Combining stock, multispecies, and ecosystem level status determination criteria: what tradeoffs can we expect?

S. Gaichas, M. Fogarty, G. DePiper (NEFSC),
G. Fay (UMass Dartmouth),
R. Gamble, S. Lucey, and L. Smith (NEFSC)

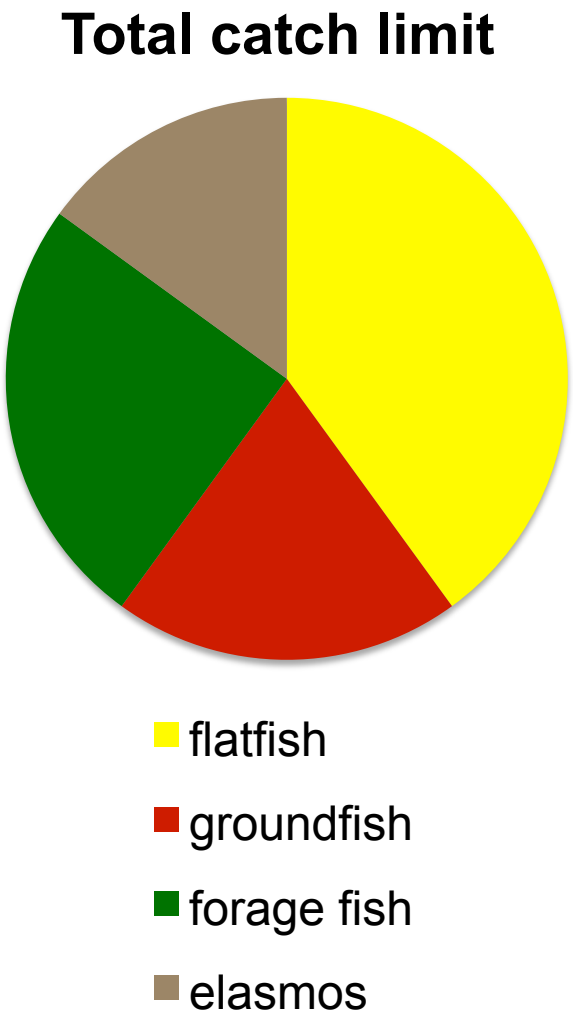
ICES Symposium Targets and Limits for Long Term Fisheries Management
October 2015

What could multispecies status determination criteria look like?

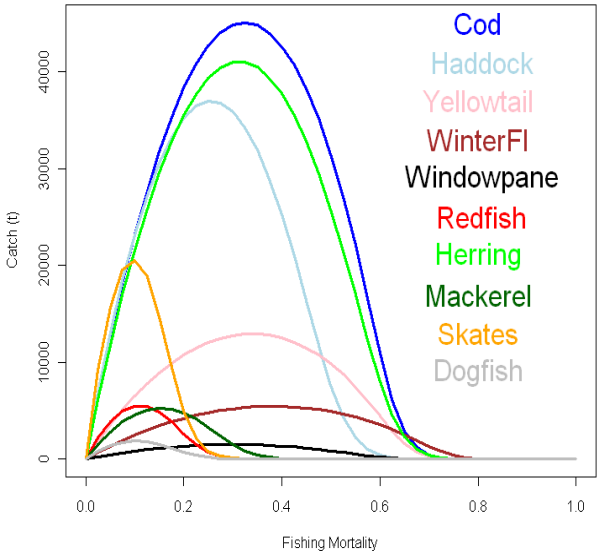
Four component management procedure:

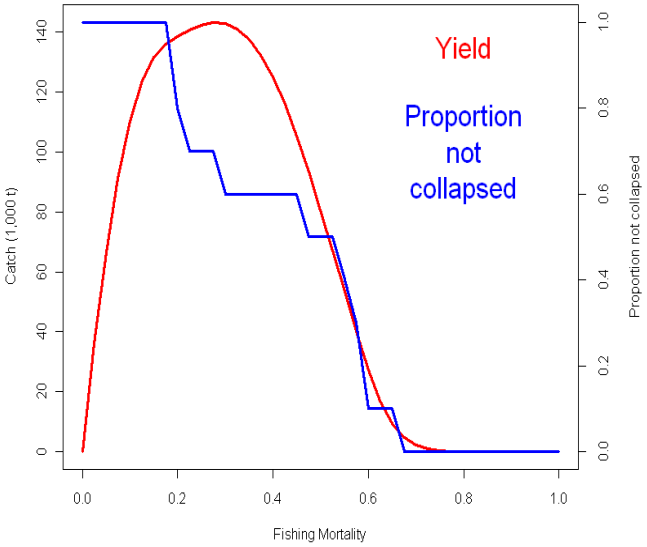
1. a limit on total removals for the ecosystem;
2. an allocation of the total removals limit to aggregate species groups;
3. minimum stock size thresholds for individual species; and
4. guidance for optimizing the species mix (within aggregates) based on bio-economic portfolio analysis.

- Manage fewer catch limits—simple, flexible
- Integrated assessment of species status

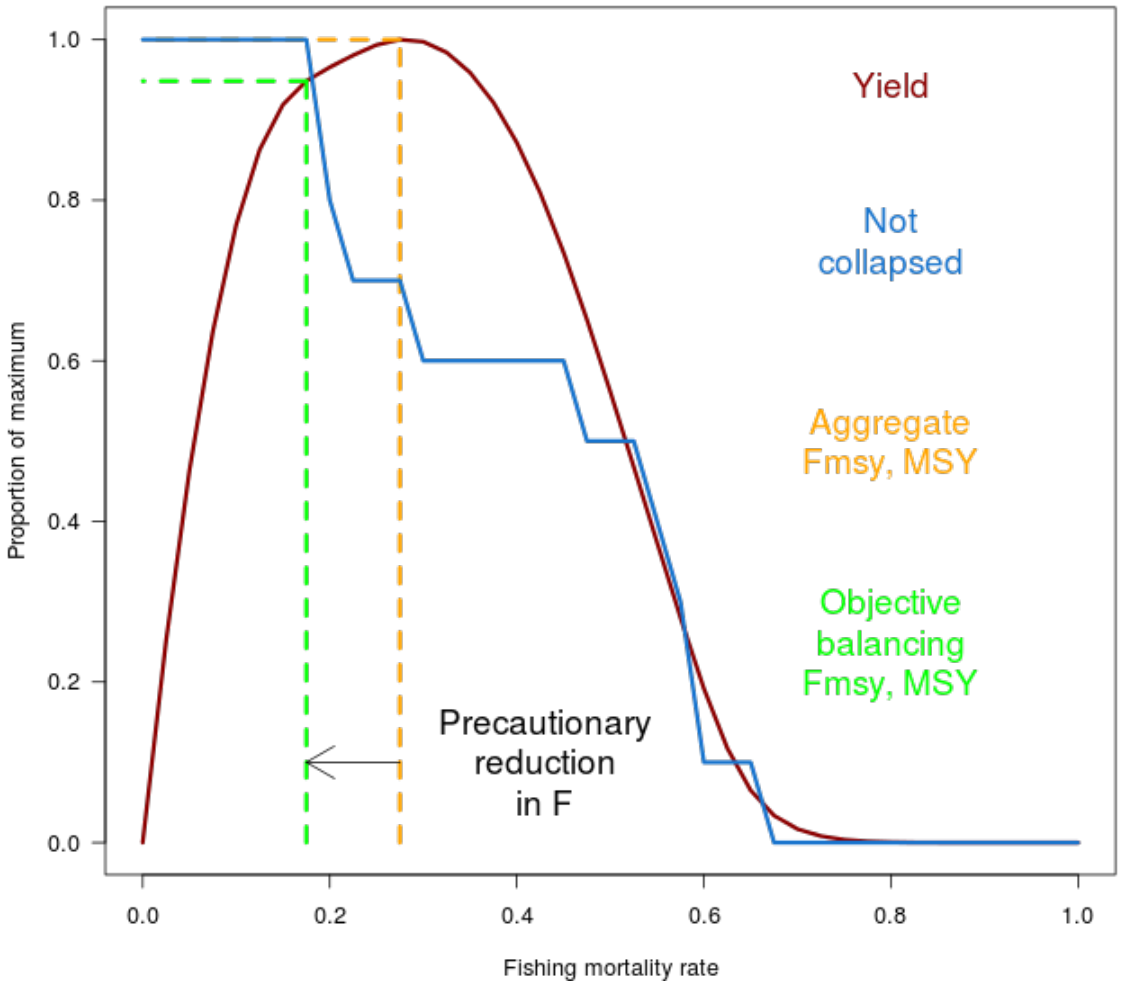


Simulations: balancing objectives

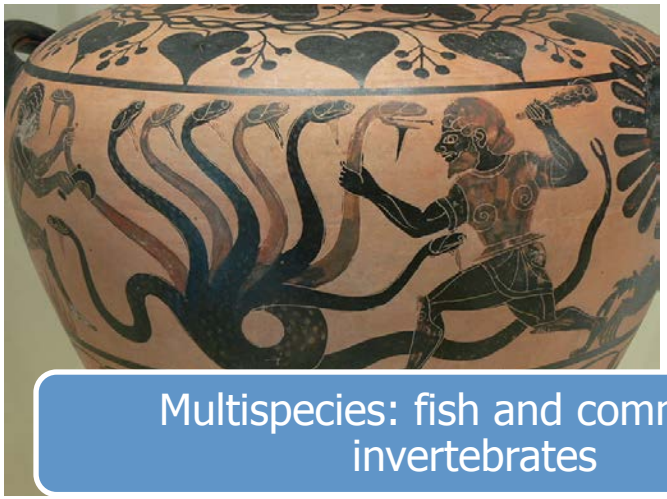




Yield maximizing biodiversity is ~95% of MMSY



Gaichas et al. 2012 MEPS



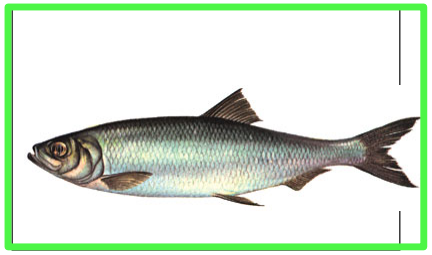
Hydra multispecies model

Multispecies: fish and commercial invertebrates	• 10 fish species: 2 elasmobranchs, 2 pelagics, 4 groundfish, 2 flatfish
Size structured	• 5 variable width size categories for each species
Estimates predation mortality	• Size specific predation mortality
Environmental covariates on growth, maturity, fecundity	• 2 growth forms, exponential and von Bertalanffy • Temperature covariate on both growth forms
Multiple recruitment functions	• 3 recruitment forms: Ricker, Beverton-Holt, Gamma (3 parameter)
Multiple fishing fleets	• 3 fleets: bottom & pelagic trawls, fixed gear
Likelihood (or Bayesian) parameter estimation in ADMB	• Simulation mode only, operating model
Spatial	• 1 area, "Georges Bank"

