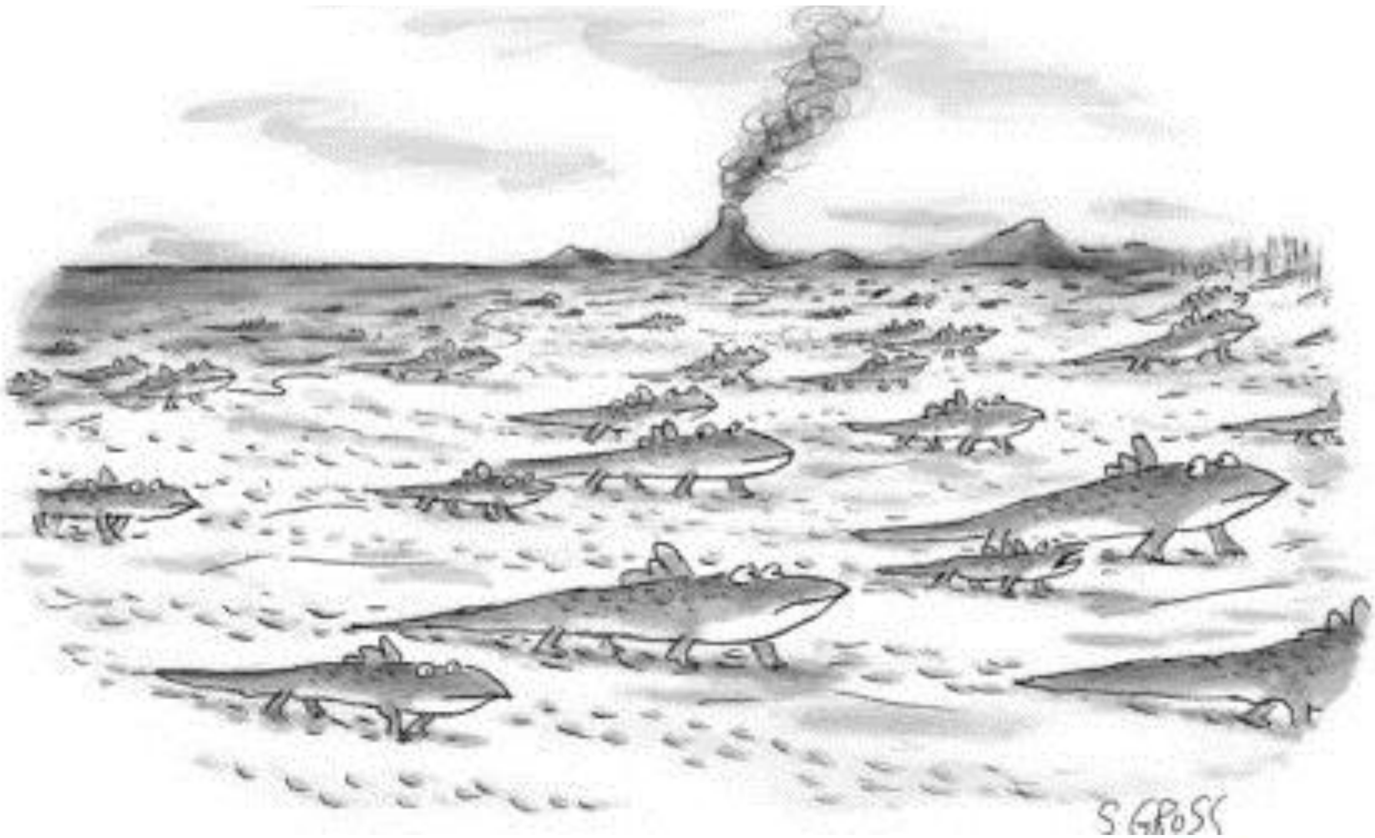
Ecosystem assessment in fisheries:

are we there yet?



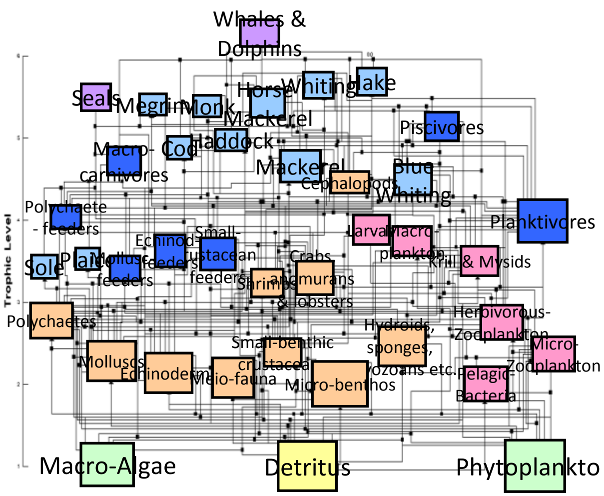
Julia Blanchard

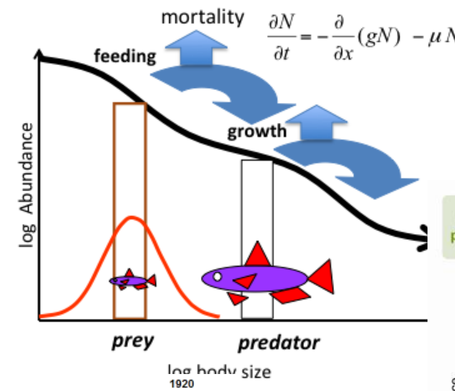
The University Of Sheffield.

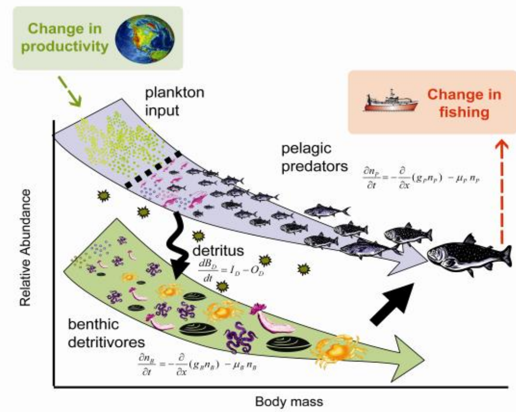
@BlanchardJulia

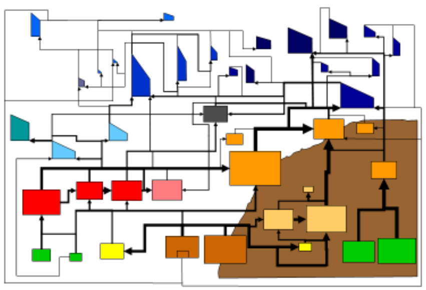
We have many different types of food web and multispecies models!

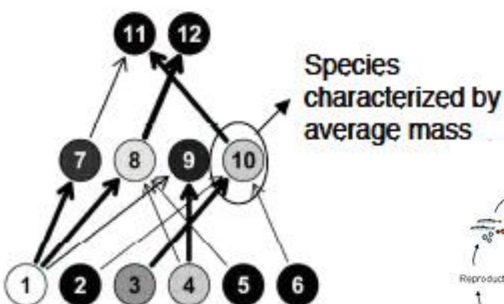
Species-based ⟷ **Size-based**

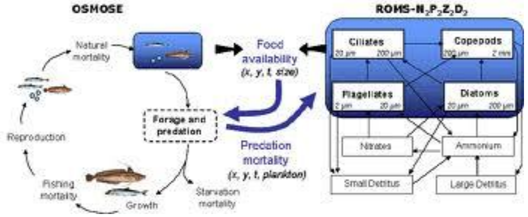


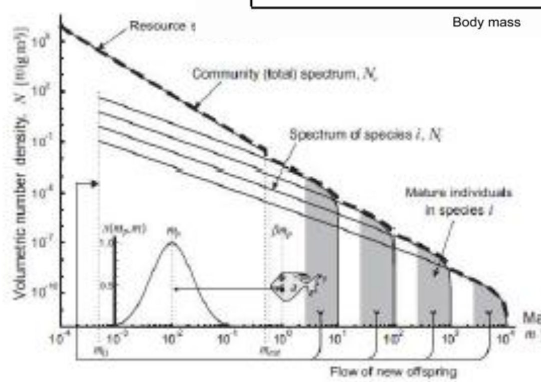












Communities, ecosystems & fisheries

PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B

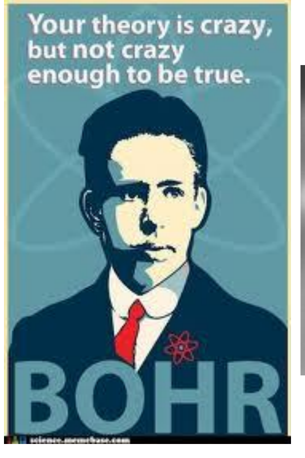
In the Theme Issue 'Fisheries: a future?'
J. R. Beddington and G. P. Kirkwood eds.

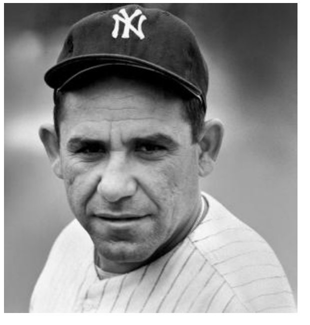
Phil. Trans. R. Soc. B (2005) 360, 95–105
doi:10.1098/rstb.2004.1571
Published online 28 January 2005

Regime, phase and paradigm shifts: making community ecology the basic science for fisheries

Marc Mangel[1*] and Phillip S. Levin[2]

"Prediction is always difficult especially about the future"
– Yogi Berra & Niels Bohr





Looking backward from 2033 they predicted:

[1] Biological reference points will be determined in a multispecies context (eg. Collie & Gislason, 2001)

[2] Overfishing will be defined from an ecosystem perspective (eg. Murawski 2000, Caddy 2002)

[3] Development of theory for the metrics of community structure and fishing (eg. Rice 2000)

[4] Management Strategy Evaluation – wider range of community and ecosystem models (& processes)

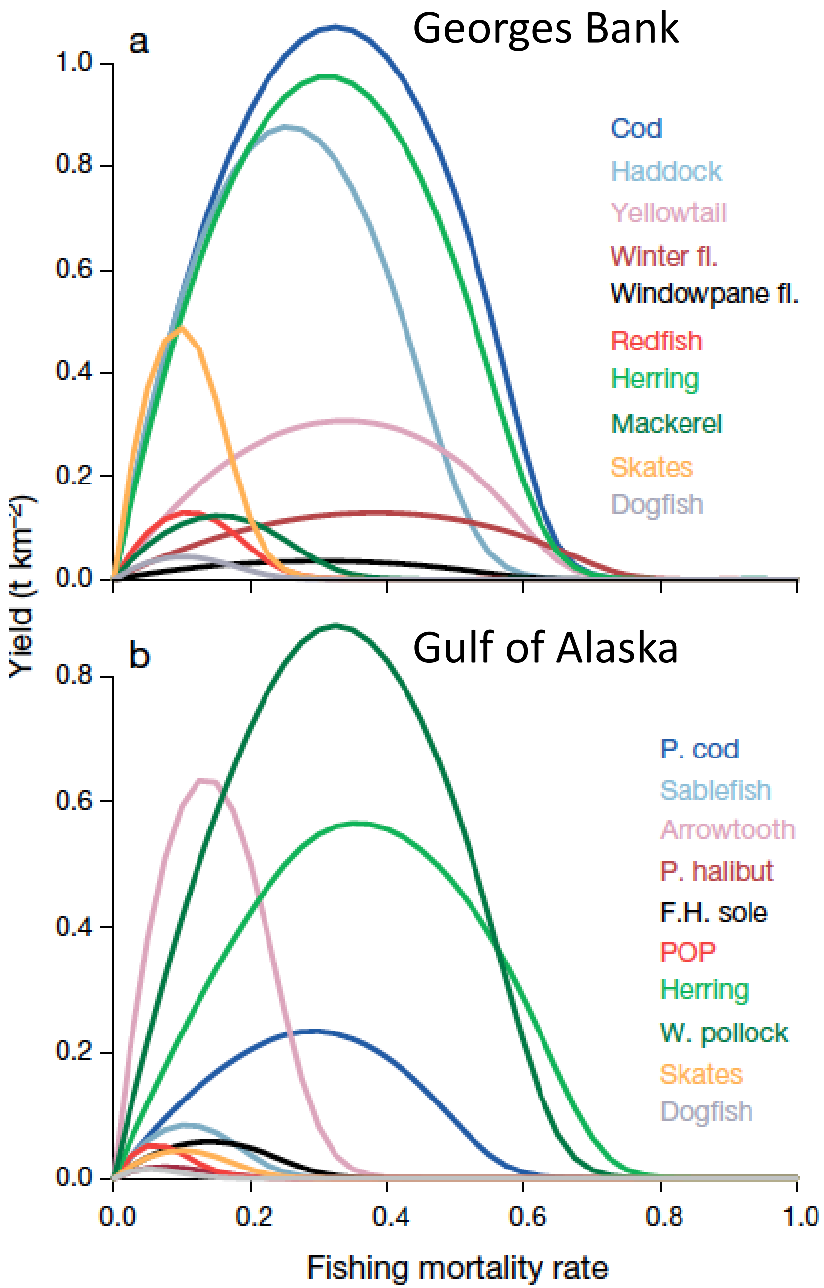
[5] Using wealth of fisheries data more actively
– hypotheses, experiments

where are we in 2013?

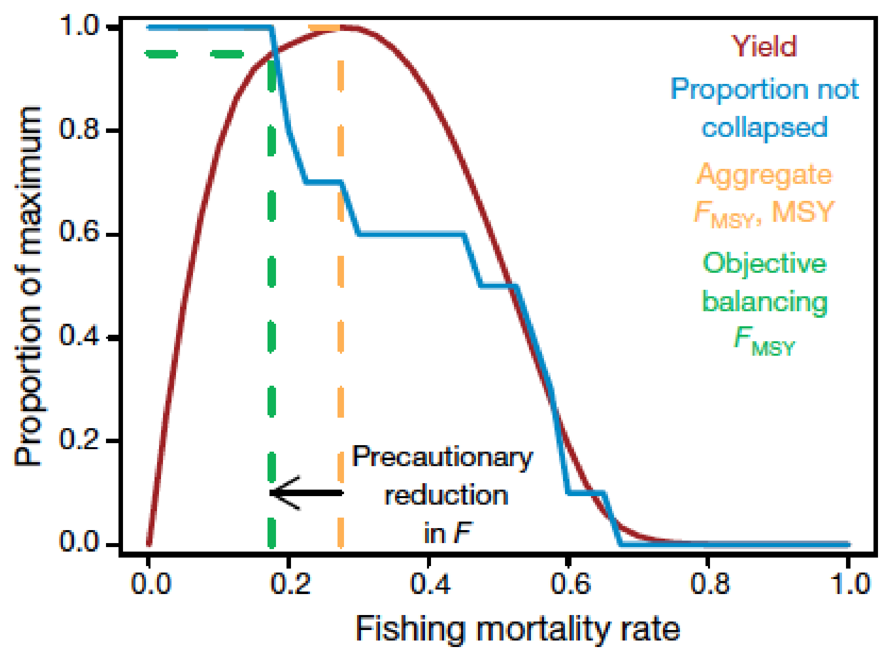
[prediction 1 - biological reference points]

Gaichas et al 2012, MEPS

MODEL: Multispecies Surplus Production with predatory and competitive interactions

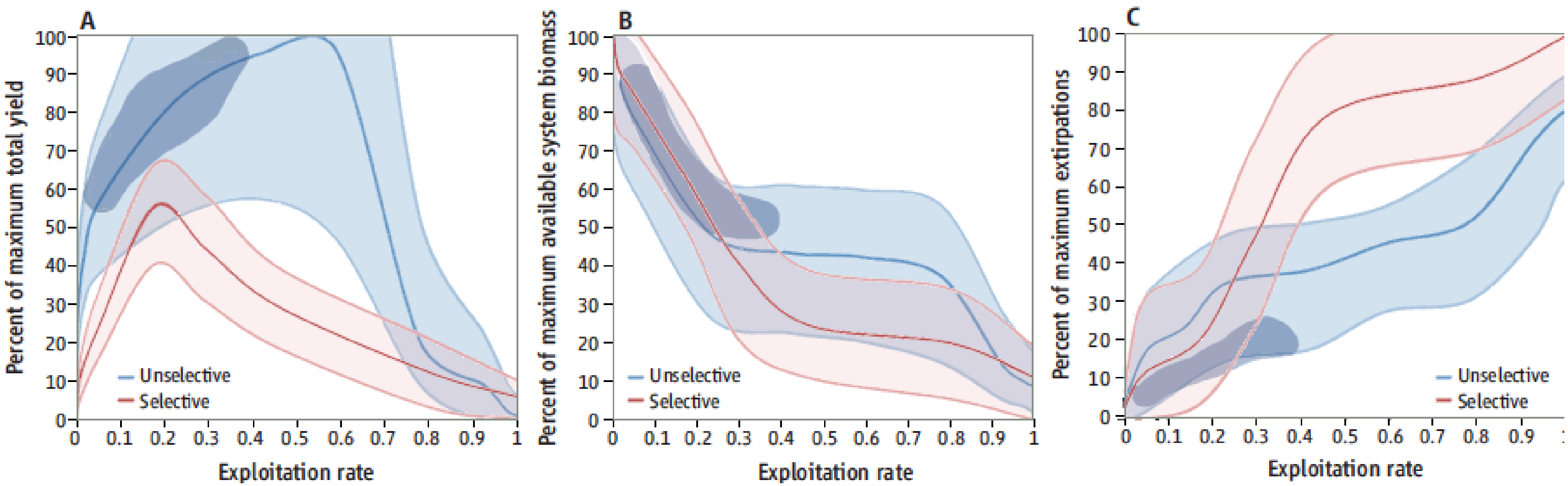


Trade-offs between balancing and fishing at Fmsy



BUT Fmsy & MSY ARE STRONGLY DEPENDENT ON SELECTIVITY, among other things
(eg. environment, model structure)

MODELS:
- Ecopath with Ecosim
- Atlantis

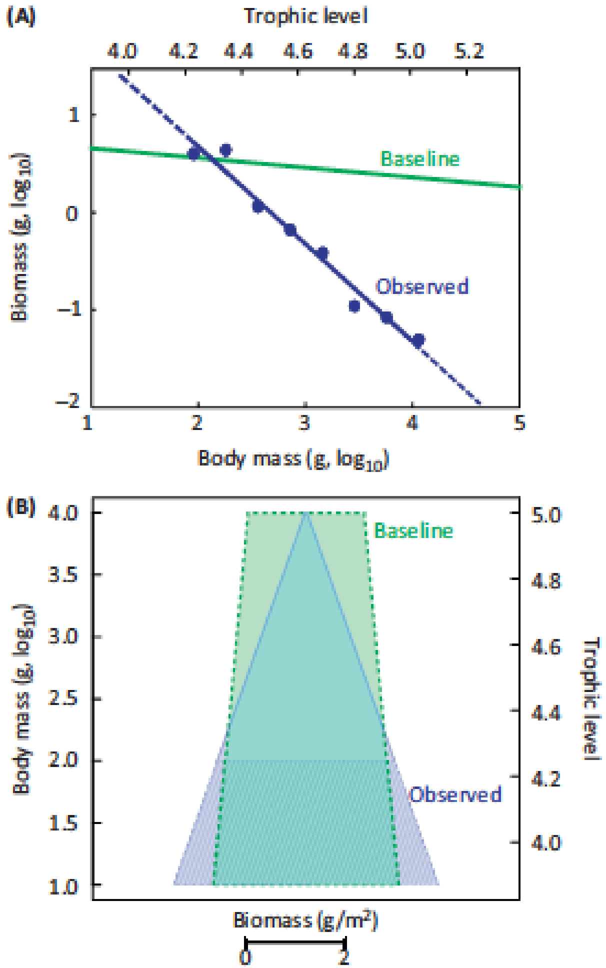


Catch — Biomass — Collapses

Garcia et al. 2012 Science
– Ideas on 'Balanced fishing'

On wider ecosystem consequences of forage fish also see:
Smith et al. Science 2012
Dickey-Collas et al. ICES JMS 2013

Effects of fishing on structure - theory



Static size spectra & trophic pyramids– a review by Trebilco et al. 2013

Fish abundance with no fishing: predictions based on macroecological theory

SIMON JENNINGS and JULIA L. BLANCHARD
Centre for Environment, Fisheries and Aquaculture Science, Lowestoft Laboratory, Lowestoft NR33 OHT, UK

A continuous model of biomass size spectra governed by predation and the effects of fishing on them

Eric Benoît[a], Marie-Joëlle Rochet[b,*]

Size-spectra dynamics from stochastic predation and growth of individuals

Richard Law,[1,4] Michael J. Plank,[2] Alex James,[2] and Julia L. Blanchard[3]

How does abundance scale with body size in coupled size-structured food webs?

Julia L. Blanchard[1,2*], Simon Jennings[1], Richard Law[2], Matthew D. Castle[1,2†], Paul McCloghrie[1], Marie-Joëlle Rochet[3] and Eric Benoît[4]

Asymptotic Size Determines Species Abundance in the Marine Size Spectrum

Damped trophic cascades driven by fishing in model marine ecosystems

K. H. Andersen[1,*] and M. Pedersen[2]

From individuals to populations to communities: A dynamic energy budget model of marine ecosystem size-spectrum including life history diversity

Olivier Maury[a,b,*], Jean-Christophe Poggiale[c,1]

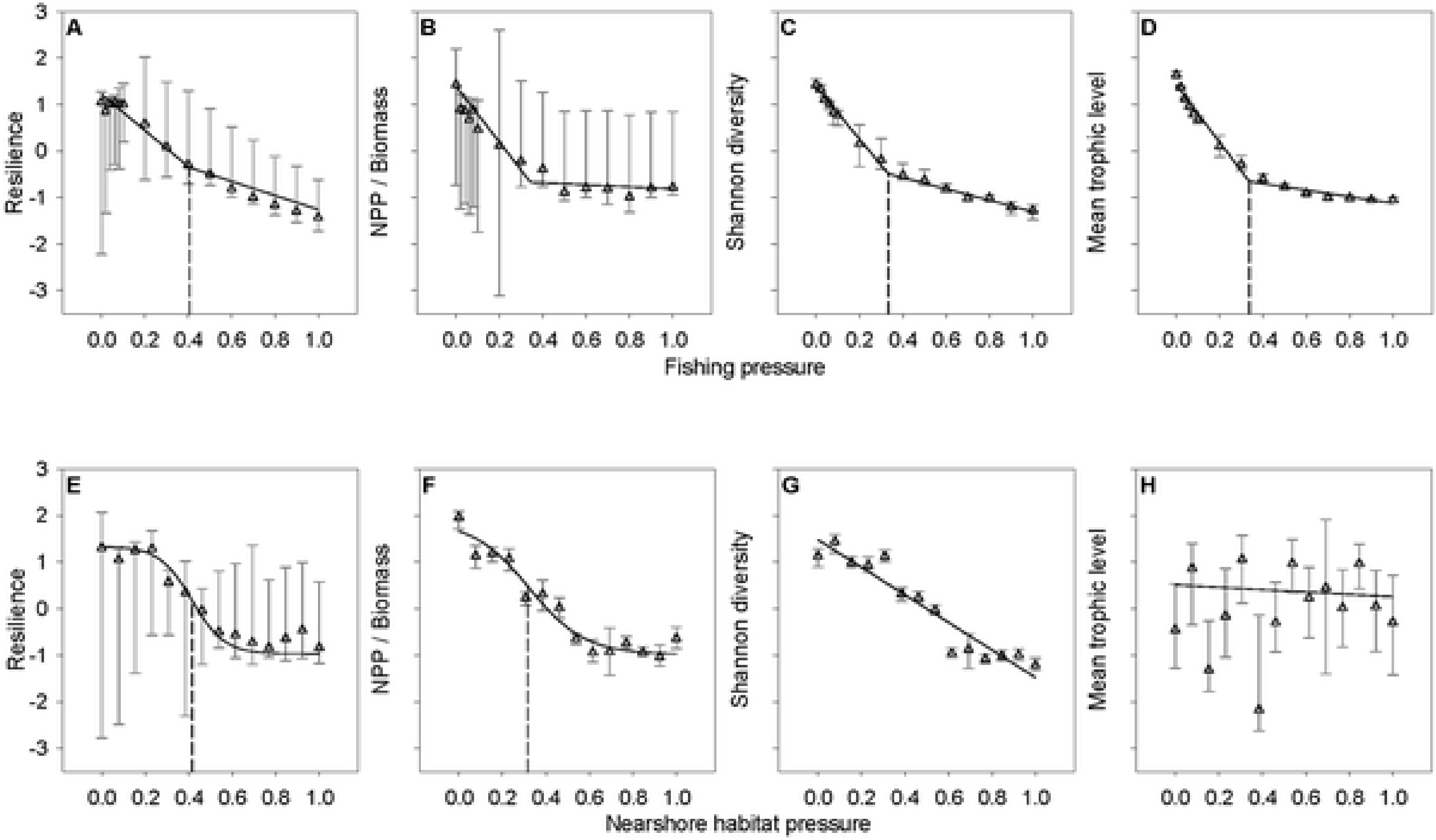
A Complete Analytic Theory for Structure and Dynamics of Populations and Communities Spanning Wide Ranges in Body Size

Axel G. Rossberg[*,†,1]
[*]Centre for Environment, Fisheries and Aquaculture Science (Cefas), Lowestoft Laboratory, Suffolk, United Kingdom
[†]Medical Biology Centre, School of Biological Sciences, Queen's University Belfast, Belfast, United Kingdom
[1]Corresponding author: e-mail address: axel.rossberg@cefas.co.uk

Size spectrum theory
Metabolic theory
Macroecology

MODEL: Ecopath with Ecosim

Ecosystem Resilience & Thresholds



Samhouri JF, Levin PS, Ainsworth CH (2010) Identifying Thresholds for Ecosystem-Based Management. PLoS ONE 5(1): e8907. doi:10.1371/journal.pone.0008907
http://www.plosone.org/article/info:doi/10.1371/journal.pone.0008907

Ecological drivers of resilience from food web & size spectrum dynamics

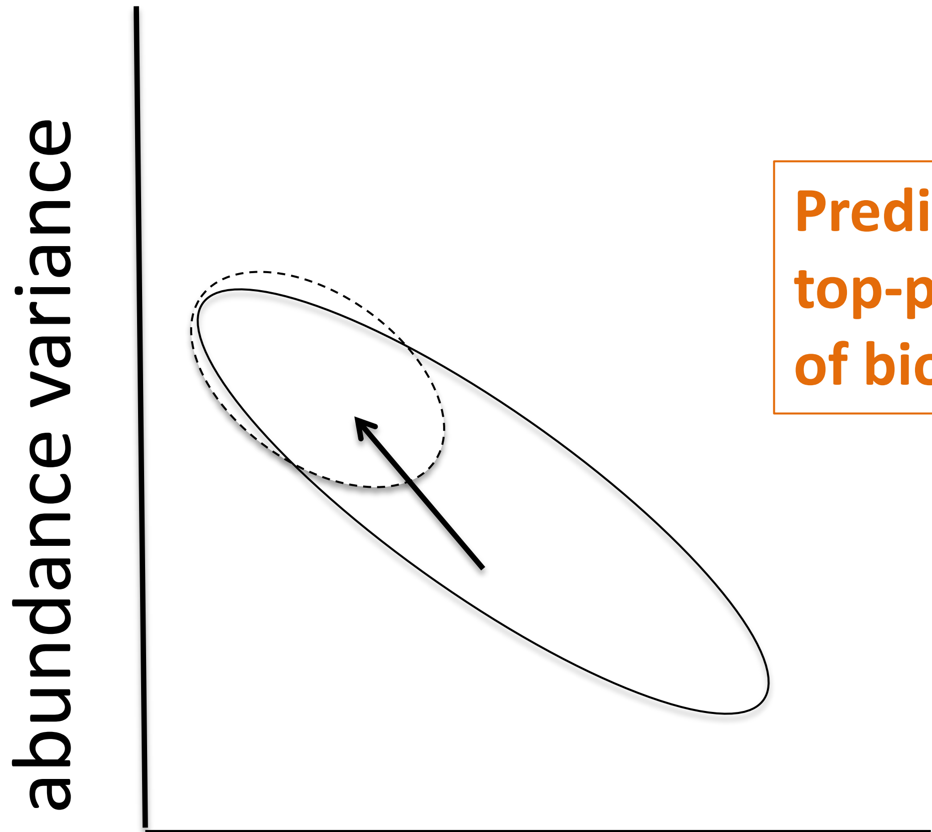
increased resilience (return speed) and stability when:

- **prey closer to their own size**
- **have wider diet breadths (generalists)**
- **larger maturation size, asymptotic size**
- **weak links**
- **trait diversity**
- **connectivity & coupling**

MODELS:
Food web models
Size spectrum models

Law et al. 2009 Ecology, Blanchard et al 2011 Theor Ecol, Plank et al. 2011 Theor Ecol, Zhang et al. 2011 Theor Ecol, Rooney & McCann 2004

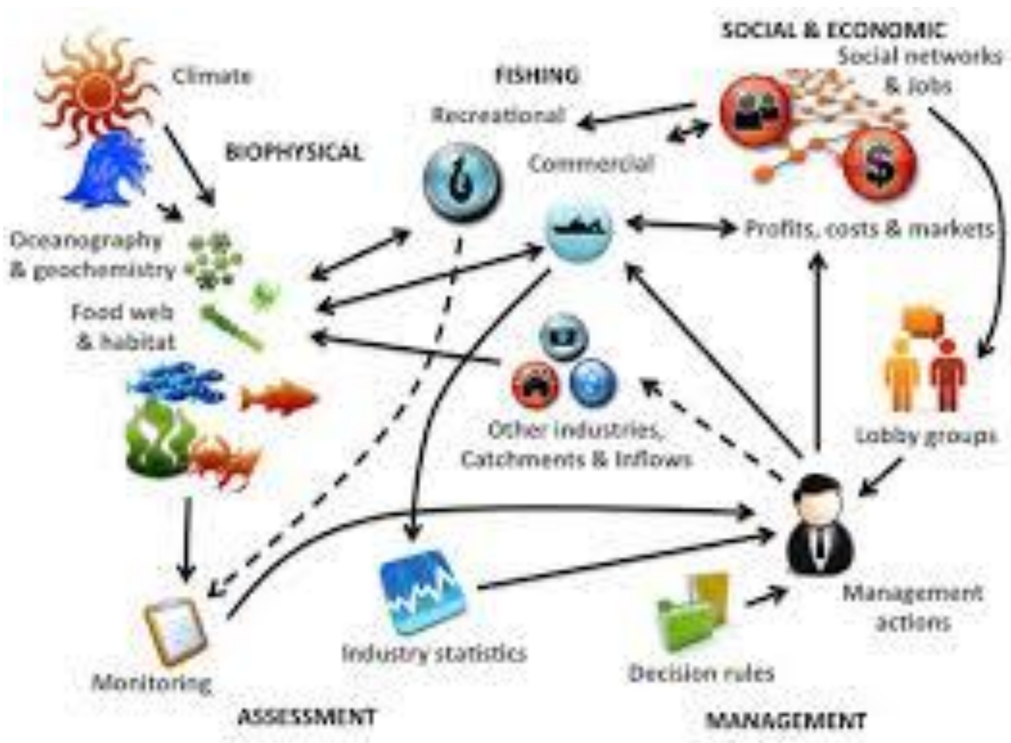
Composition of traits within communities **changes** in response to fishing – resilience consequences



trait
(eg. maximum body size, predator-prey mass ratio, diet breadth)

Prediction: loss of larger, generalist top-predators will increase variance of biomass

Atlantis



Fulton et al.2010 Fish Fish

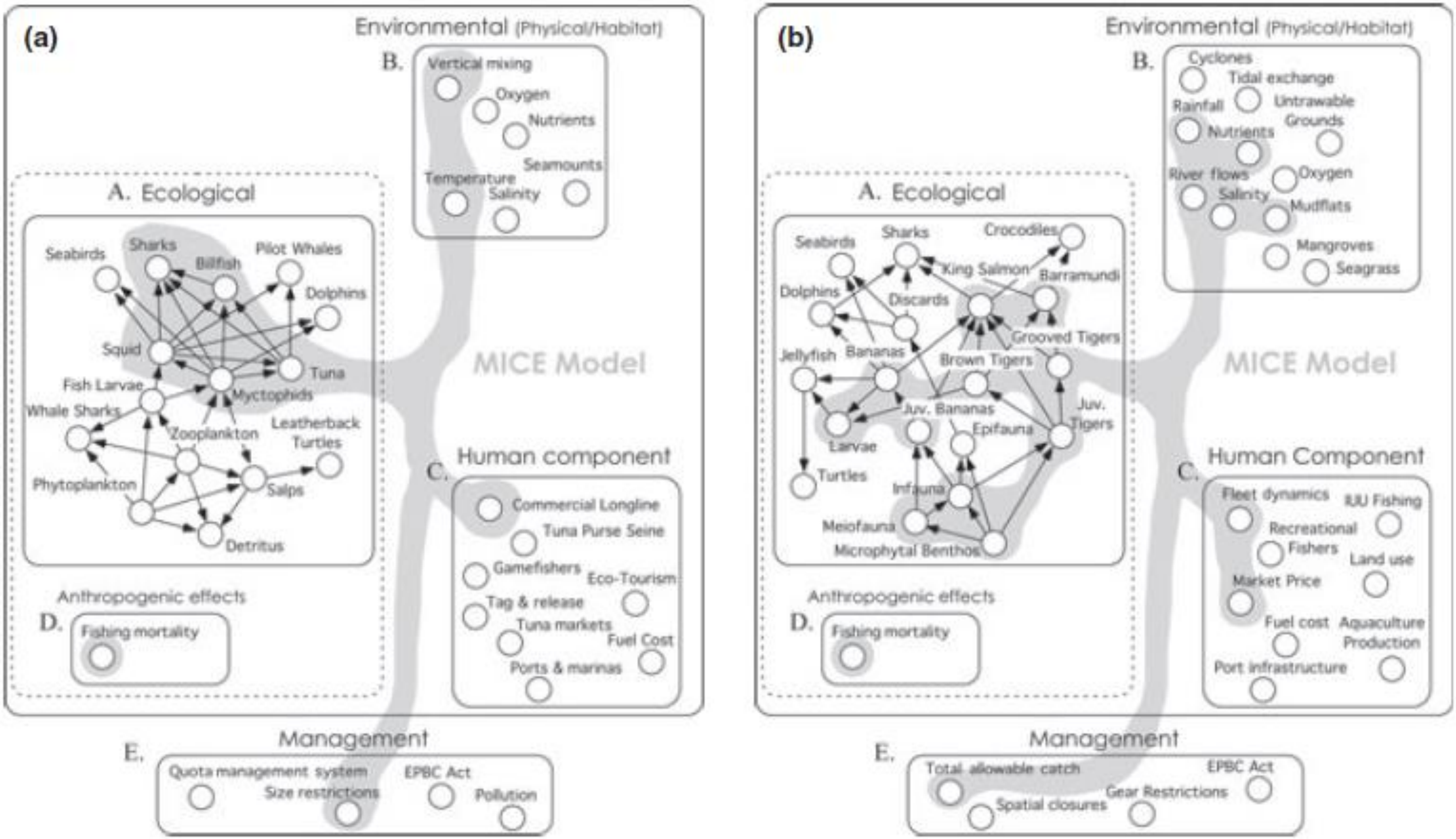
End-to- end models

Physics to humans

Growing application around the world

Simulation test bed for wider range of human activities, different types of management models, indicators etc.

