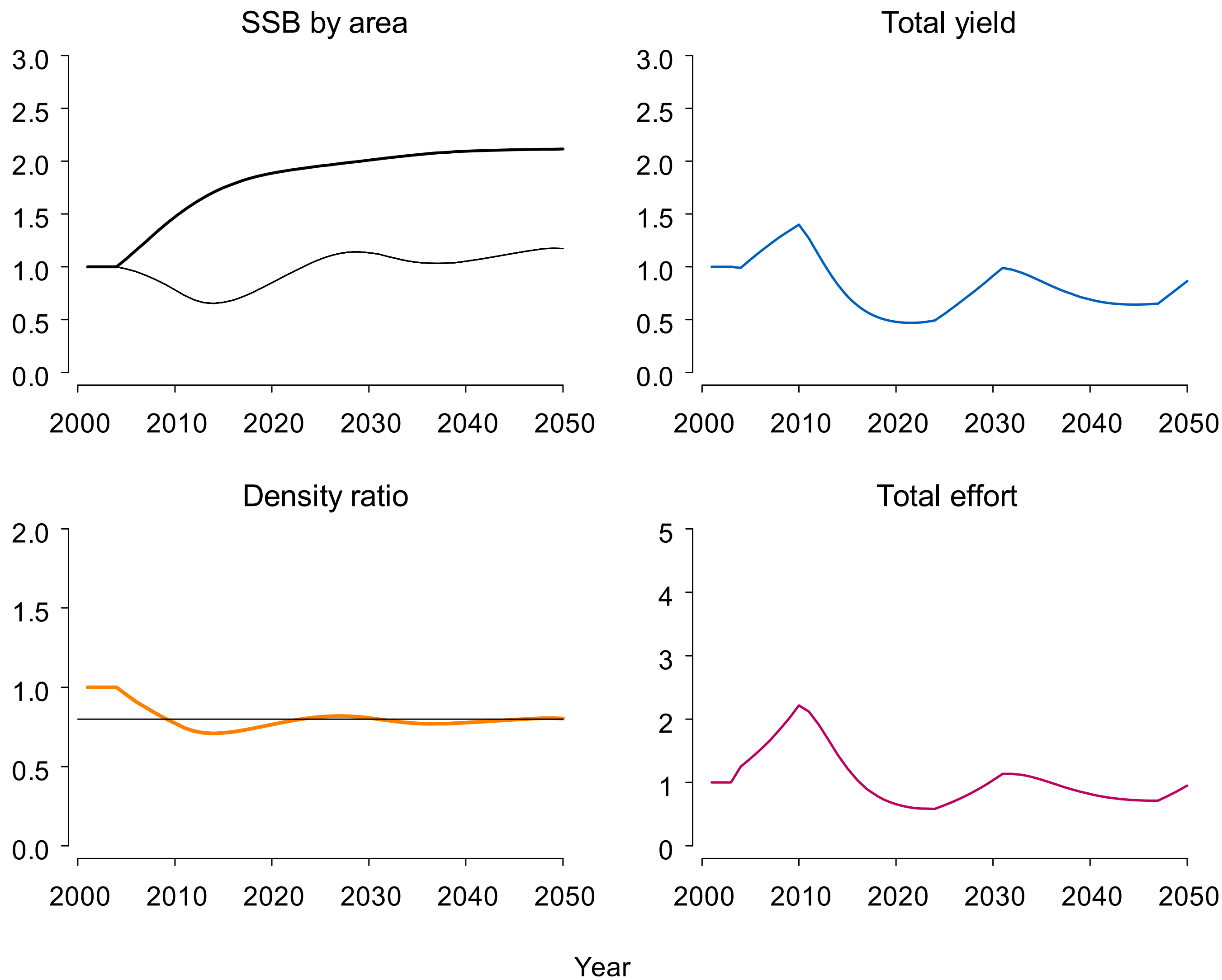
Black rockfish spawning stock biomass in each decade, by DRCR, plus yield