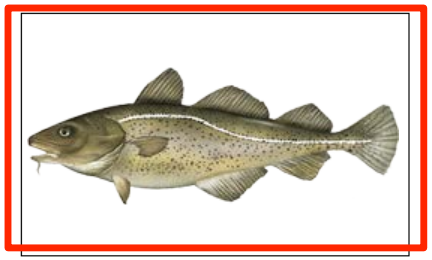
dogfish

skate

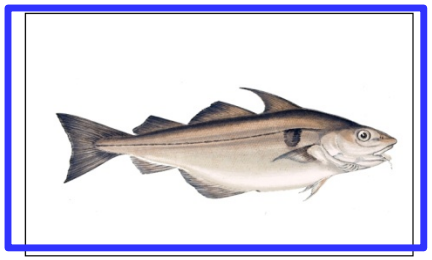
herring



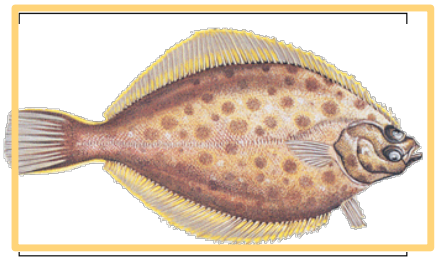
cod



haddock



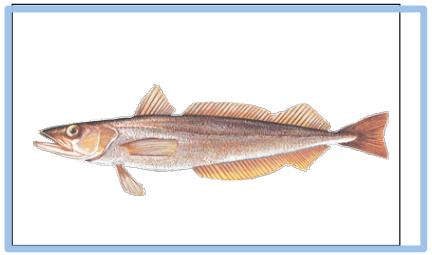
ytail_fl



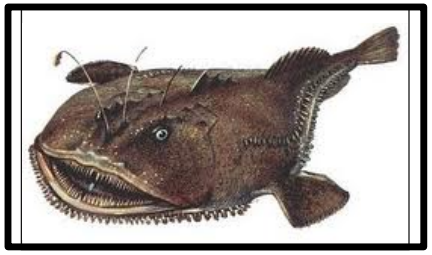
wint_fl

mackerel

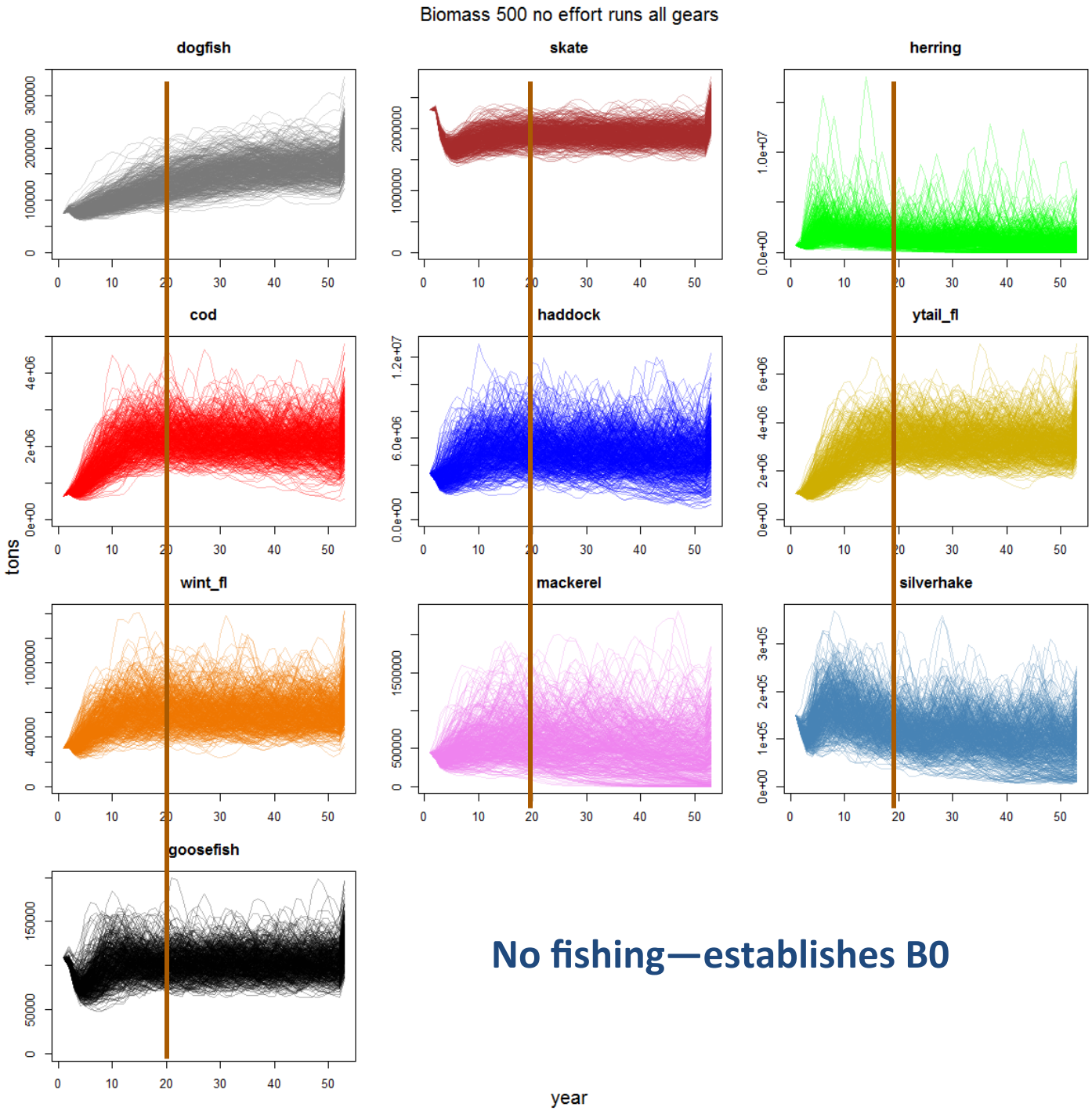
silverhake



goosefish



Species and color codes



No fishing—establishes B0

Design

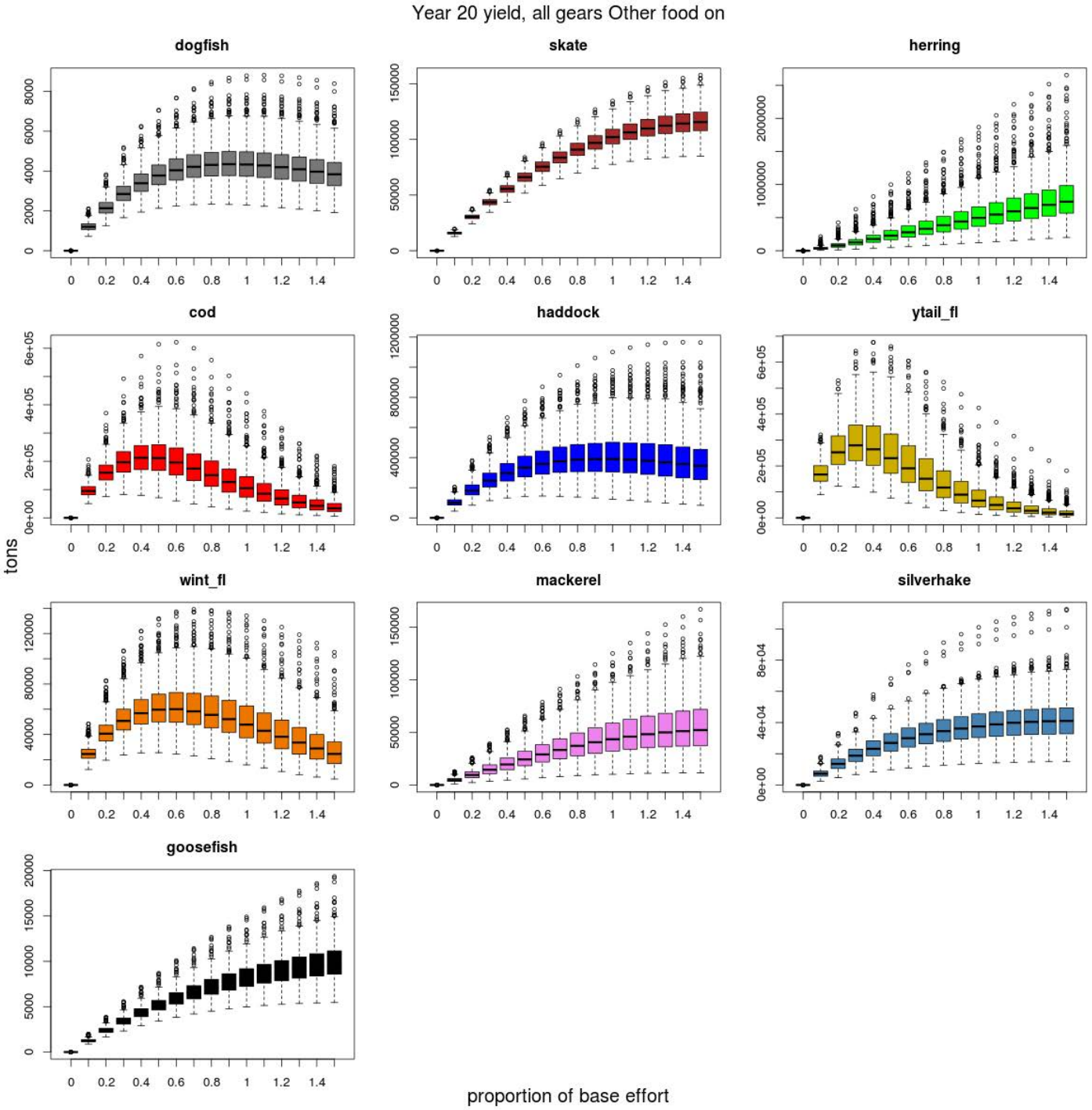
50 year run:

- Recruitment variation
- Constant proportion of average fishing effort

500 iterations

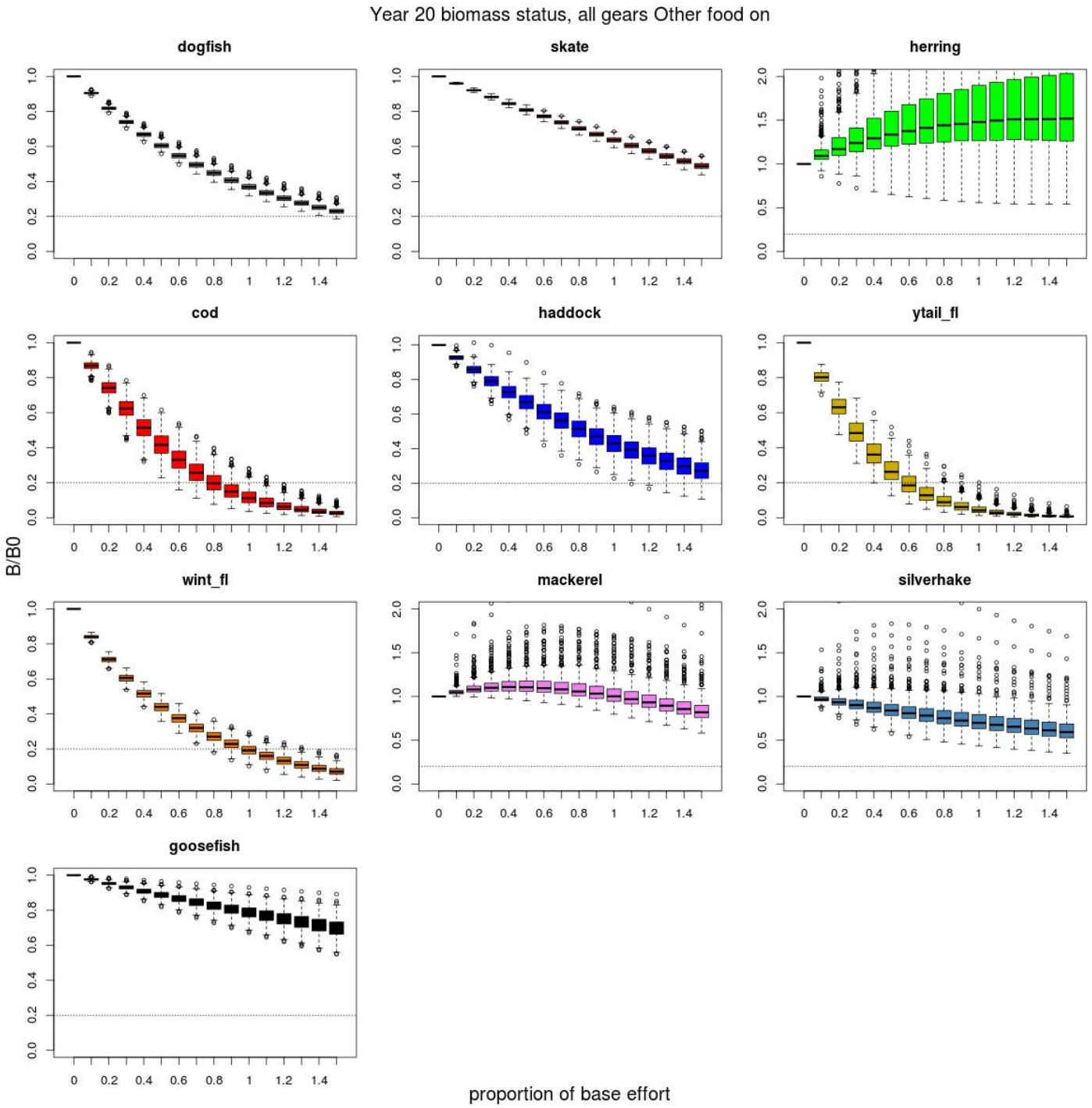
Snapshots:

- Year 20
- Year 50



Example Species Yield Curves

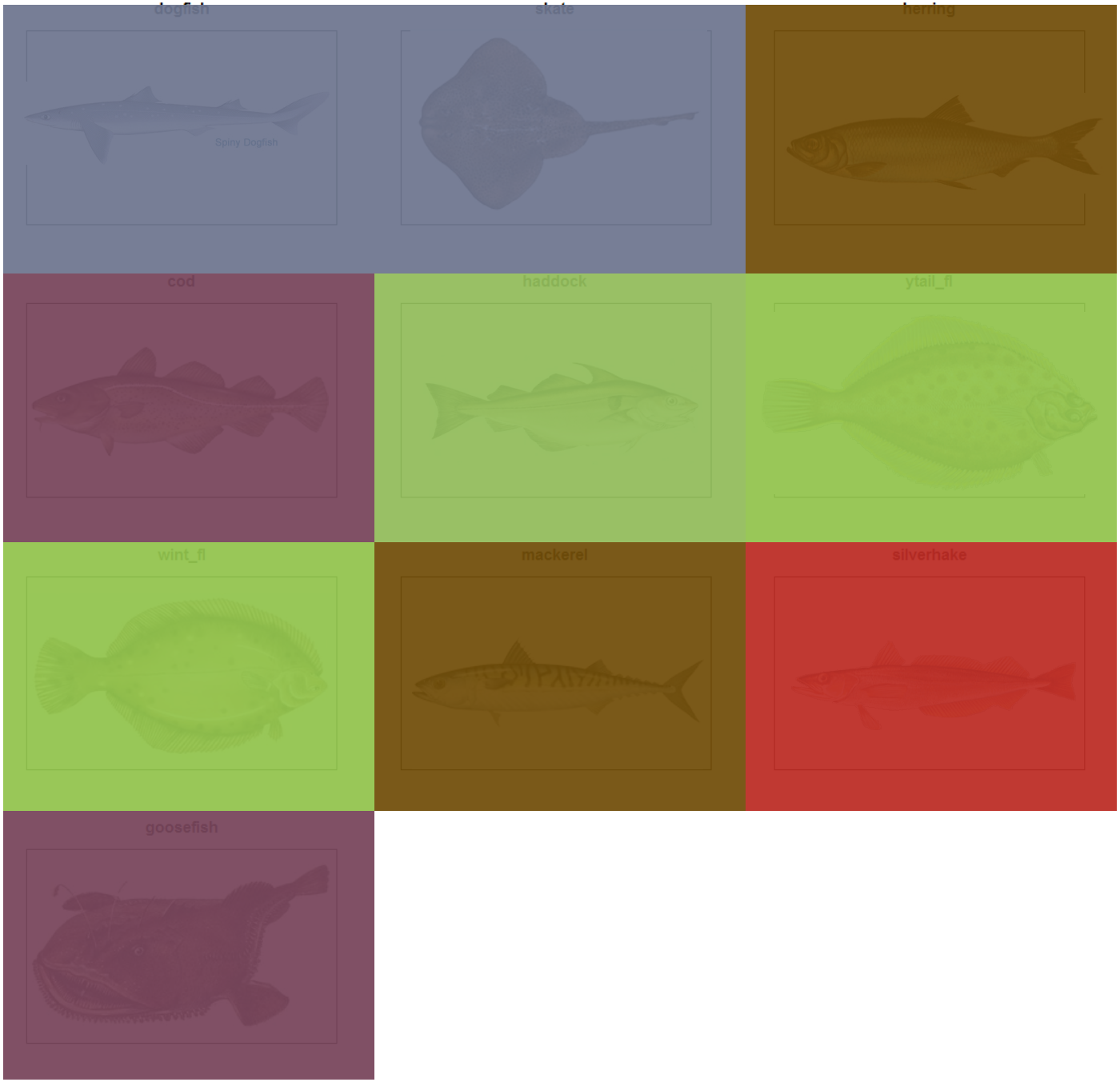
Distribution of catches over 500 iterations



Example Biomass Status

B relative to B0 for that year and iteration

Threshold: 20% of B0



Possible species groupings

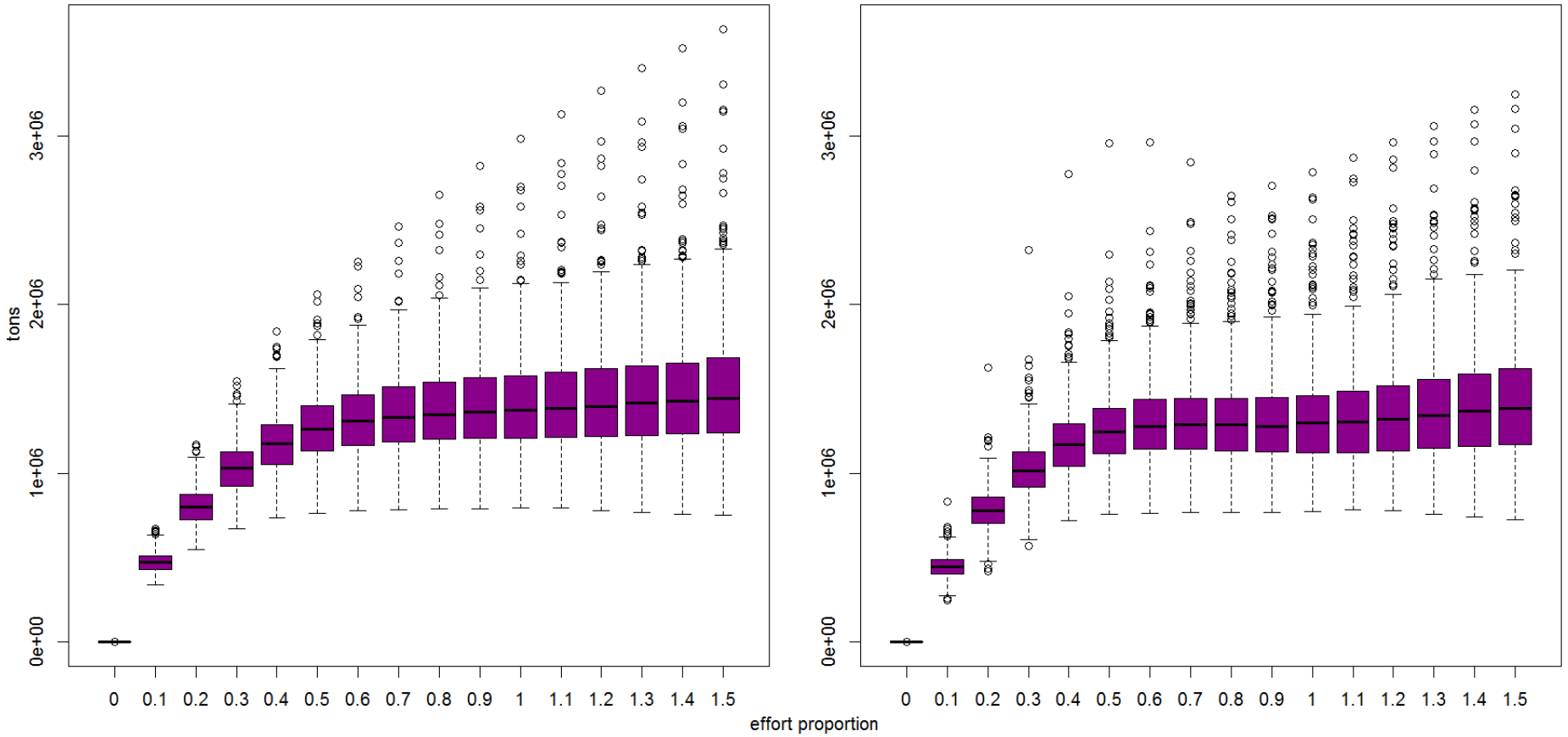
- Full system
- Taxonomic
- Habitat
- Taxonomic + Feeding guild
- Size based
- Fleet based
- Area based
- …