Models of Intermediate Complexity (MICE)



Plaganyi et al 2012

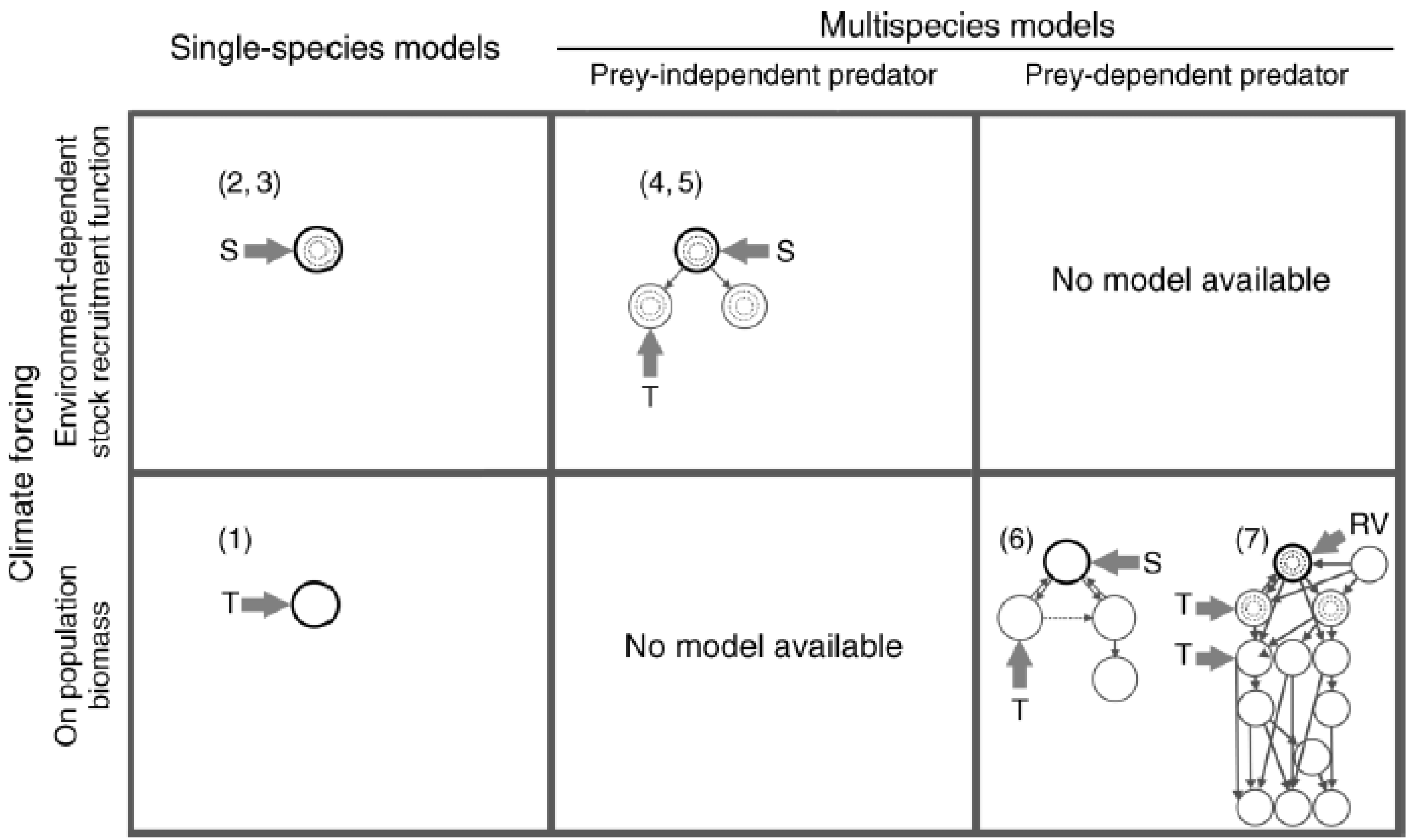
Next steps needed for advancement of ecosystem models:

1) Structural uncertainty (ensembles, model inference)

2) MUCH more rigorous validation and testing of predictions across time/space scales (experimental tests of assumptions, hypotheses, predictions)

3) Improved open integration of whole ecosystem data and many different models

uncertainty across models



Gårdmark et al. 2013 Ecological Applications

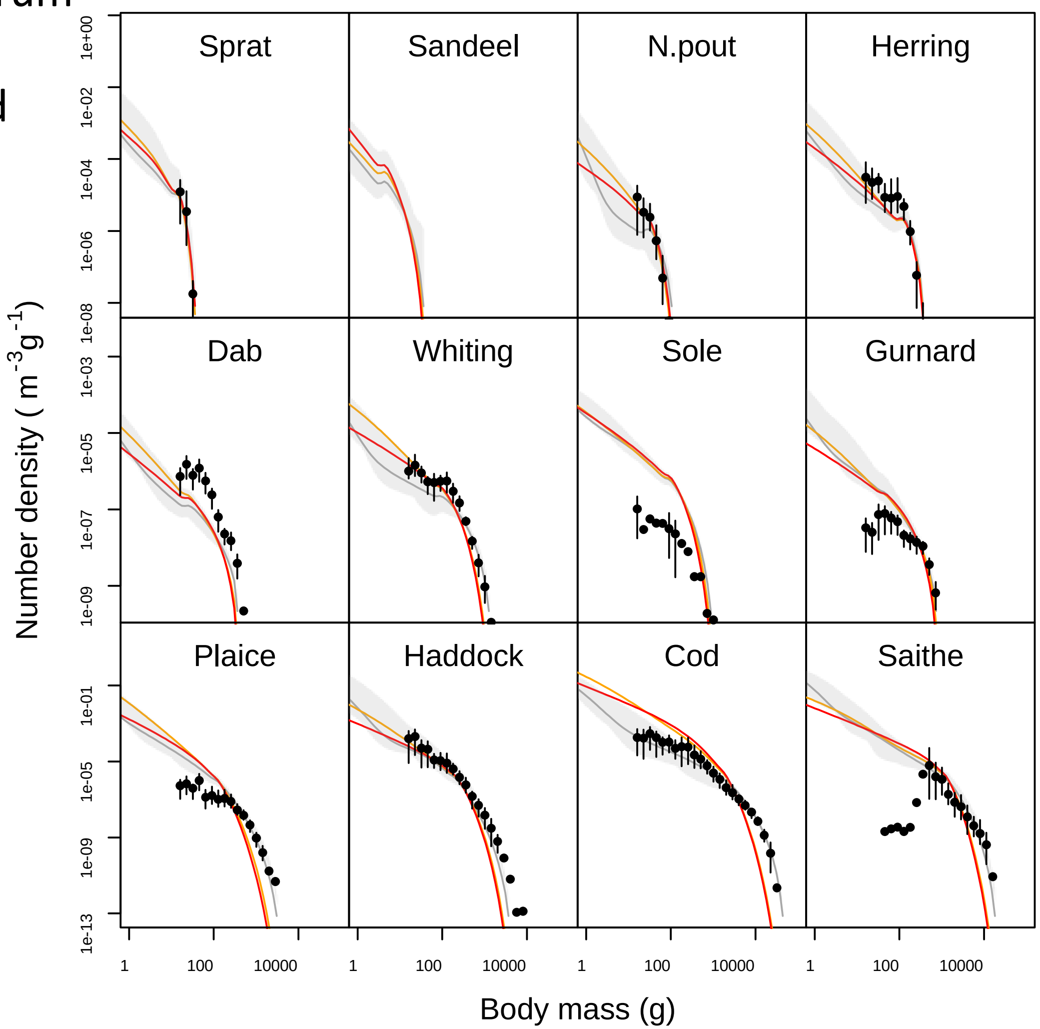
Baltic Sea cod in Ecosystem& Climate Change Context

uncertainty within models

Multispecies Size Spectrum

3 sub-models calibrated to time-averaged data and cross validated

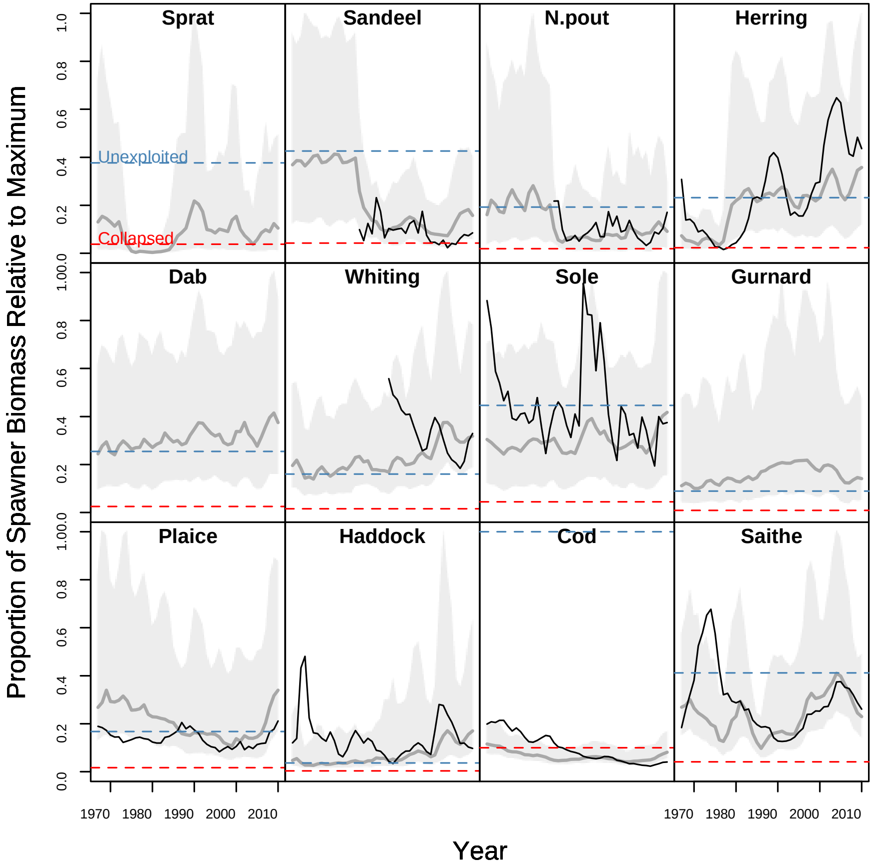
1. Full feedback
2. Fixed growth
3. Fixed growth & predation

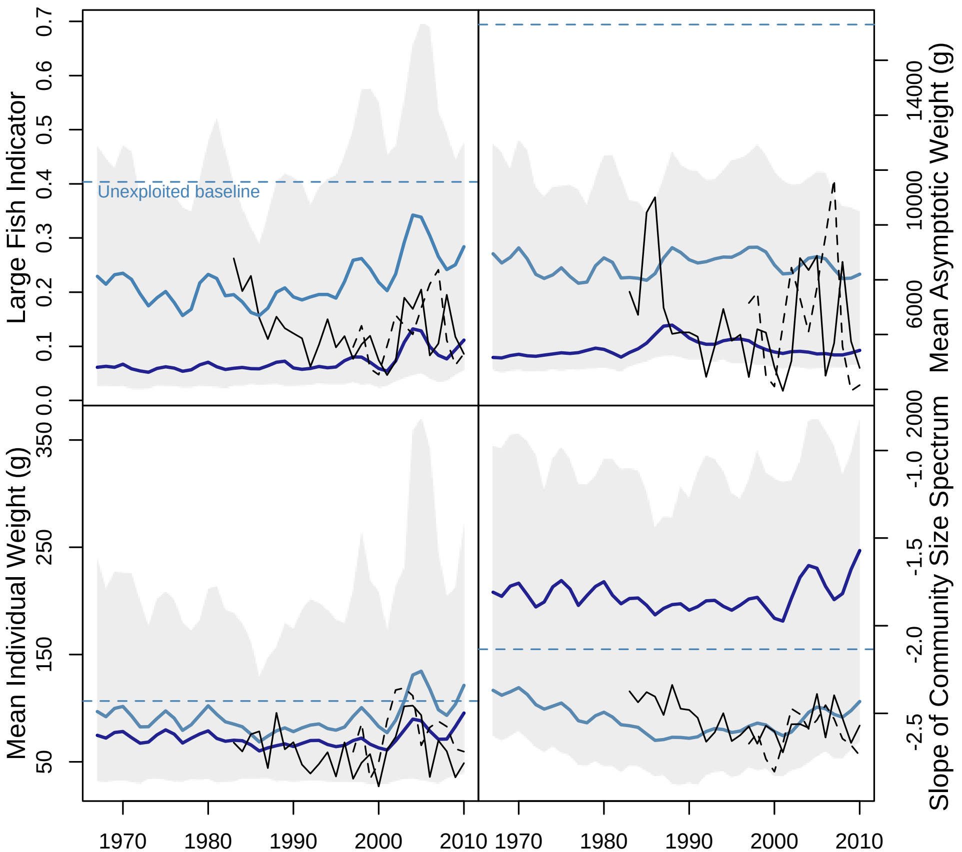


Context: exploring Marine Strategy Framework Directive indicators & targets

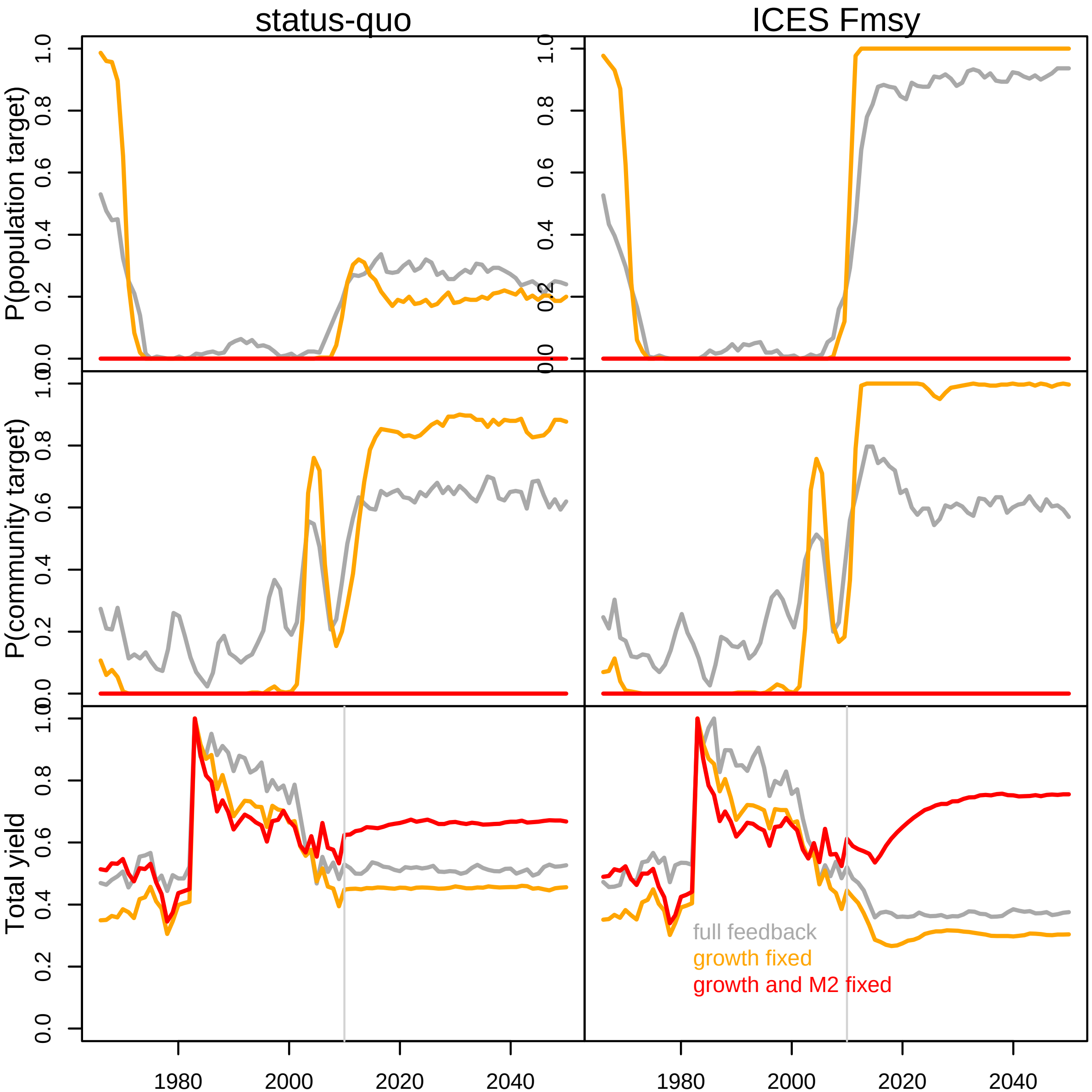
Blanchard, Andersen, Scott, Hintzen, Piet & Jennings

Use each model to assess population and community baselines and change under past time-varying fishing (forcing)





Set indicator targets and evaluate probability under single-species management scenarios



[5 – wealth of fisheries data more active use]

We need to adapt & evolve models (our thinking)

data ⇄ theory

BIG [OPEN] DATA & MODEL SYNTHESIS

transparency
repeatability

http://ropensci.org/

British Ecological Society –
Macroecology & Computational Ecology Groups
International Meeting in Sheffield last week

RAM Legacy, ICES Data Centre, FLR,
NCEAS working groups

Some closing thoughts

Diversity of approaches is a good thing – bring on ensembles!

Ecoinformatic tools & ALL available data - whole ecosystem data analysis

Improved methods fitting models to data (Maximum Likelihood, Bayesian) – learn or collaborate

More rigorous testing and cross validation within and across models across scales – evolve the tools!

The next phase shift:
population -> community/ecosystem -> <u>macroecology</u>

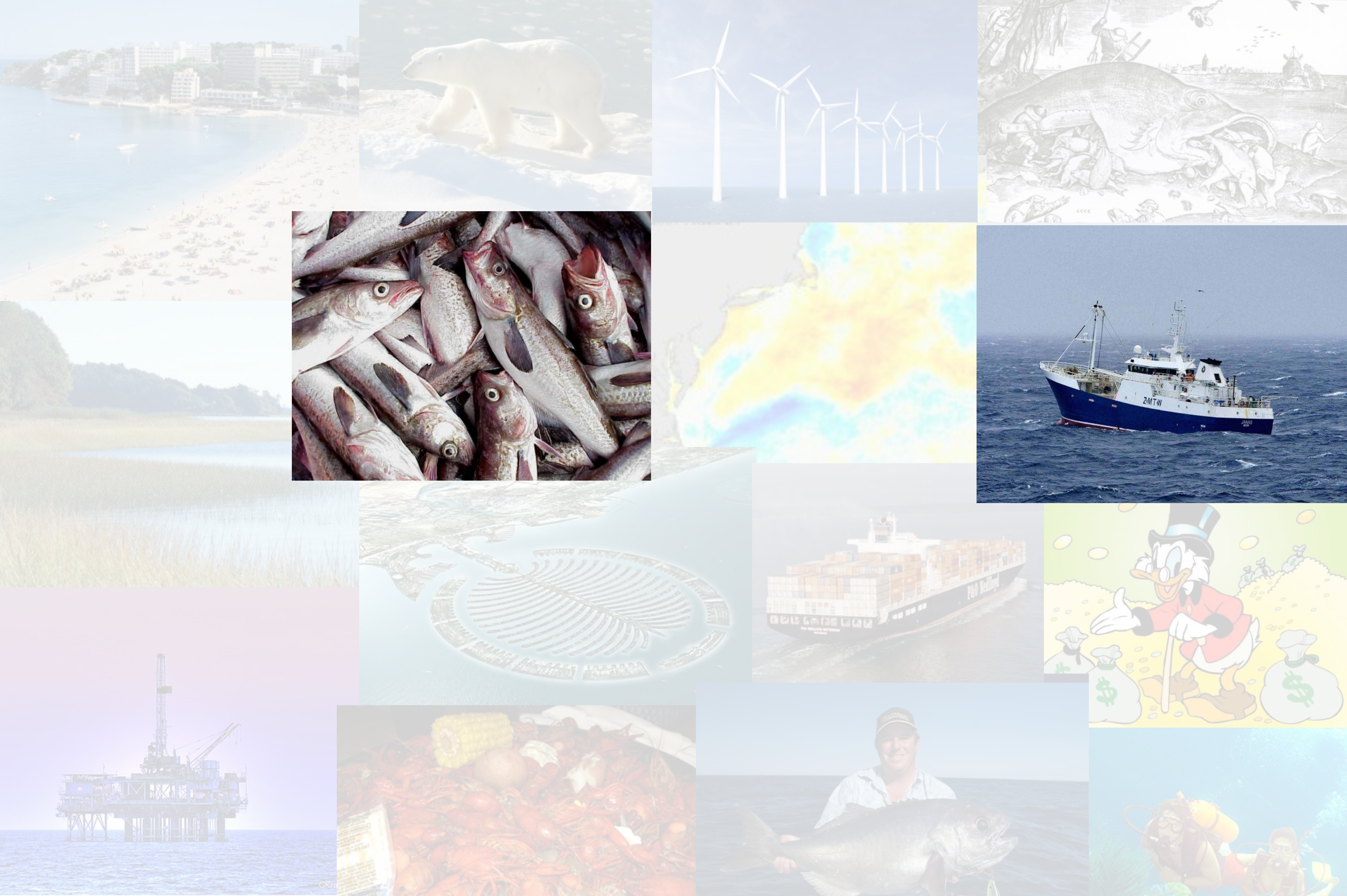
Comparing single-species and ecological indicator-based assessments: practical approaches for implementing ecosystem-based fisheries management

Gavin Fay1, Scott Large[1], Jason Link[1], Robert Gamble[2]
[1]Office of the Assistant Administrator
[2]Northeast Fisheries Science Center

gavin.fay@noaa.gov

World Conference for Stock Assessment Methods, 17-19 July 2013

Ecosystem Based Fisheries Management



Ecosystem Based Fisheries Management

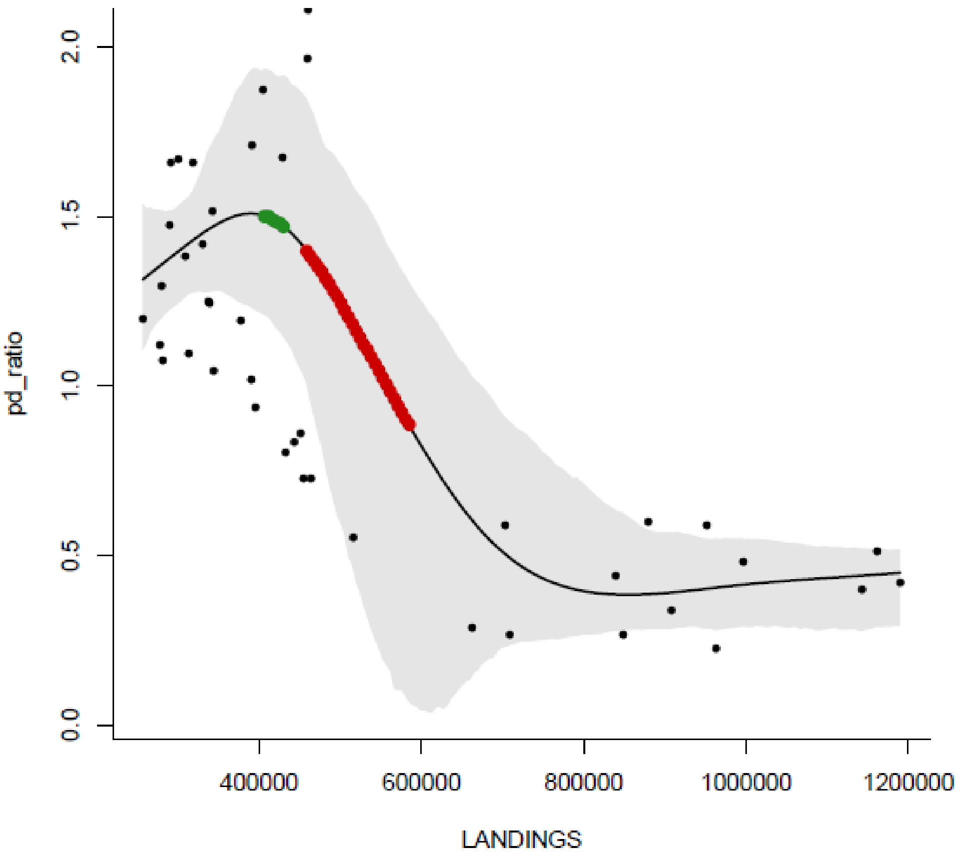
Indicators as tools for Ecosystem Based Fisheries Management

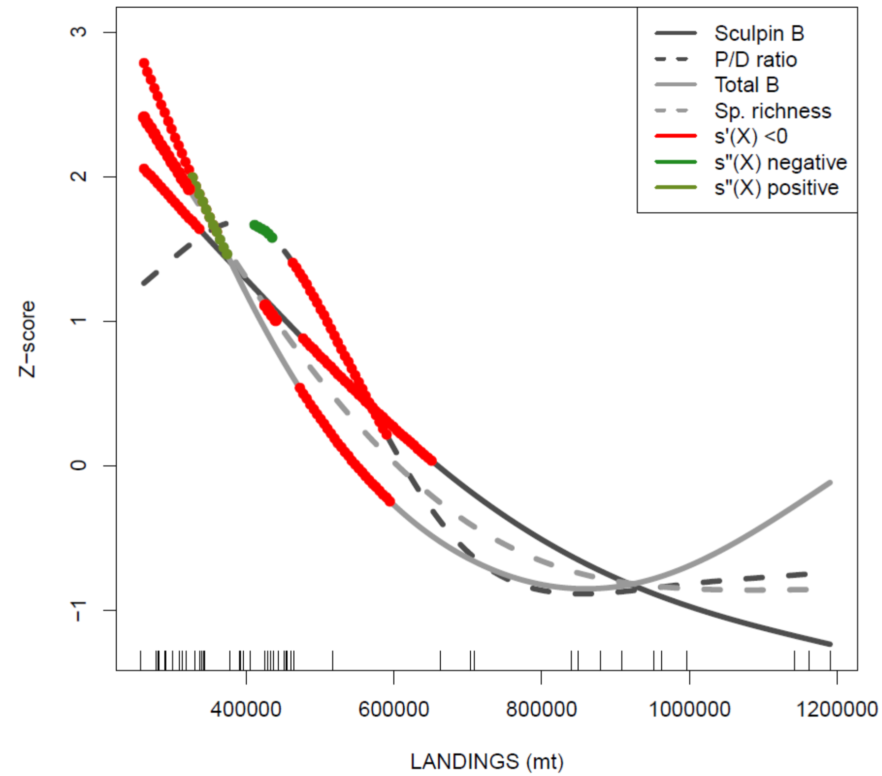
Indicators provide multidisciplinary perspective on ecosystem condition. Many have been suggested.

Threshold values may reveal system change

Challenge: Translate Indicator thresholds into practical fishery control rules and test performance.

Indicators and Reference points
Empirical analysis of Indicator response





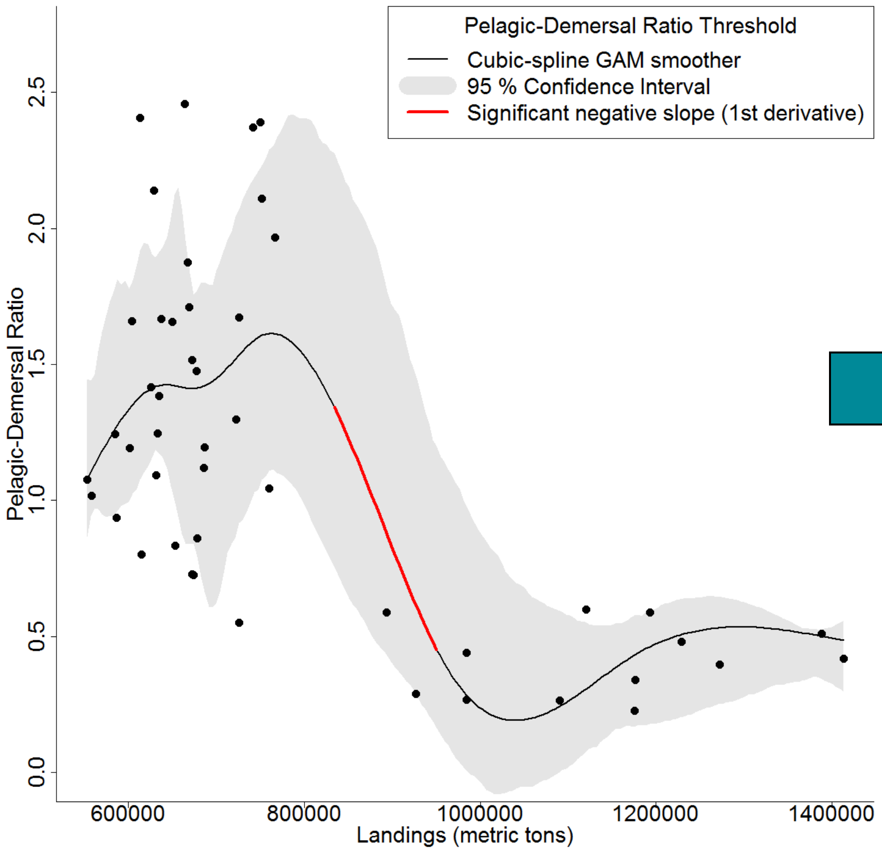
Thresholds in Indicators with respect to system drivers

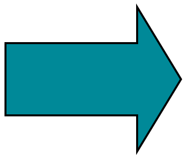
Multiple indicators show change points at similar levels of landings

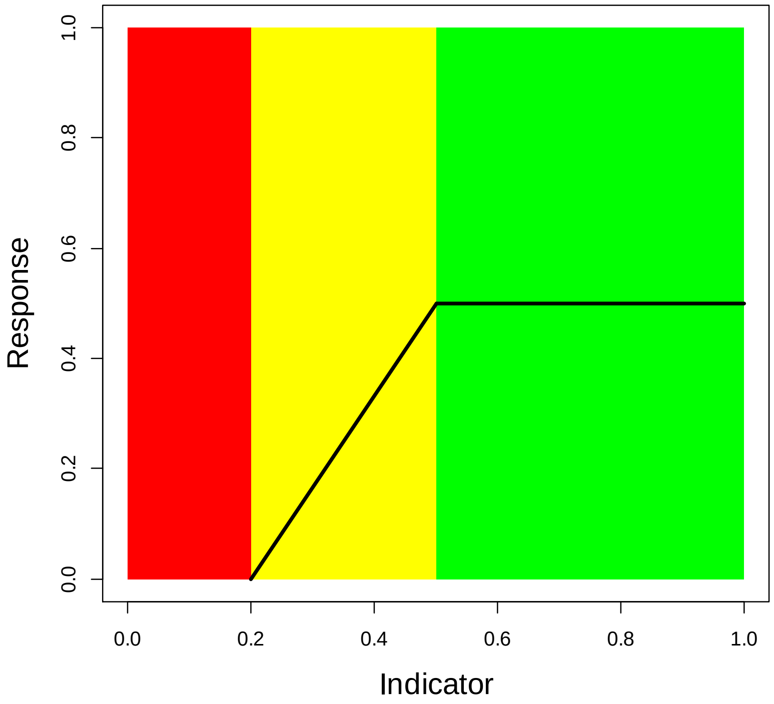
NOAA

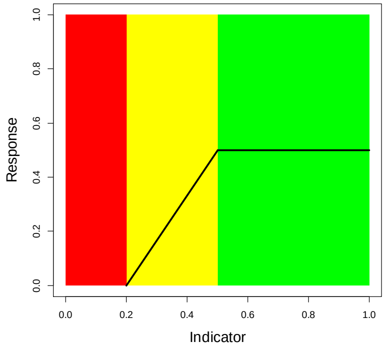
Large, S. I., Fay, G., Friedland, K. D., and Link, J. S. 2013. Defining trends and thresholds in responses of ecological indicators to fishing and environmental pressures. – ICES Journal of Marine Science, 70: 755–767.

Can we translate thresholds in indicators to decision criteria for fisheries control rules?

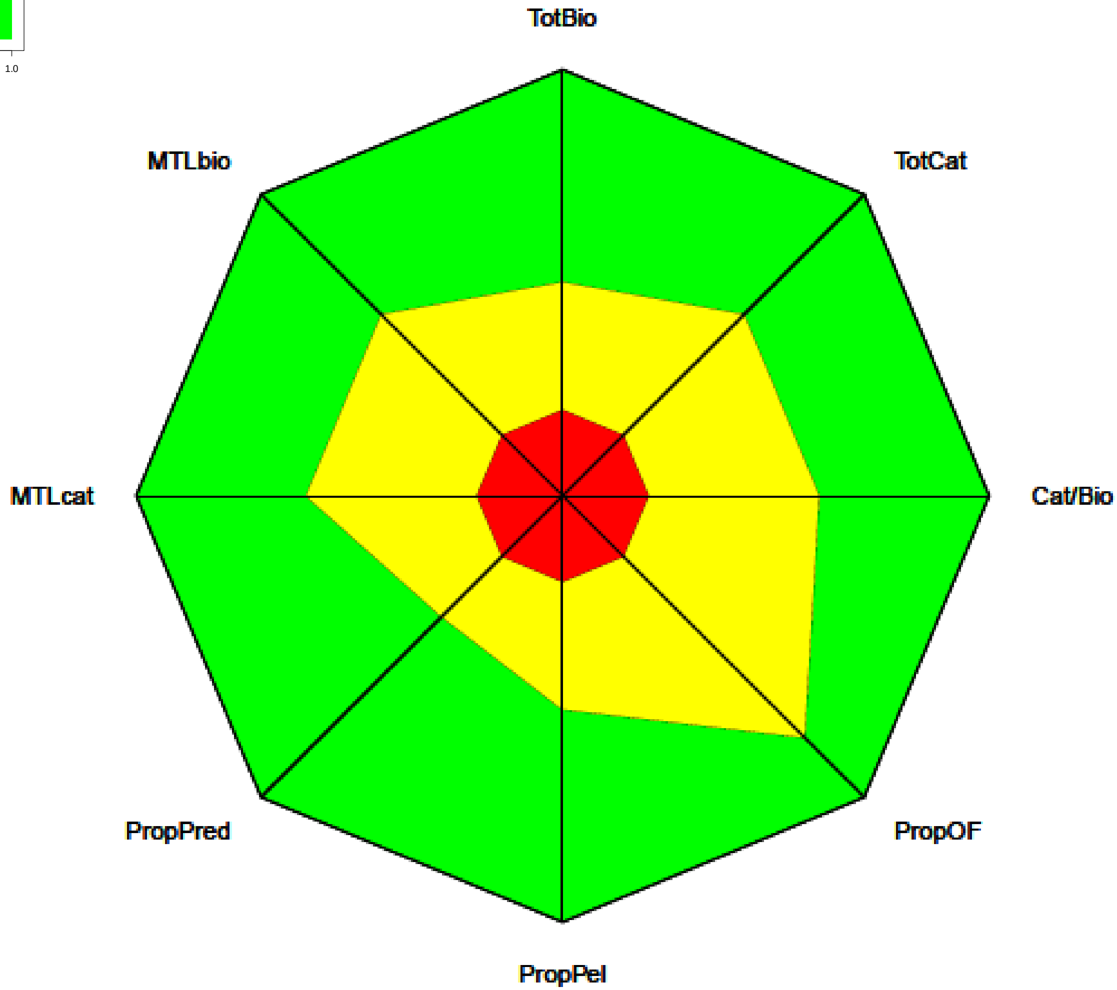


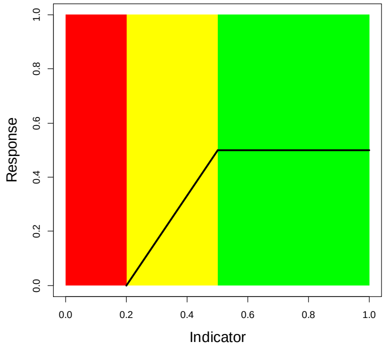




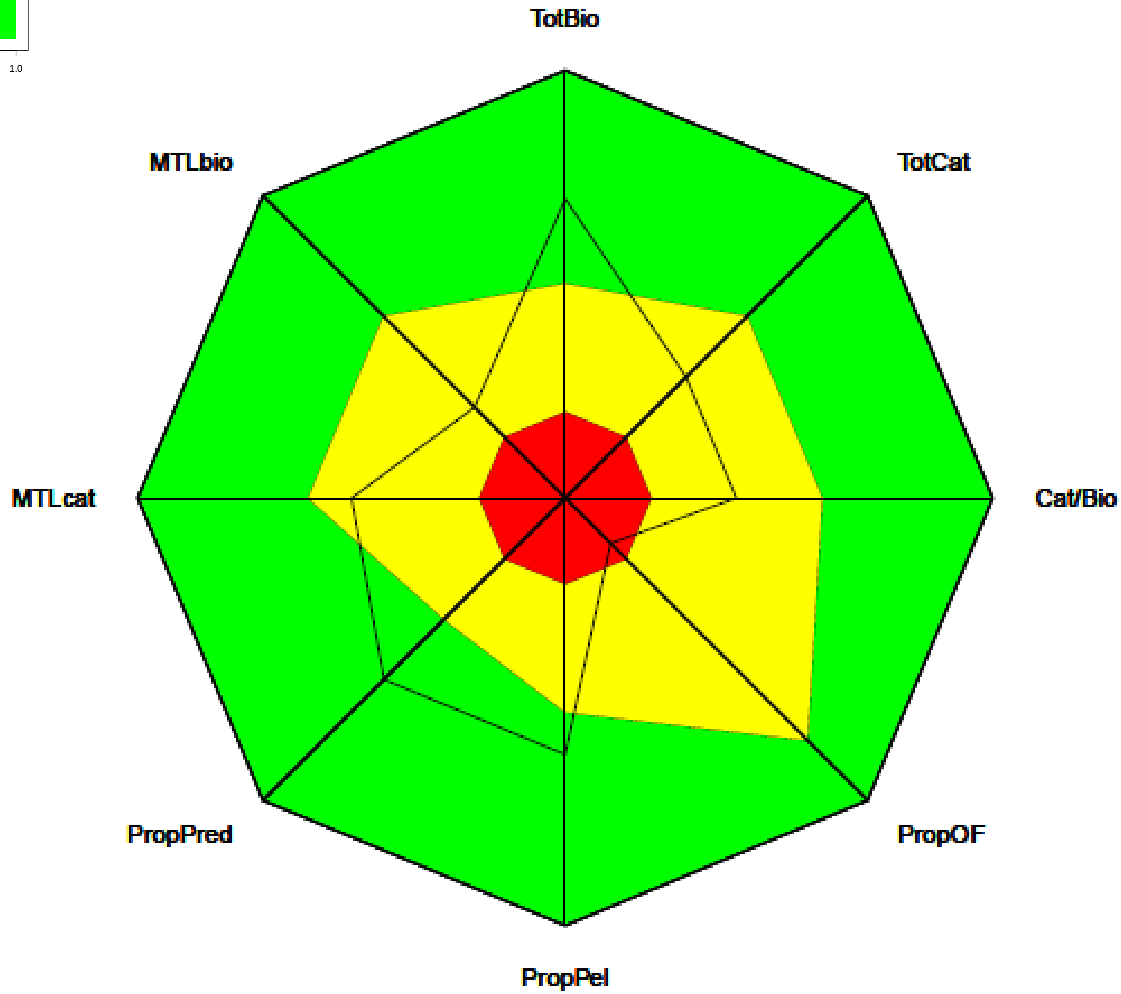


Indicator-based control rule

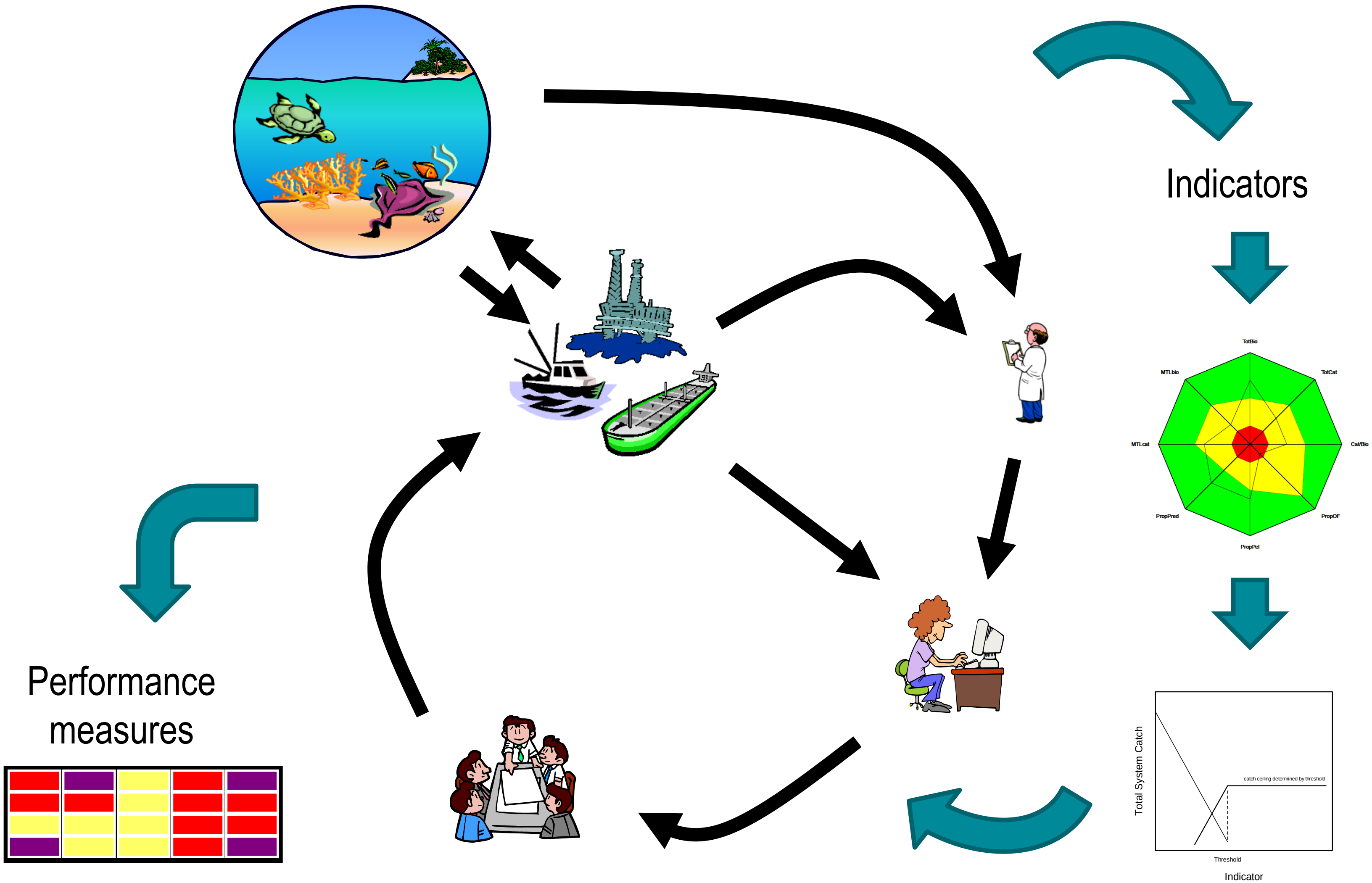




Indicator-based control rule



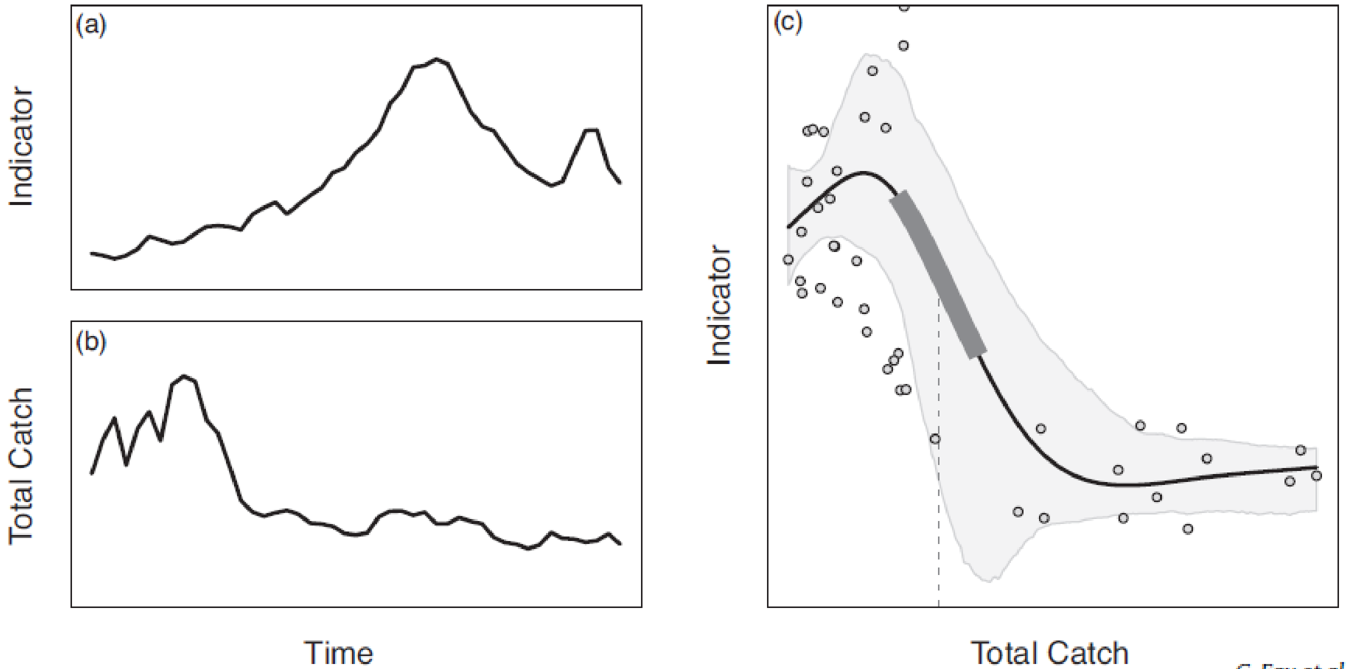
Testing Indicator based control rules using simulation methods (e.g. MSE)



Redrawn with permission of Beth Fulton

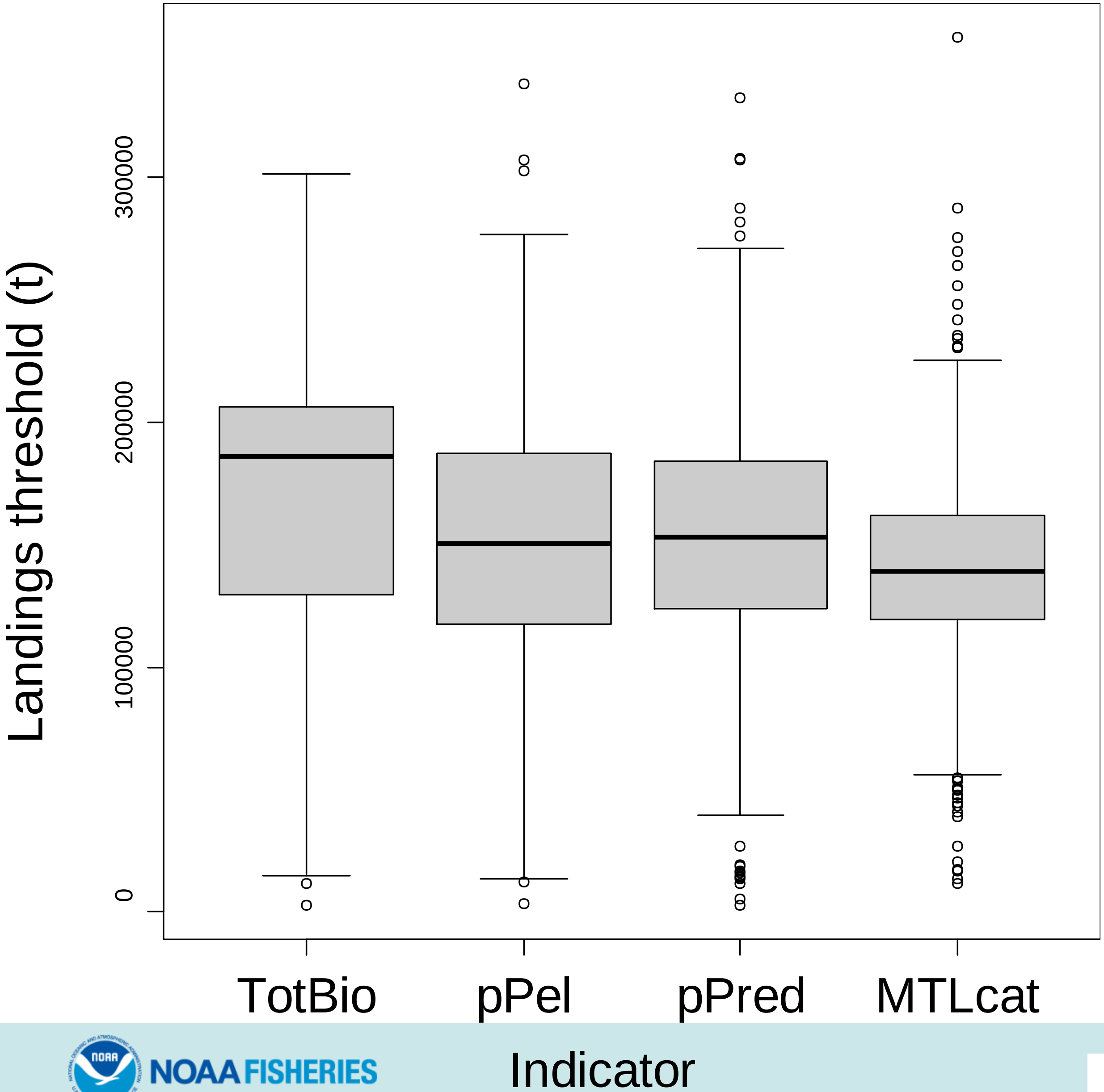
Using thresholds in indicators to set ceilings on total catch

- Time series of indicators from multispecies operating model.
- Values for ceilings obtained from thresholds in indicator/catch relationships.
- Run models with ceilings, calculate performance metrics.