DRCR versus $F_{40\%}$ strategy

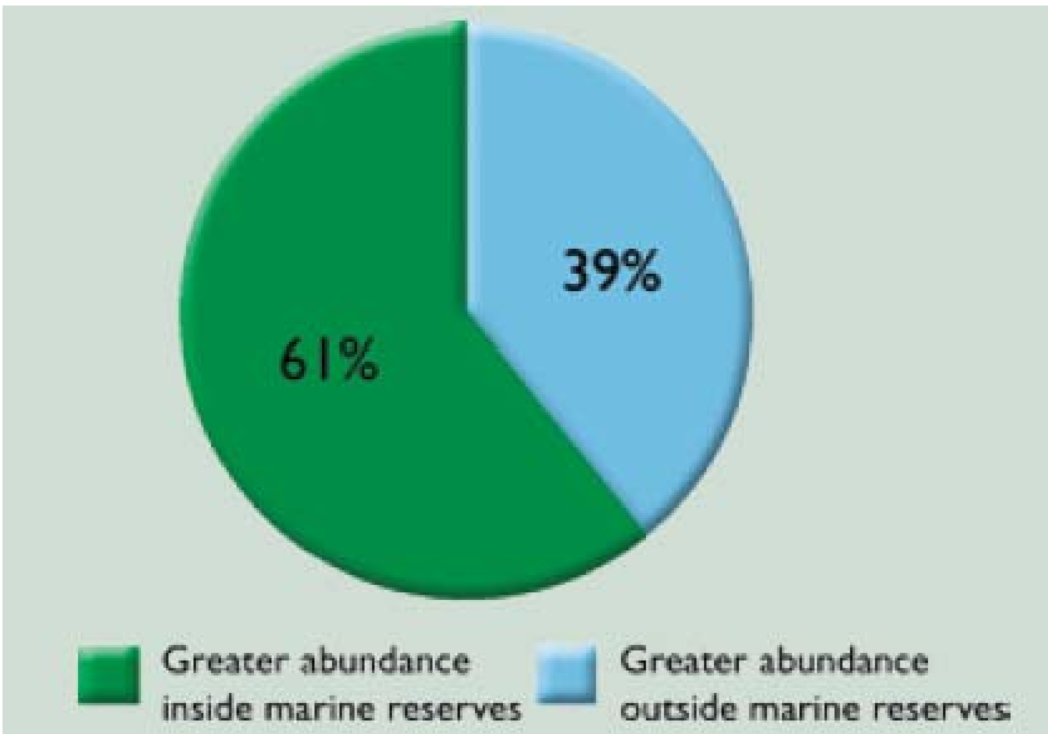
- After 50 years of using DRCR with a target of 60% of mature fish or 80% of all fish:
- Spawning stock biomass 103-114% of $F_{40\%}$ level
- Total yield of 80-89% of $F_{40\%}$ level
- This low-data method performs nearly as well as a data-intensive stock assessment
- It works equally well for overfished (blue RF) and not-overfished species (black RF) so *it is not necessary to know status*