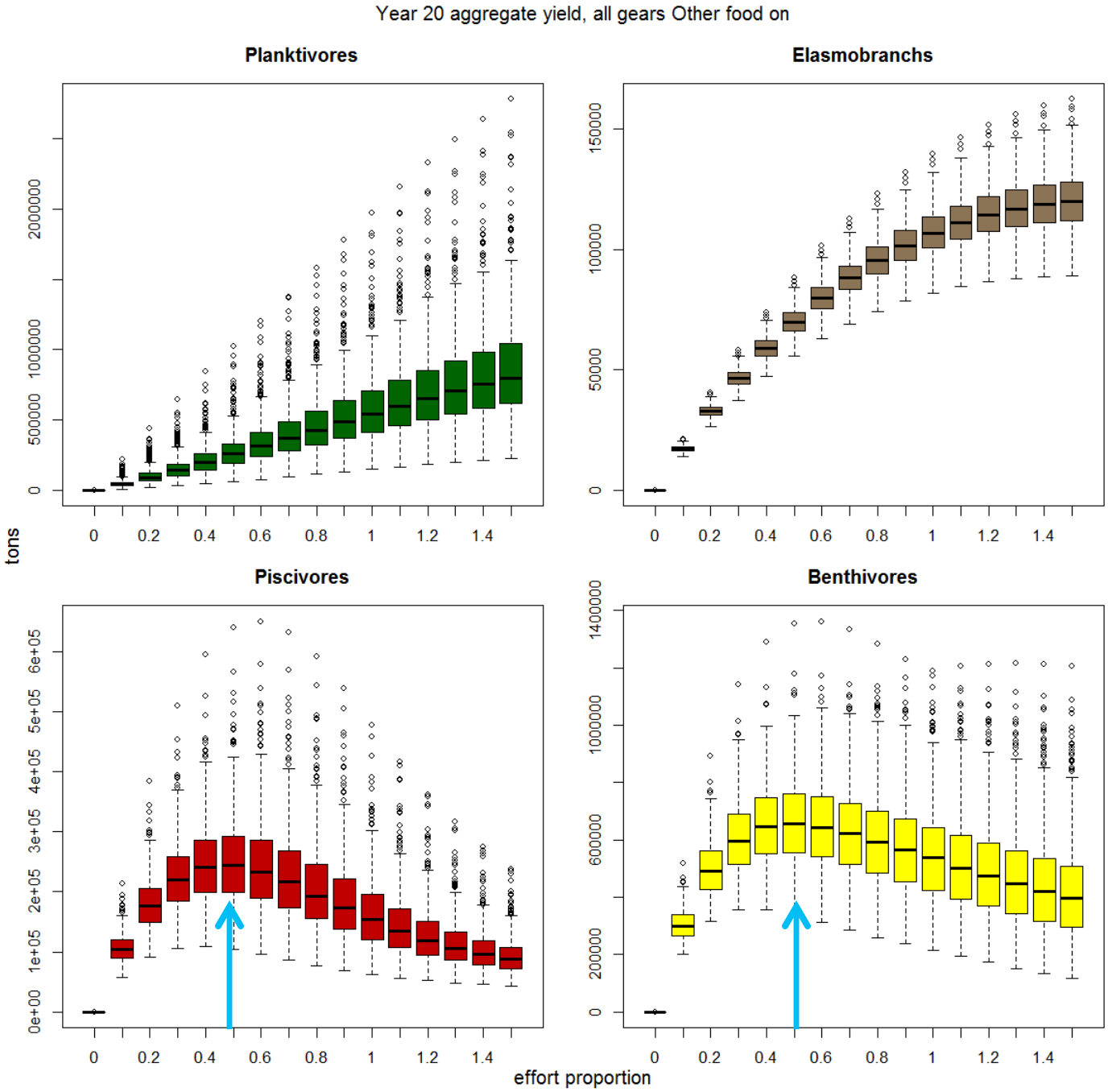
Yield curve, all species combined, all gears