G. Fay et al. / Ecological Modelling 265 (2013) 45–55

Indicator Thresholds from simulation testing



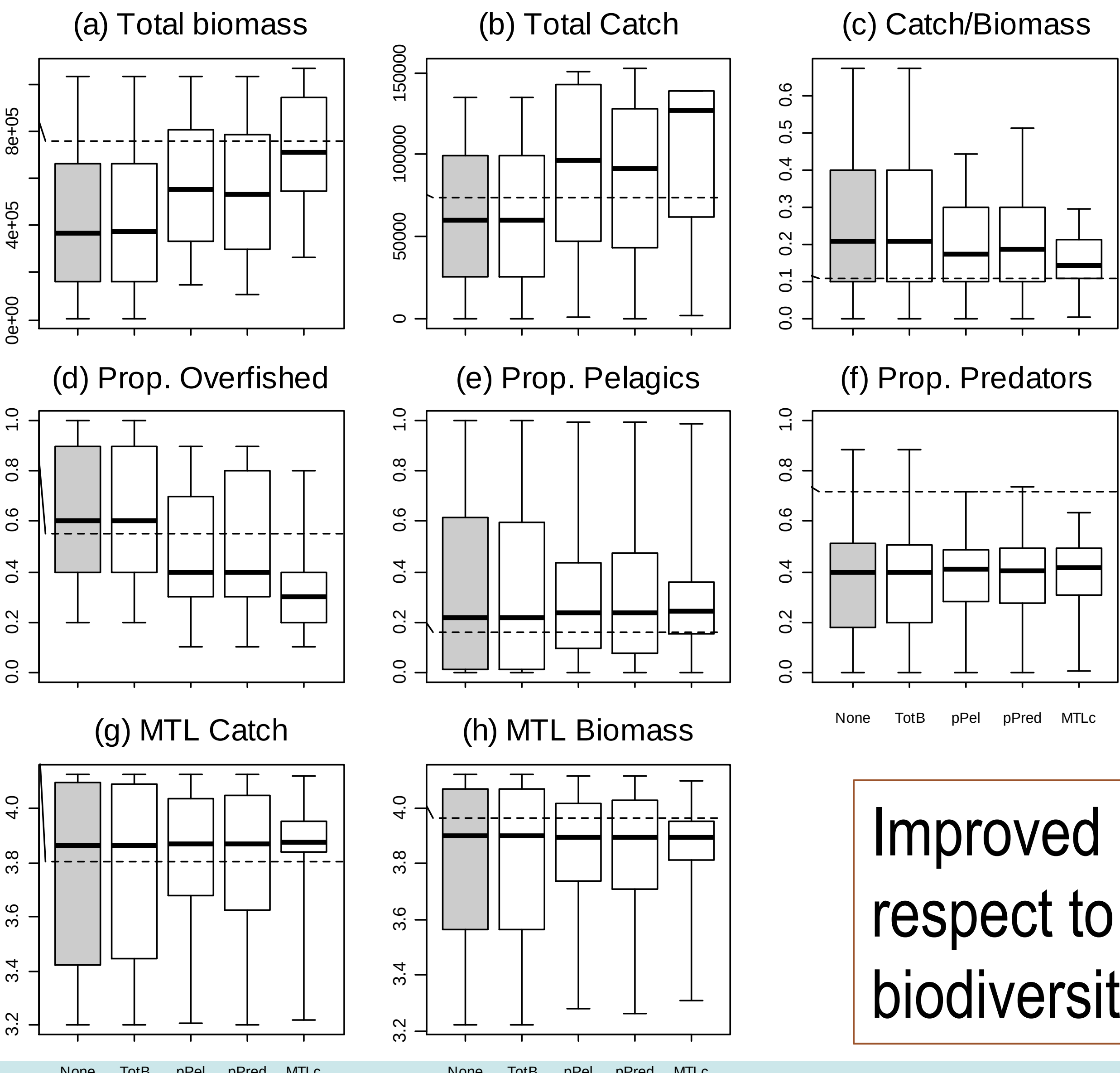
Values depend on exploitation history.

Thresholds for community composition indicators occur at lower levels of total landings.

NOAA FISHERIES

G. Fay et al. / Ecological Modelling 265 (2013) 45–55

Ceilings on system catch based on indicator thresholds



Indicator used to set ceiling

Improved performance with respect to catch and biodiversity objectives.

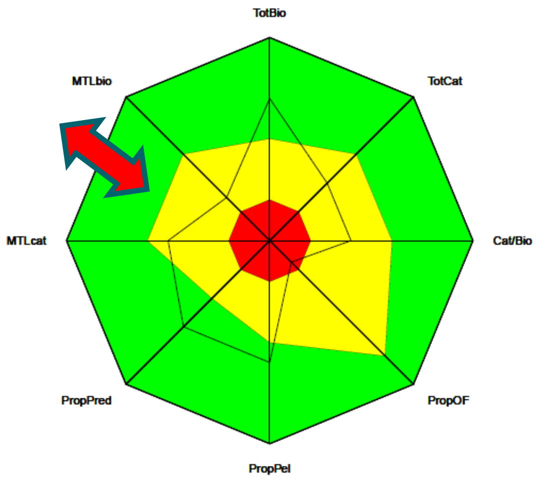
NOAA FISHERIES

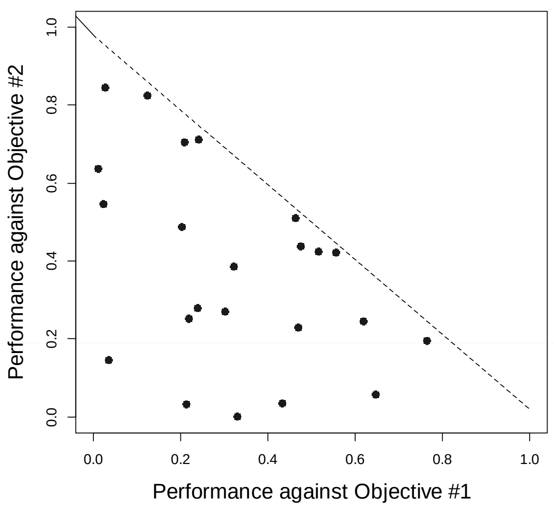
G. Fay et al. / Ecological Modelling 265 (2013) 45–55

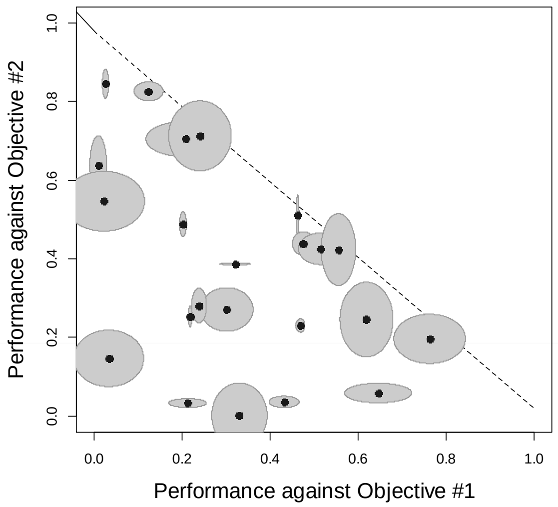
Testing alternative reference points

- How do combinations of indicators and reference points perform with respect to yield and biodiversity?
- Operating Model: Multispecies Production Model
- Estimation Model(s):

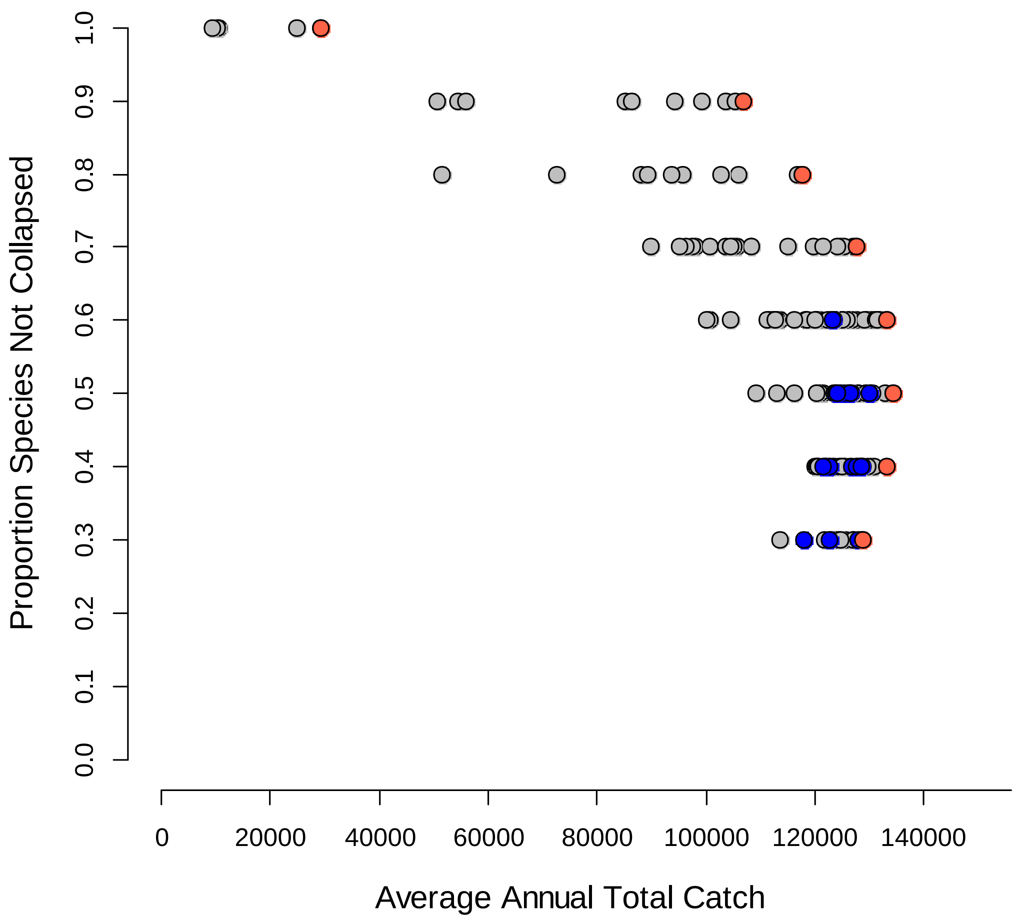
  Single species biomass dynamics, and/or Indicators.



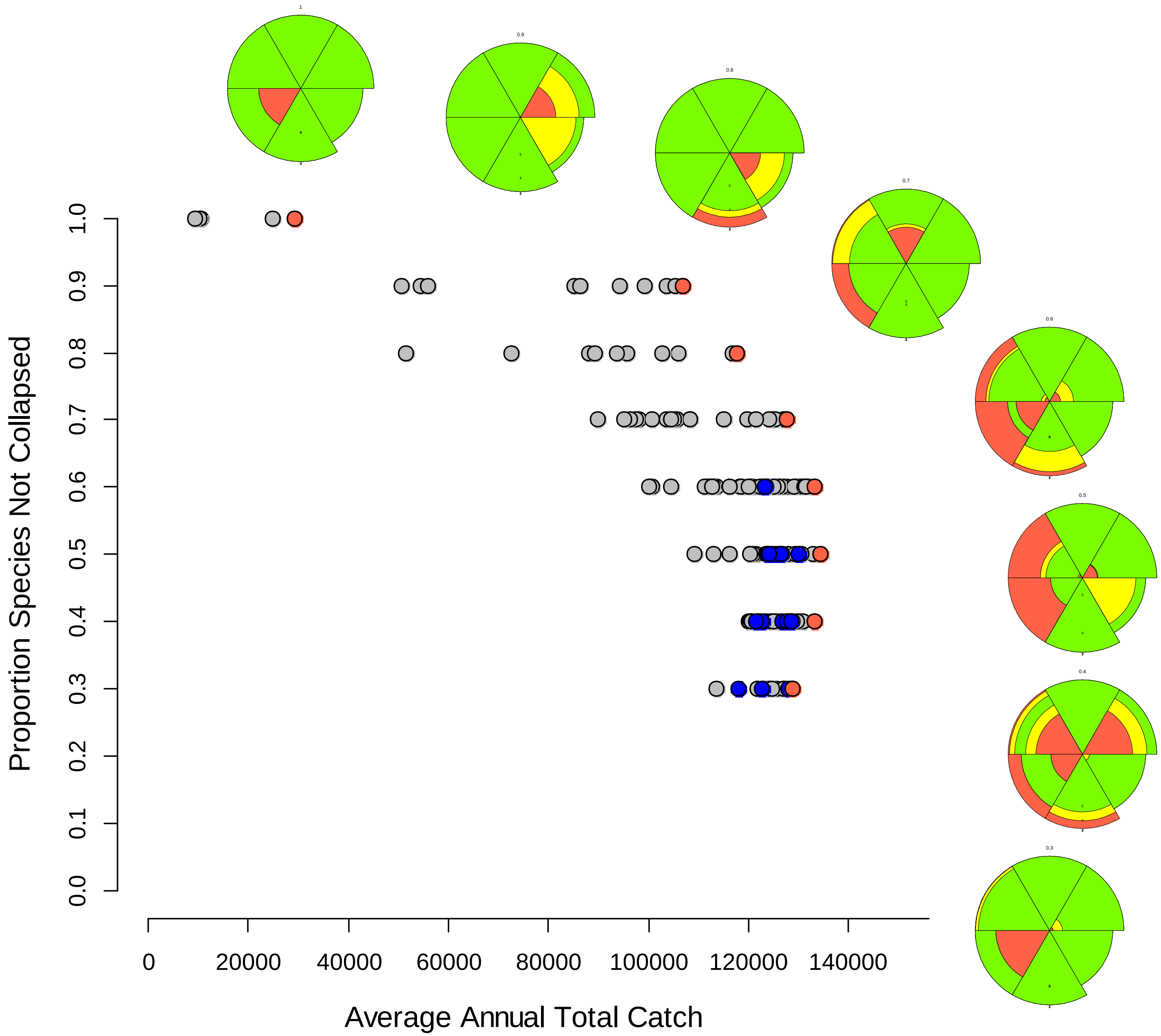




Tradeoffs: Indicator-based control rules



Tradeoffs: Indicator-based control rules



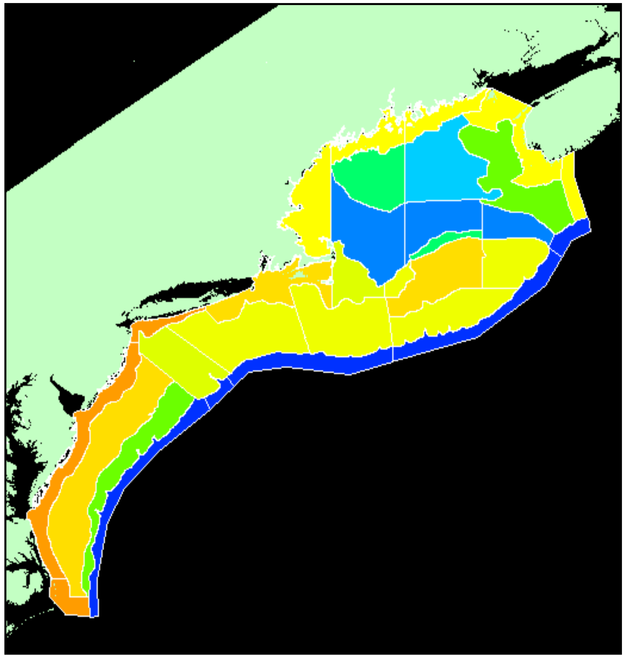
End-to-End System Modelling: Atlantis

Full suite of indicators

(including lower trophic level, climate, and socioeconomic)

Linkages to additional models

(physics, climate, regional economy)



Northeast US application

v1.0 (*Link et al. 2010 PiO*)

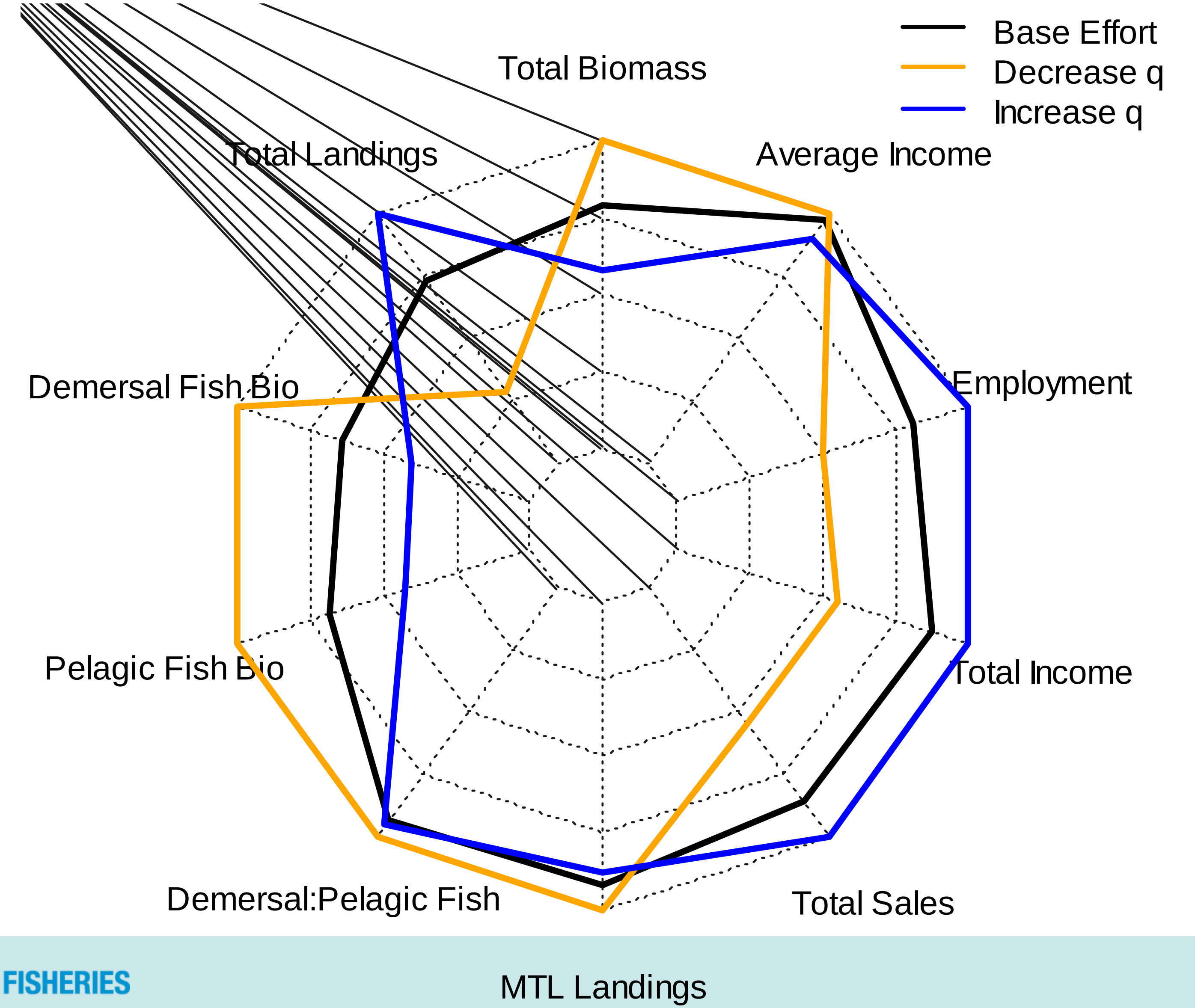
v1.5 (*in development*)

1. Used for Scenario testing
2. Not full MSE (yet)
3. As an operating model

Assessments (and management strategies) can be tested given (very) complicated mechanistic dynamics.

Quantifying economic and conservation tradeoffs:

evaluating fisheries management strategies using multiple criteria



Further work

- Additional methods for assessing indicator response to system drivers and pressures.

- Integrate indicator assessment and control rule into the Atlantis assessment module.

- Run MSE style scenarios with Atlantis as an operating model.

It’s all about the Questions

- Indicator-based assessments can complement advice from single-species models and be integrated into fishery control rules.

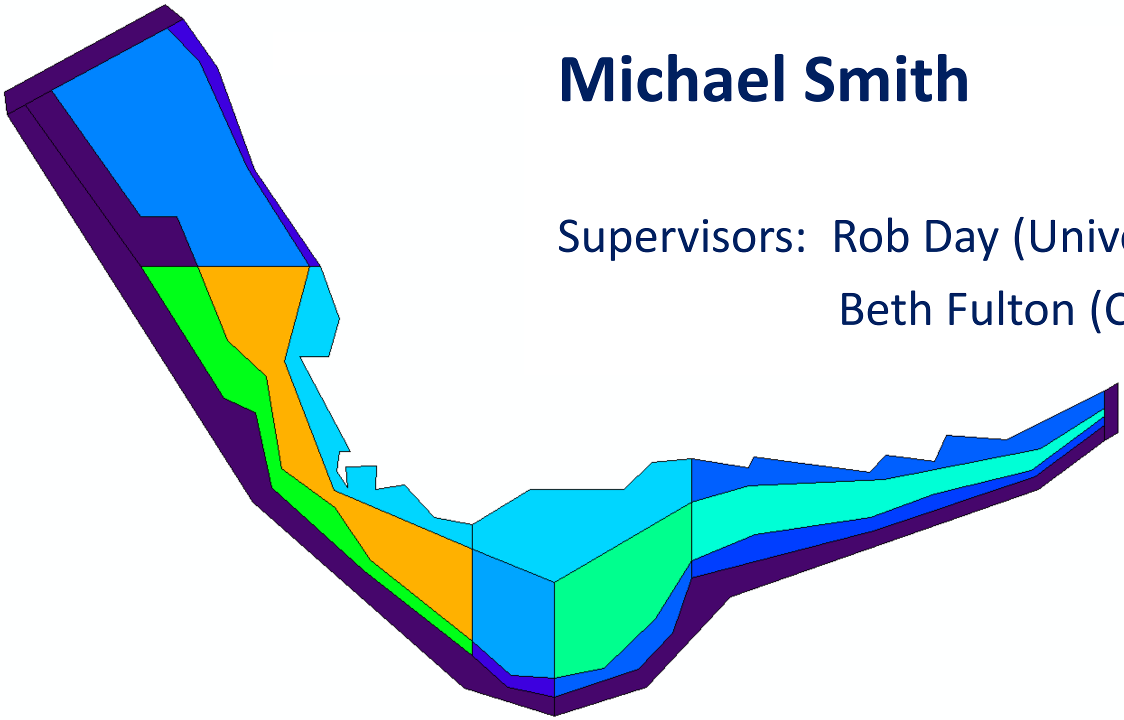
- What do we mean by assessment performance? Implications for management, robustness.

- What is the type and scale of advice required?

Thank you.

gavin.fay@noaa.gov

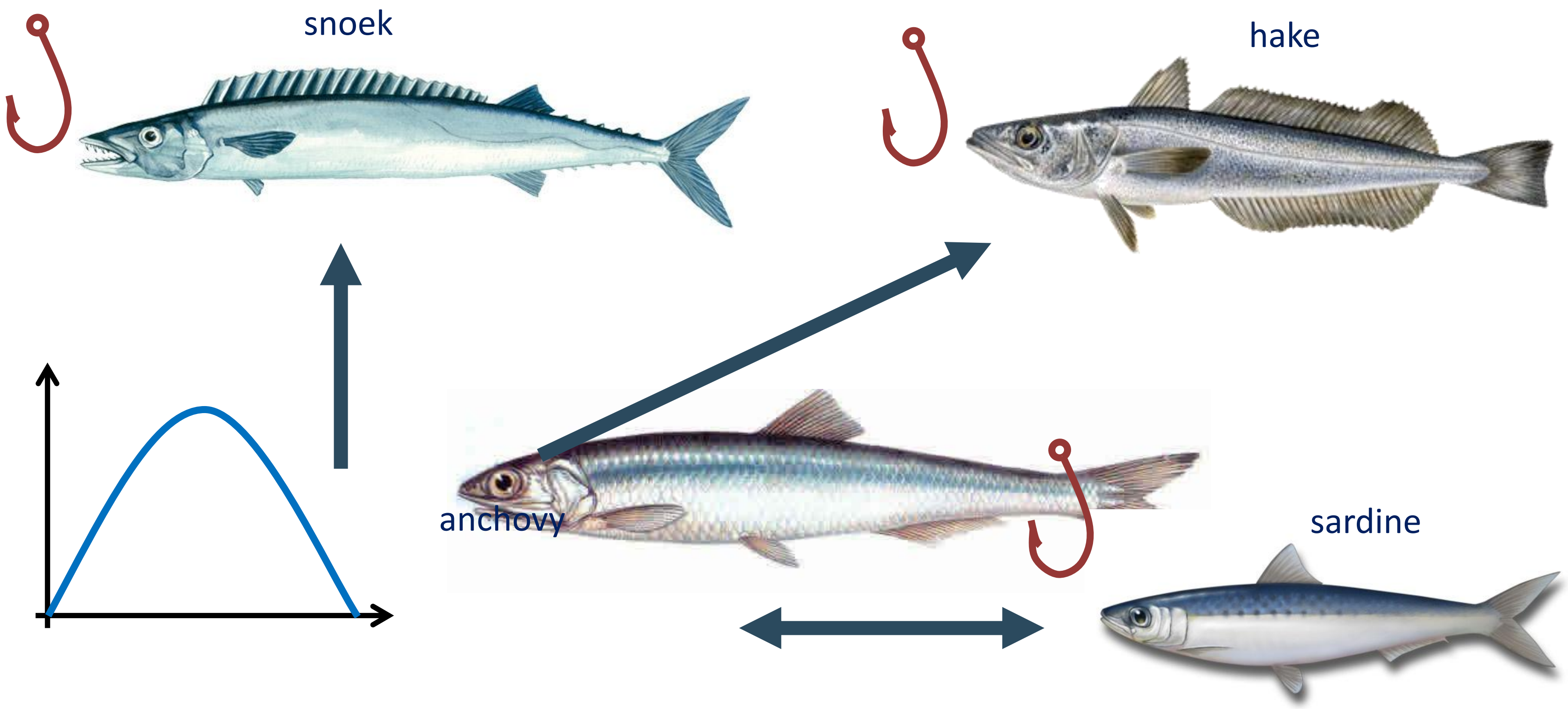
An investigation into fisheries interaction effects using Atlantis

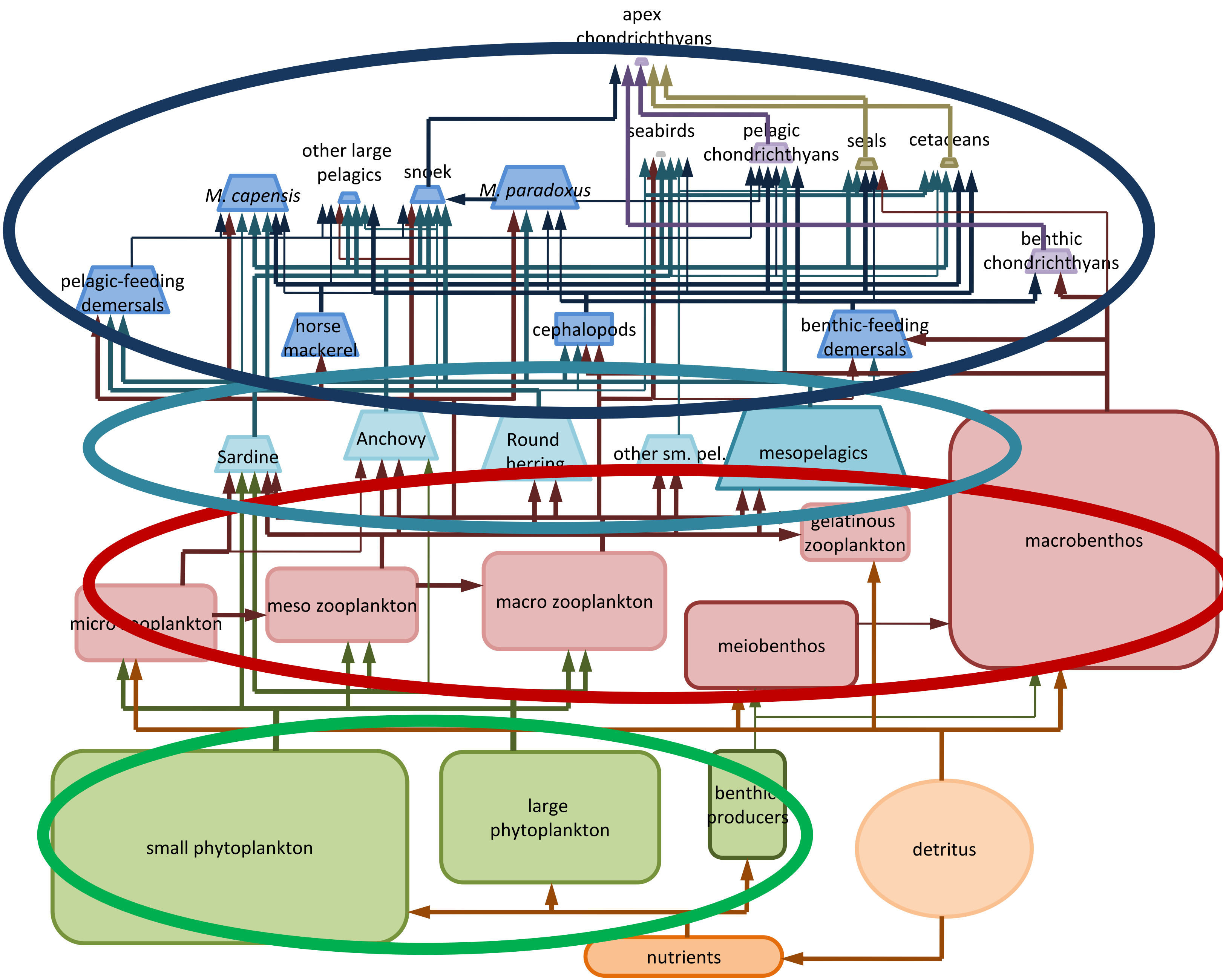


Michael Smith

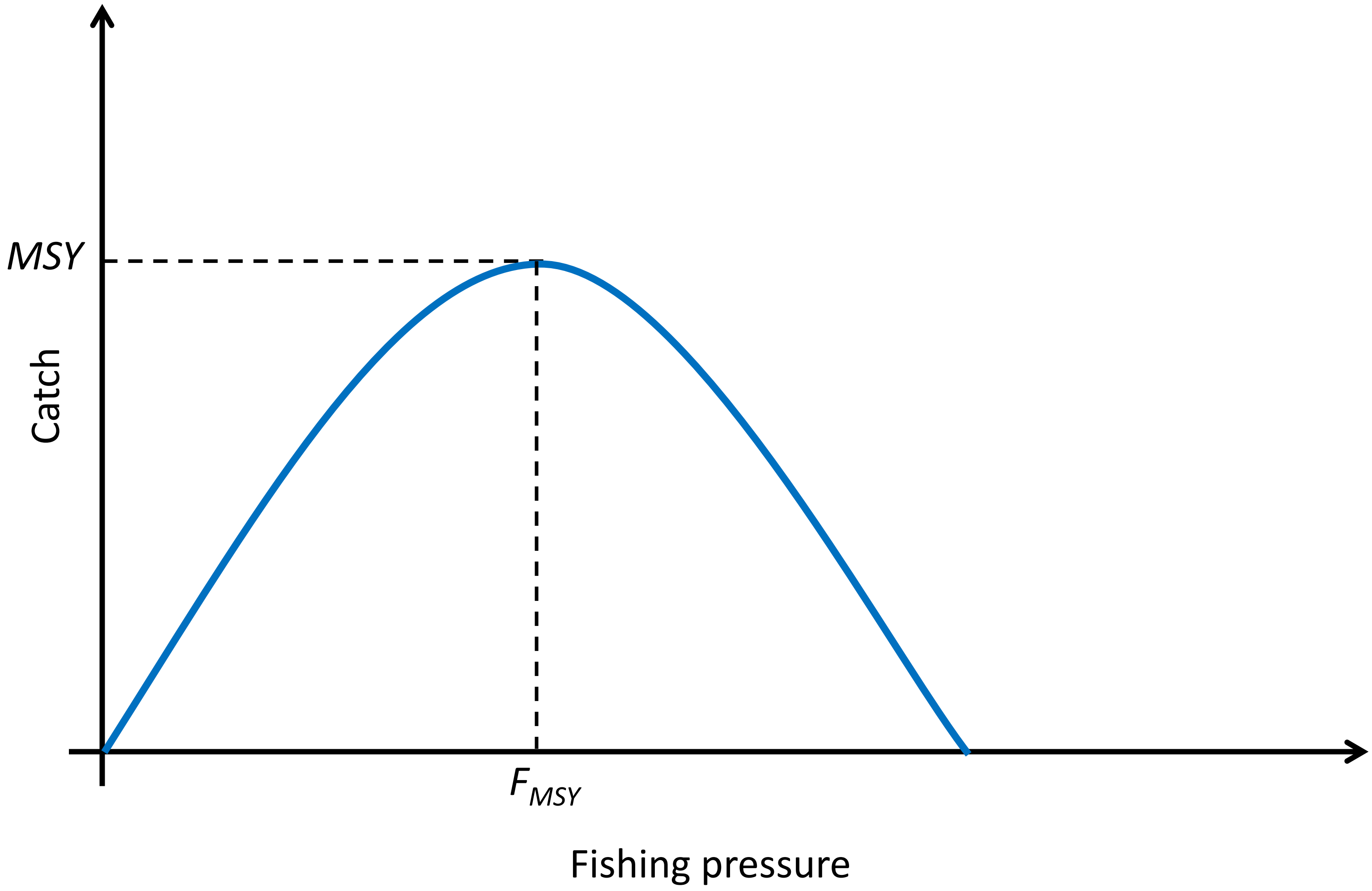
Supervisors: Rob Day (University of Melbourne)
Beth Fulton (CSIRO)

Why model an ecosystem?