Caveat: effort increase in early years may not be desirable



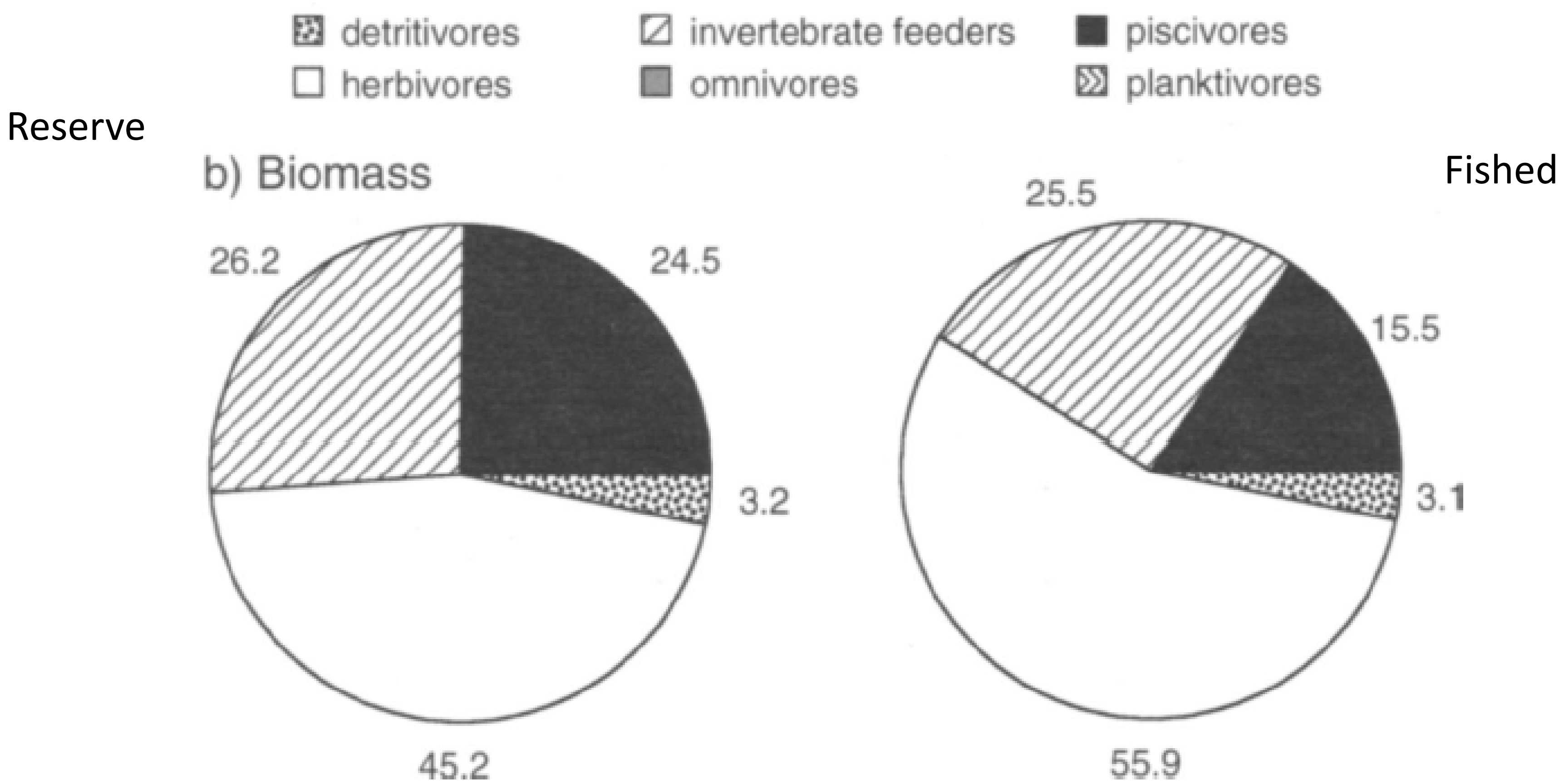
Which species are good candidates for DRCR?