Year 20

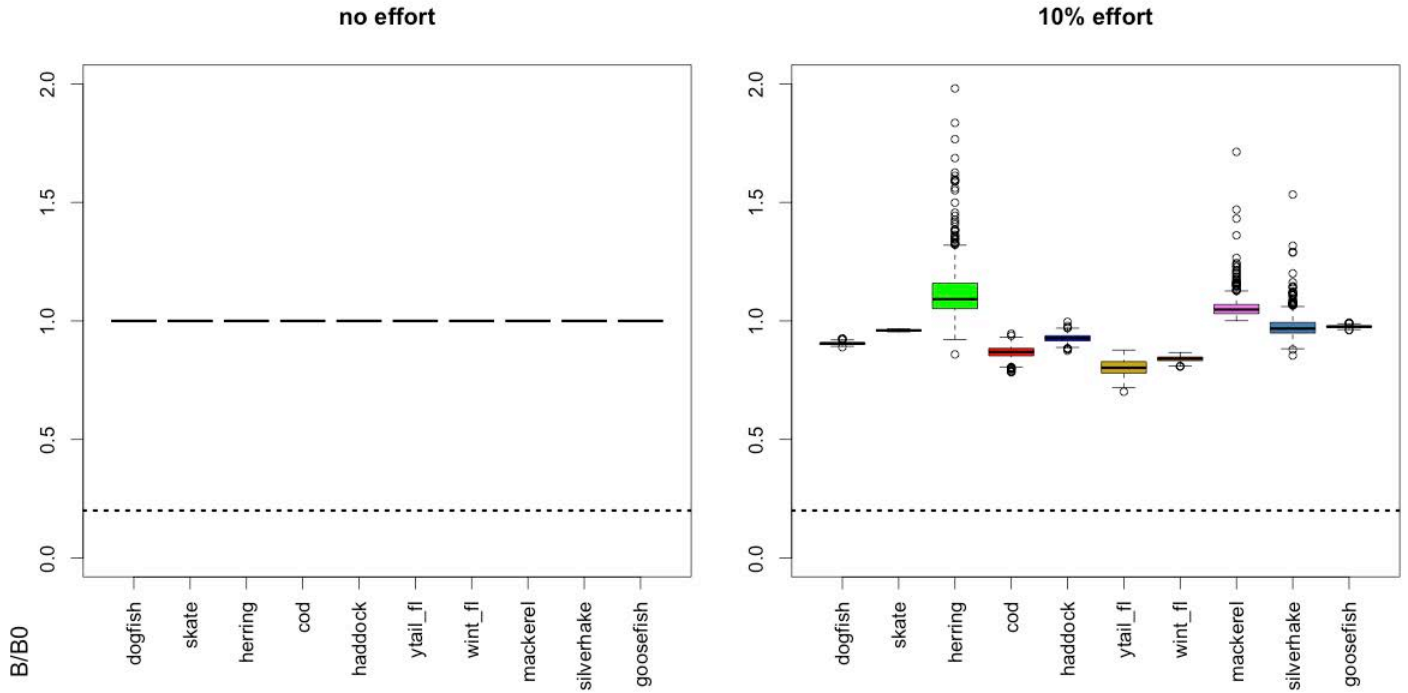
Years 20 and 50 total yield, all gears

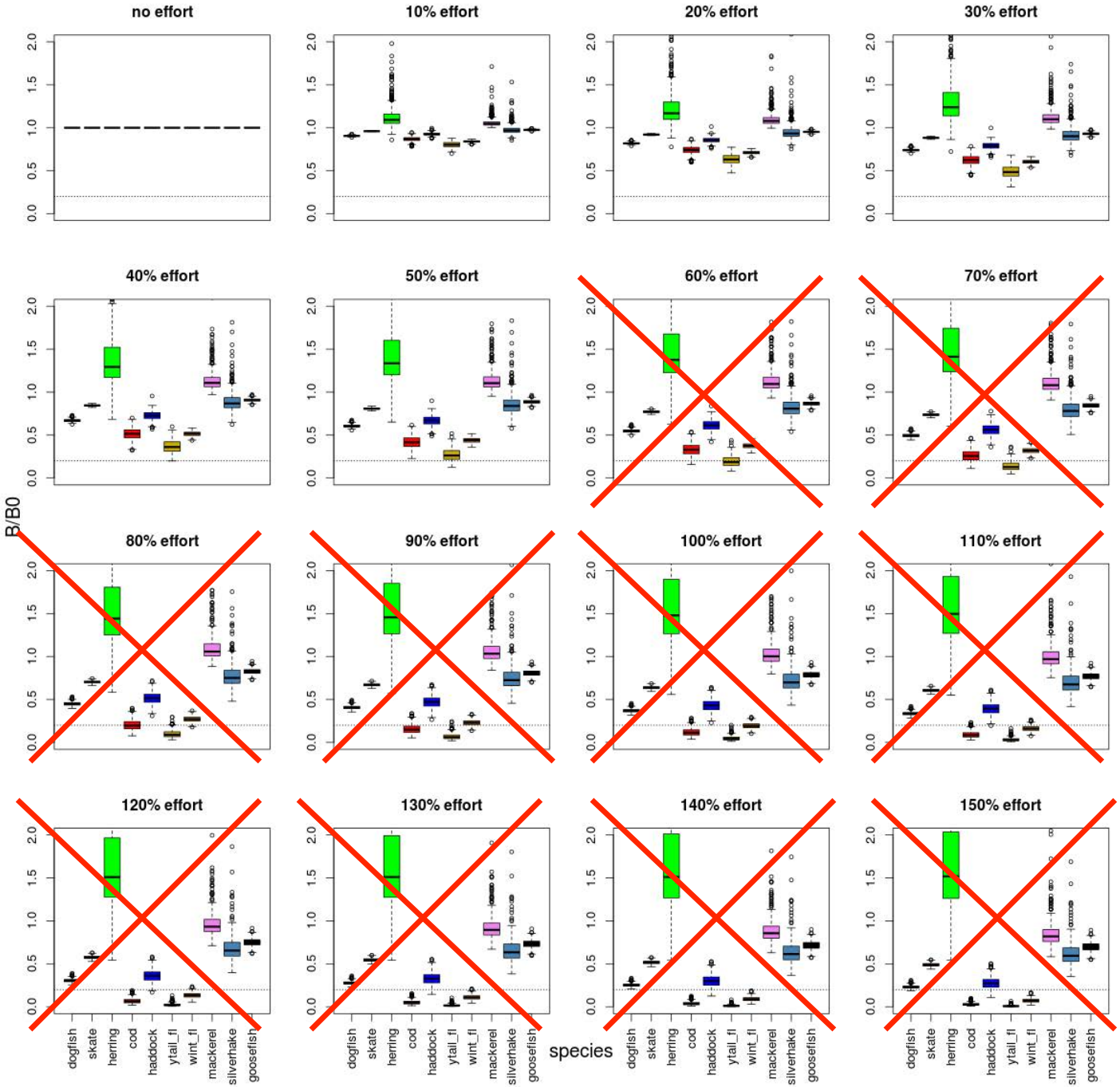
Year 50



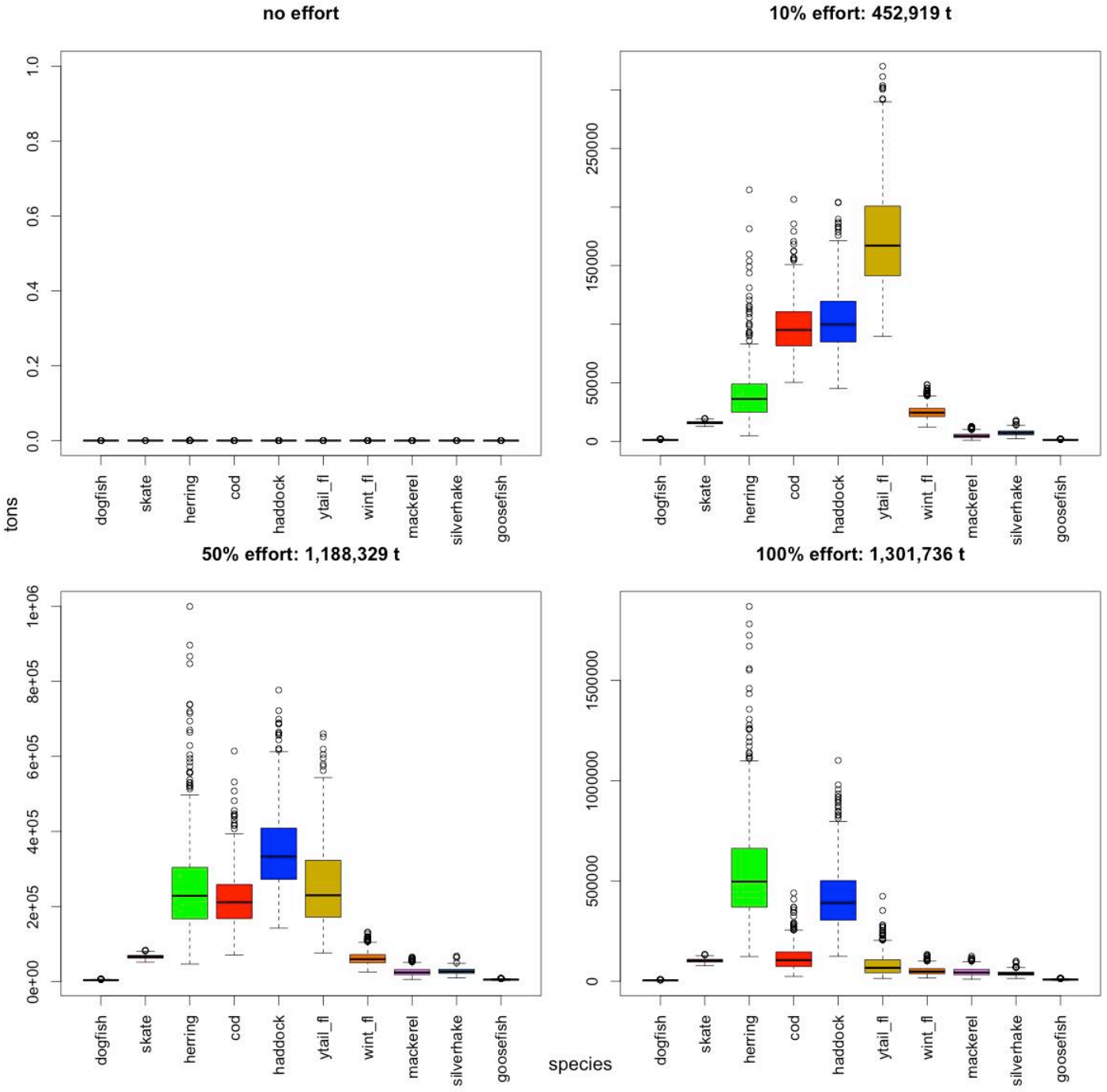

Year 20 aggregate yield, all gears Other food on
Planktivores
Elasmobranchs
Piscivores
Benthivores
tons
effort proportion
0
500000
1000000
2000000
50000
100000
150000
200000
600000
1400000
0e+00
1e+05
2e+05
3e+05
4e+05
5e+05
6e+05
0.2
0.4
0.6
0.8
1
1.2
1.4

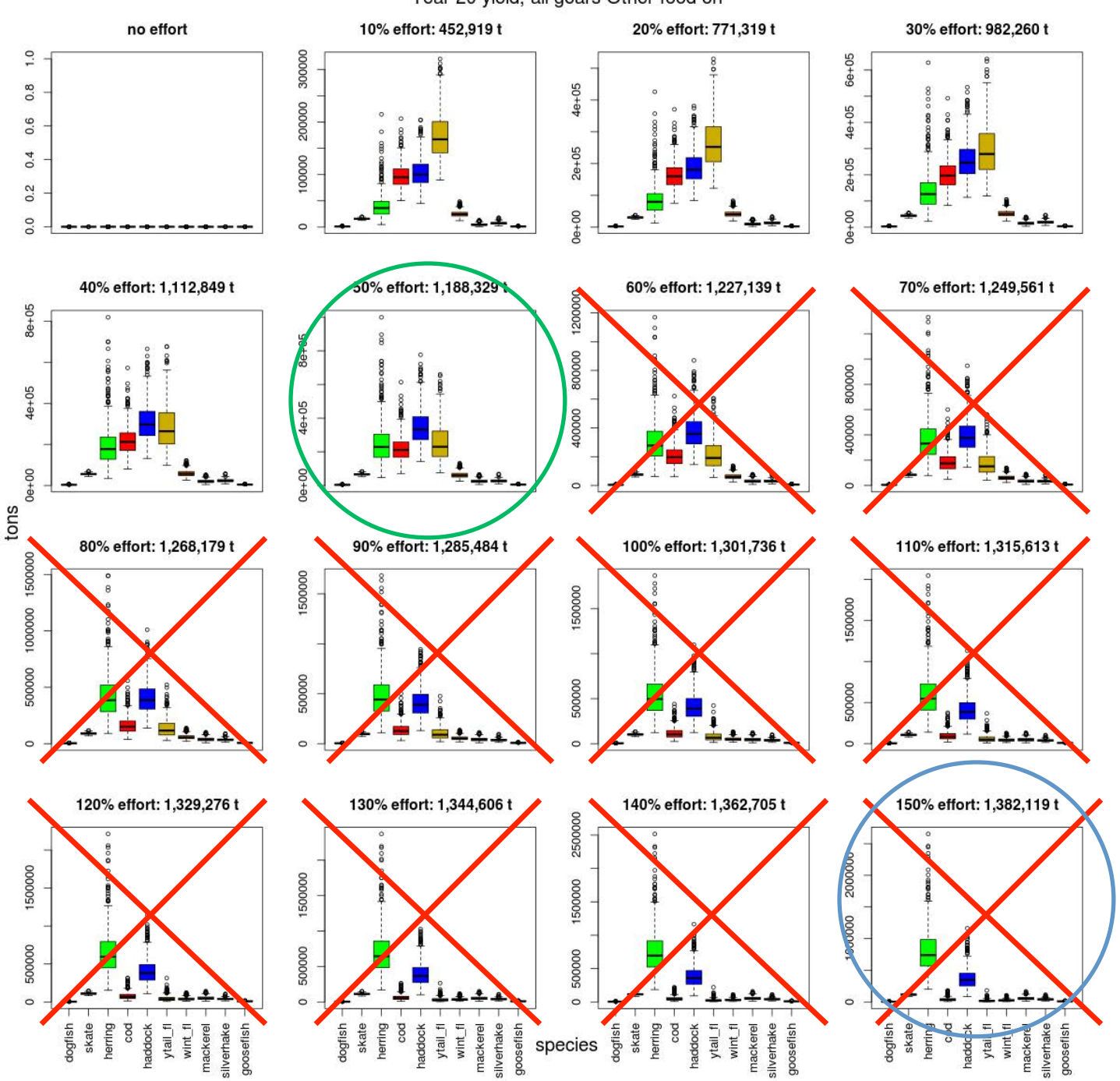
Year 20 biomass status, all gears Other food on



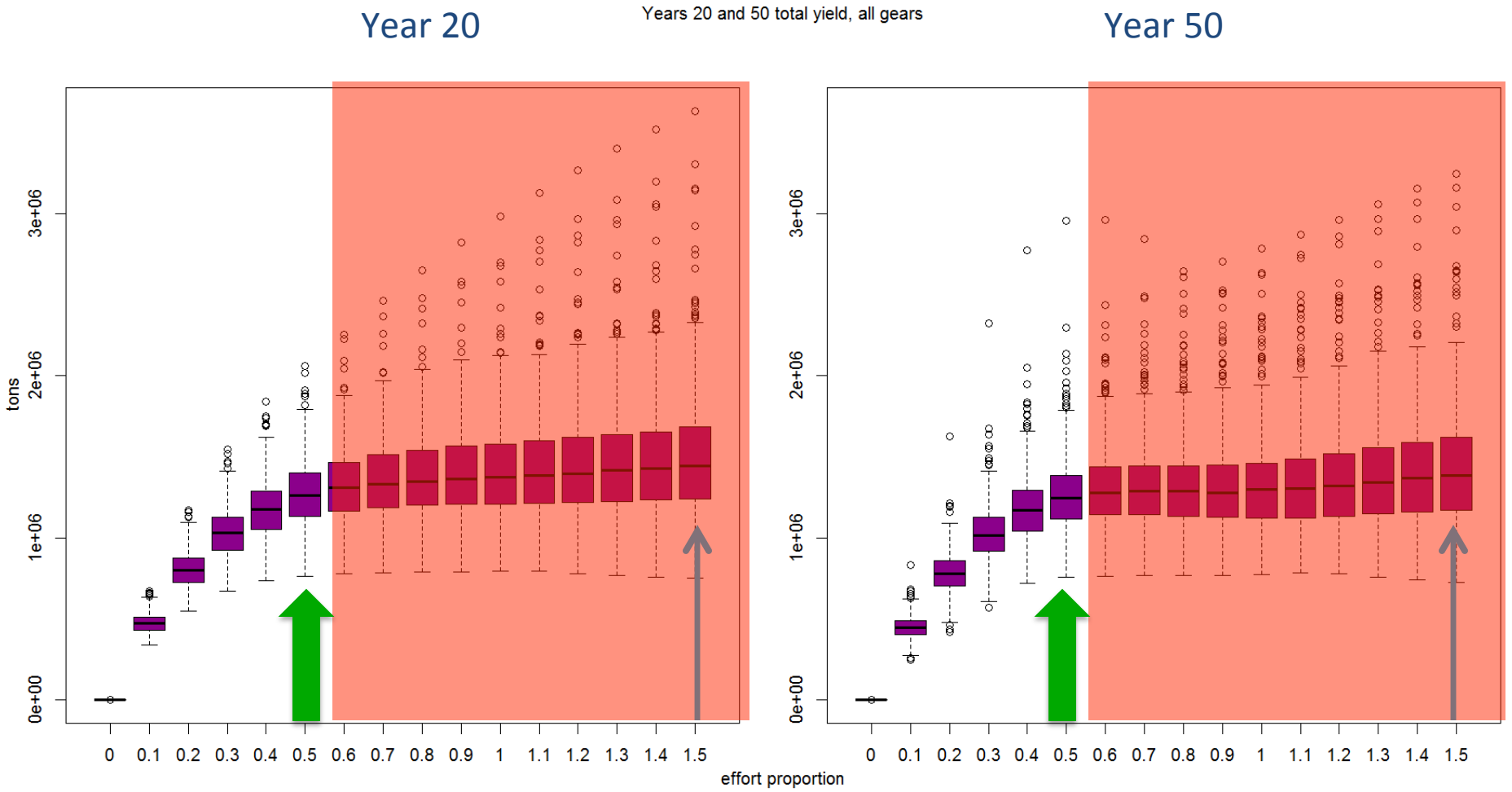

Year 20 biomass status, all gears Other food on
no effort
10% effort
20% effort
30% effort
40% effort
50% effort
60% effort
70% effort
80% effort
90% effort
100% effort
110% effort
120% effort
130% effort
140% effort
150% effort
B/B0
0.0
0.5
1.0
1.5
2.0
dogfish
skate
herring
cod
haddock
ytail_fl
wint_fl
mackerel
silverhake
goosefish
species