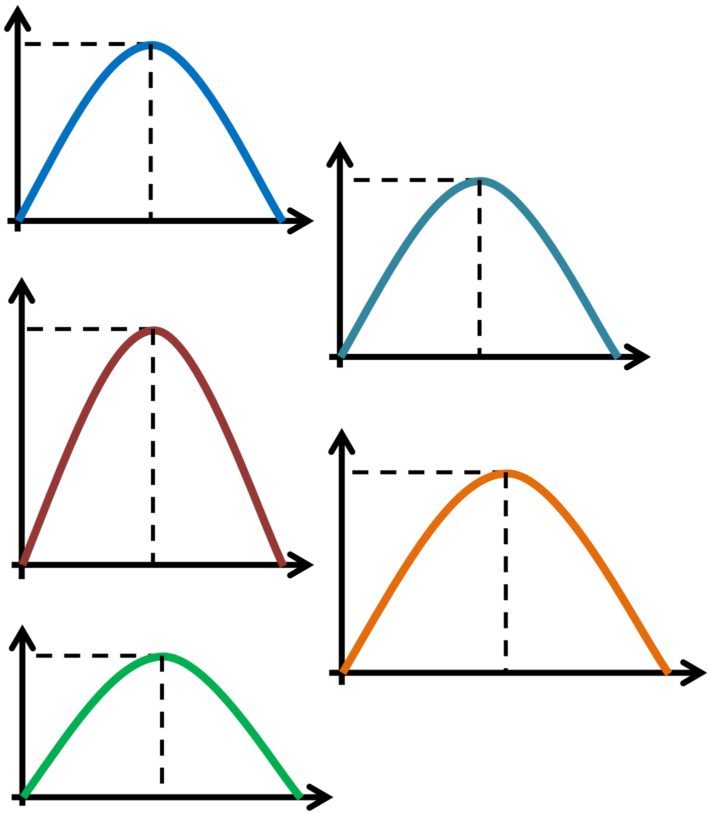



apex chondrichthyans
seabirds
pelagic chondrichthyans
seals
cetaceans
other large pelagics
snoek
M. capensis
M. paradoxus
benthic chondrichthyans
pelagic-feeding demersals
horse mackerel
cephalopods
benthic-feeding demersals
Sardine
Anchovy
Round herring
other sm. pel.
mesopelagics
macrobenthos
gelatinous zooplankton
micro zooplankton
meso zooplankton
macro zooplankton
meiobenthos
small phytoplankton
large phytoplankton
benthic producers
detritus
nutrients

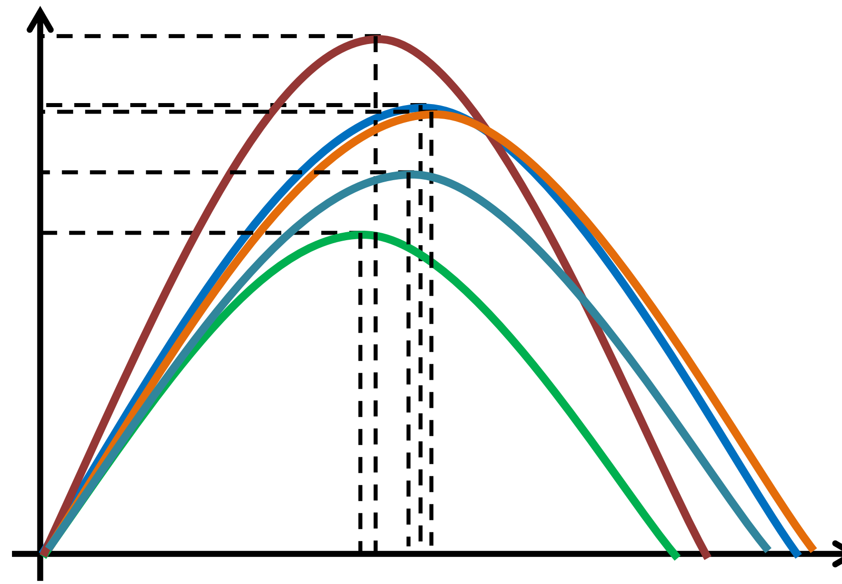
The F_{MSY} experiment



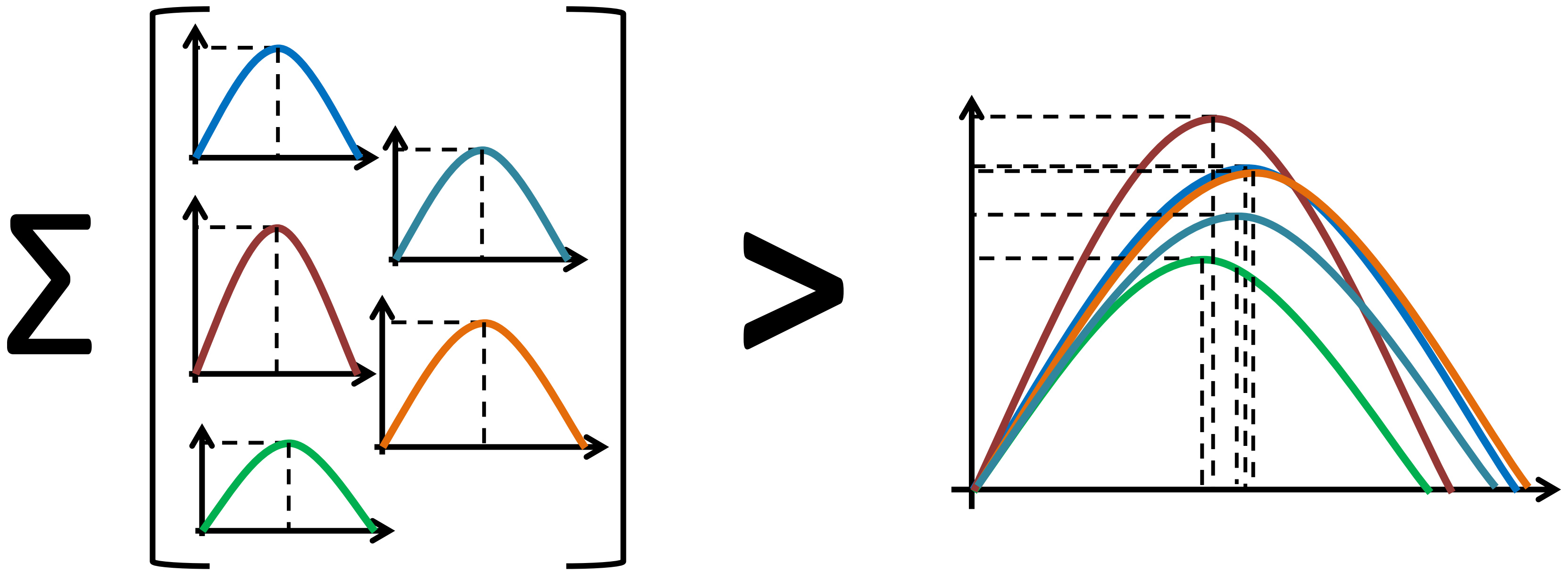
The F_{MSY} experiment



vs.



The F_{MSY} experiment: prediction



Exploring F_{MSY} in Atlantis

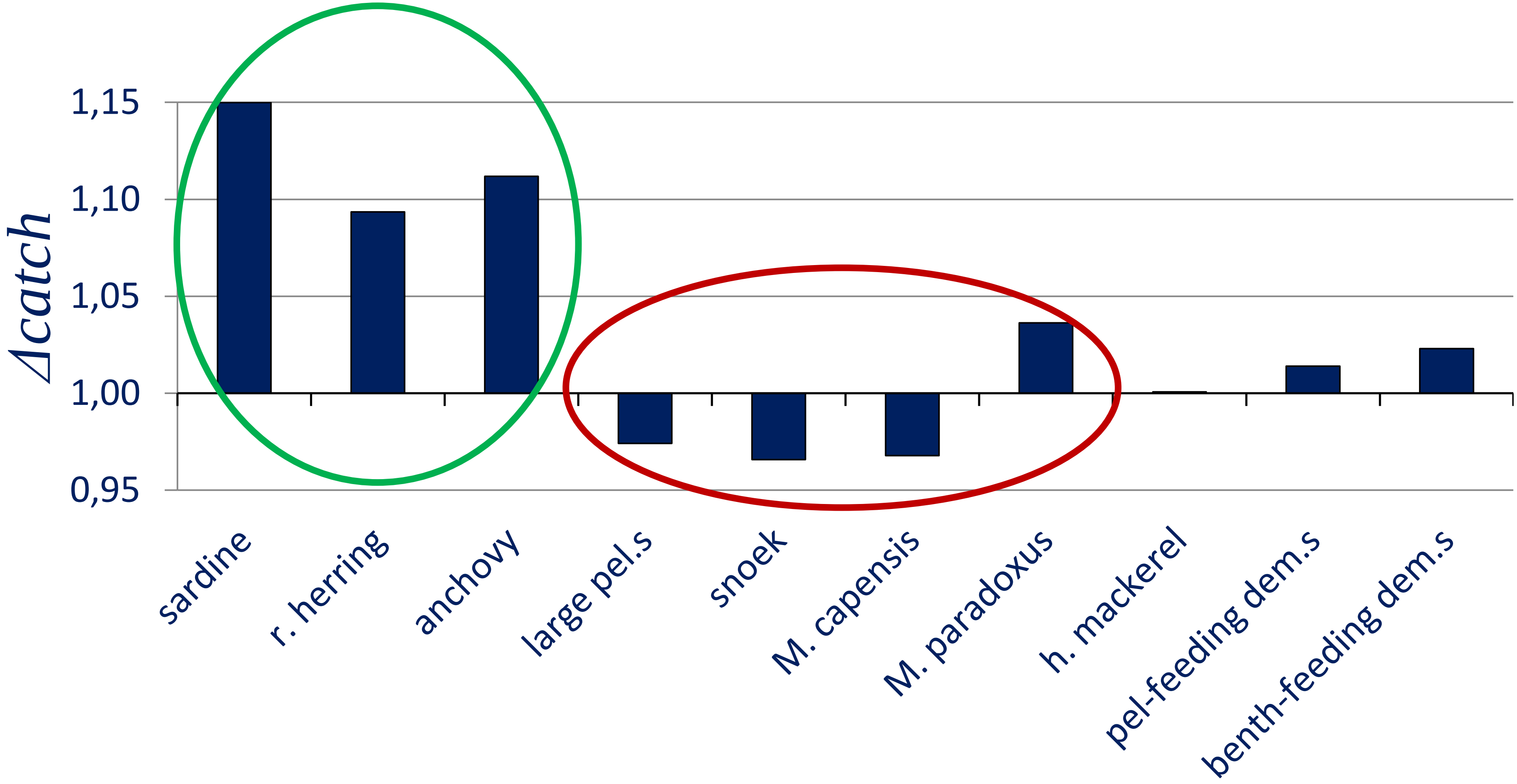
- Prediction:

$$\sum \text{single-spp. MSY} > \text{simultaneous MSY}$$

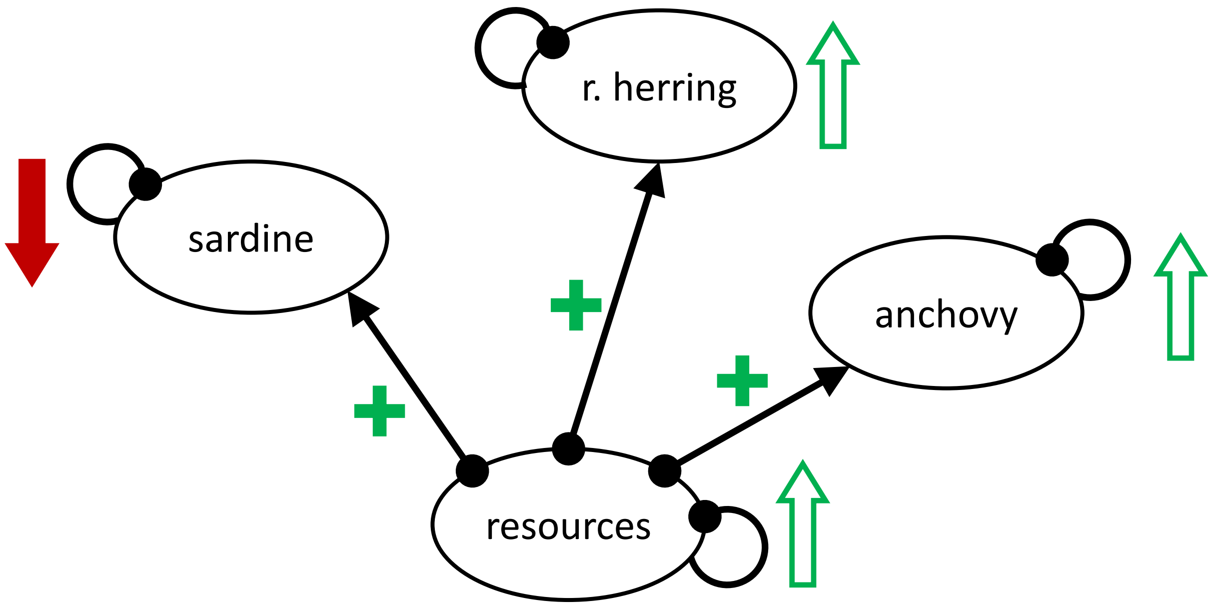
- Our results:

$$\text{simultaneous MSY} > \sum \text{single-spp. MSY}$$

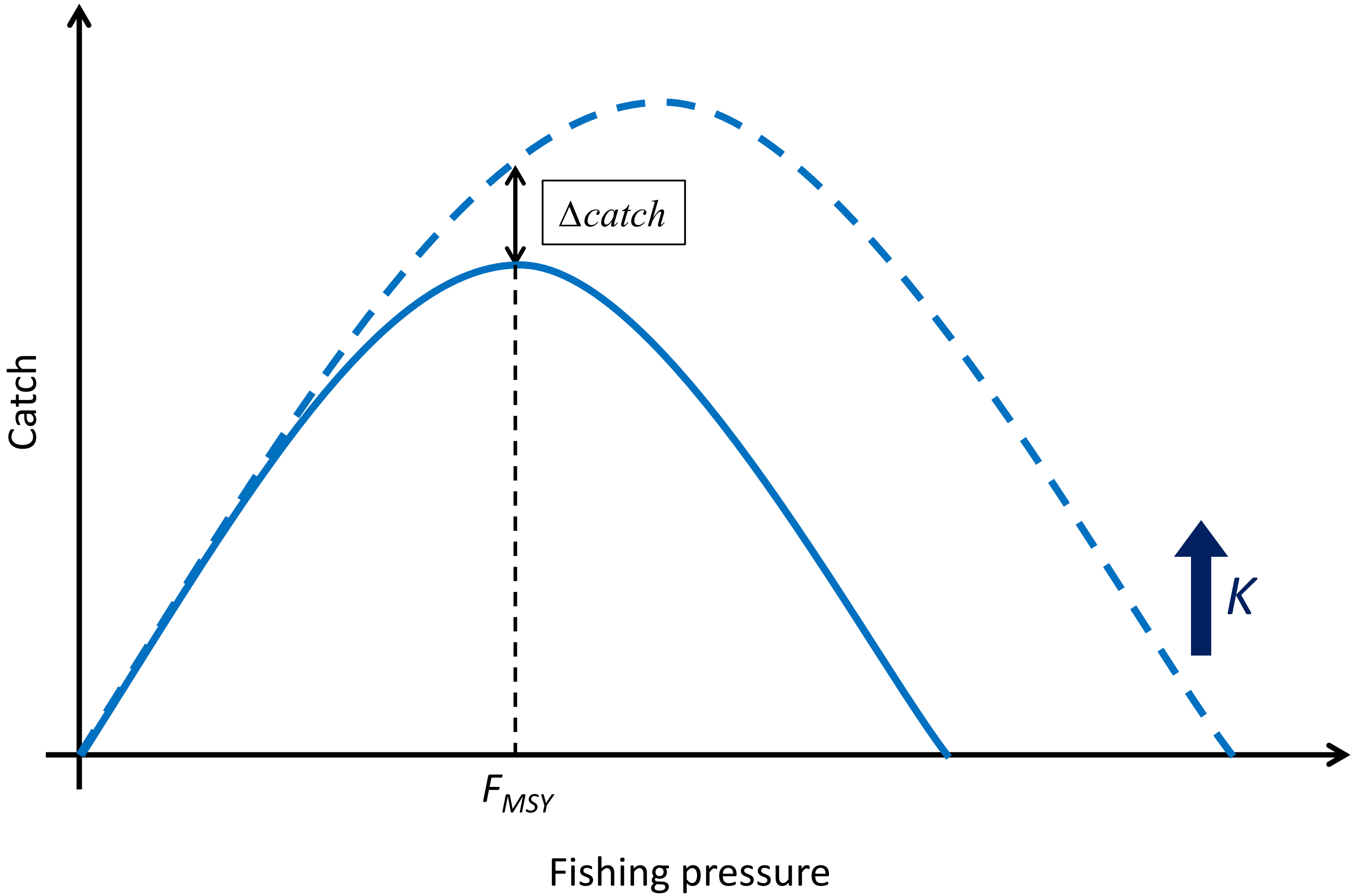
Simultaneous F_{MSY} *vs* individual F_{MSY}



Competition interaction between planktivores



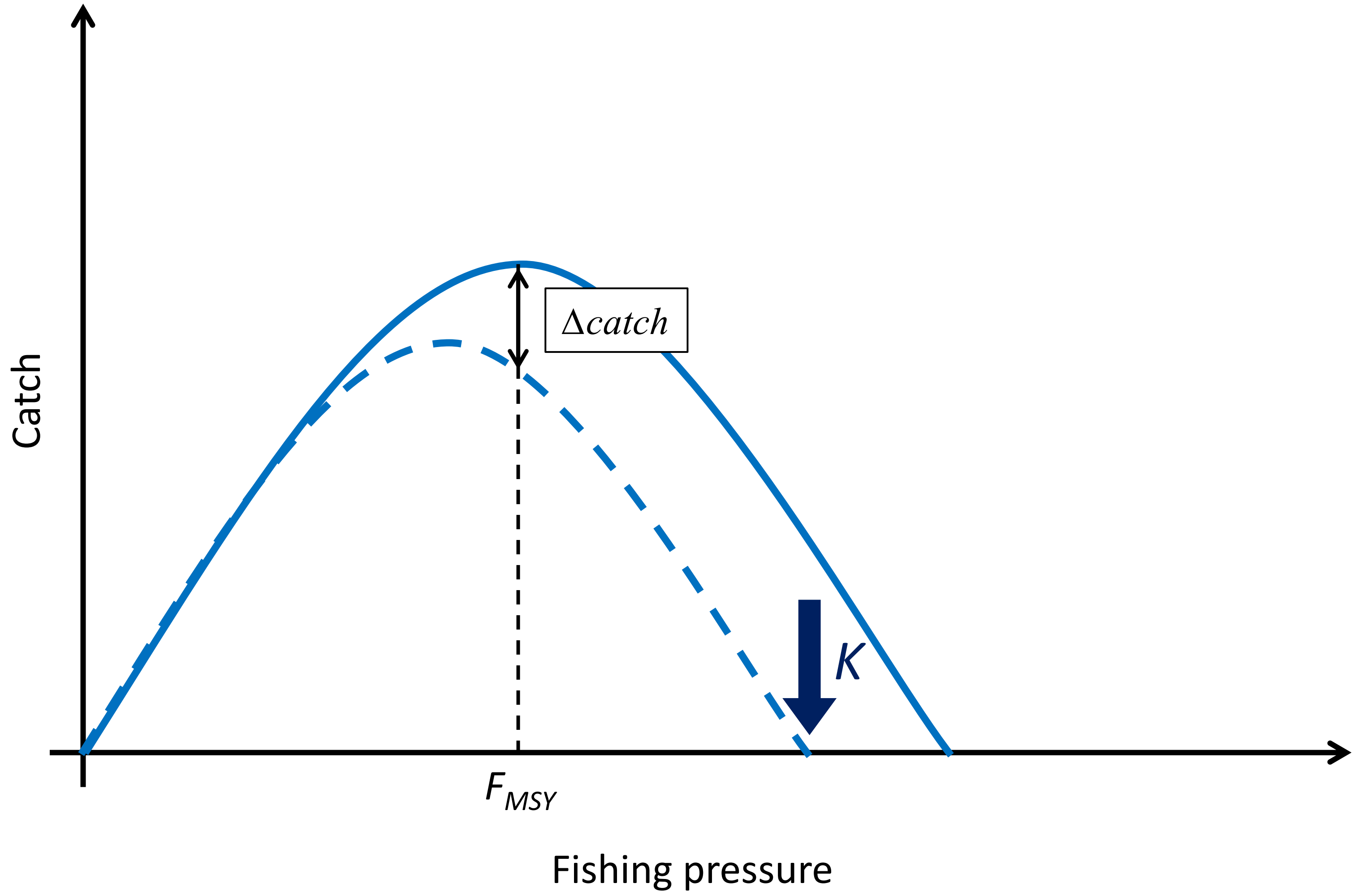
Increased carrying capacity (*K*)



Predation interactions

Affected group	**Targeted group**			
	sm. pelagics	snoek	*M. capensis*	*M. paradoxus*
sm. pelagics	--	↑	↑	↑
mesopelagics	↑	↑	↑	↑
snoek	↓	--	↑	↑
M. capensis	↓	↑	--	≈
M. paradoxus	≈	↑	↑	--

Reduced carrying capacity (K)



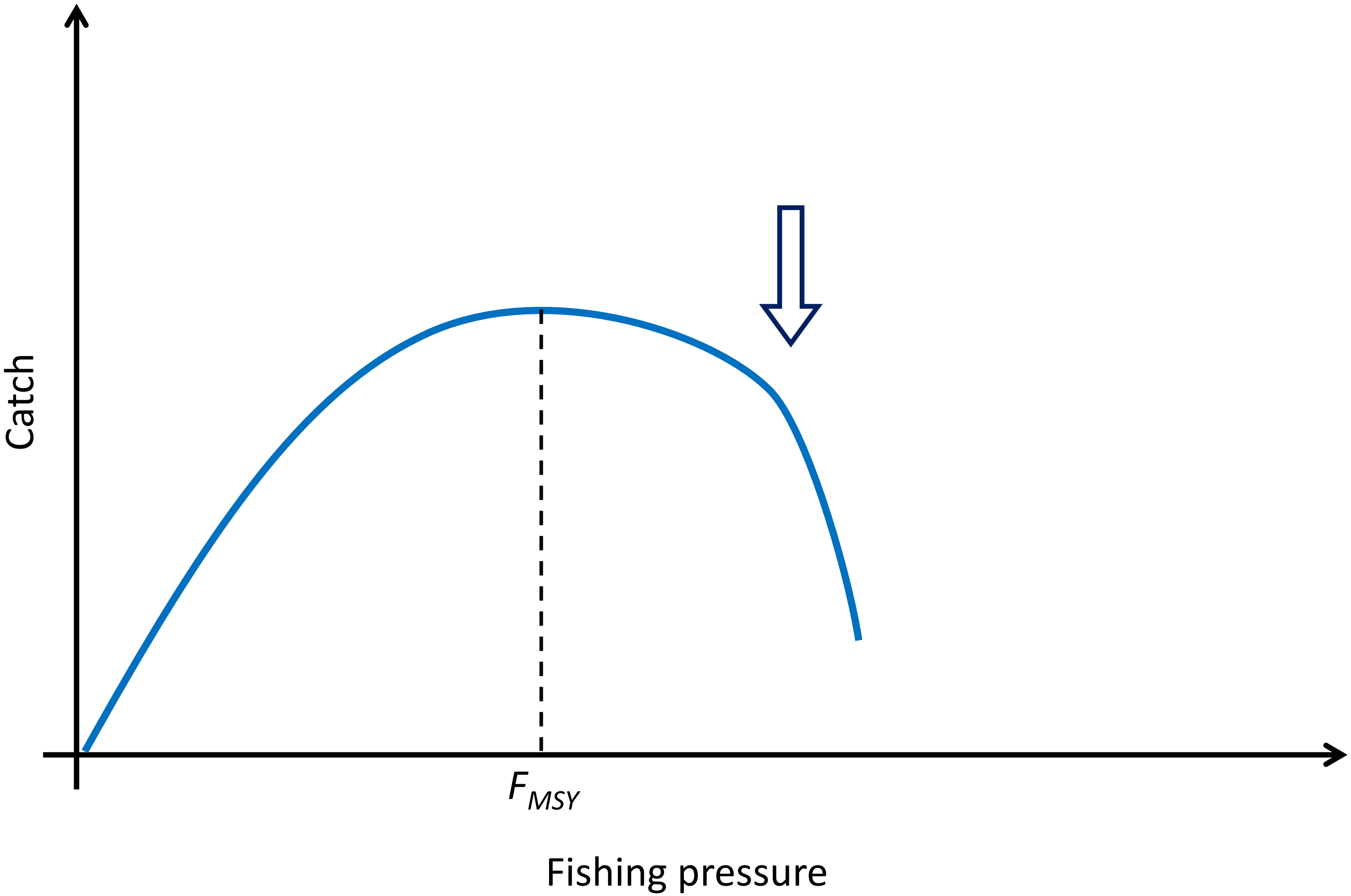
The take-home messages:

- Competition and predation have different importance at different trophic levels.
- Small pelagics dominated the catch for our model
- Results from one system may not be universal

Thank you!

THE UNIVERSITY OF MELBOURNE

CSIRO



Catch
F_{MSY}
Fishing pressure

What multi species and ecosystem models can do for you - examples from ICES WGSAM

Kempf, A.[1], Howell, D.[2], Link, J.[3], Mackinson, S.[4] and Rindorf, A.[5]

[1] TI- SF, Palmaille 9, 22761 Hamburg, Germany
[2] IMR, P.O. Box 1870 Nordnes, 5817 Bergen, Norway
[3] NOAA, NMFS, 166 Water St., Woods Hole, MA 02543, USA
[4] CEFAS, Pakefield Road, Lowestoft, Suffolk, NR33 0HT, UK
[5] DTU, Jægersborg Alle 1, DK-2920 Charlottenlund, Denmark

ICES WGSAM (Working Group on Multispecies Assessment Methods)

Experts from many areas in the North Atlantik (Barent Sea, Iceland, US West Atlantic, Canadian West Atlantic, North Sea , Baltic, Celtic Seas, Bay of Biscay, Mediterranean, Black Sea)

Main aim: Model development + **integration into practical management advice!**

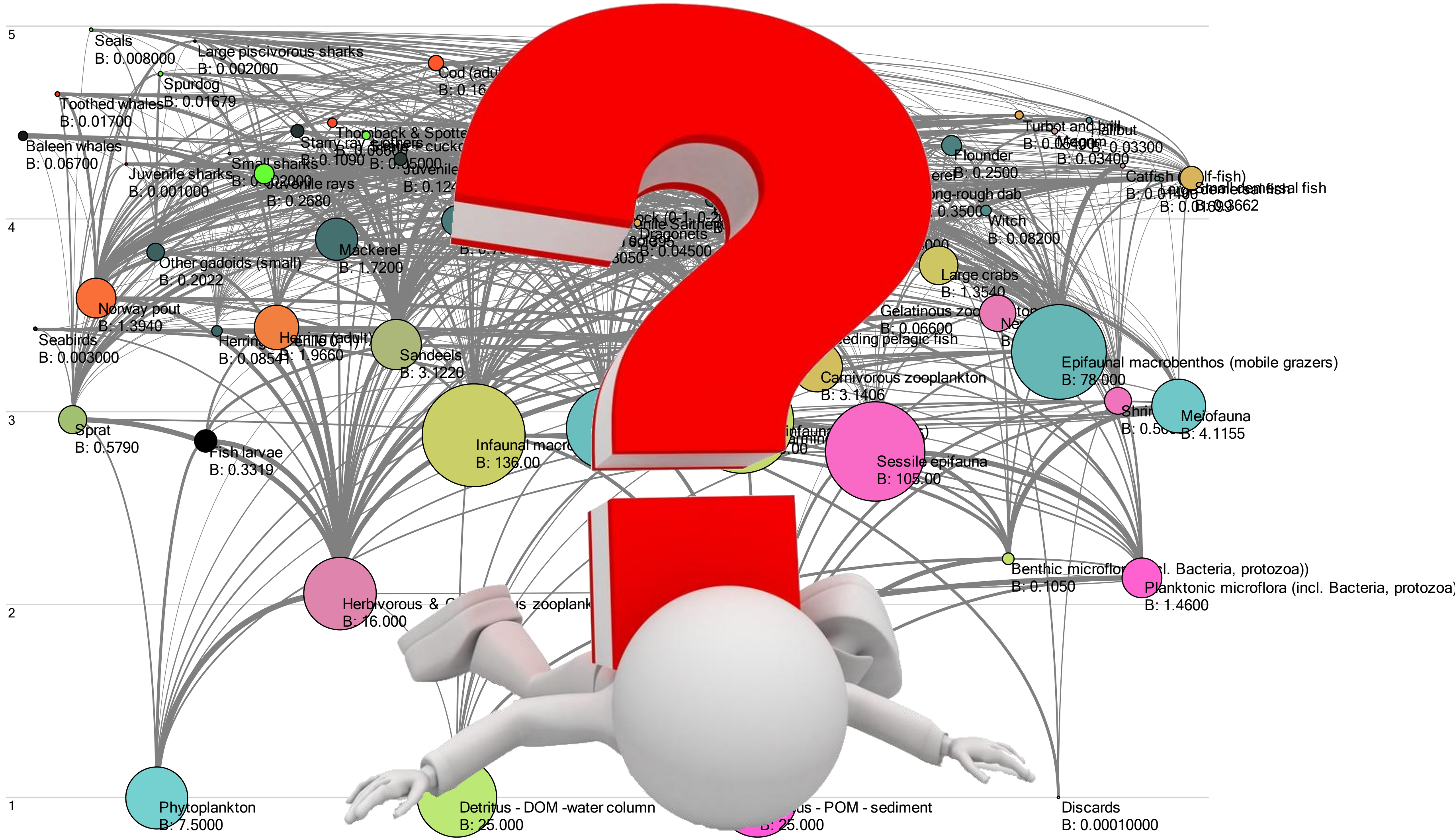
- establishing best practice in multi-species assessment

➔ defining standards for models ("Keyruns")

- identifying and promoting the research needed (e.g., joint stomach sampling projects)

- aligning ToRs with emerging policy needs (e.g., Food Web Indicators, Multi Species MSY)

Main challenge: Communication and processing of complex results



Examples from ICES WGSAM

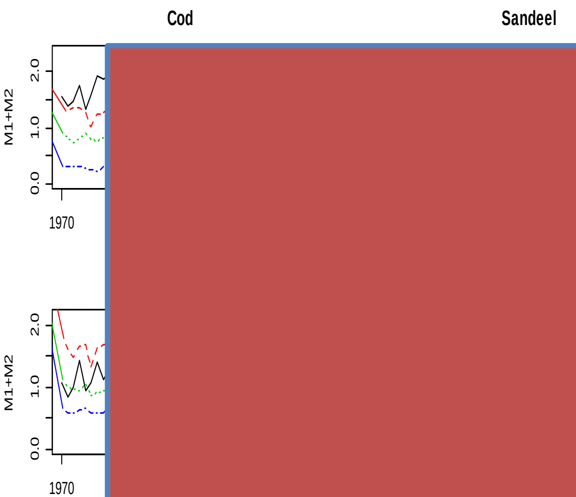
1. Food web and community indicators to be used in stock assessment and other working groups

2. Advice on MSY in a multi species context

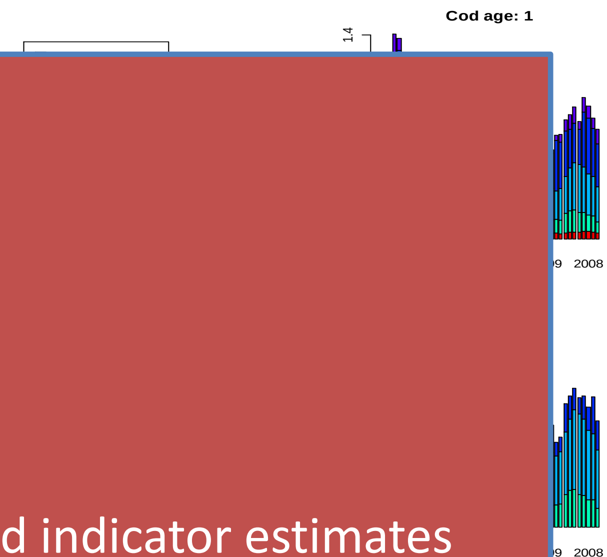
3. Implementing multi species effects in MSE simulations

Food web and community indicators

Natural mortality



Who eats whom

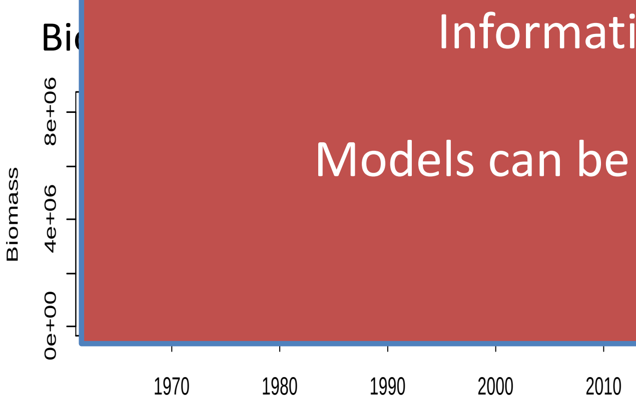


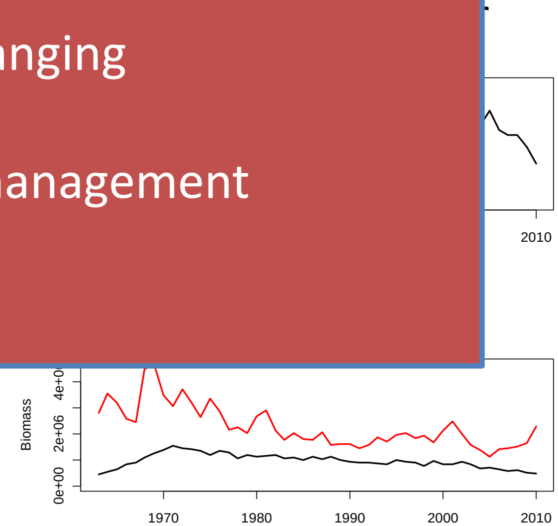
Why models?

Alternative and complimentary to survey based indicator estimates

Information on **why** is an indicator changing

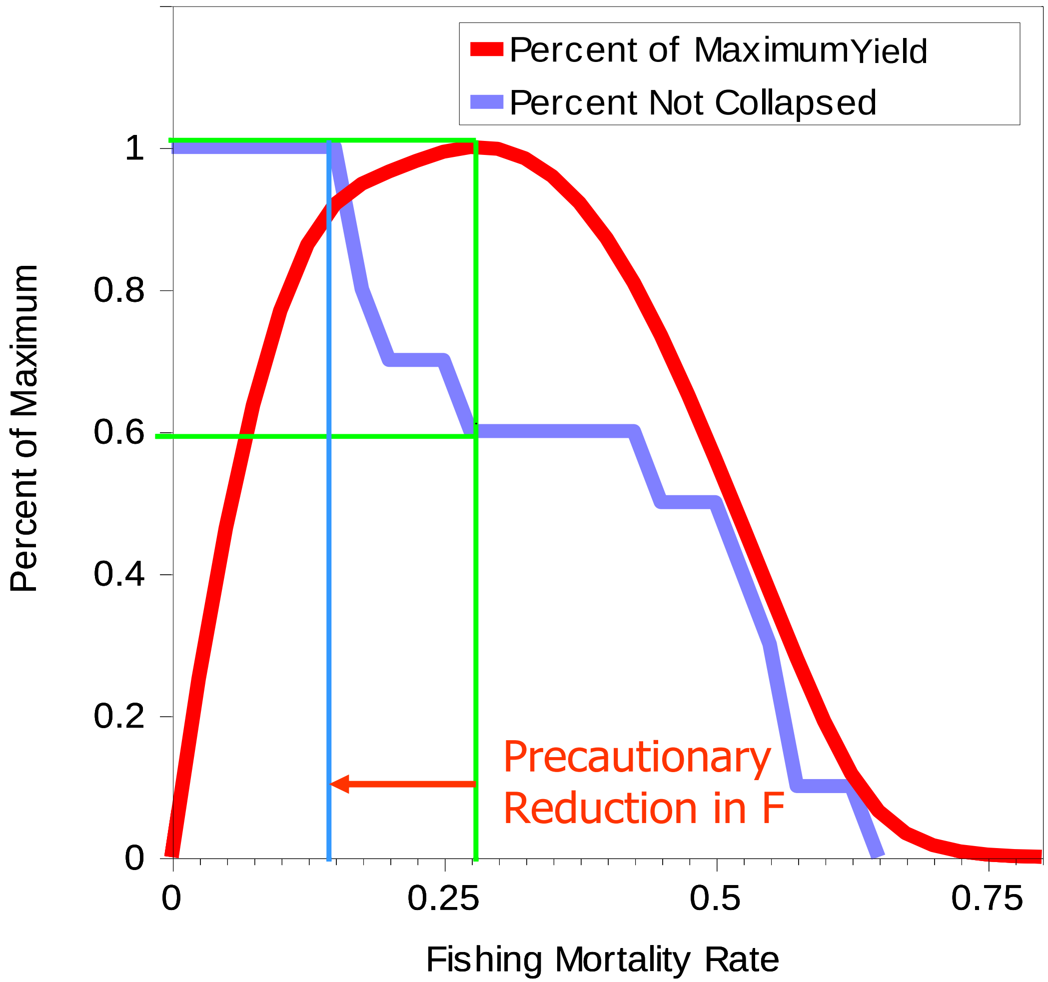
Models can be used to **predict** changes in management





MSY in a multi species context: multiple objectives

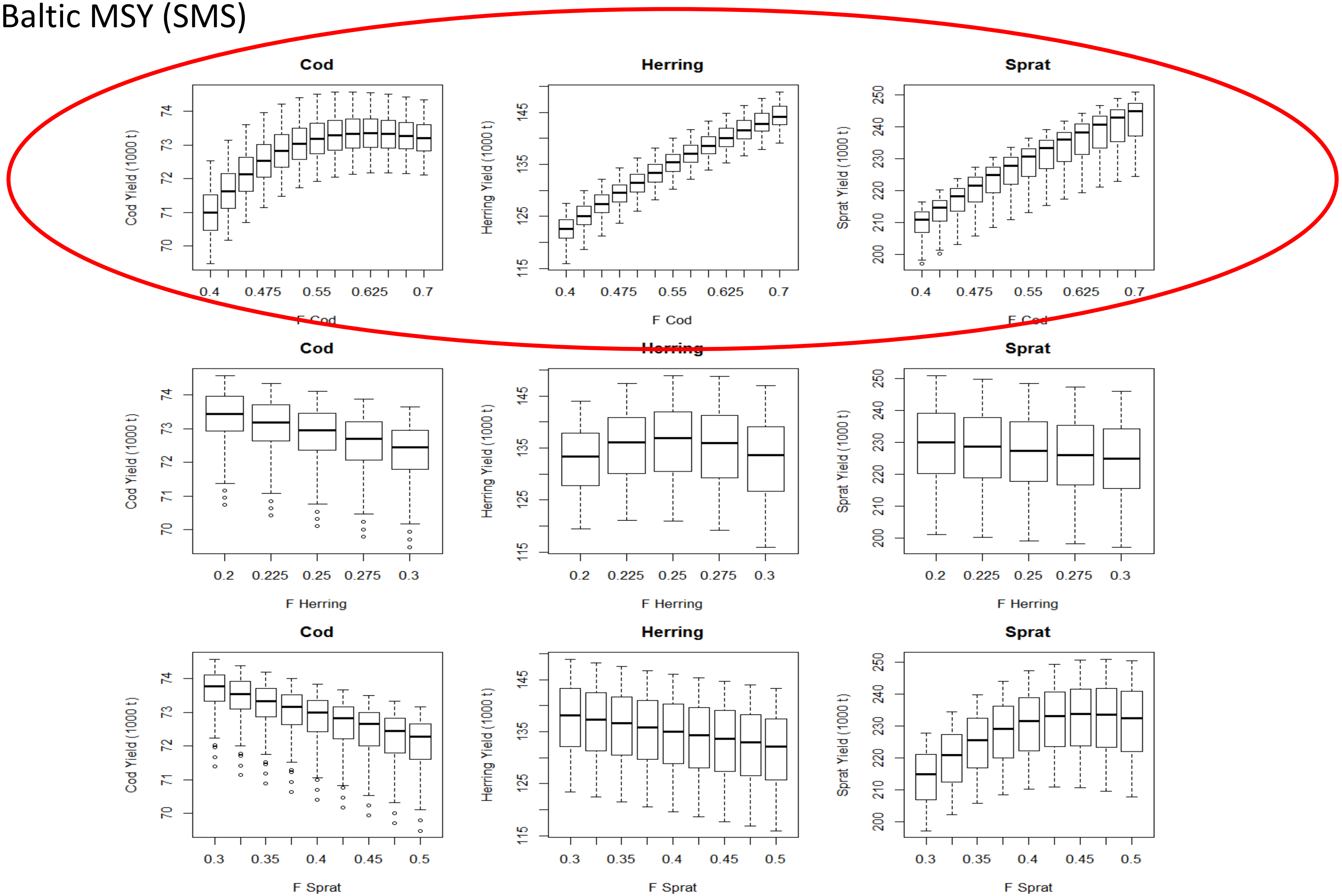
Advice on precautionary reference points



(from: Gamble and Link 2012)

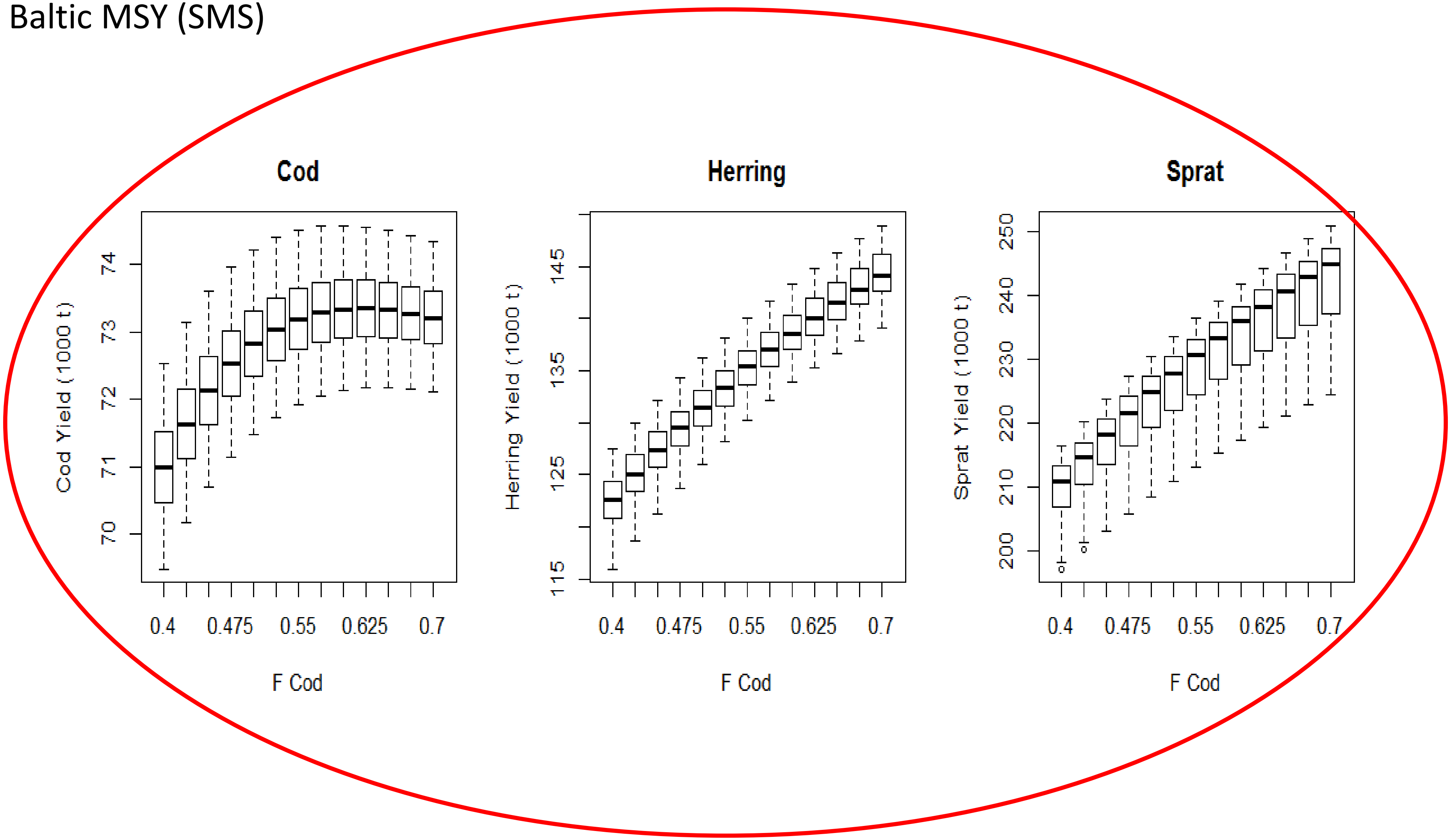
MSY in a multi species context: **important** trade-offs

Baltic MSY (SMS)



MSY in a multi species context: **important** trade-offs

Baltic MSY (SMS)



MSY in a multi species context: **important** trade-offs

Baltic MSY (SMS)

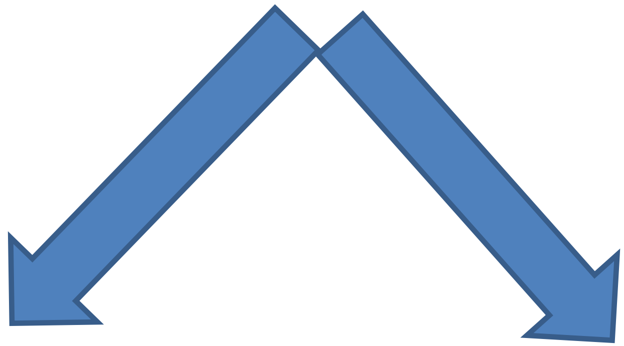
Inclusive governance

Simulations can delimit the space for sustainable exploitation within acceptable good environmental status . However, inside this space stakeholders have to decide on trade-offs and acceptable risk levels!