- Species that become more abundant in reserves



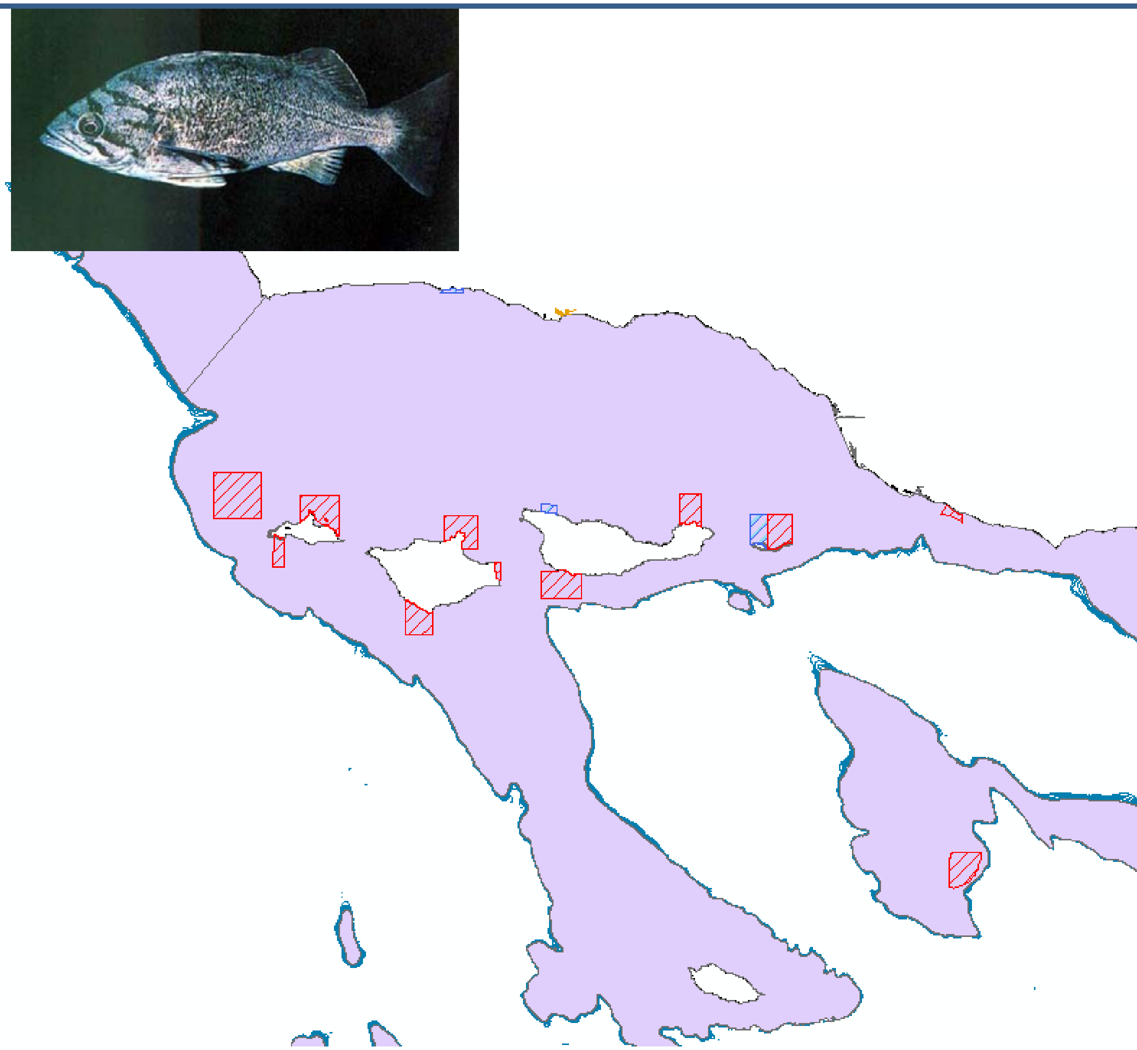
PISCO. Science of Marine Reserves

Top predators are more likely to increase



Micheli et al. 2004

Species with limited adult movement

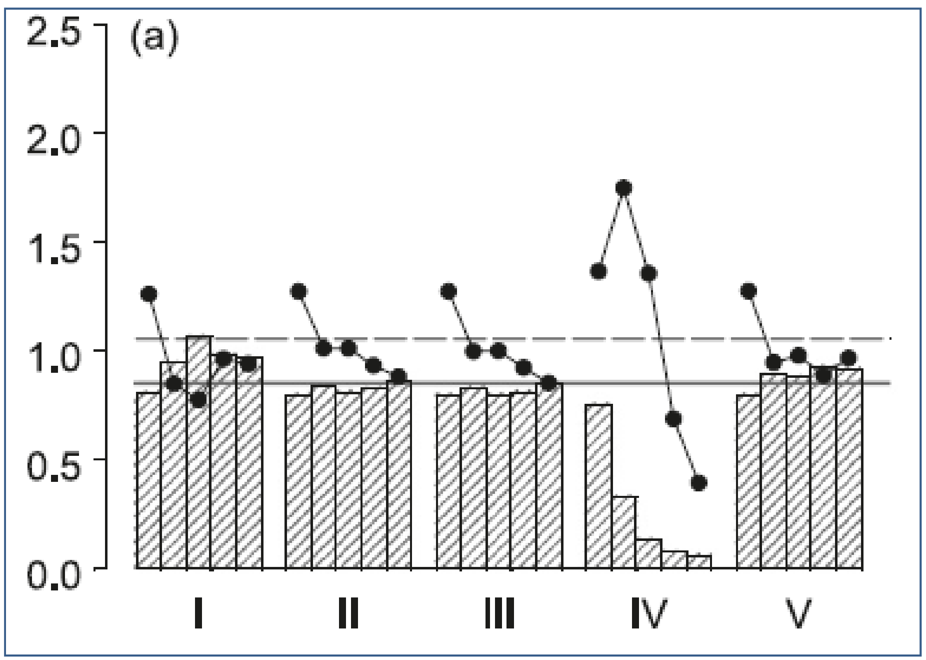


Blue rockfish

- Home range size = 8783 m^2
- Rarely move more than 100 m from core area
- Jorgensen et al. 2006.

Nuances of life history matter

- Recruitment models with different timing/nature of density dependence
- DRCR performs poorly if recruitment is lower in areas with higher adult abundance (e.g. because of competition).



Conclusion

- For species that are more abundant in reserves (e.g. non-migratory predators, shellfish), a density ratio control rule can perform nearly as well as assessment based management
- Using a target density ratio of 60% (in terms of mature fish) or 80% (in terms of all recruited fish) worked well in the simulations
- It may take decades for density to build up in the reserve so that the DRCR controls effort (other methods should be used while MPA is new).