Year 20 yeild, all gears Other food on

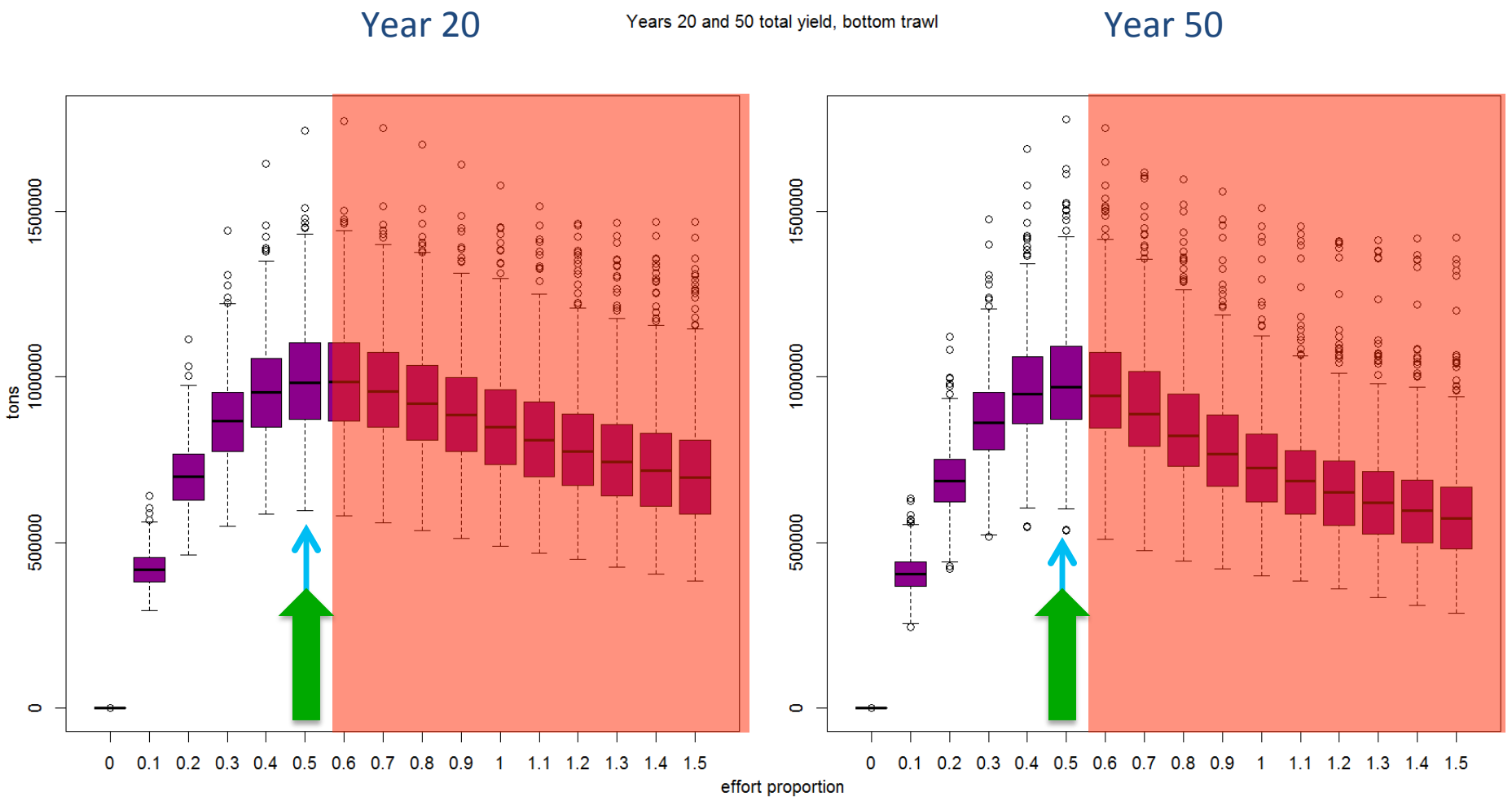



Year 20 yield, all gears Other food on
no effort
10% effort: 452,919 t
20% effort: 771,319 t
30% effort: 982,260 t
40% effort: 1,112,849 t
50% effort: 1,188,329 t
60% effort: 1,227,139 t
70% effort: 1,249,561 t
80% effort: 1,268,179 t
90% effort: 1,285,484 t
100% effort: 1,301,736 t
110% effort: 1,315,613 t
120% effort: 1,329,276 t
130% effort: 1,344,606 t
140% effort: 1,362,705 t
150% effort: 1,382,119 t
tons
species
dogfish
skate
herring
cod
haddock
ytail_fl
wint_fl
mackerel
silverhake
goosefish

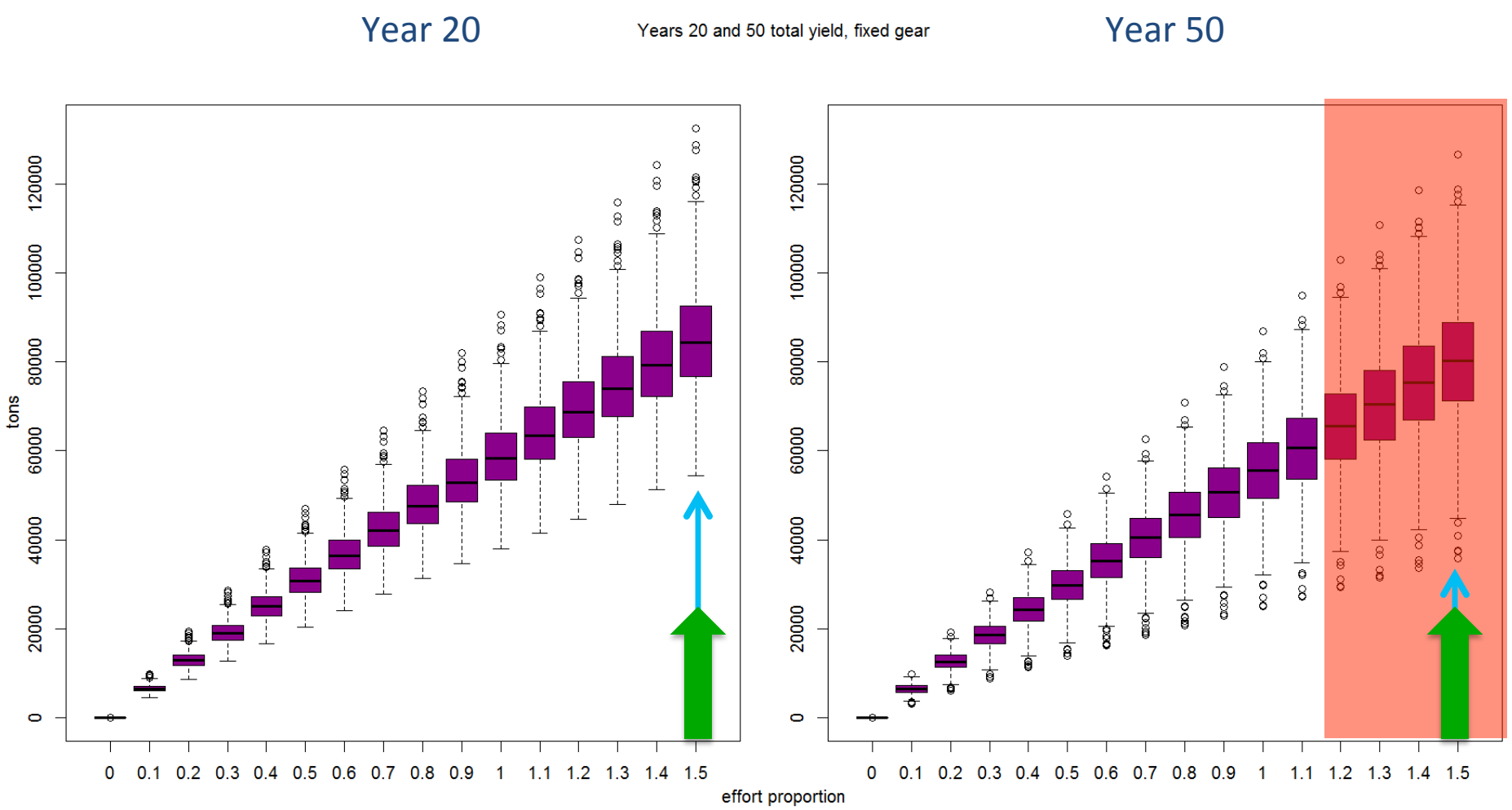
Yield curve, all species combined, all gears