➔ Decision support in a suitable format

Multi species effects in MSEs

Multi species effects



Multi species or ecosystem model as operating model

Single species MSE + identify relationships between natural mortality and predator biomass

Simple relationships

$$\text{Predation index}_{year,prey,preyage} = \sum_{predator=1}^{n} BIO_{year,predator,predatorage} * \overline{pM2}_{predator,predatorage,prey,preyage}$$

N

Pros

- Can be used in single species models
- Relatively easy to use and understand

Cons

- relationships sometimes weak
- Processes (e.g., functional feeding response) will be ignored
- Only valid for historically observed states of the food web

0 40000 80000 0e+00 4e+04 8e+04 0 20000 40000 0 20000 40000

Predation index

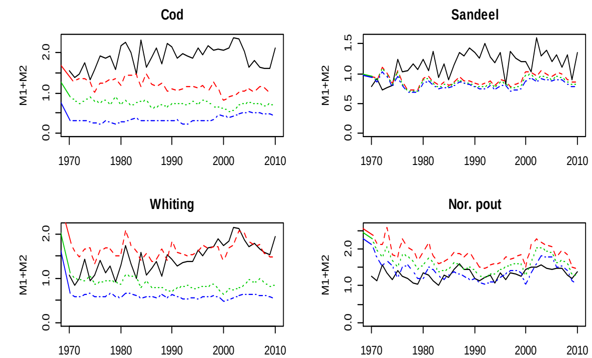
Conclusions: Multi species advice

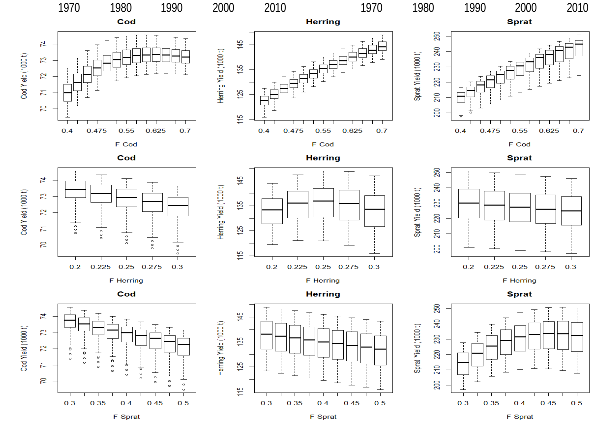
Advice on community and food web indicators (including natural mortality). Tables of natural mortality and any other relevant parameter must be available for download.

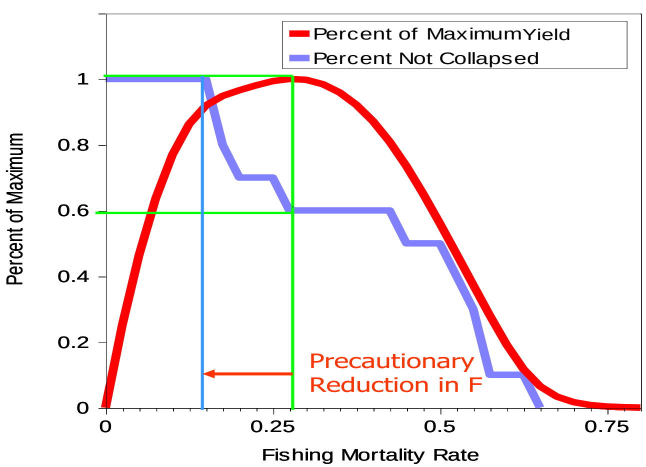
Advice on important interactions and trade offs

Advice on precautionary target fishing mortalities producing close-to-MSY

Advice on limitations of the model results







Thanks for your attention!

DEFINEIT

GAP
Connecting Science
Stakeholders and Policy

FACTS
Forage Fish Interactions

ICES
CIEM

myfish
Maximising yield of fisheries
while balancing ecosystem,
economic and social concerns

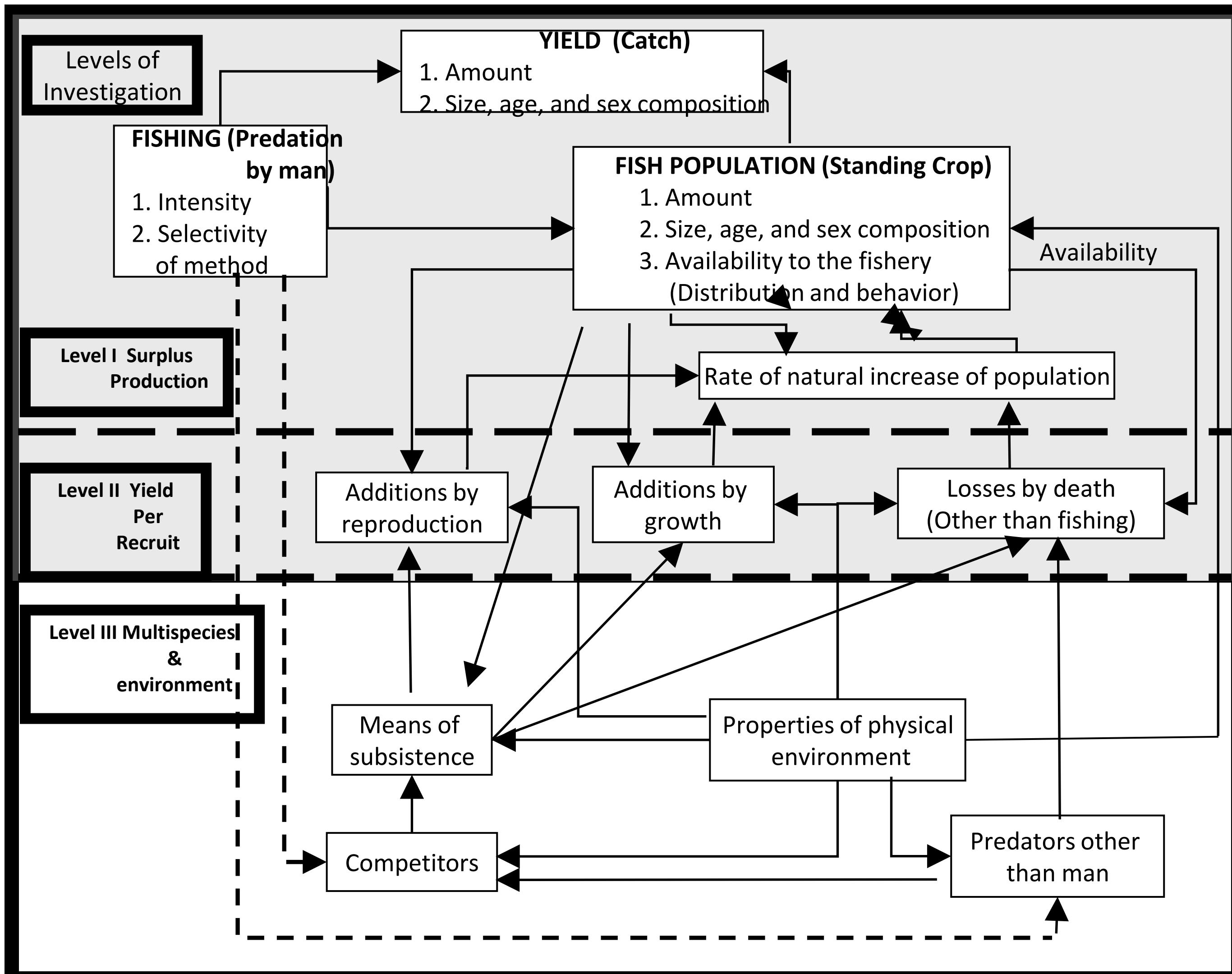
NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

Ecosystem Data Criteria for Use in Stock Assessment Models

Jason S. Link, Chris Legault, Tim Essington, André Punt, Steve Cadrin, Richard Methot

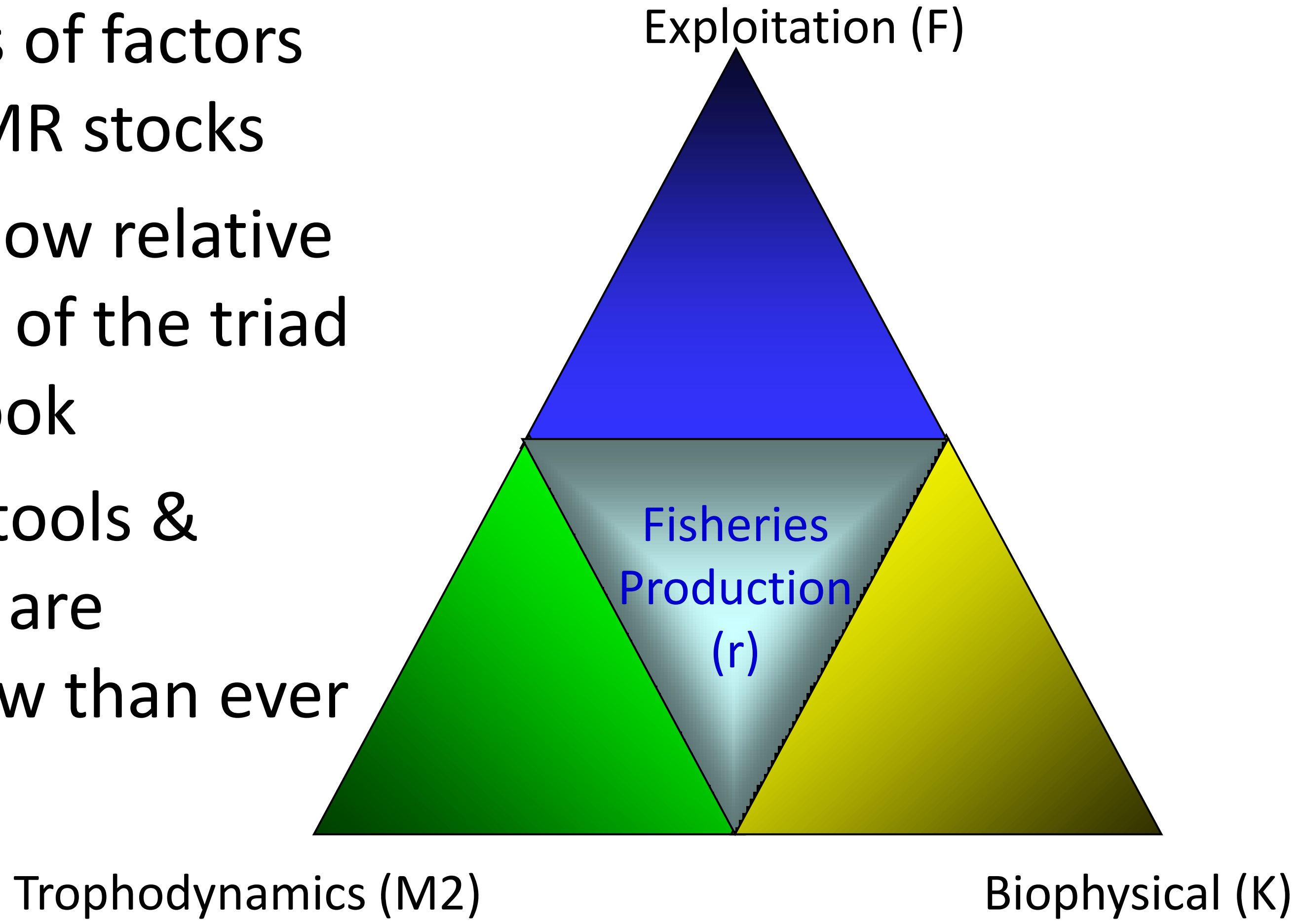
The History

- Spencer Baird
- Johan Hjort…
- Thompson - Burkenroad debate
- Schaefer’s 3rd Tier



The Need

- Broad suites of factors influence LMR stocks
- We don't know relative prominence of the triad unless we look
- More data, tools & information are available now than ever before



Concerns for Ancillary Data Use in Stock Assessments

- Avoid Extremes
- Meet minimal standards

General Data Types

- Abundance (B, N)
  - Aka Surveys
- Biological
- Catch/Landings
- Ecological
- Environmental
- Socioeconomic

Types of Data Use in Stock Assessments

Context

Alter stock information (e.g. Stock ID, area, etc.)

Change model parameter choice/defaults

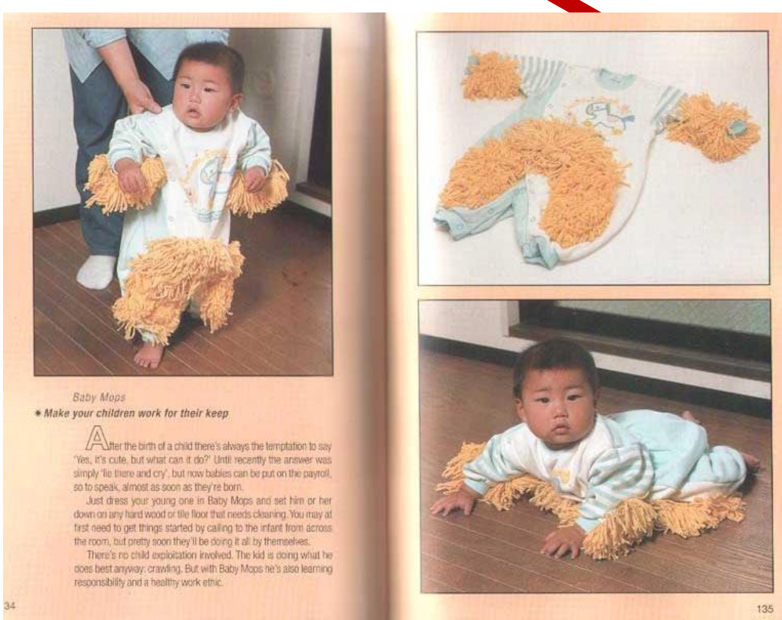
Alter other input data to model

Alter structure of model

Scalars/ Magnitude checks

Model covariates

Data inputs to model



Proposed Core Criteria

- Adequate length of time series (as a fraction of life history [e.g. maturity age] of stock)
- Synoptic coverage of stock, else estimable fraction of geographic coverage
- Variance mainly estimable
- Consistency of collection/sampling protocols, else adequate conversion coefficients
- Relates to key facet of the life history of stock
- Captures main contrasts and dynamics over time and space of major processes affecting stock
- International or regional, "diplomacy" considerations

Criteria & Use

Data Criteria/Data Use	Context	Alter stock info	Change parameters	Alter other input	Alter structure	Scalars/Magnitude	Model covariates	Data inputs
Length of time series	Lo	Lo	Med	Lo	Lo	Med	Med	Hi
Synoptic coverage of stock	Lo	Med	Med	Lo	Lo	Med	Med	Hi
Variance estimable	Lo	Lo	Med	Lo	Lo	Med	Med	Hi
Consistency of sampling	Lo	Med	Hi	Med	Med	Hi	Hi	Hi
Life history of stock	Lo	Med	Hi	Med	Med	Hi	Hi	Hi
Contrasts and dynamics	Lo	Med	Hi	Med	Med	Hi	Hi	Hi
Diplomacy considerations	Lo	Med	Med	Lo	Med	Med	Med	Med

Example #1: Habitat & Climate

E.g., small pelagic fish

Consistently sampled temperature, B/N & C

Well estimated variance

Broad spatiotemporal coverage

Captures major changes in thermal habitat of ecosystem over time and space

Known linkages to key life history and physiology

Suggested possible uses of this data stream:

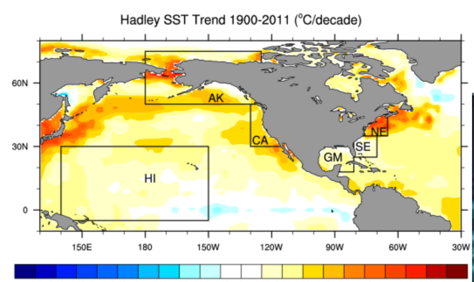
Alter Stock Info

Change model parameters

Scalars/Magnitude

Model covariates

Data inputs to model



Example #2: Trophic Ecology

E.g., invertebrate fishery

Consistently sampled predator stomachs & B/N, & C

Variance poorly known of stomachs, catch

Decent spatio-temporal coverage

Strongly suggested links to life history

Suggested possible uses of this data stream:

Context

Change model parameters

Alter other input data to model

Alter structure of model

Magnitude checks of model outputs/Scalars

Example #3: Data Poor

- E.g., high diversity reef fish
- Inconsistently surveyed B/N; Consistent C sampling
- Variance hard to estimate
- Moderate spatio-temporal coverage
- Observed shifts in C & B distribution
- Suspected thermal relationships

Suggested possible uses of this data stream:

- Context
- Evaluate stock info
- Alter other input data
- Consider simplifying model structure

Questions?

Multispecies considerations in stock assessments: yes we can

Daniel Howell and Sam Subbey

With thanks to
Lary Alade, Eider Andonegi, Höskuldur Björnsson, Bjarte Bogstad, Alida Bundy, Santiago Cerviño, Jonathan Deroba, Daniel Duplisea, Jim Ianelli, Alexander Kempf, Jason Link, Éva Plagányi, Jim Penn, Ross Tallman, Sigurd Tjelmeland, Morten Vinter

Multispecies considerations in stock assessments: yes we do

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Background

- General legal requirements around the world to manage and protect ”the ecosystem”
- ICES 2013 ASC theme session text
  - “While there has been much recent progress in the understanding of foodweb dynamics in marine ecosystems, the application of this knowledge in marine management is however, still scarce”
- Perception that this is important, but difficult

Current situation

- We are in a single species assessment world
  - No, not always
- We want to be in the promised land of "ecosystem assessments"
  - No, not necessarily
- But there is a huge gulf between the two
  - No, not really

WRONG

Current situation

- We are in a single species assessment world
  - No, not always
- Various experimental or exploratory multispecies or ecosystem assessments
  - Environmental drivers
  - Bottom up effects
  - Density dependence
  - Variable predation/M2

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Current situation

- We are in a single species assessment world
  - No, not always
- Various experimental or exploratory multispecies or ecosystem assessments
  - Environmental drivers
  - Bottom up effects
  - Density dependence
  - **Variable predation/M2**

Current situation: take two

- We are using variable predation mortalities in **assessments** within ICES **right now**
  - And have been for almost 25 years
  - Currently around a dozen stocks
  - In different ways
  - Use ”extra” data to derive M variability
- Barents Sea (cod, capelin), North Sea (cod, whiting, herring), Baltic (herring, sprat), Greendlandic shrimp, Atlantic herring, silver hake, walleye pollock, others?

Two types of different approaches

- Within model (extended single species)
  - Externally derived predator biomasses and consumption
  - Add to single-species model of the prey species
  - Calculate the predation mortality directly
  - E.g. Barents Sea capelin, Atlantic herring

- External
  - Run a multispecies model
  - Extract predation-induced mortalities (M2s)
  - Import these to single species assessments
  - E.g. North Sea, Baltic

Examples

- Three different examples
- Brief overview
- Techniques (how?)
- Rationale (why?)

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Example 1: Barents Sea Capelin

- Forage fish, industrial fishery, important prey
- Lives for c.3-4 years in the Barents Sea
- Eaten by cod (among others)
- Start to mature in summer
- Survey maturing fish in early autumn
- Swim south to near coast the following spring
- Spawn and die
- Fished en route with an escapement rule
  - 95% chance for SSB>200,000 tonnes

Example 1: Barents Sea Capelin

- Recognized early in the fishery that **variable** cod predation was critical in stock assessment
- Cod predation is large and variable
  - Have stock assessment of cod
  - Extensive annual time series of cod stomachs
- These are incorporated in the capelin model, which calculates cod-induced predation
  - Including uncertainties
- First done for assessment in 1990

Example 2: Barents Sea cod

- Cannibalistic
- XSA stock assessment
  - Most cannibalism before the fish enter the fishery
  - Not required in assessment (straight single species)
- BUT:
- HCR requires three year forecasts
  - Cannibalized fish in year 1 are definately important in the fishery by year 3

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Example 2: Barents Sea cod

- Ad hoc, no requirement for uncertainty
- Take assessment XSA stock (by age)
- Use with stomach content data to get cannibalism by predator and prey age
- Add cannibalism by prey age in to XSA as an extra ”fleet”
- Refit XSA to account for this extra fleet
- Iterate to convergence

Example 3: Baltic

- Similar process conducted in the North Sea
- Cod predates on sprat, herring and young cod
- Important fishery on all three species
- Fishing on one species noticably impacts the biomass and catch of other species
  - Requires going beyond single species assessments and management

Example 3: Baltic

- Run a multi-species SMS model key run
  - Every 3 years
- Cod as a predator; cod, herring, sprat as prey
- Fixed prey preferences, variable biomasses
- Identify where **important** interactions occur
- Export smoothed M2 values (for herring and sprat, **not** cod)
- Import to annual single-species assessment models (SAM)

Strengths/Weaknesses: Within model

- Everything consistent (within same model)
- Gives flexibility
- Easier to validate
- Requires a lot of development and expertise
- Requires good data on predation variability
  - Makes medium term forecasts problematic
- Difficult to generalize

Strengths/Weaknesses: external

- Extendable, generalized
- Divides out the work
- Allows medium-term forecasts (model biomasses, fix prey preferences)
- Avoids need for frequent stomach datasets
  - For better or worse
- Allows the models to be run seperately
  - For better or worse
- Moving M2s between models problematic

How is this different from "full" multispecies assessments?

- Can capture (some) key pressures
- Only unidirectional effects
  - limits the degree of feedback and interactions

- Allows use by single-species modelling experts

Stepping stone to integrated multispecies assessments?

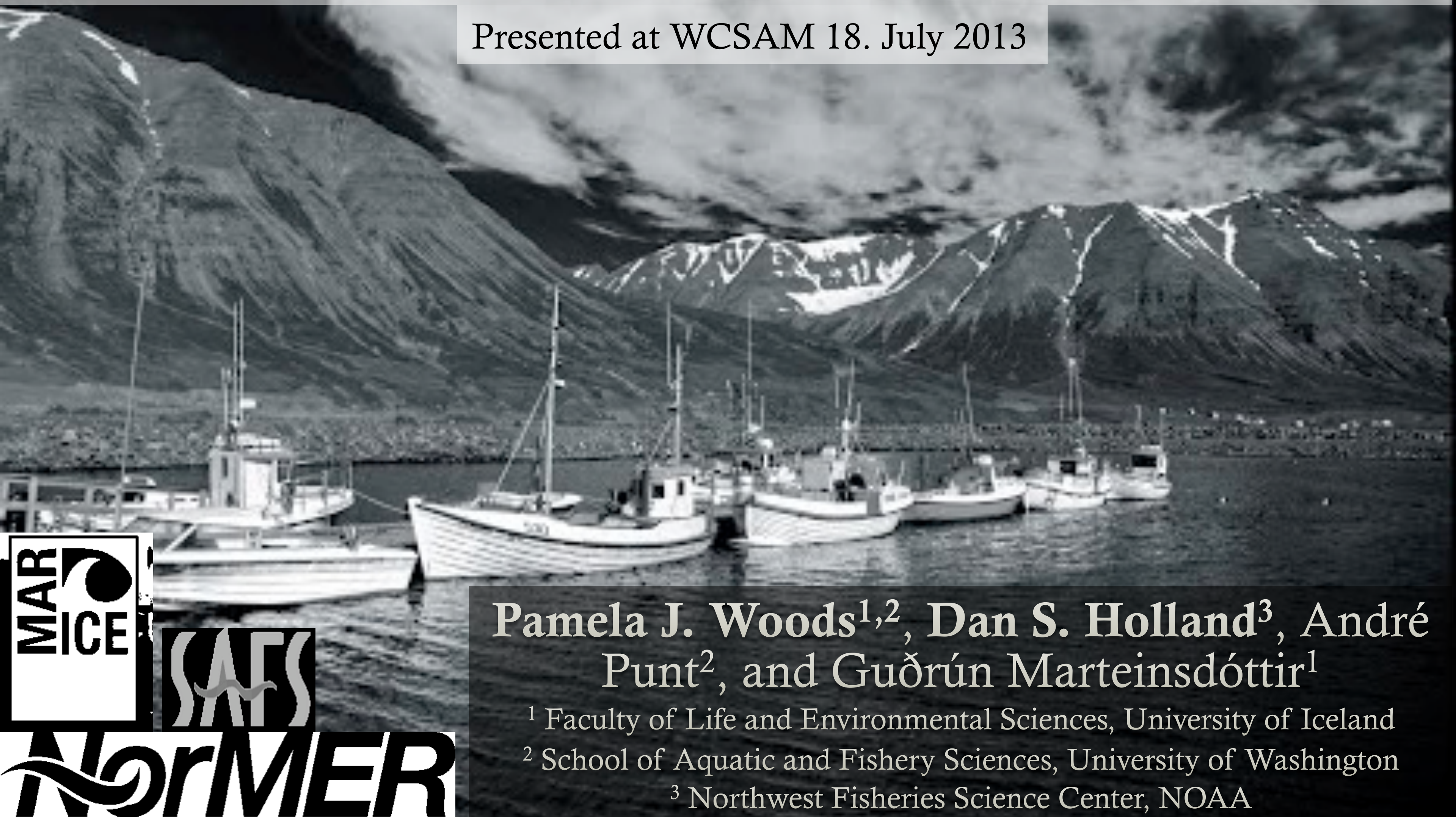
- Maybe, maybe not
- Valuable in and of itself
  - Not clear that ”integrated” assessments should be the general goal
- Leading to developing competance in extending single-species assessment models
  - But still large amount of competance in single species models, much less in multispecies ones

Thoughts on the way forward

- This is already ”the norm” for some stocks
- Do what is required (stock, management)
- Key is to use appropriate levels of complexity
  - M2 variability may be minor, or it can be critical
  - Data may be available or absent
  - Management requirements (uncertainties, HCRs,…)
  - One size does not fit all
- Needs underlying data
  - It is *variability* that matters here
  - Regular (stomach) data to capture variability

Catch-quota balancing regulations in the Icelandic multi-species demersal fishery: are they useful for advancing an ecosystem approach to fisheries?

Presented at WCSAM 18. July 2013



Pamela J. Woods[1,2], Dan S. Holland[3], André Punt[2], and Guðrún Marteinsdóttir[1]

[1] Faculty of Life and Environmental Sciences, University of Iceland

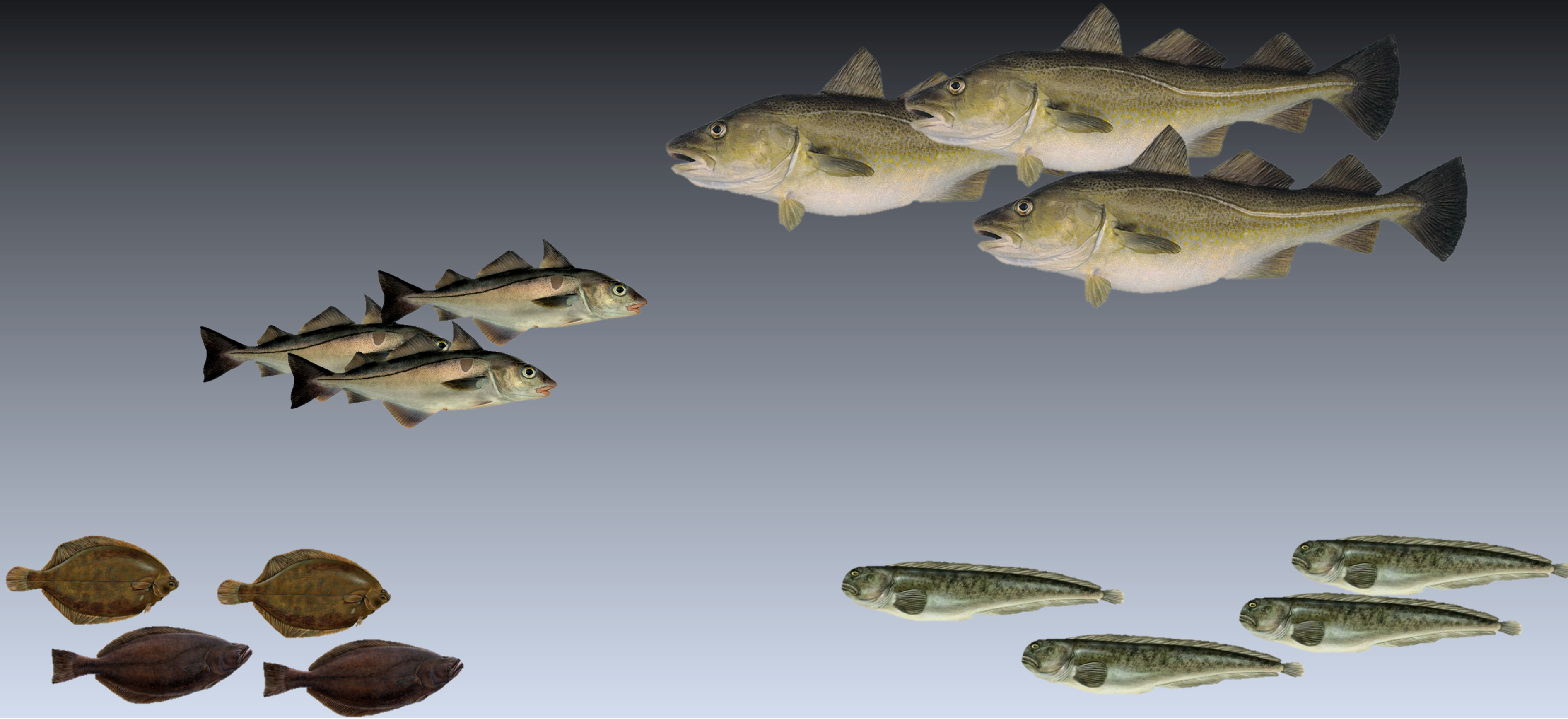
[2] School of Aquatic and Fishery Sciences, University of Washington

[3] Northwest Fisheries Science Center, NOAA

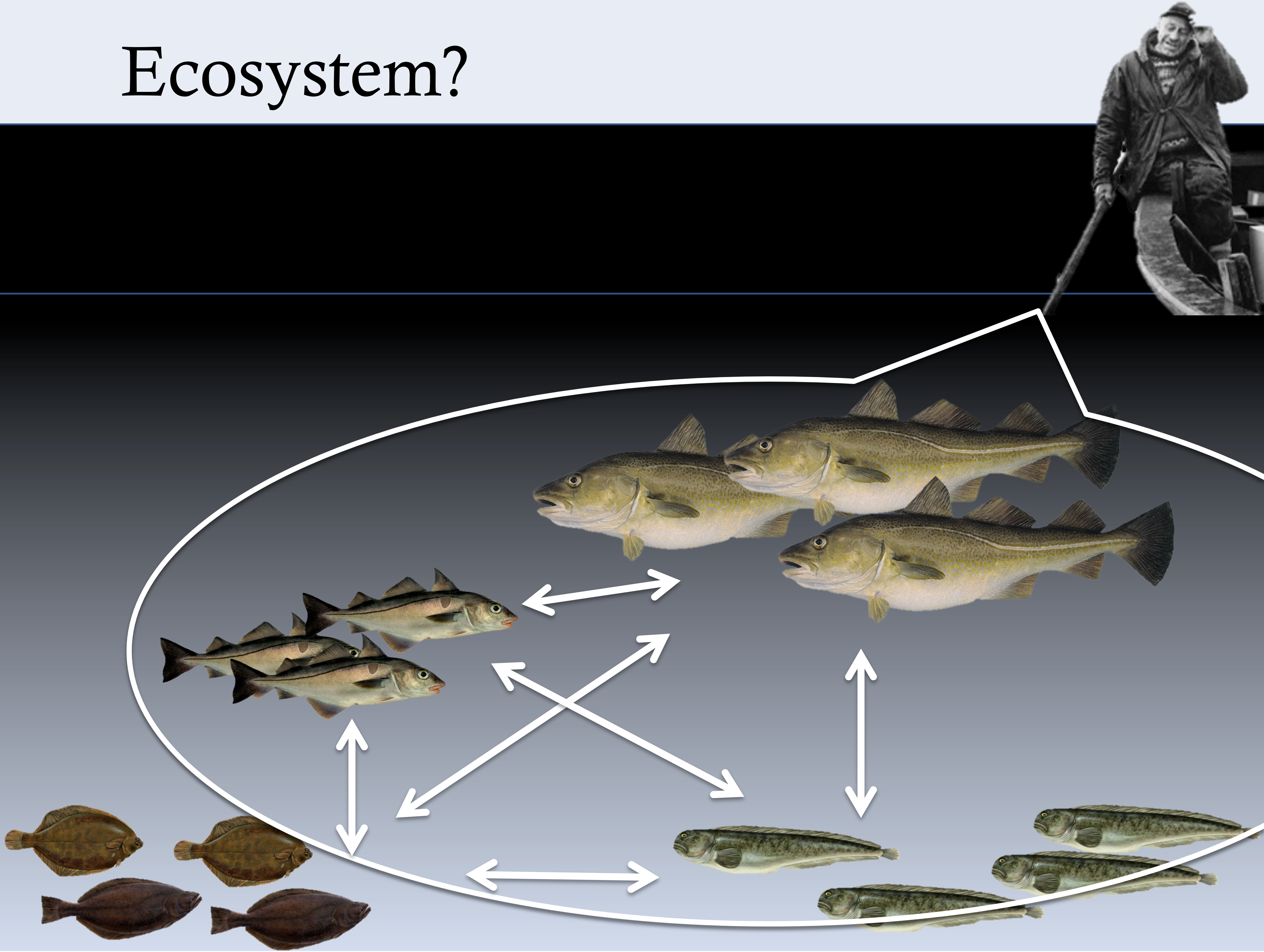
Catch-quota balancing mechanisms (Sanchirico et al. 2006)

- trade (permanent or temporary)
- between-year transfers
- species transformations
- quota baskets
- deemed value fees
- surrendur
- [discarding]

Ecosystem?



Ecosystem?



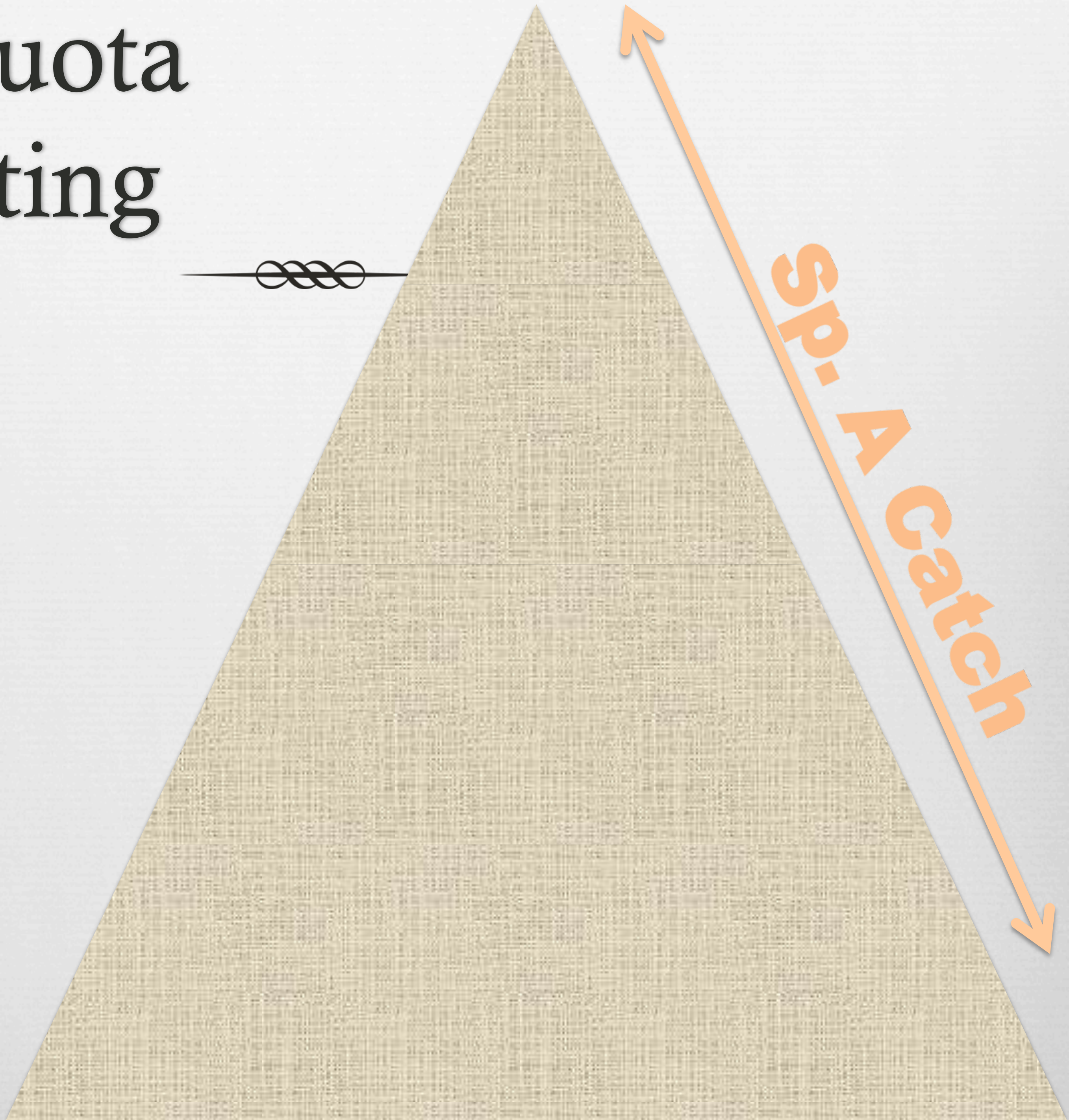
Catch-quota balancing mechanisms (Sanchirico et al. 2006)

- trade (permanent or temporary)
- between-year transfers
- species transformations
- quota baskets
- deemed value fees
- surrendur
- [discarding]

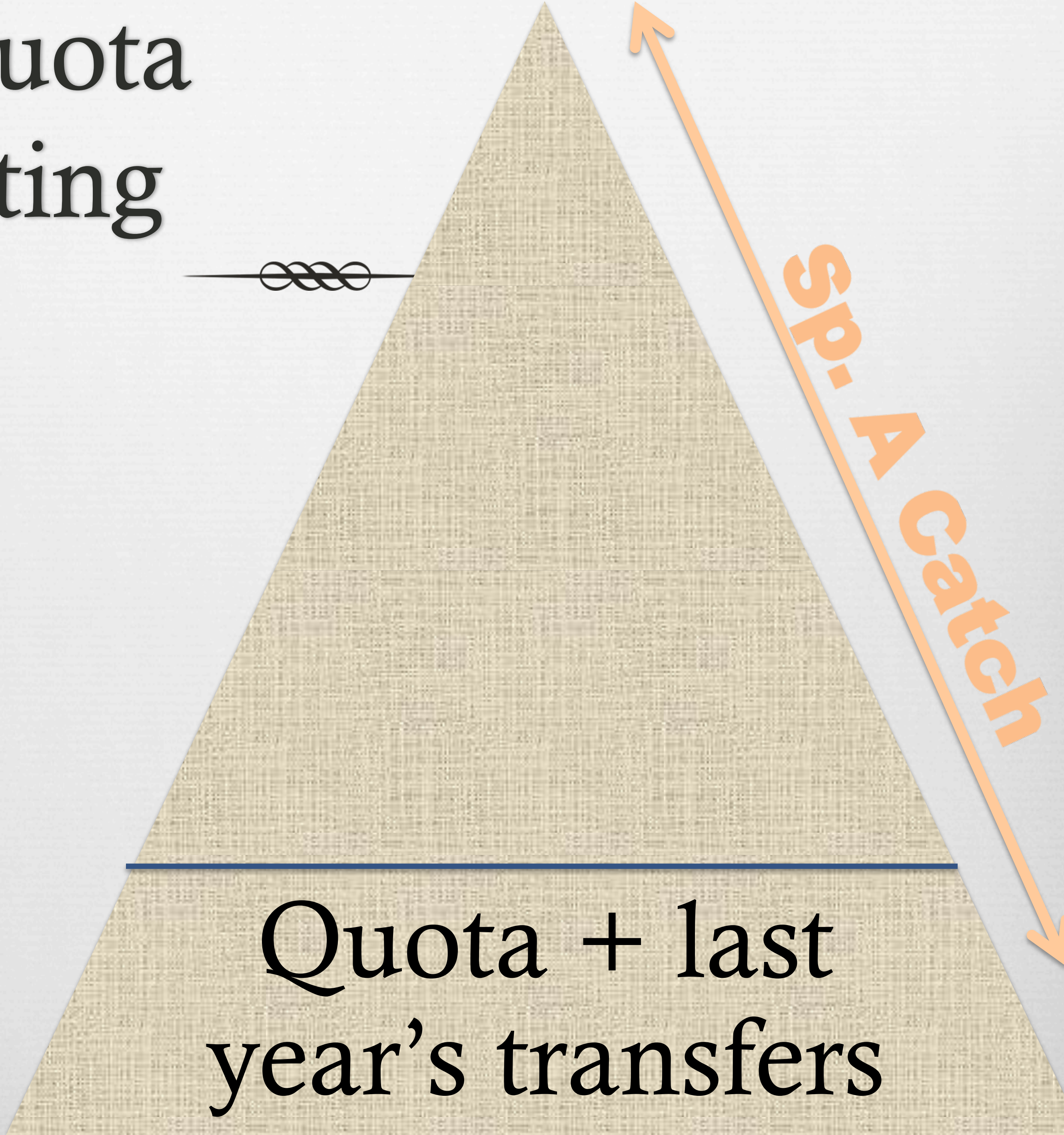
Iceland as a case study

- Virtually all managed demersal spp. (& some non-demersal) included in system.
- Rules have been in place for a long time (~20 yrs) and alongside trade and between-year transfers.
- All fleets managed together (generally).
- Discards illegal.
- Industry likes them.
- Automatic and subject to limitations.