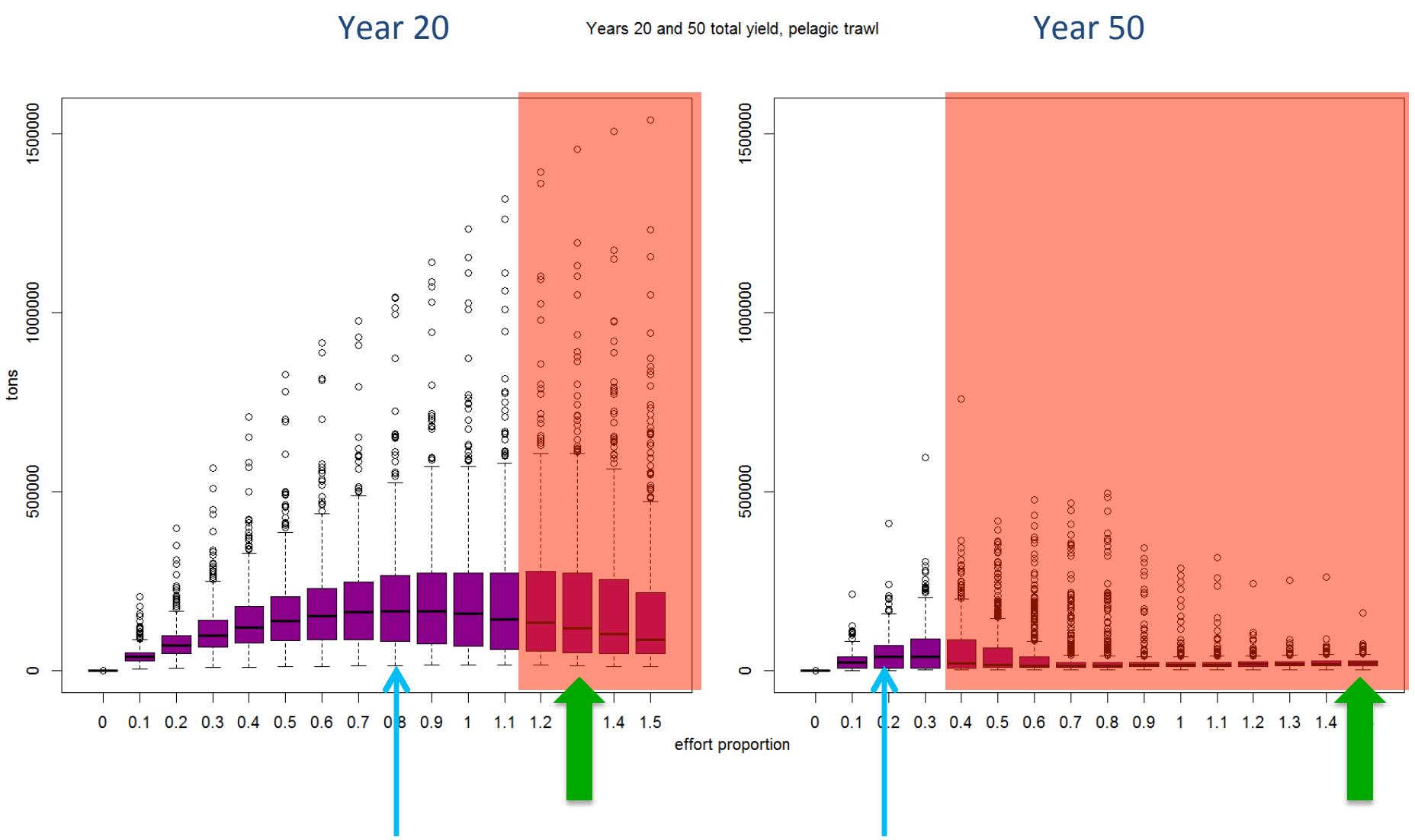
Yield curve, all species combined, bottom trawl only

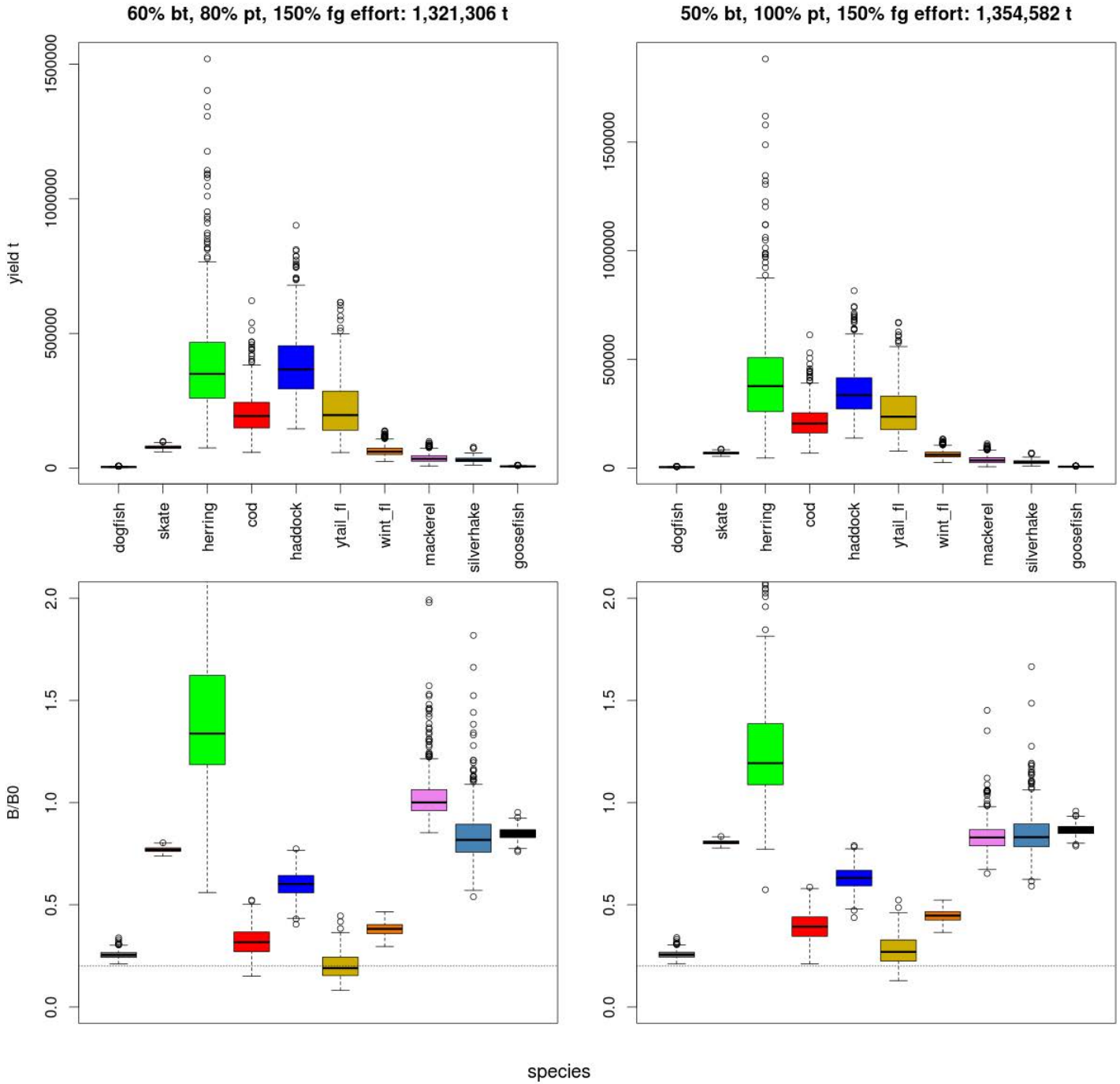


Yield curve, all species combined, fixed gear only



Yield curve, all species combined, pelagic trawl gear only





Can an improved mix of gears → higher yields?

+ ~15%

Conclusions

Aggregate fishing limits that maximize yield and conserve biomass exist

Community composition and (likely) value trade off across the range of fishing effort

Species interactions and environmental signals change yield over time

Next steps:

Add cost and portfolio analysis results

Add prey feedbacks to predators

Evaluate with environmental variability

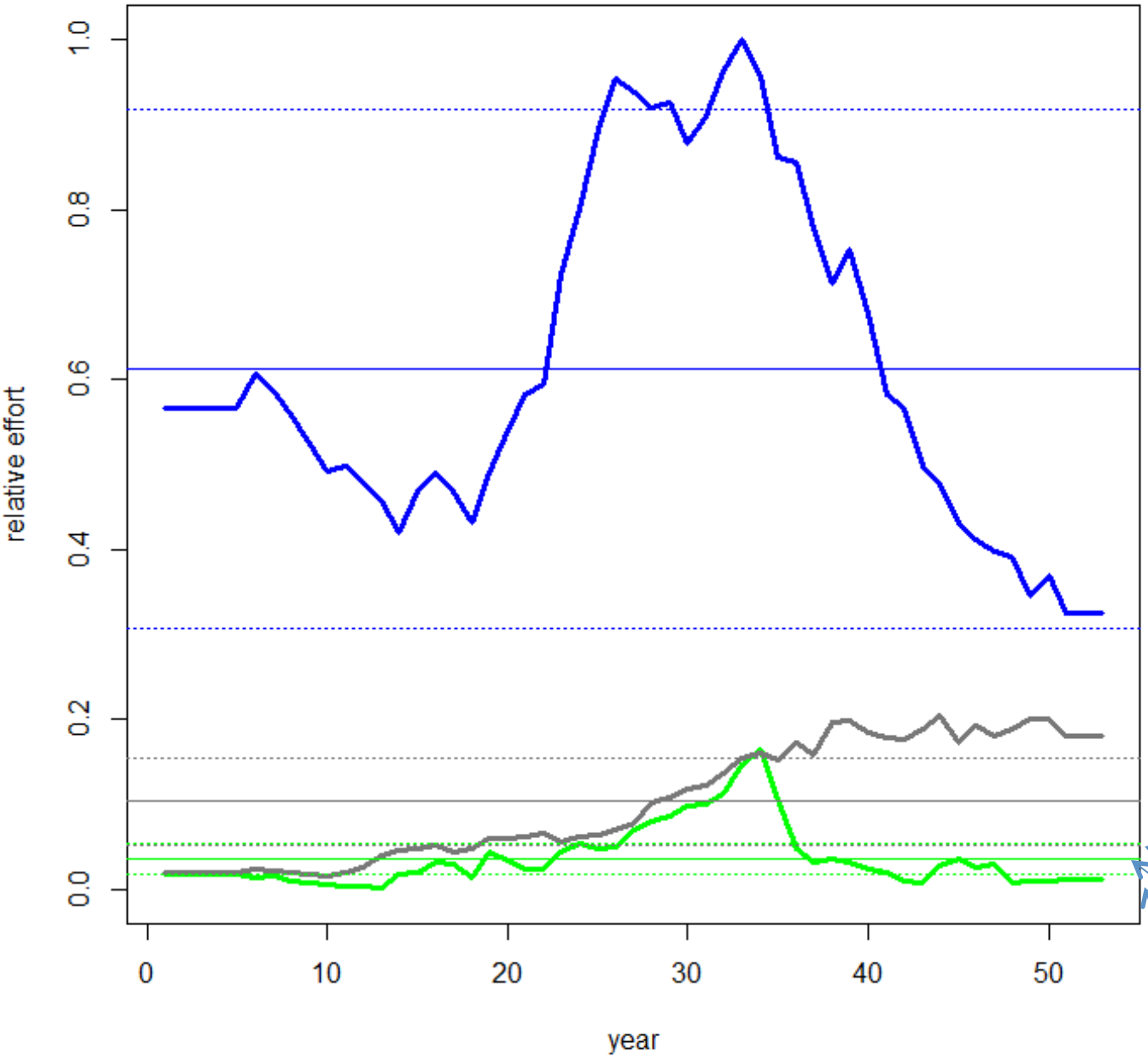
Use additional models (Atlantis, etc.)

Thank you!

Questions?