Catch-quota accounting



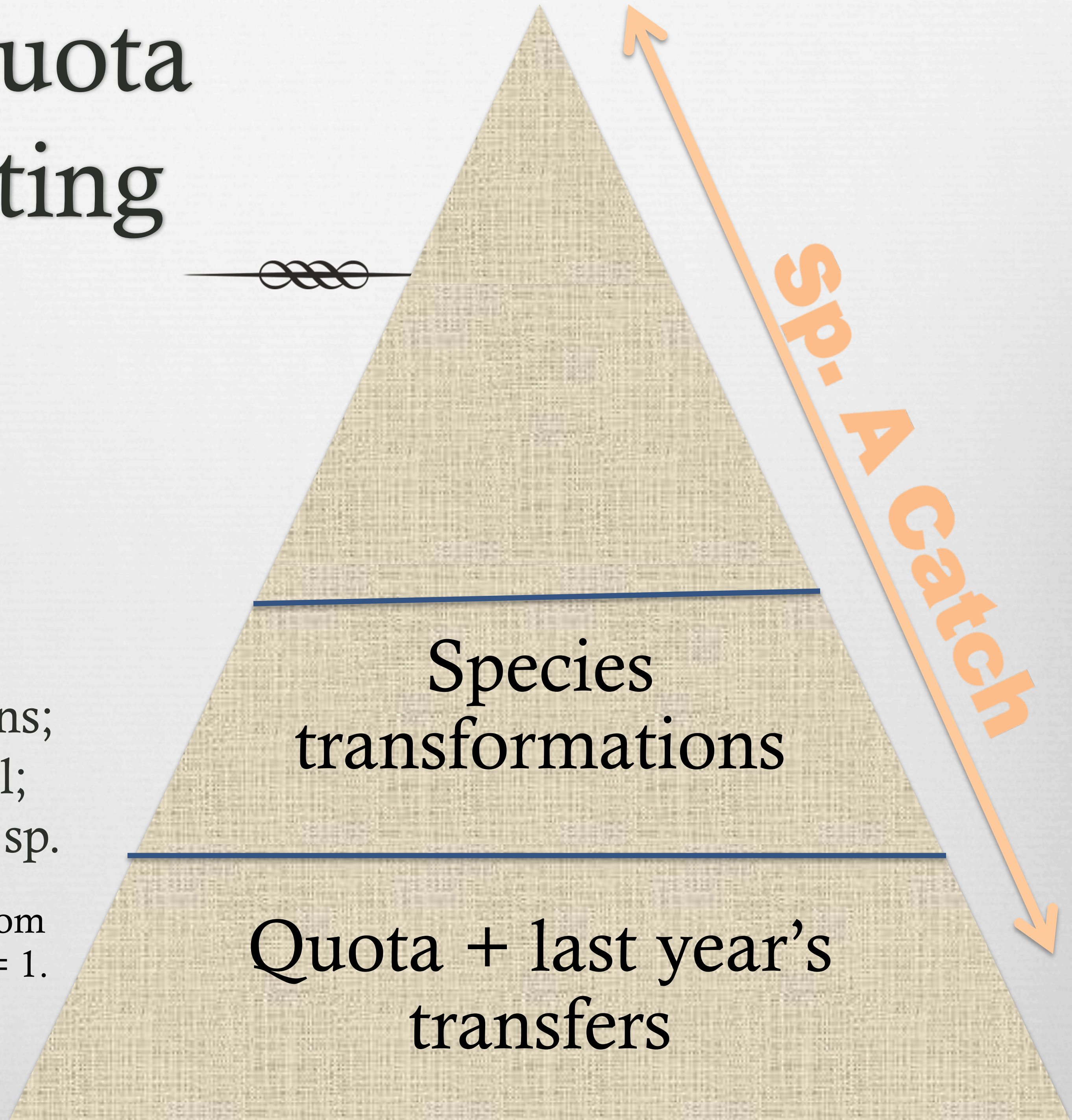
Catch-quota accounting



Catch-quota accounting

- C.E. conversions; 5% total overall; 1.5% total to a sp.

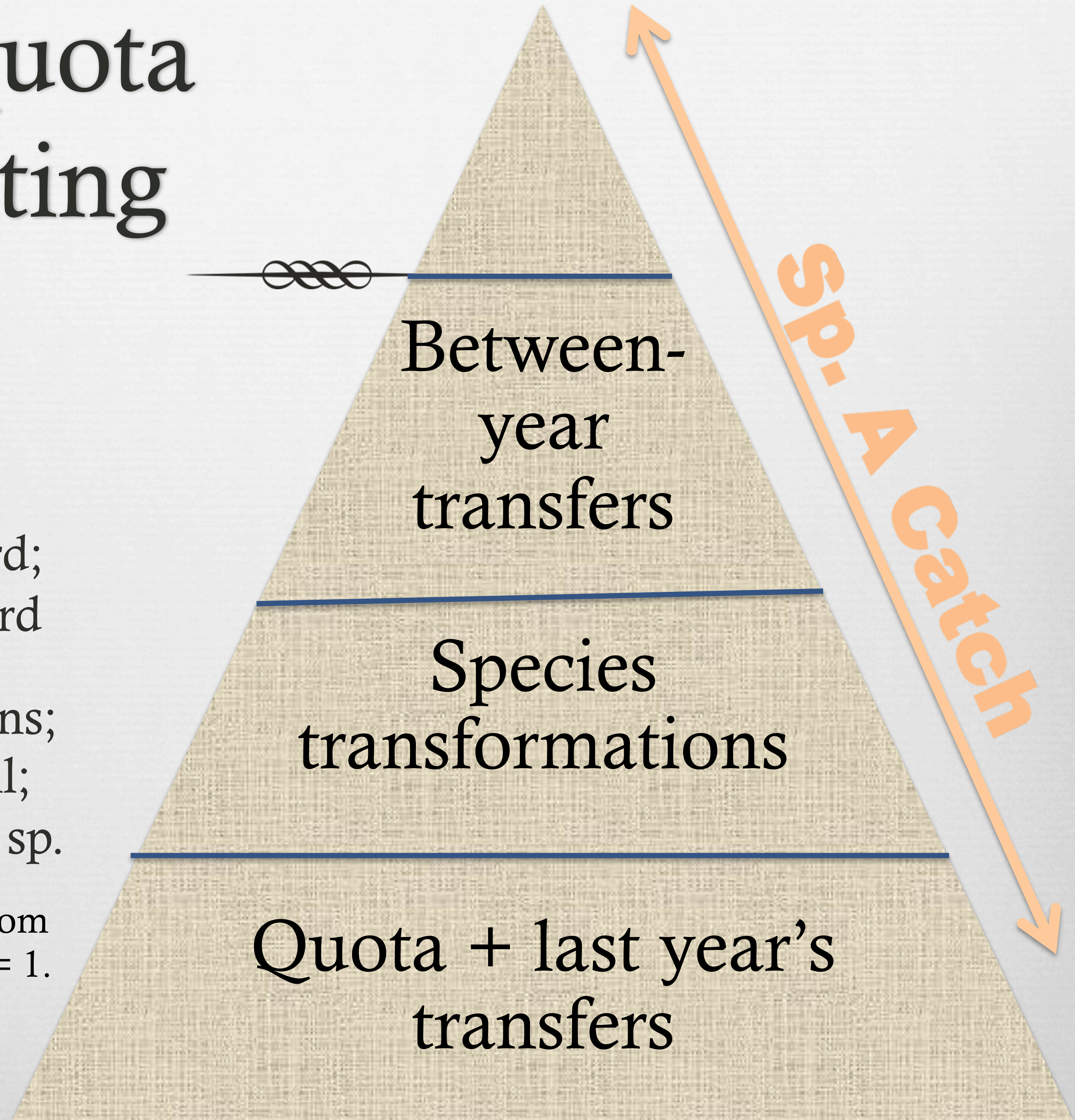
Cod are excluded from system, set as base = 1.



Catch-quota accounting

- 15% sp. forward; 5% sp. backward
- C.E. conversions; 5% total overall; 1.5% total to a sp.

Cod are excluded from system, set as base = 1.



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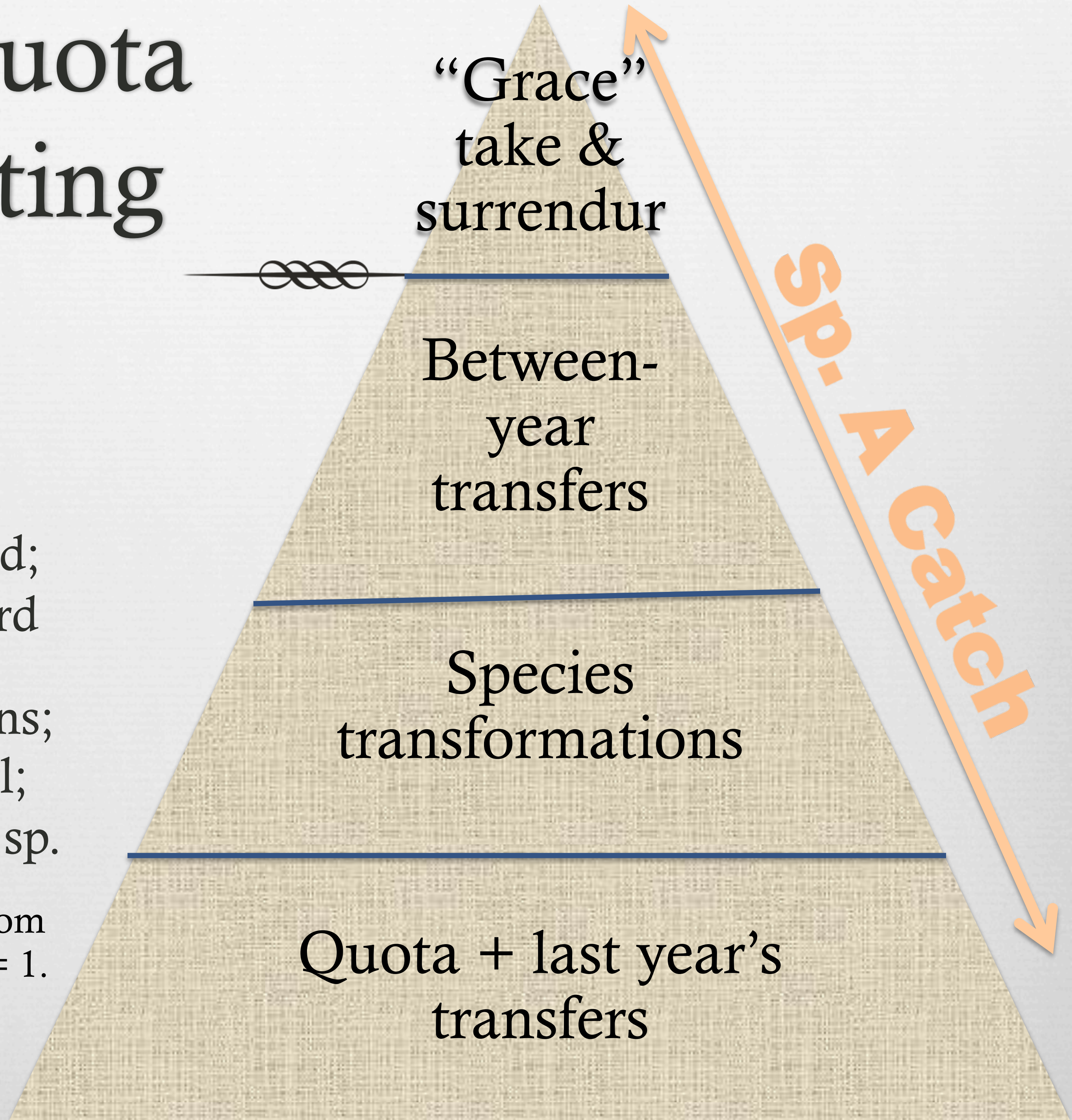
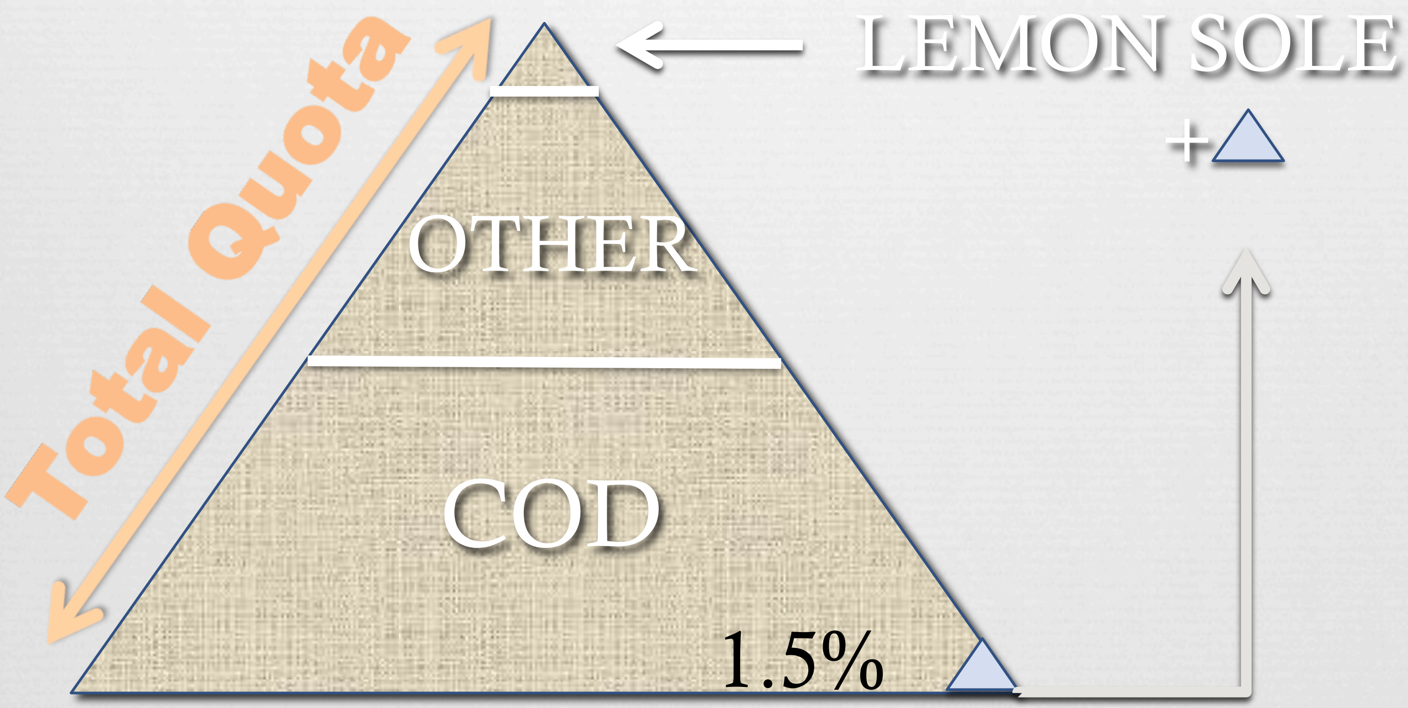
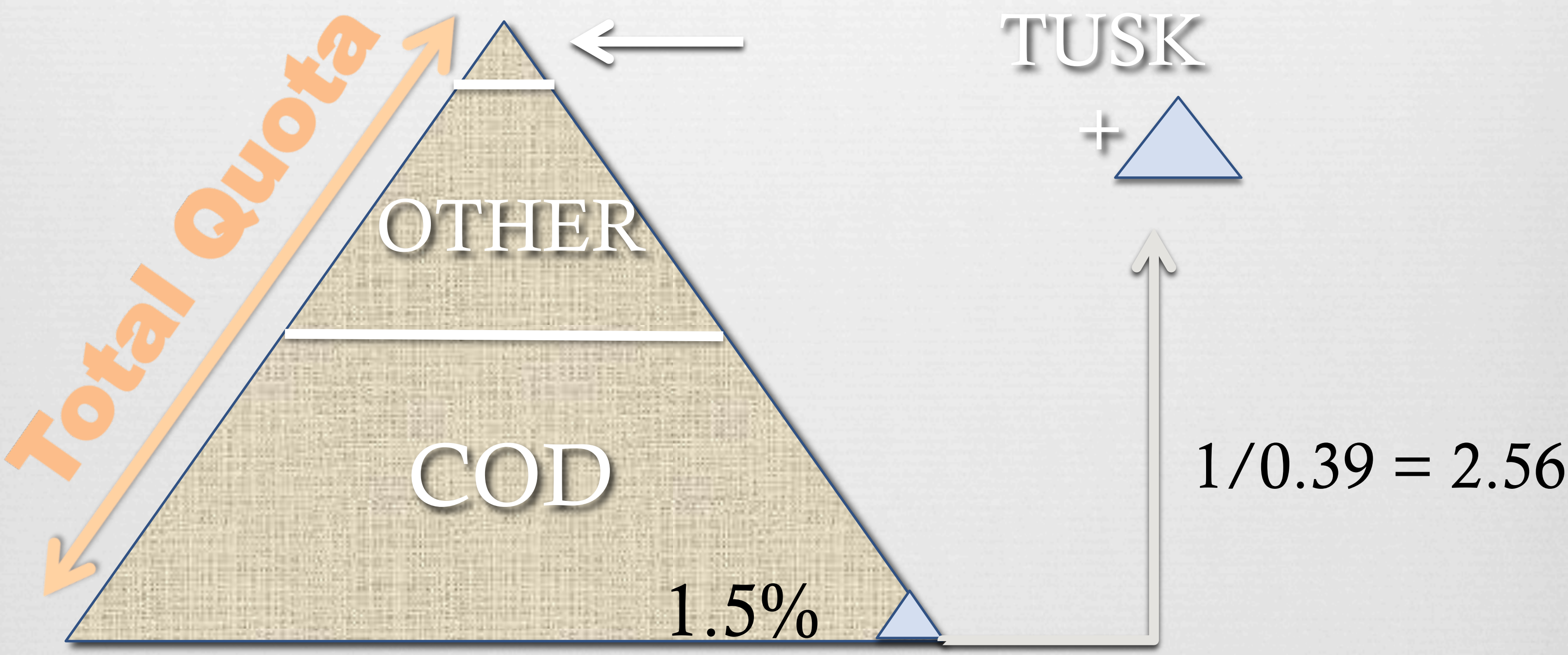


Some potential problems: abundance imbalance



Some potential problems: value imbalance



Goal of this study

Use multi-spp. bioeconomic model to analyze how short-term profit-maximizing behavior affects long-term sustainability & profitability.

What explains today's fishing patterns?

- Joint production & fixed ratios among catches: unavoidable bycatch

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Reality lies somewhere in-between

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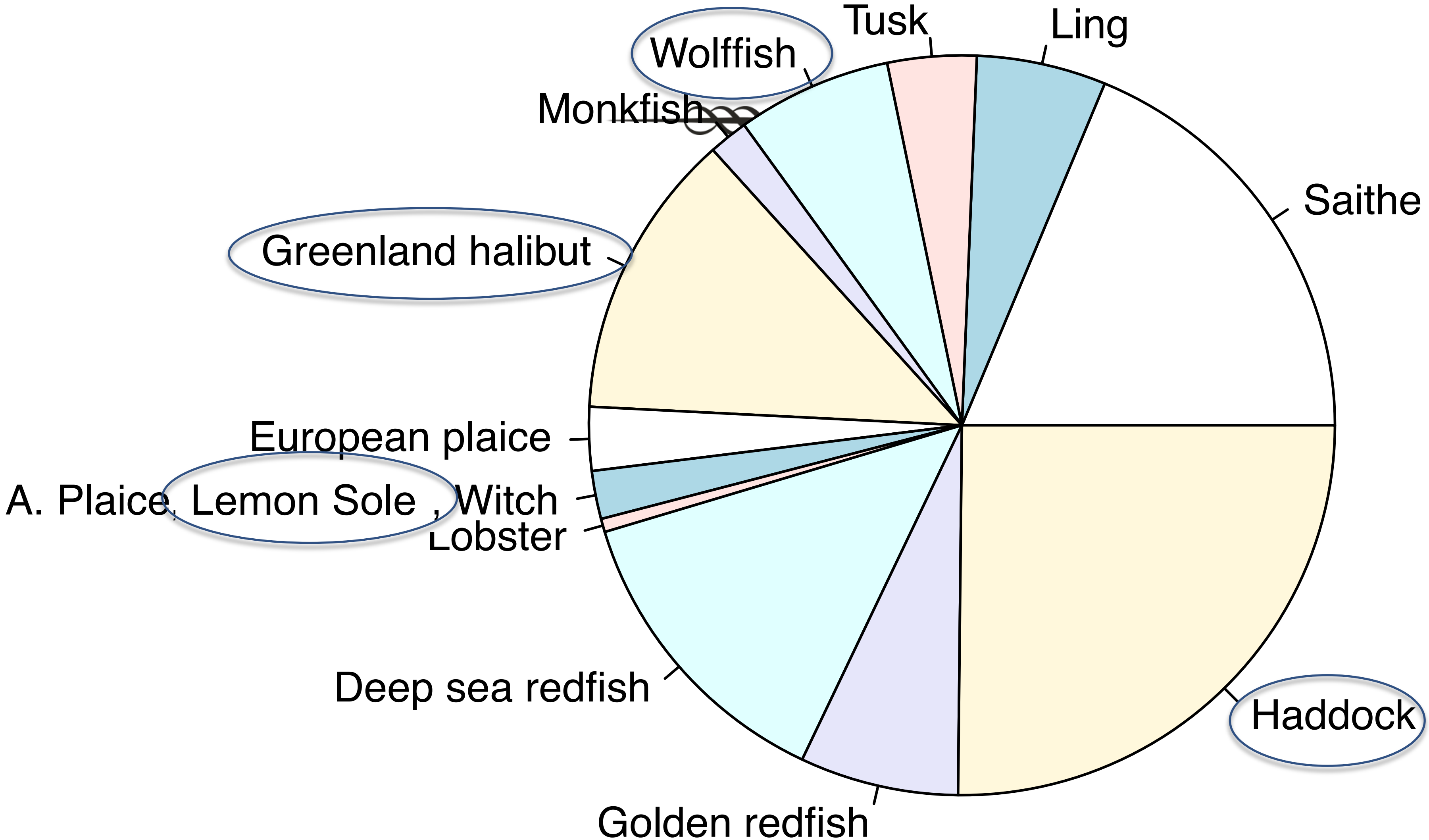
Model attributes

- Age-structured models for 5 species.

Landings in Iceland



Model attributes

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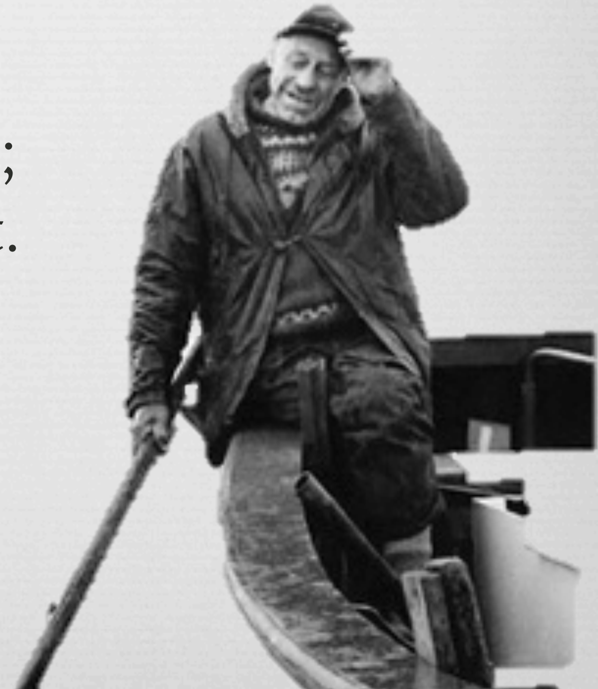
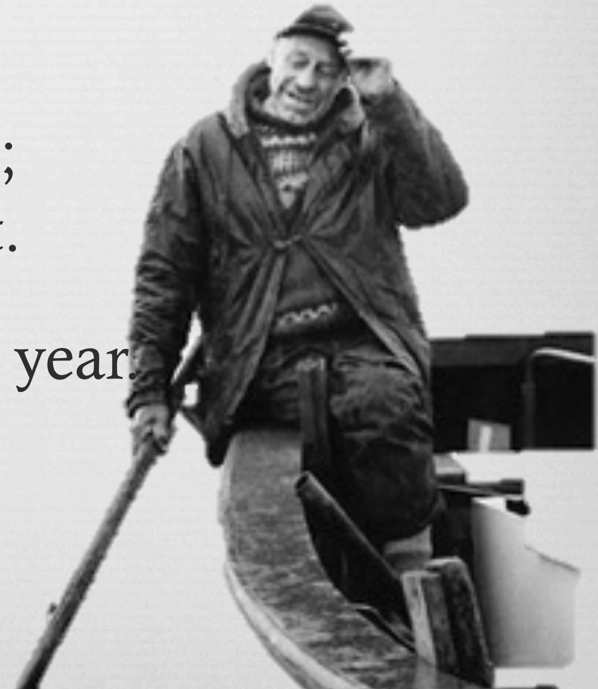


Model attributes

- Age-structured models for 5 species.
- Industry is the single user.
- Cost linearly increases with the sum of effort over all species.
- TACs based on F_{MSY} and are not binding; penalties invoked when catch surpasses it.
- Effort optimized to maximize profit each year. Profit = Revenue – Cost – Penalties.



Model attributes

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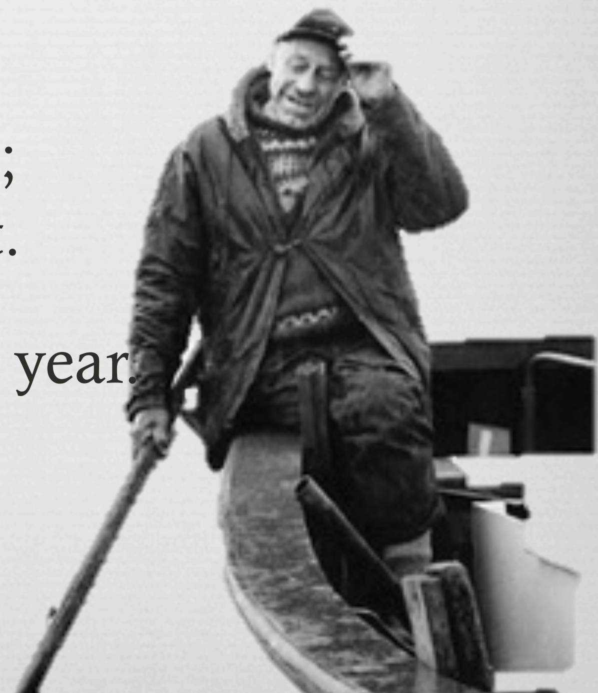
- Industry is the single user.
- Cost linearly increases with the sum of effort over all species.
- TACs based on F_{MSY} and are not binding; penalties invoked when catch surpasses it.
- Effort optimized to maximize profit each year. Profit = Revenue – Cost – Penalties.
- Deterministic.



How are species catches related in the model?

LINKED:

- Cost per unit effort.
  - Relative catchability.

NOT LINKED:

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LINKED:

- Cost per unit effort.
  - Relative catchability.
- Penalties. (Species transformation accounting)

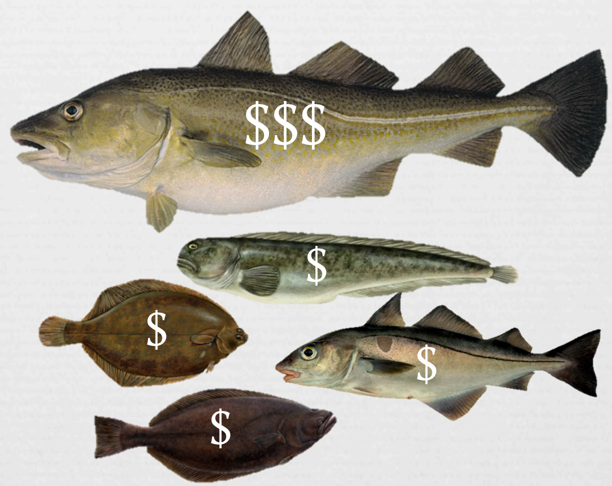
NOT LINKED:

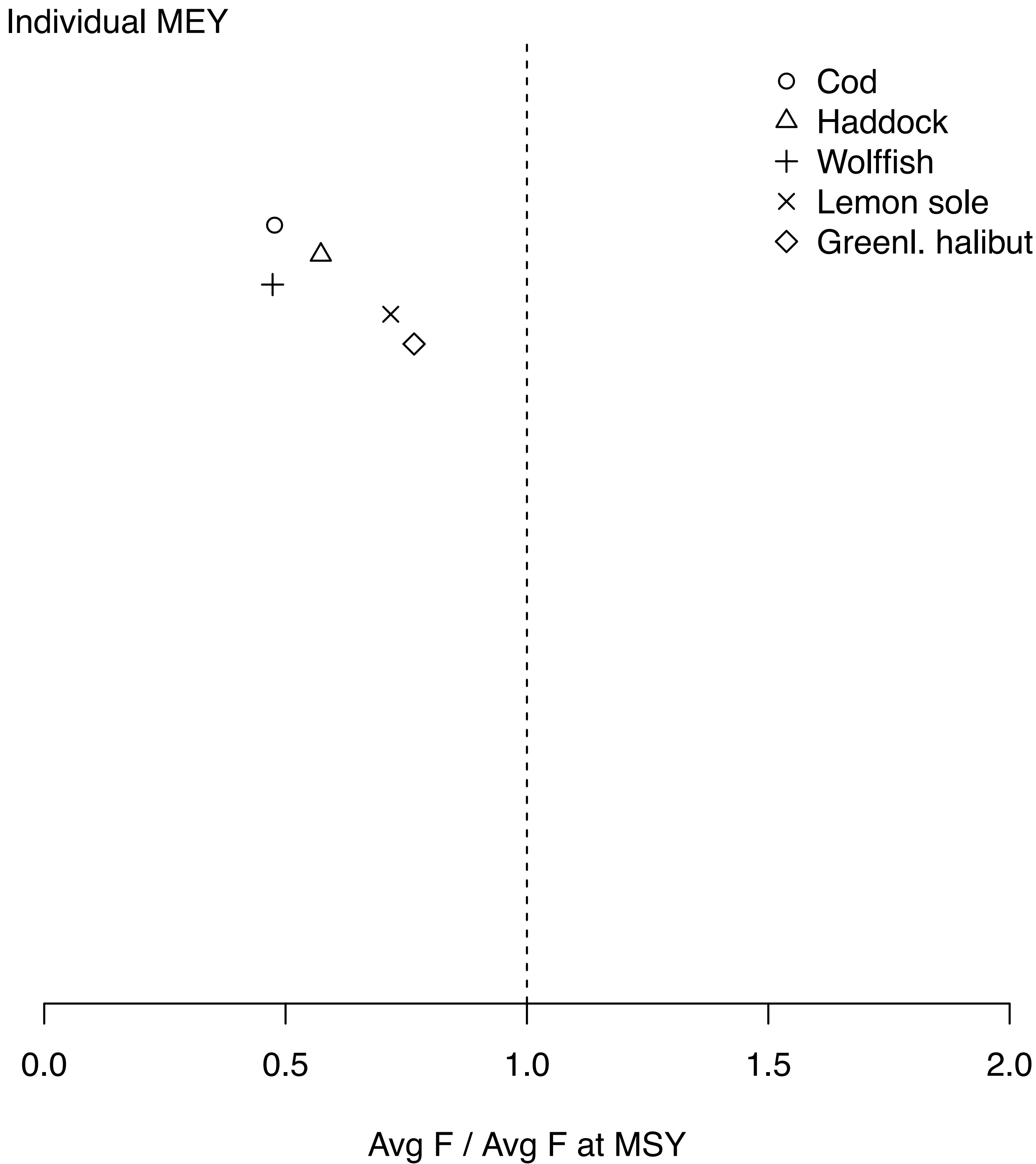
- Ecologically.
- Spatially.
- Socially (e.g., catch share distributions)

Thought experiment

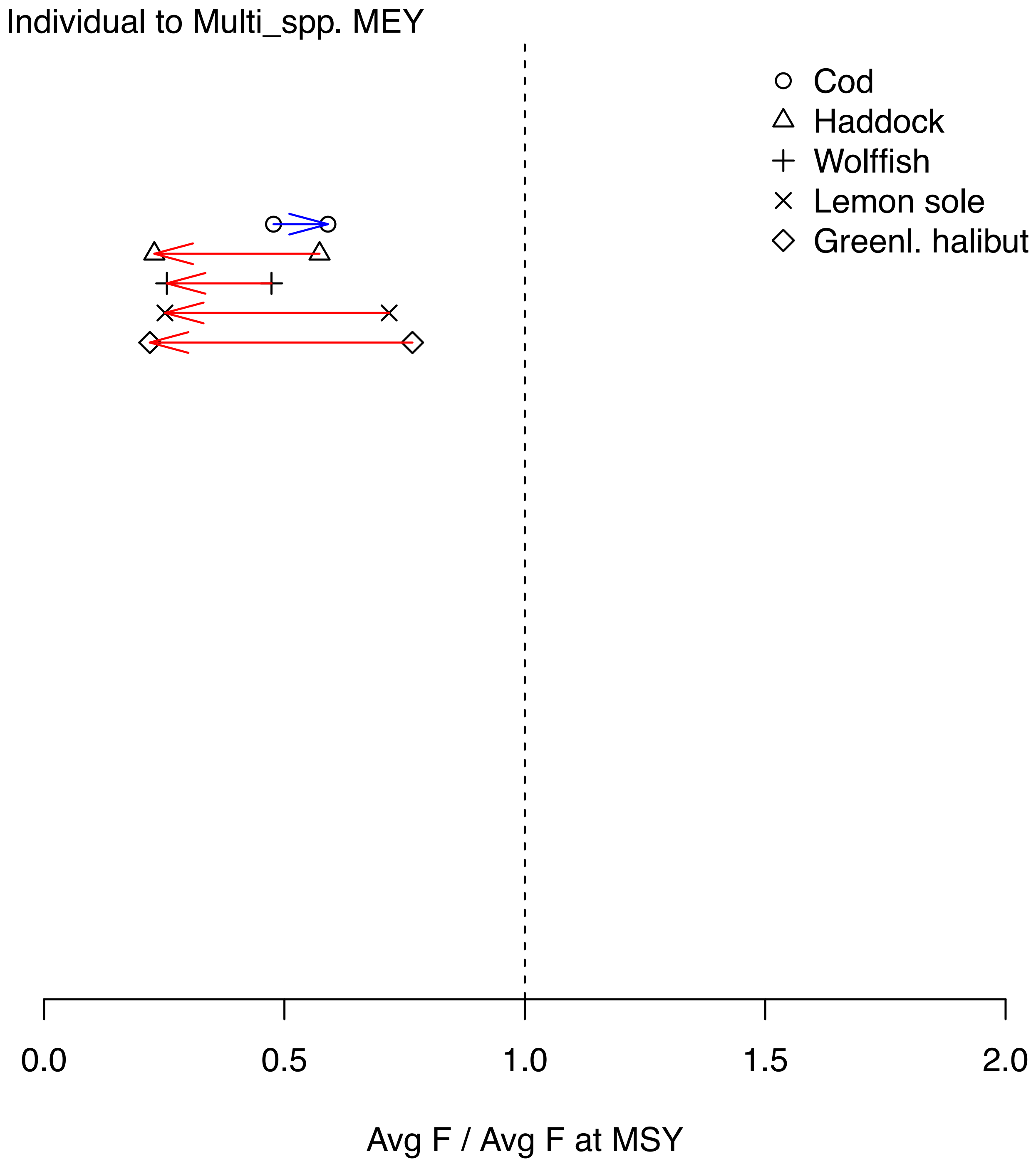
What is the long-term profitability when:

1. Catchability set so revenue / effort is equal among all species but cod.





Individual MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



Individual to Multi_spp. MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

Thought experiment

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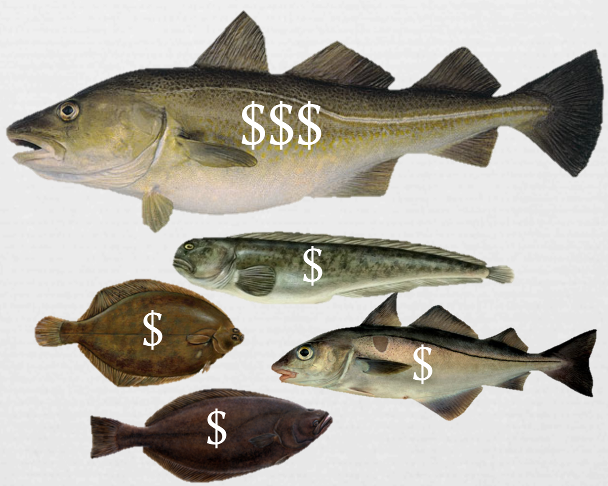
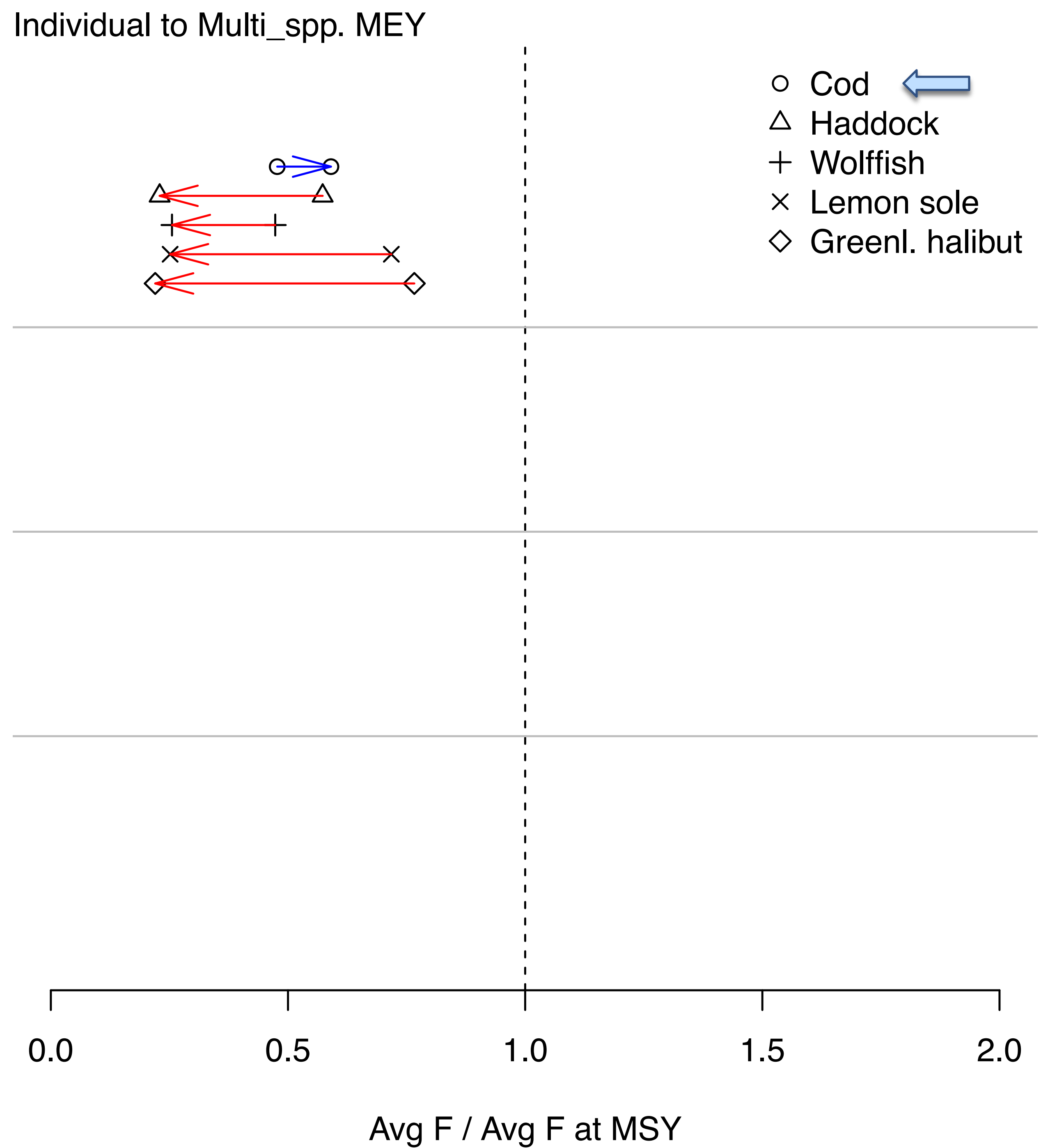


Thought experiment

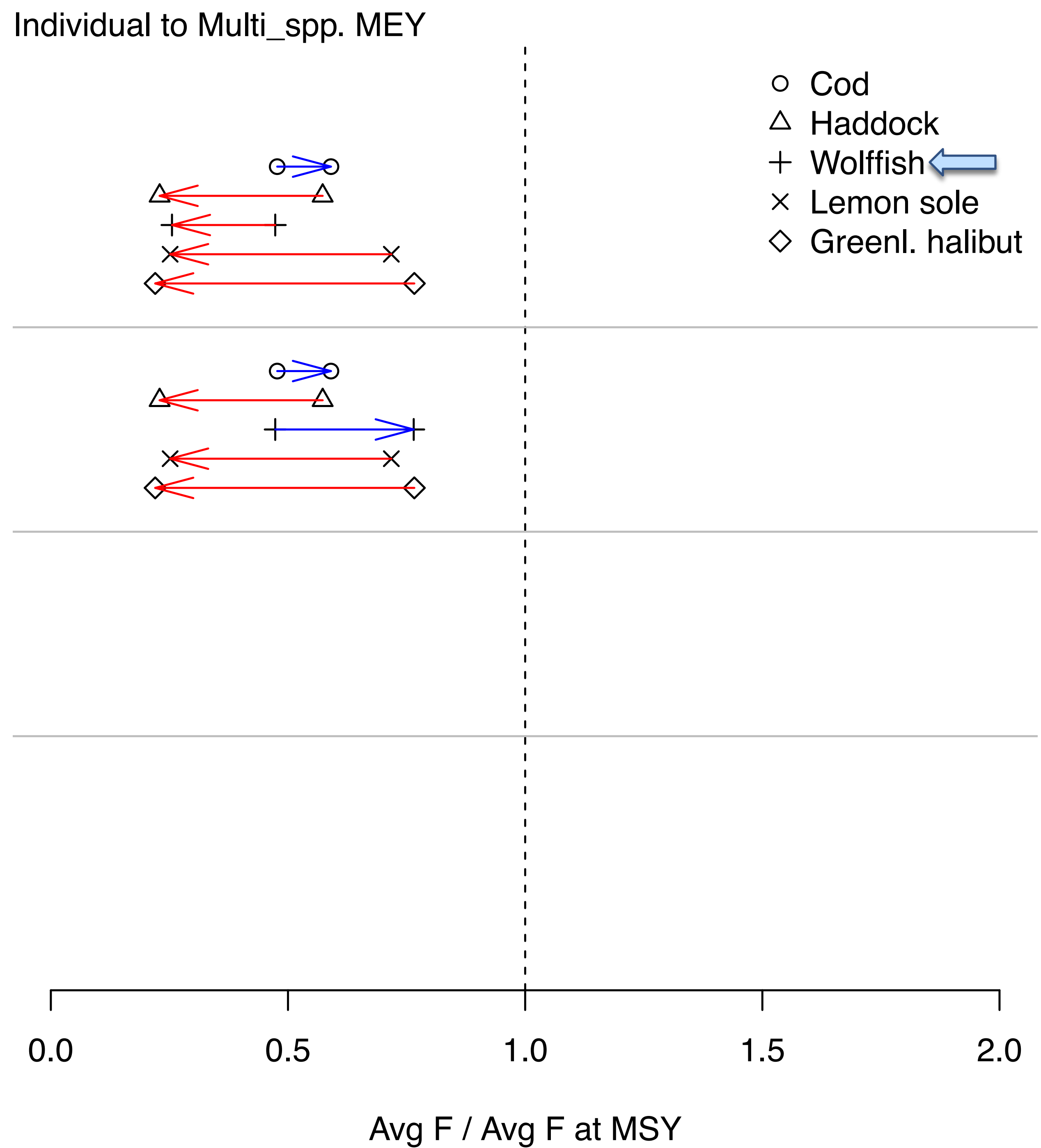
What is the long-term profitability when:

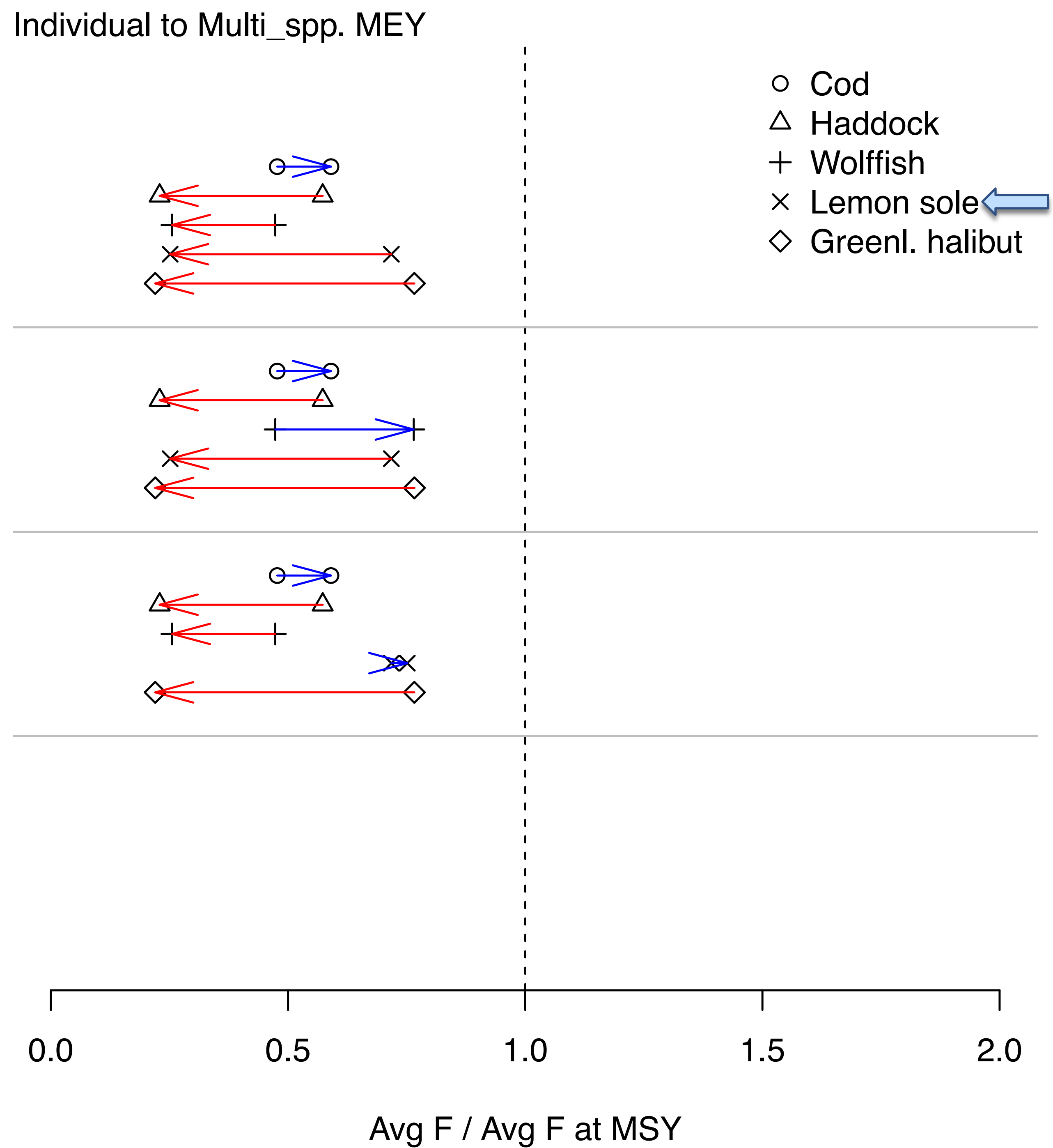
1. Catchability set so revenue / effort is equal among all species but cod.

2. Increase catchability so that revenue / effort is high for each species.

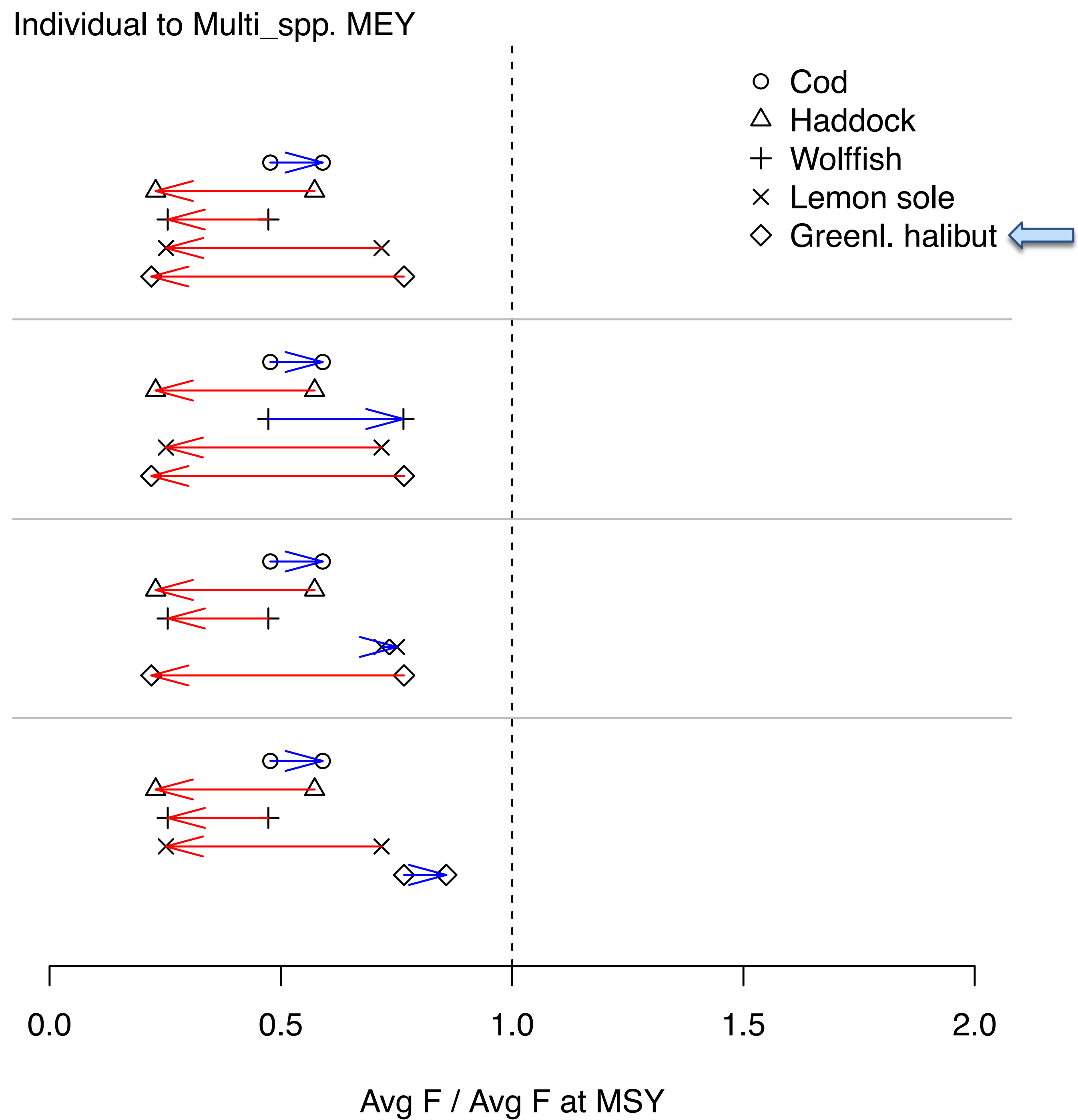


Individual to Multi_spp. MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY


Individual to Multi_spp. MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



Individual to Multi_spp. MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

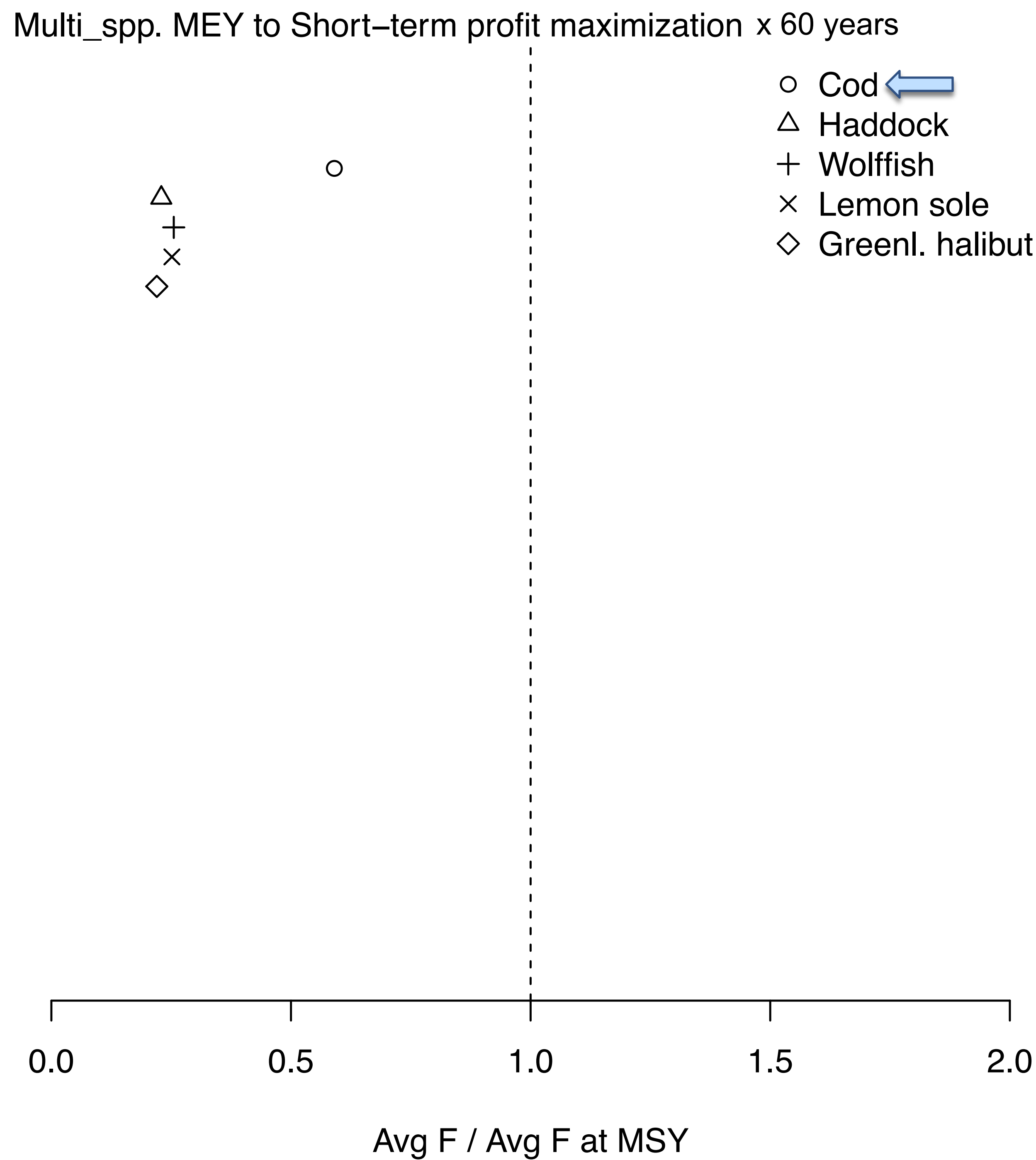


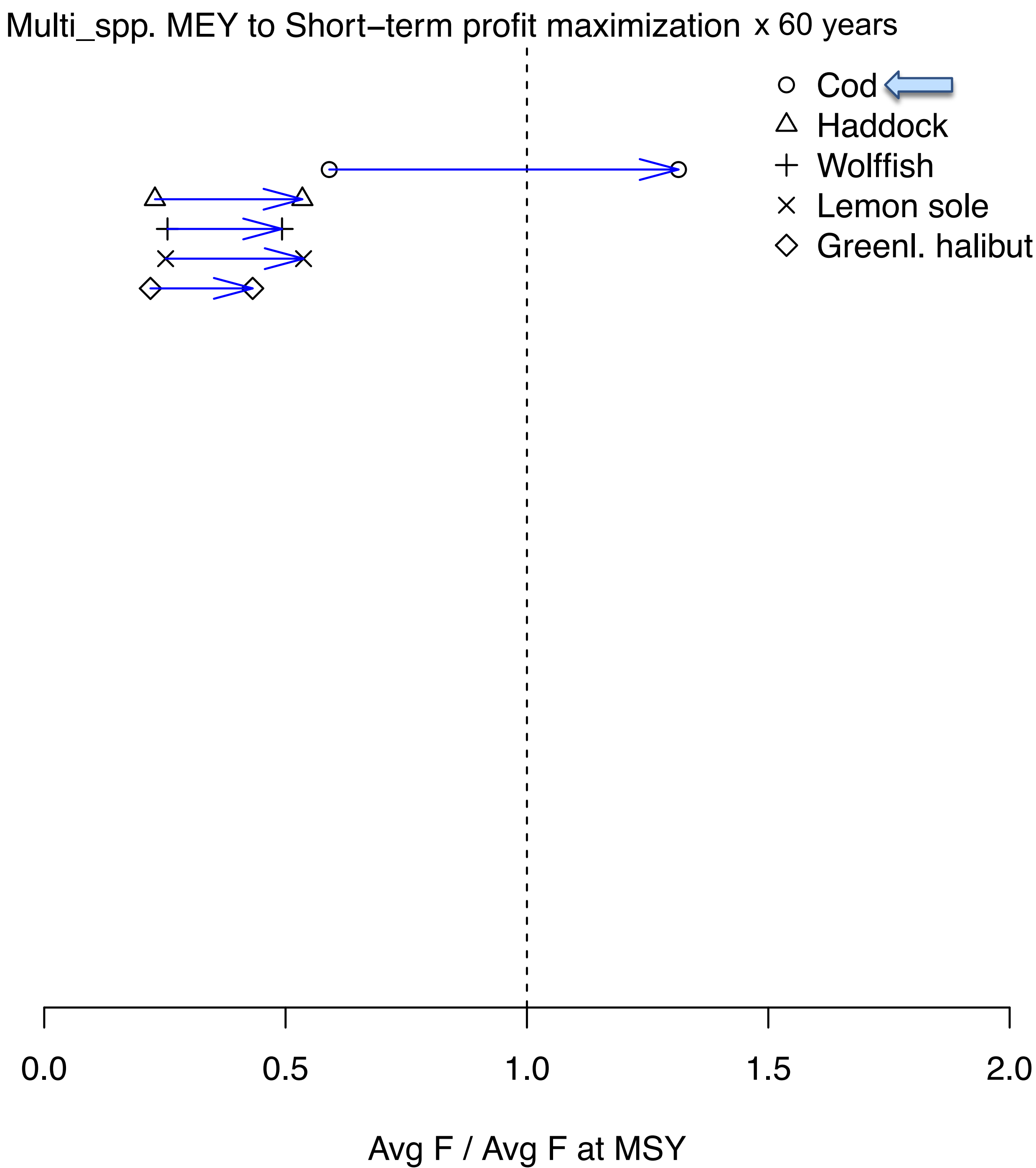
Individual to Multi_spp. MEY
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

Thought experiment

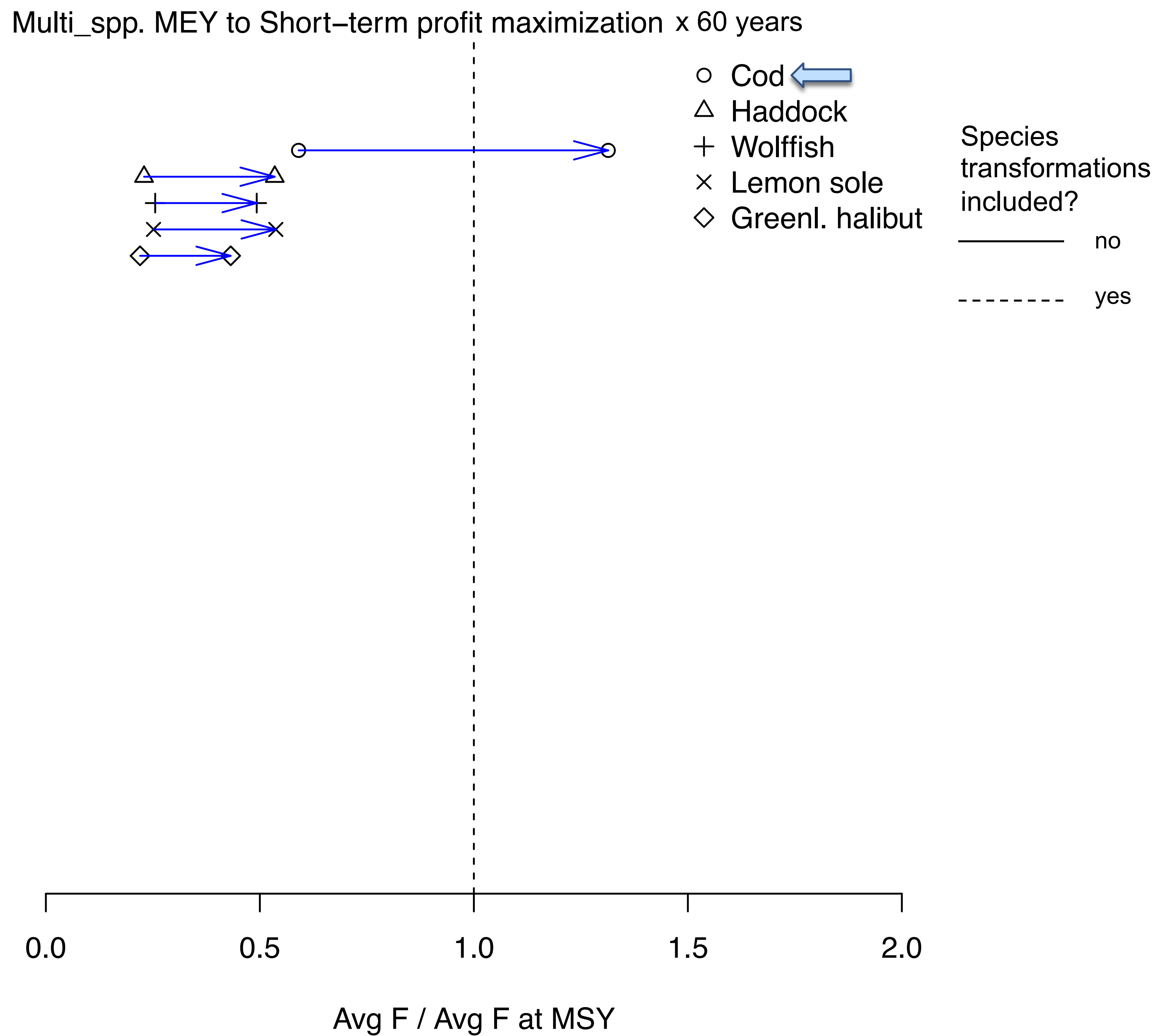
How do results from long-term profitability compare with an assumption of annual short-term profit-maximizing behavior?

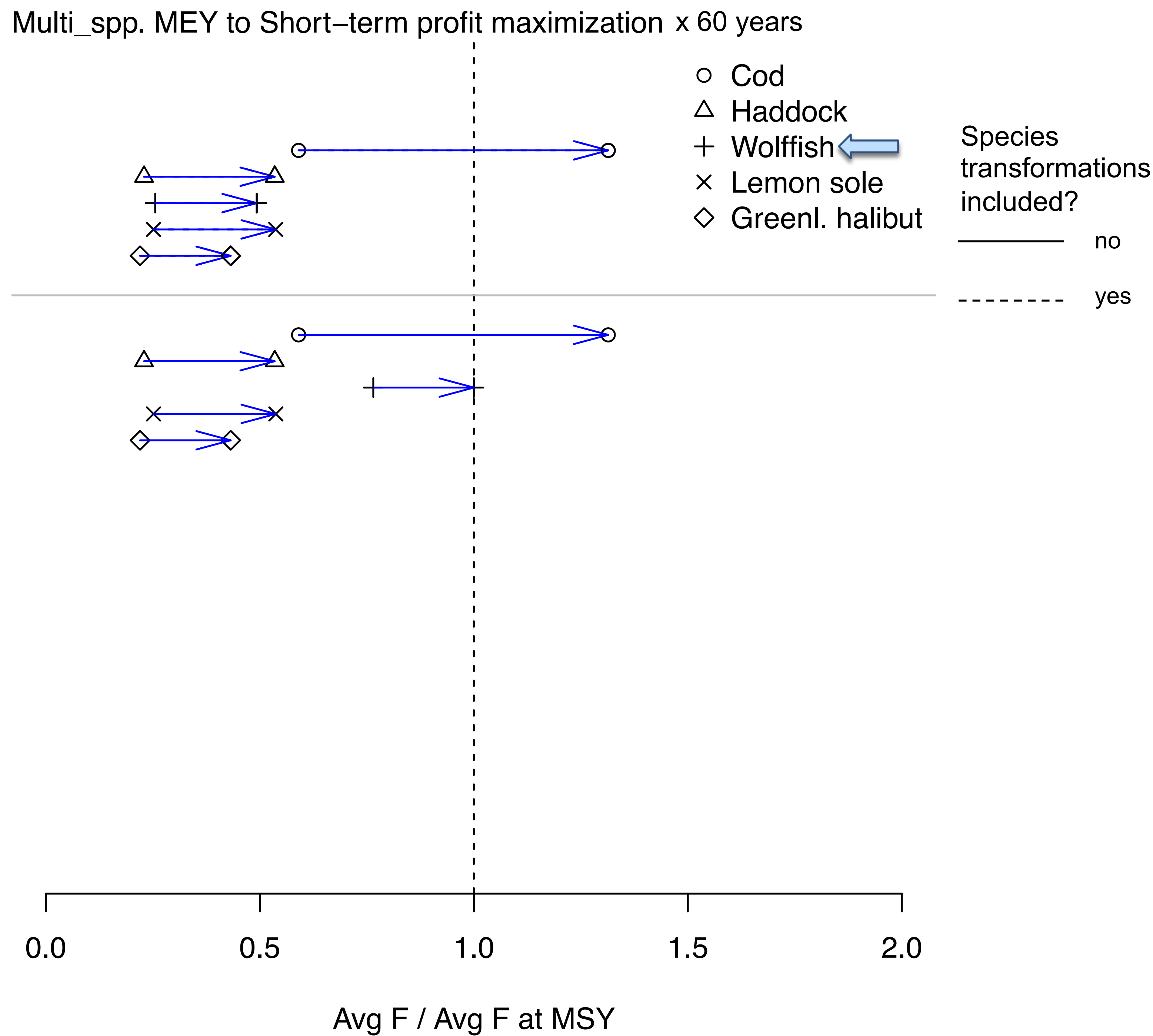
With and without species transformations implemented?


Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

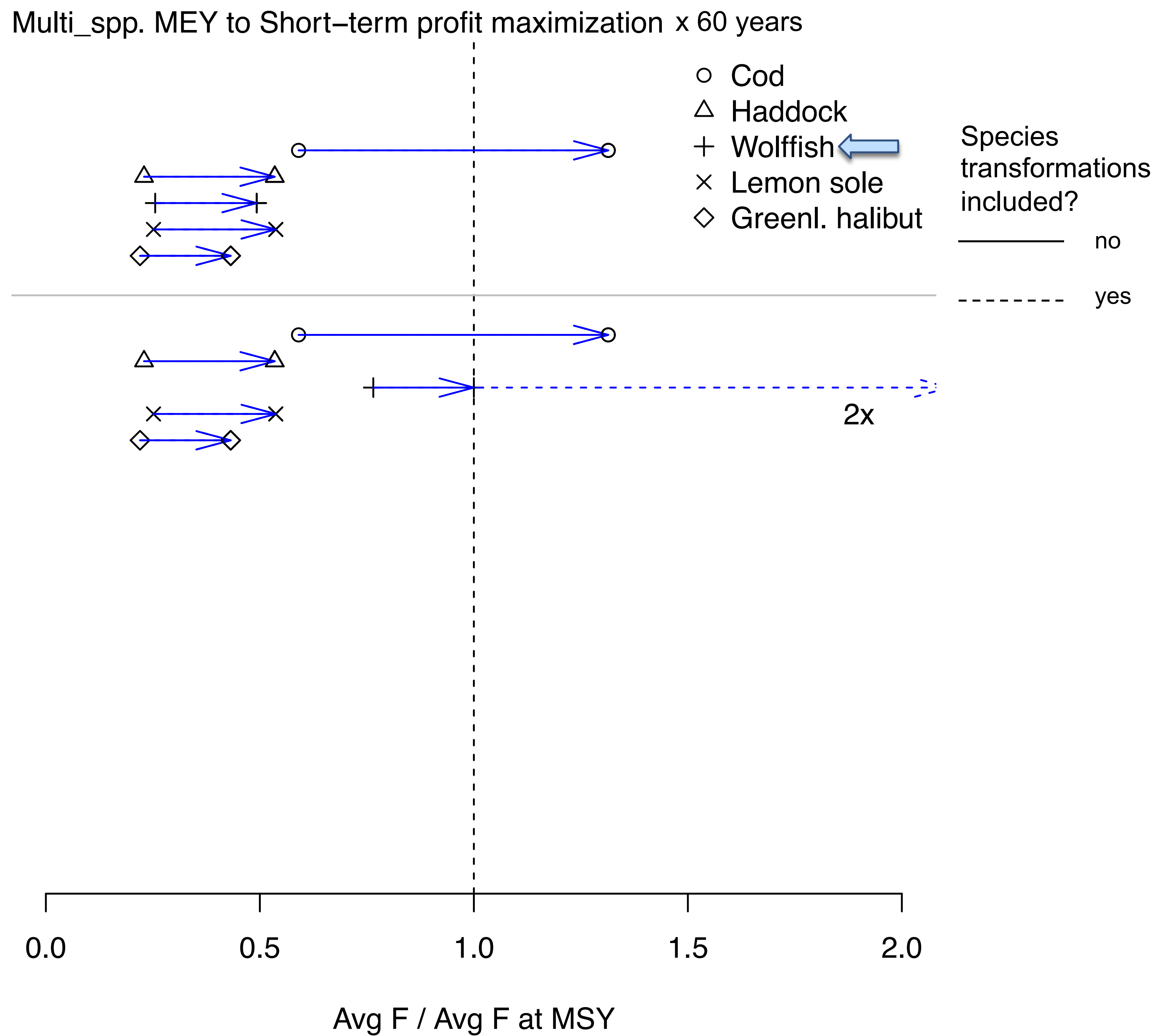


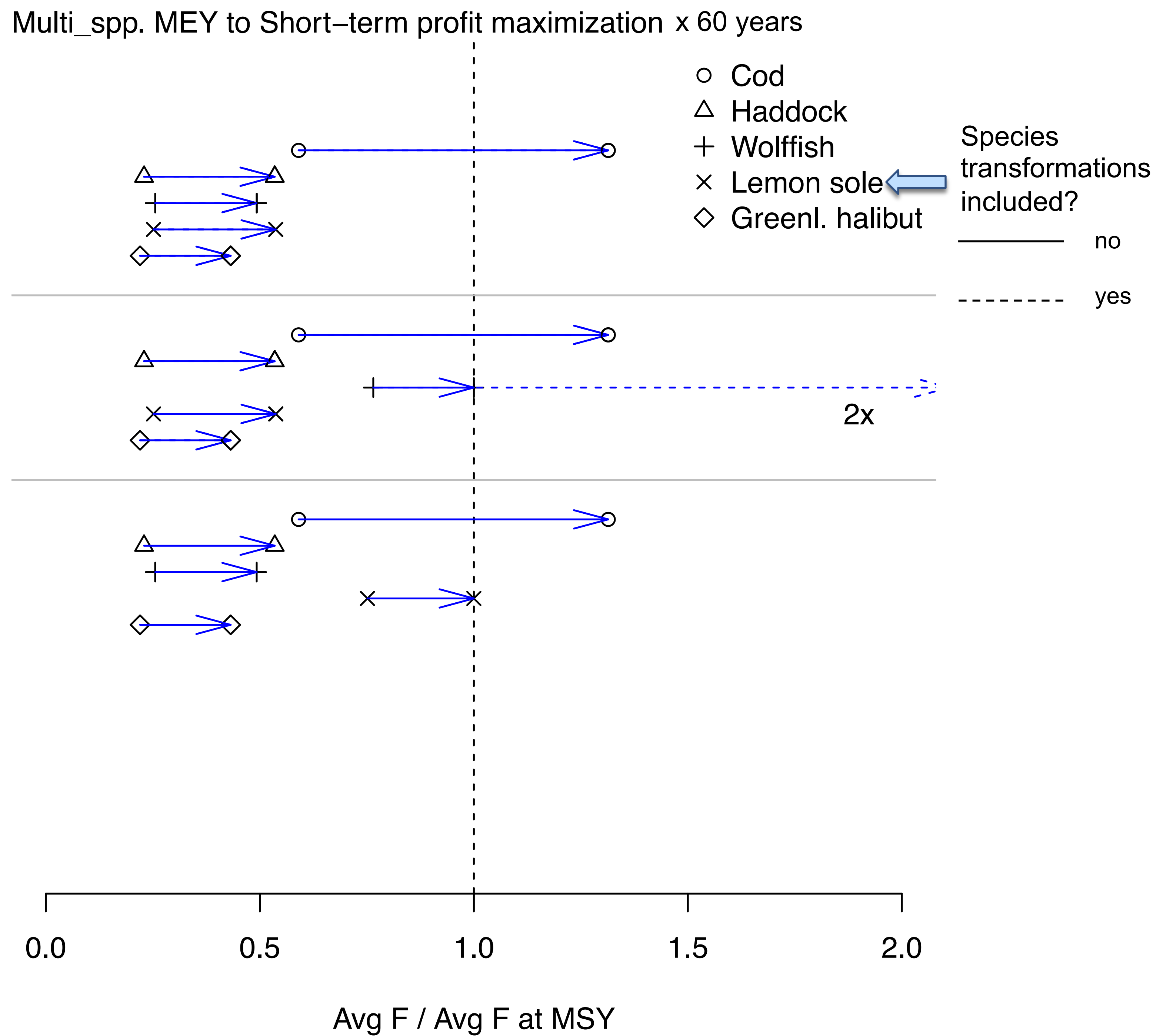
Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

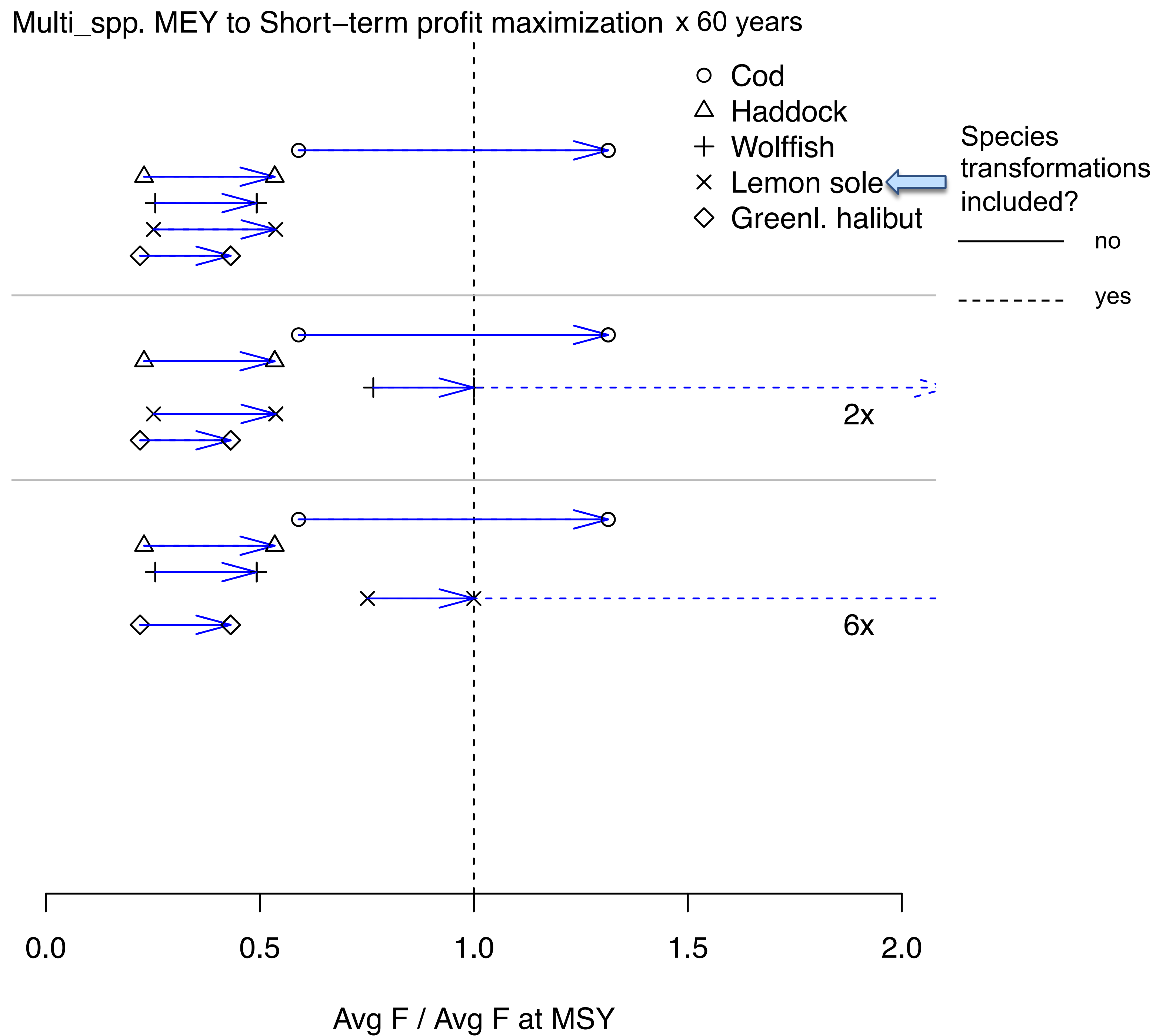

Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



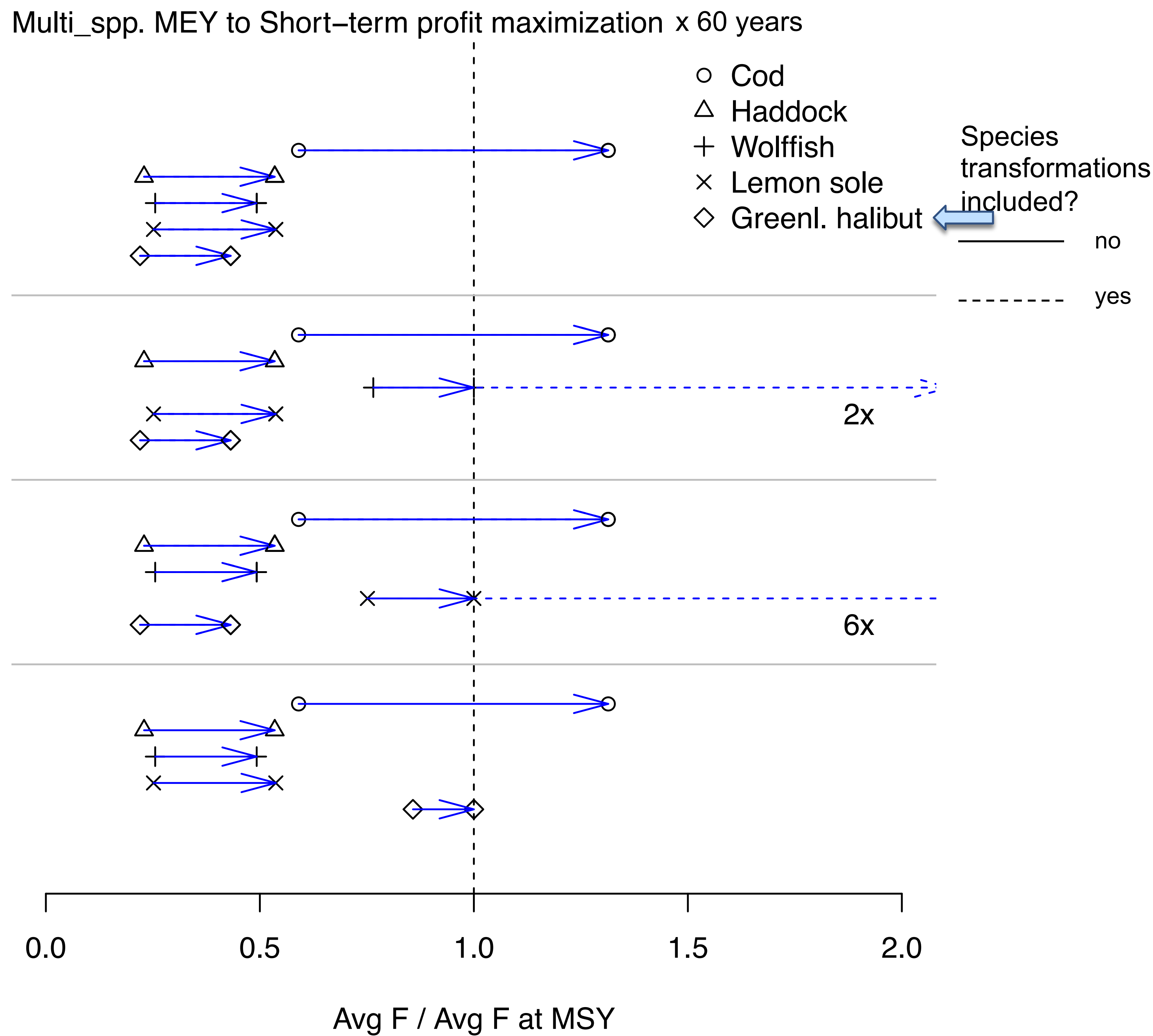
Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY


Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
2x
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

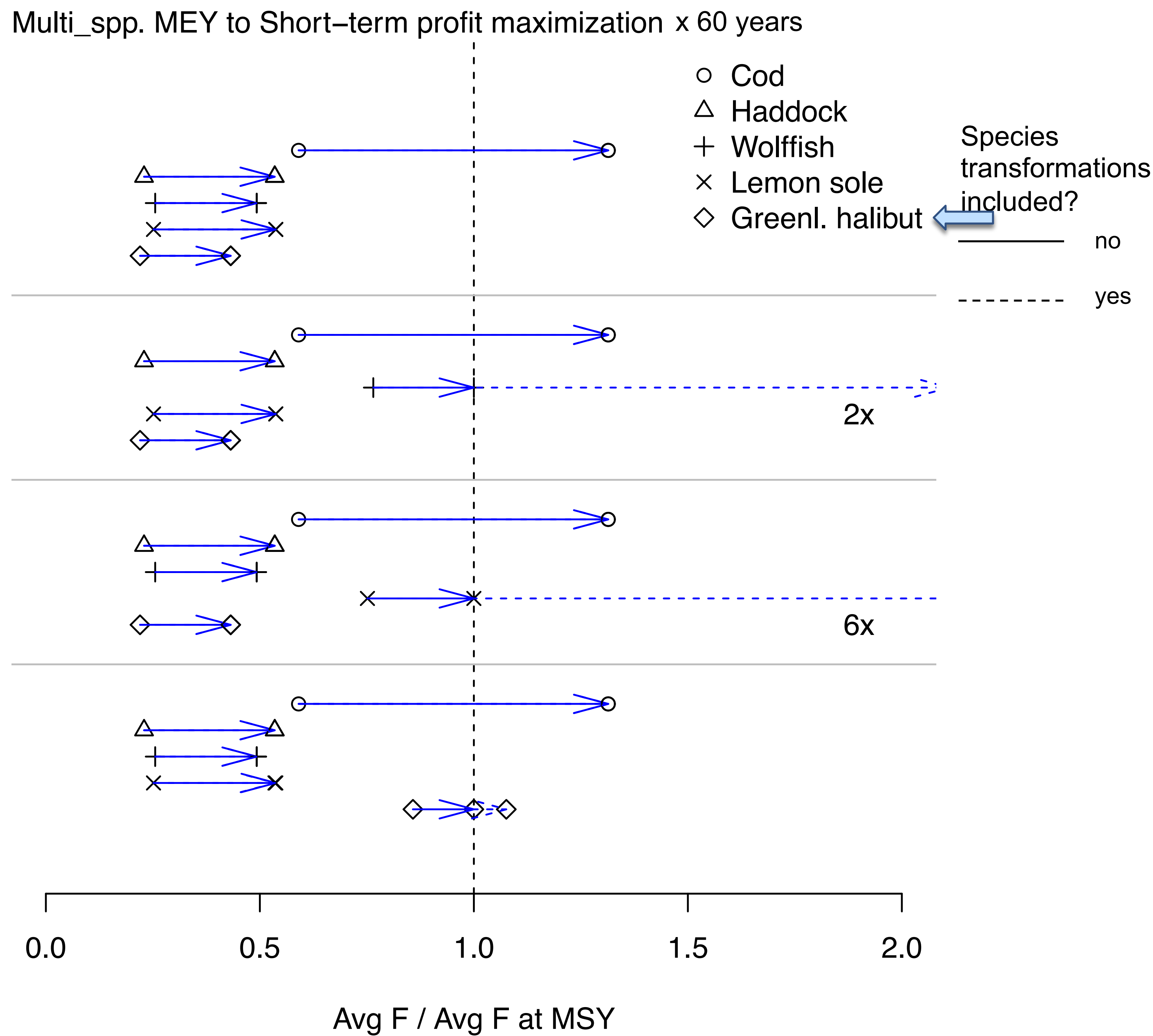

Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
2x
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
2x
6x
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



Multi_spp. MEY to Short–term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
2x
6x
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY



Multi_spp. MEY to Short−term profit maximization x 60 years
Cod
Haddock
Wolffish
Lemon sole
Greenl. halibut
Species transformations included?
no
yes
2x
6x
0.0
0.5
1.0
1.5
2.0
Avg F / Avg F at MSY

BUT…TACs rarely exceeded to the extreme…why?

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  - catchability; metíer components
  - spp.-partitioned costs

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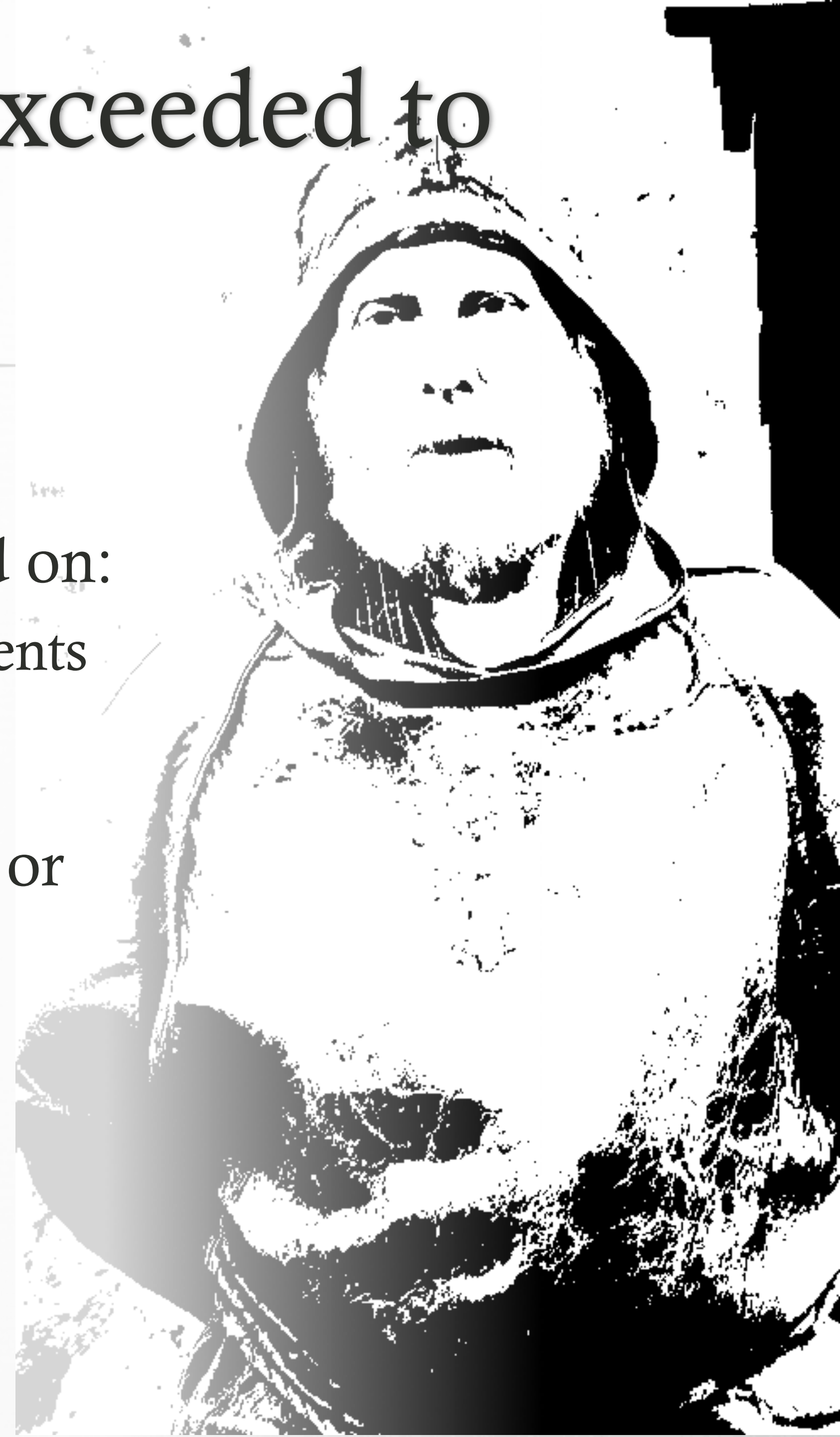
  - spp.-partitioned costs
- Unpredictable environmental or price fluctuations
- Sequential within-year usage.

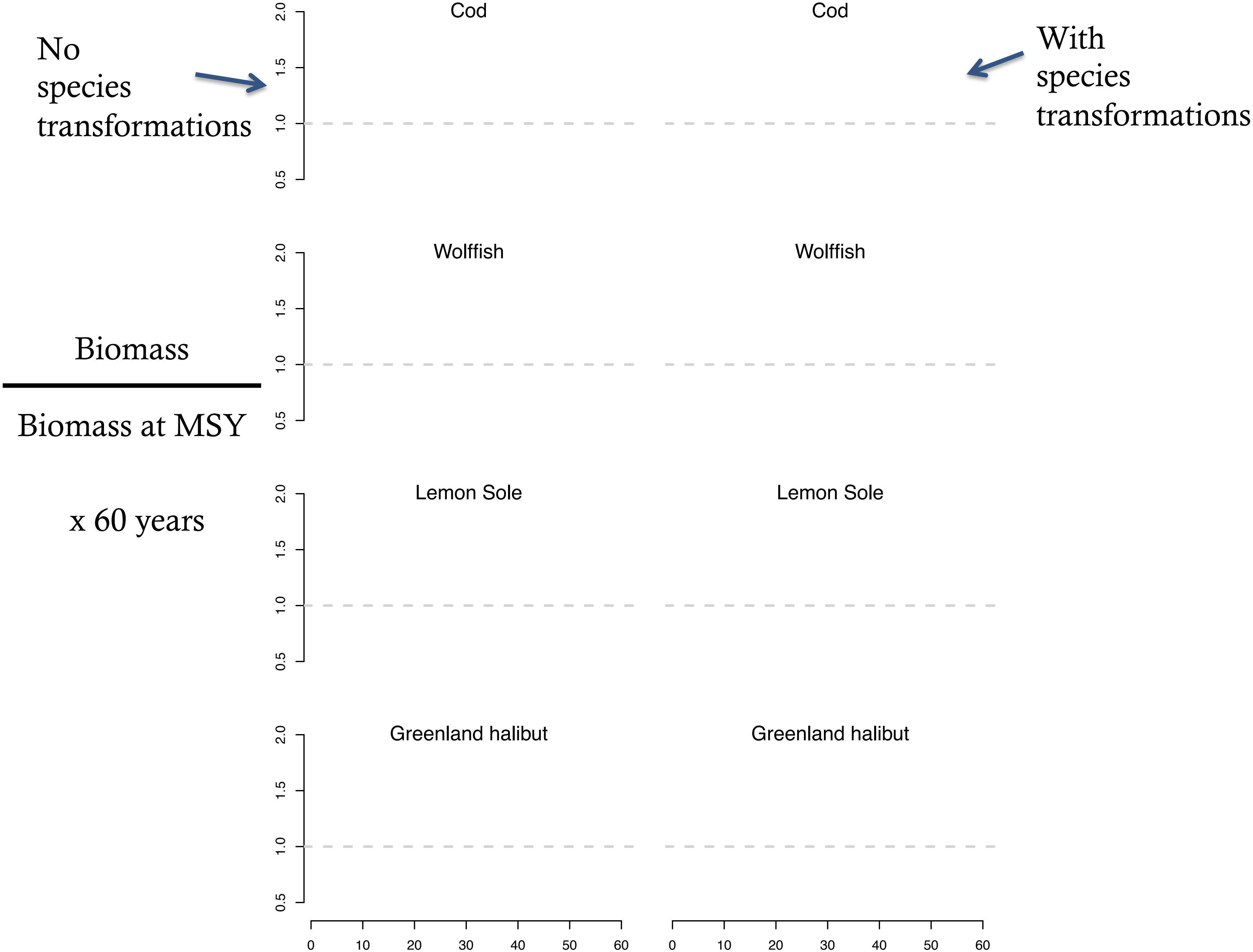


BUT…TACs rarely exceeded to the extreme…why?

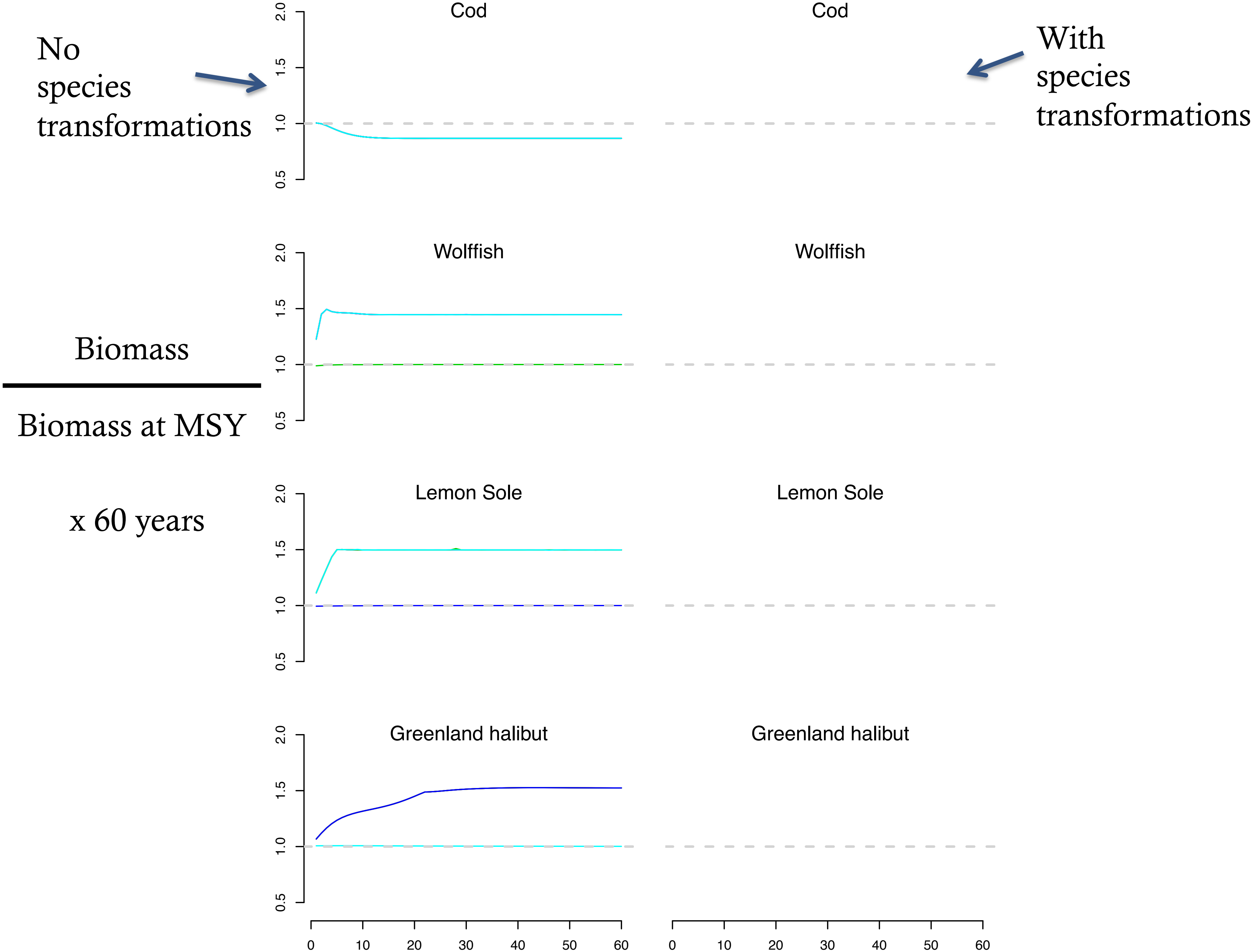
- Unavoidable bycatch is substantial? More info needed on:
  - catchability; metíer components
  - spp.-partitioned costs
- Unpredictable environmental or price fluctuations
- Sequential within-year usage.
- Is short-term profitability not the only motivator?

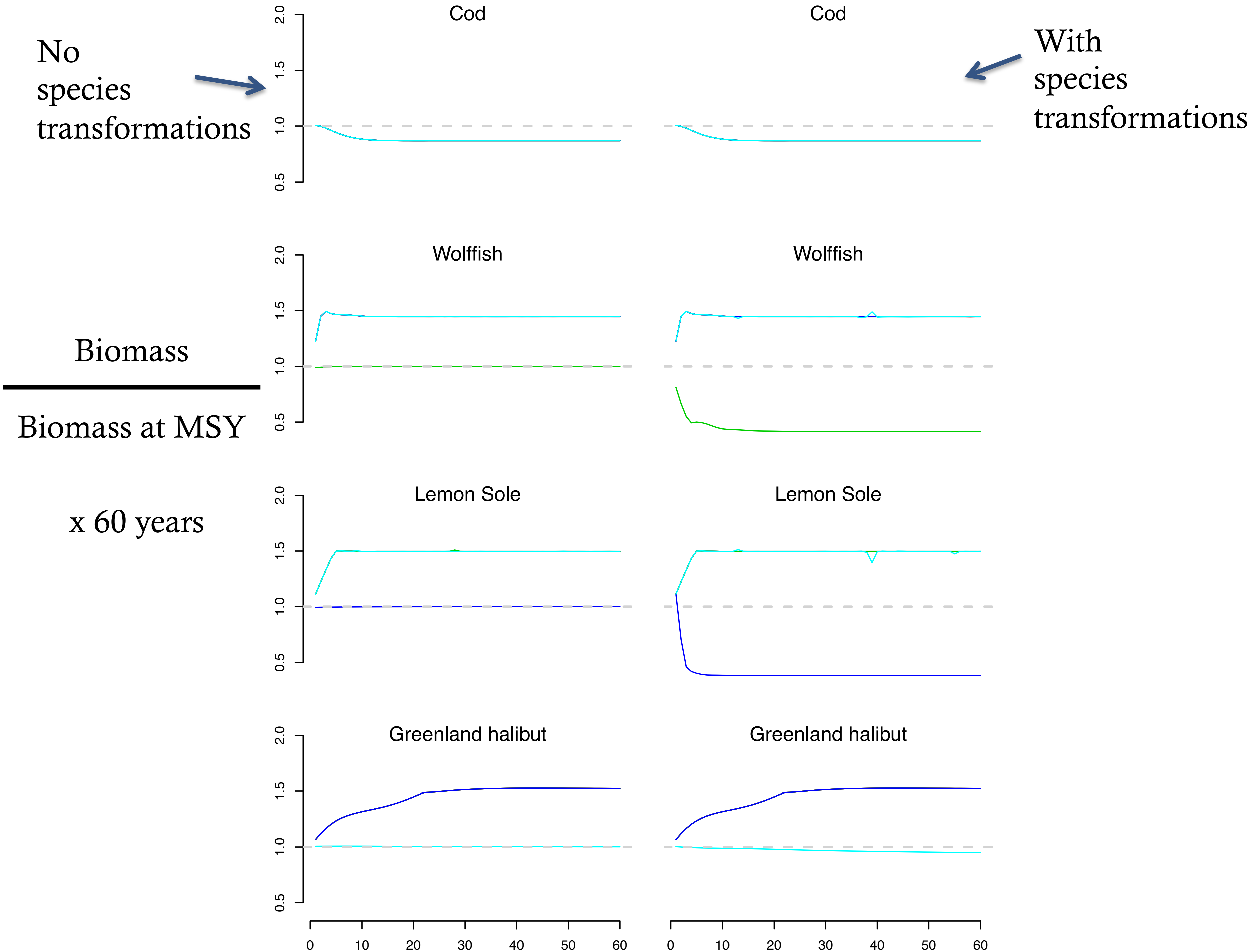
Thought experiment

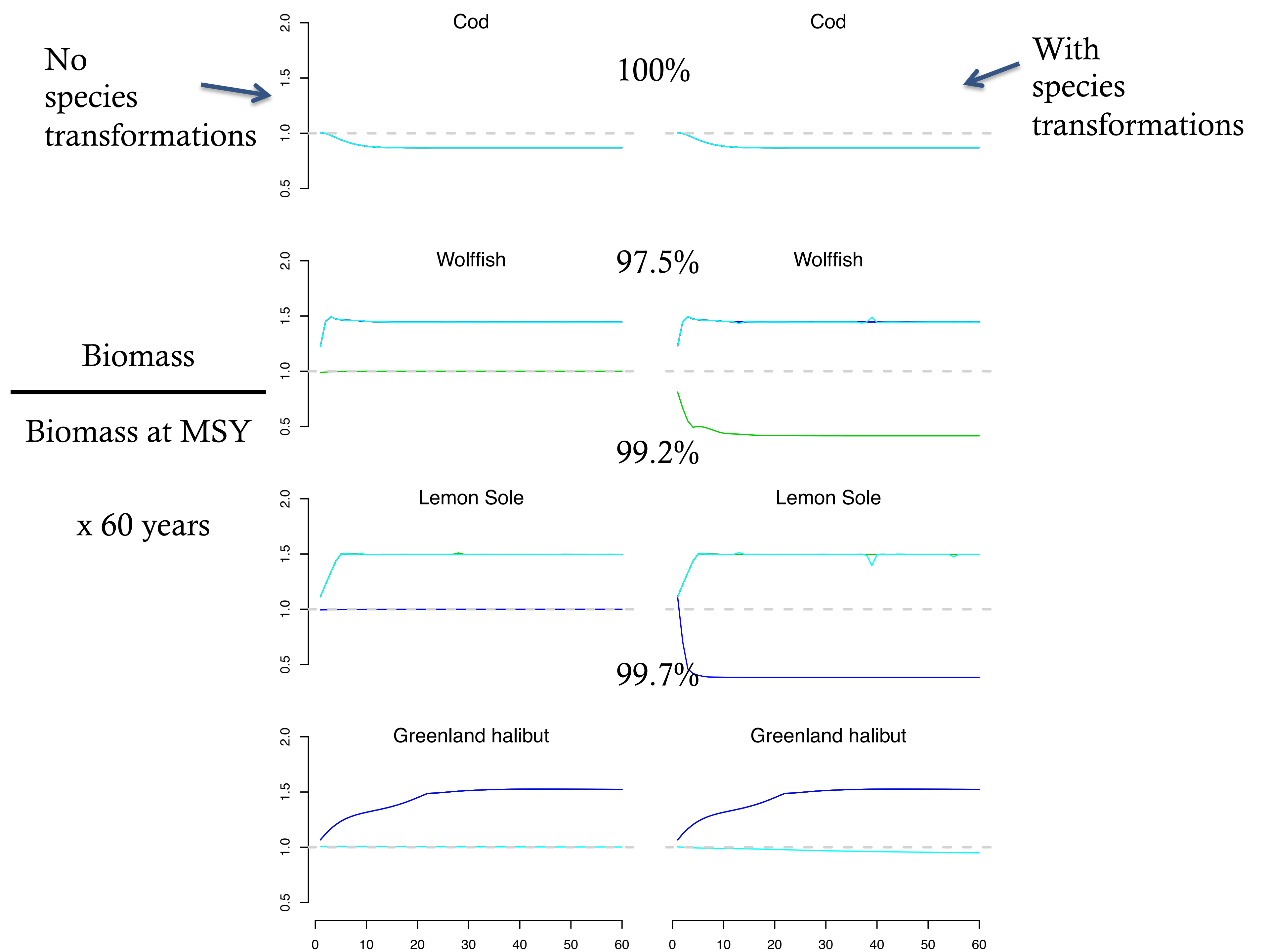
Sustainability or profitability?



No species transformations
With species transformations
Biomass
Biomass at MSY
x 60 years
Cod
Cod
Wolffish
Wolffish
Lemon Sole
Lemon Sole
Greenland halibut
Greenland halibut
2.0
1.5
1.0
0.5
0
10
20
30
40
50
60


No species transformations
With species transformations
Biomass
Biomass at MSY
x 60 years
Cod
Cod
Wolffish
Wolffish
Lemon Sole
Lemon Sole
Greenland halibut
Greenland halibut
0.5
1.0
1.5
2.0
0
10
20
30
40
50
60


No species transformations
With species transformations
Biomass
Biomass at MSY
x 60 years
Cod
Cod
Wolffish
Wolffish
Lemon Sole
Lemon Sole
Greenland halibut
Greenland halibut
2.0
1.5
1.0
0.5
0
10
20
30
40
50
60



No species transformations
With species transformations
Biomass
Biomass at MSY
x 60 years
Cod
Cod
100%
Wolffish
Wolffish
97.5%
99.2%
Lemon Sole
Lemon Sole
99.7%
Greenland halibut
Greenland halibut
2.0
1.5
1.0
0.5
0
10
20
30
40
50
60

One step forward?

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- Yields avenue for formalizing links among species regulations.

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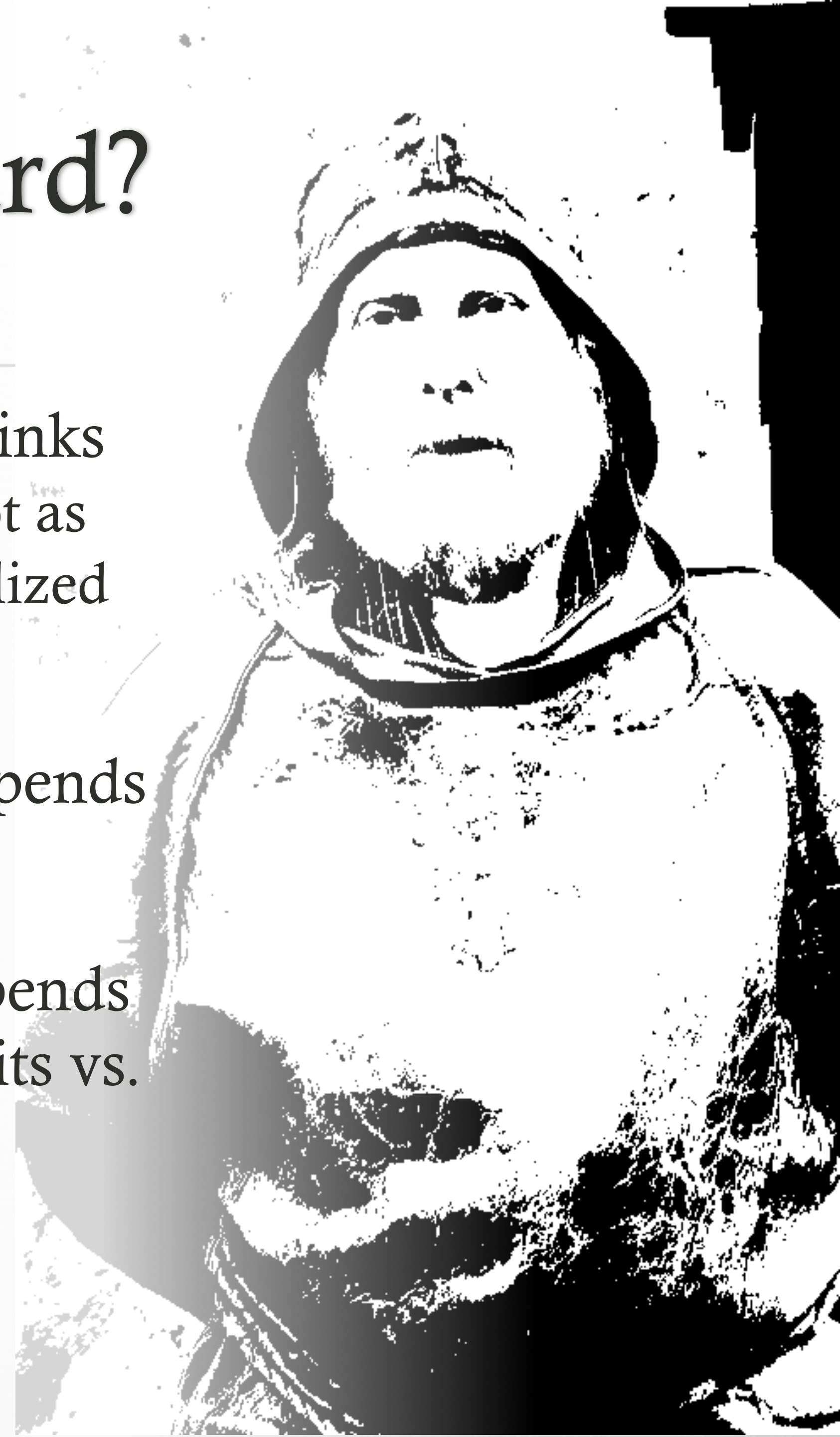

One step forward?

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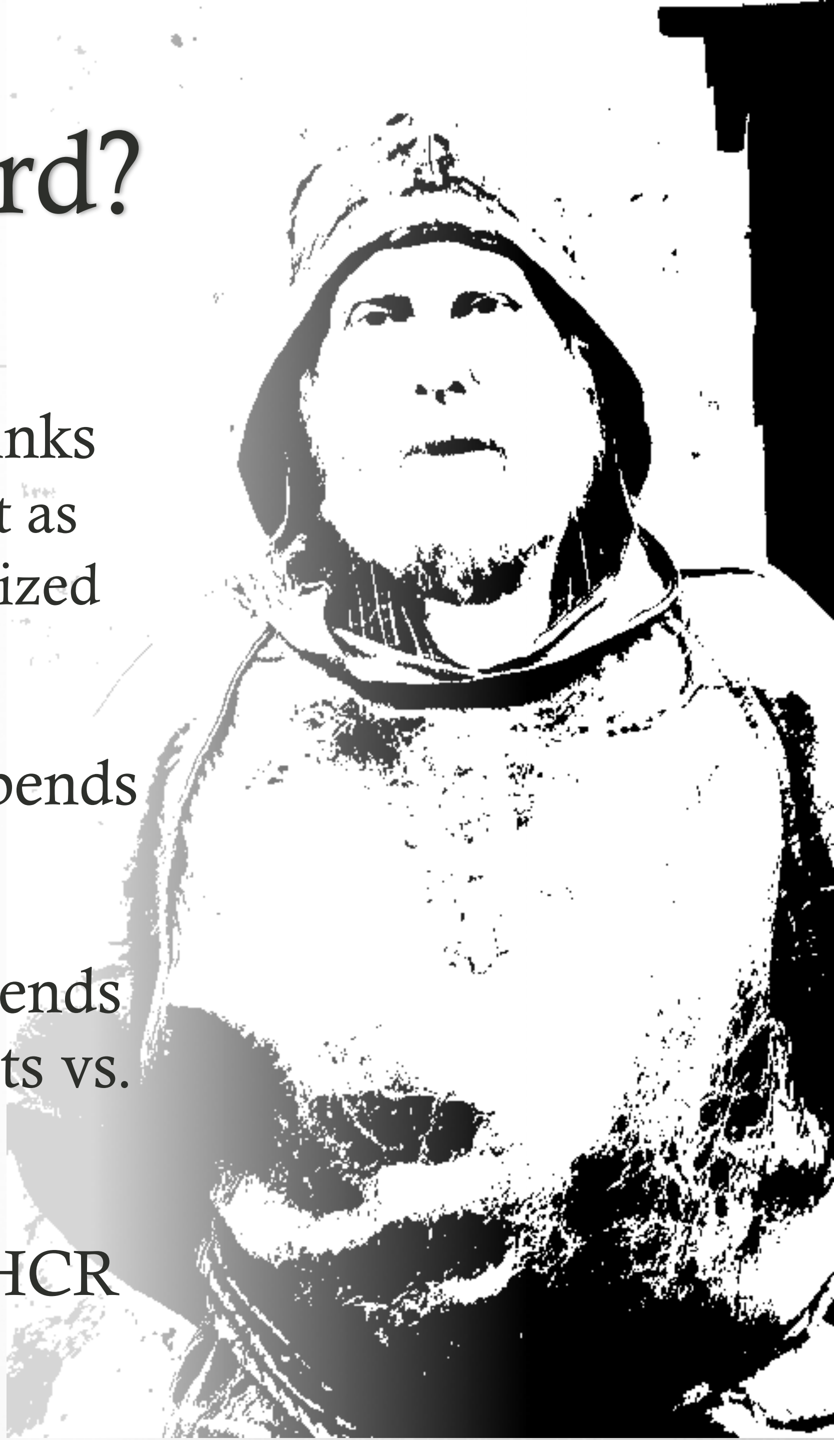
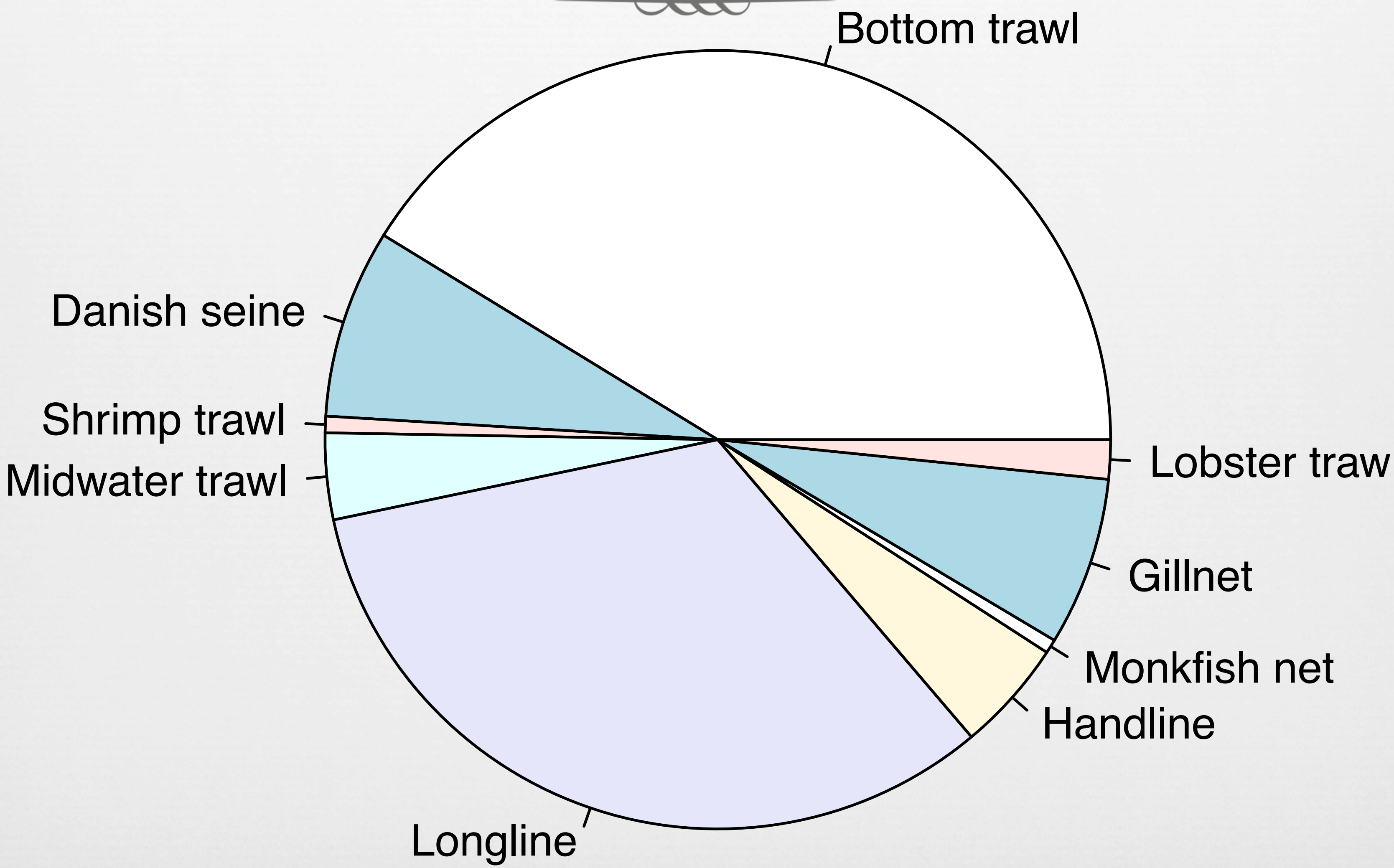
- Highly system-dependent. (Depends on relative profitability).
- Highly values-dependent. (Depends on profitability vs. social benefits vs. acceptable risk.)
- Next step: ADMB. (Optimize HCR or spp. conversion rates?)



Thank you!

- University of Iceland
- University of Washington
- Northwest Fisheries Science Center
- RAX photos

Icelandic demersal fisheries




ÍSLAND
13.00
1983
BETEMPS


ÍSLAND
11⁰⁰
BETEMPS
1983

Prospects

Prospects

- Data analysis.

Prospects

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- Explore how to set TACs or conversion rates to achieve long-term sustainability.

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- Add “component” variation to compartmentalize the constraints.

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- Explore how to set TACs or conversion rates to achieve long-term sustainability.
- Add "component" variation to compartmentalize the constraints.
- Determine effects of
  1. cod equivalent misspecification
  2. environmental change
  3. chronic over-setting of the TAC
  4. exchange rate parameterization