Extra slides

Design: Increments of average effort



Effort levels

Bottom trawl 150%

Bottom trawl 100% (average)

Bottom trawl 50%

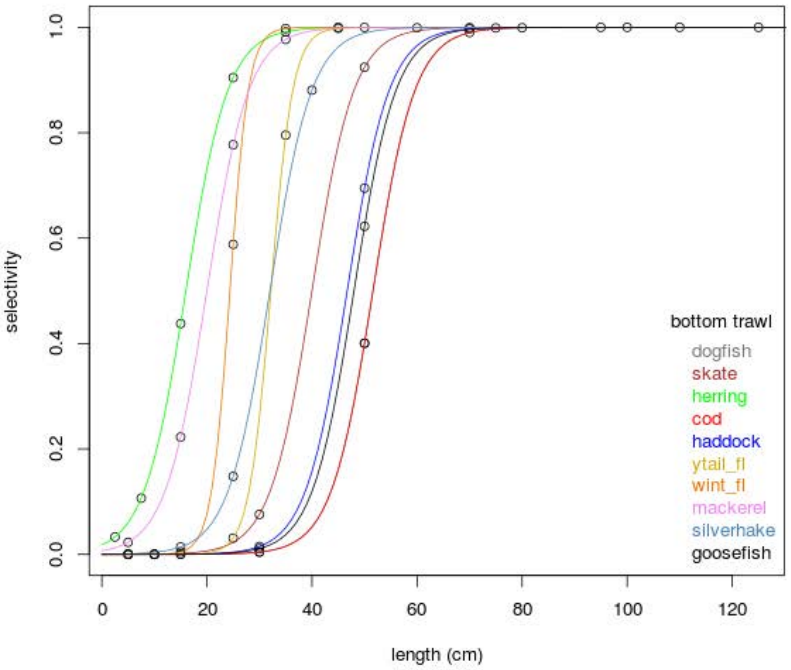
Fixed gear 150%

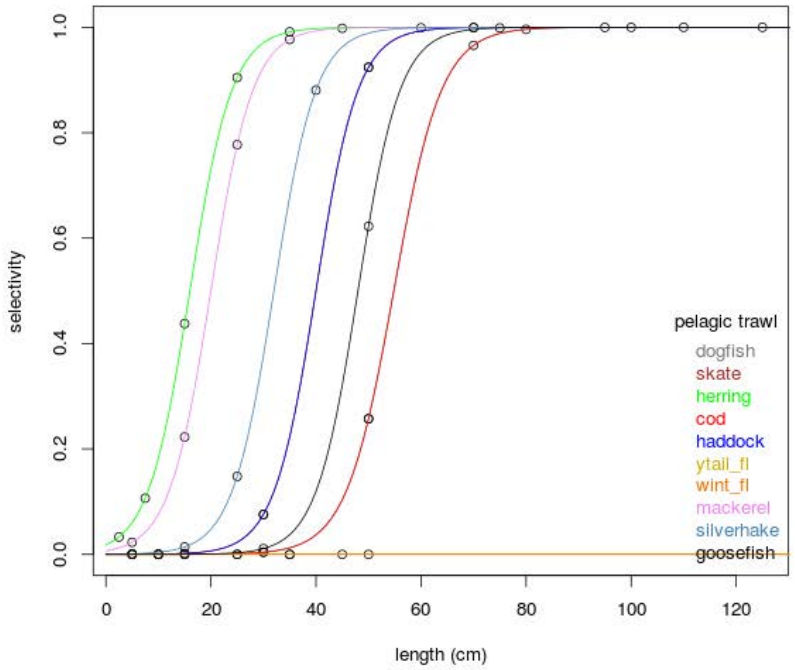
Fixed gear 100%

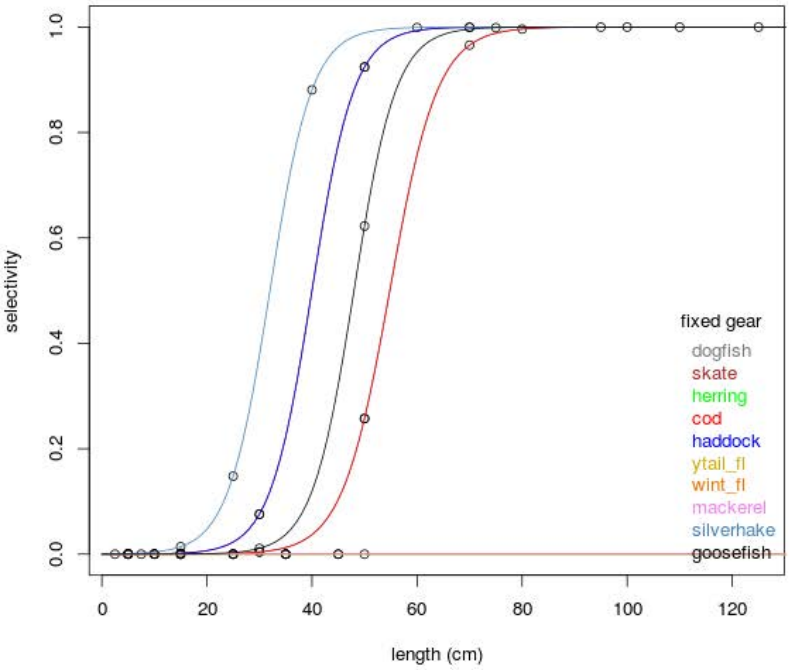
Fix 50, **Pelagic 150%**

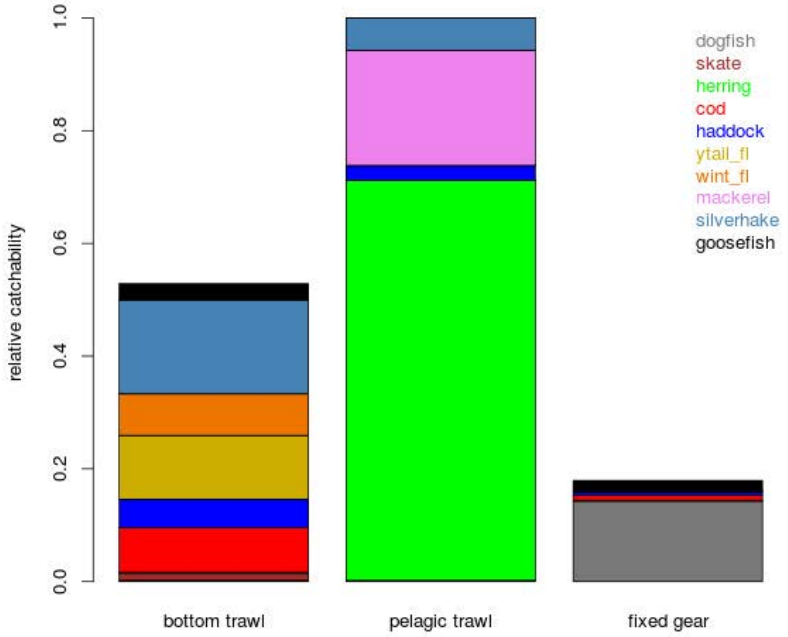
Pelagic 100%

Pelagic 50%

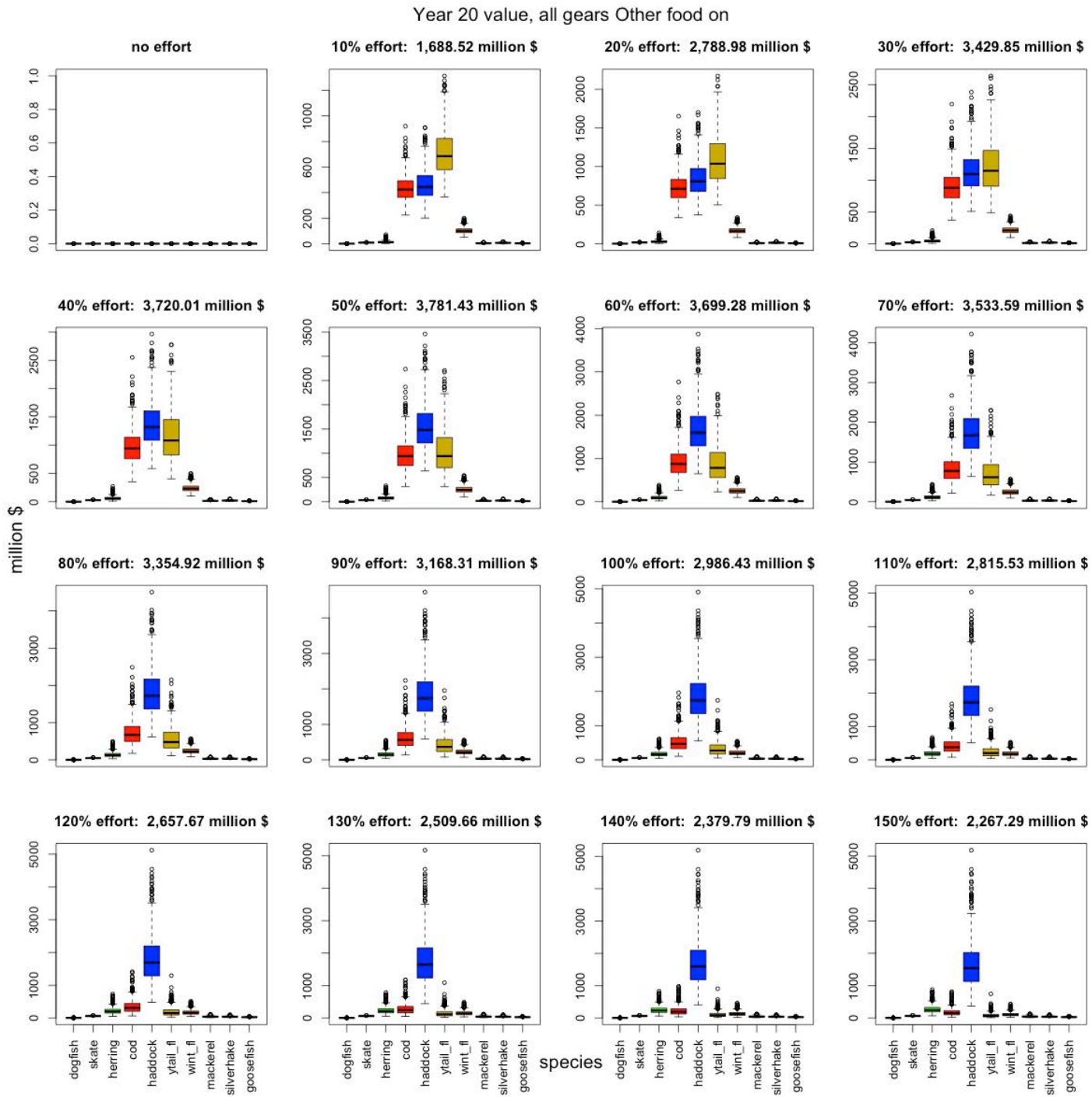








Three fisheries: selectivity and catchability


Year 20 value, all gears Other food on
no effort
10% effort: 1,688.52 million $
20% effort: 2,788.98 million $
30% effort: 3,429.85 million $
40% effort: 3,720.01 million $
50% effort: 3,781.43 million $
60% effort: 3,699.28 million $
70% effort: 3,533.59 million $
80% effort: 3,354.92 million $
90% effort: 3,168.31 million $
100% effort: 2,986.43 million $
110% effort: 2,815.53 million $
120% effort: 2,657.67 million $
130% effort: 2,509.66 million $
140% effort: 2,379.79 million $
150% effort: 2,267.29 million $
million $
species
dogfish
skate
herring
cod
haddock
ytail_fl
wint_fl
mackerel
silverhake
goosefish