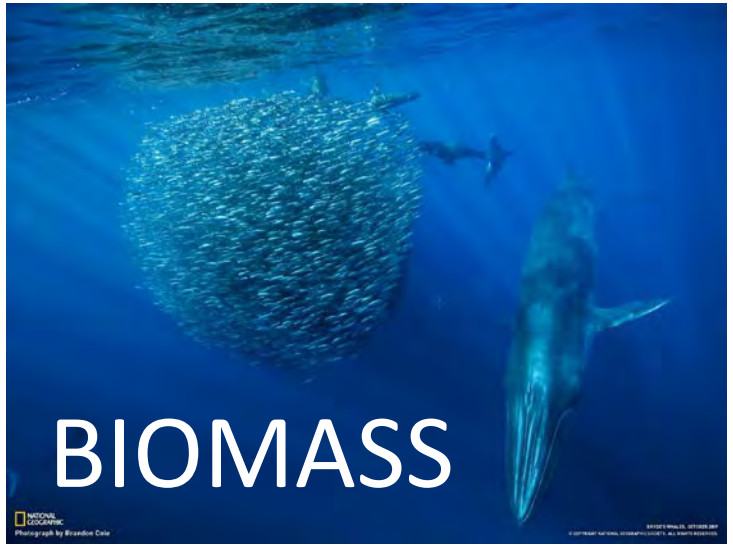
Managing modified ecosystems

Cody Szuwalski
University of California, Santa Barbara
September 29, 2017

How would management reform impact:



Global + single species

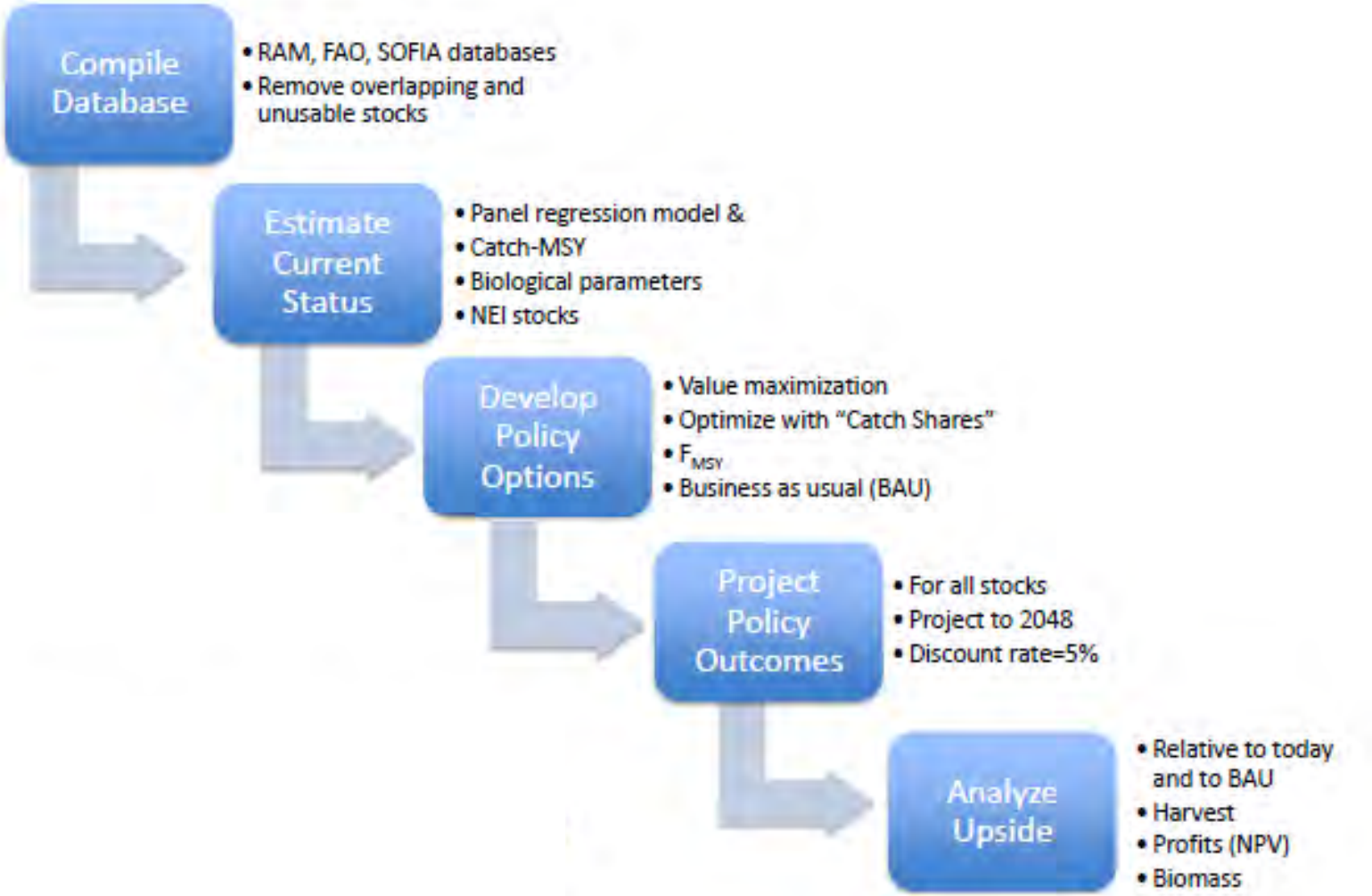
China + ecosystem

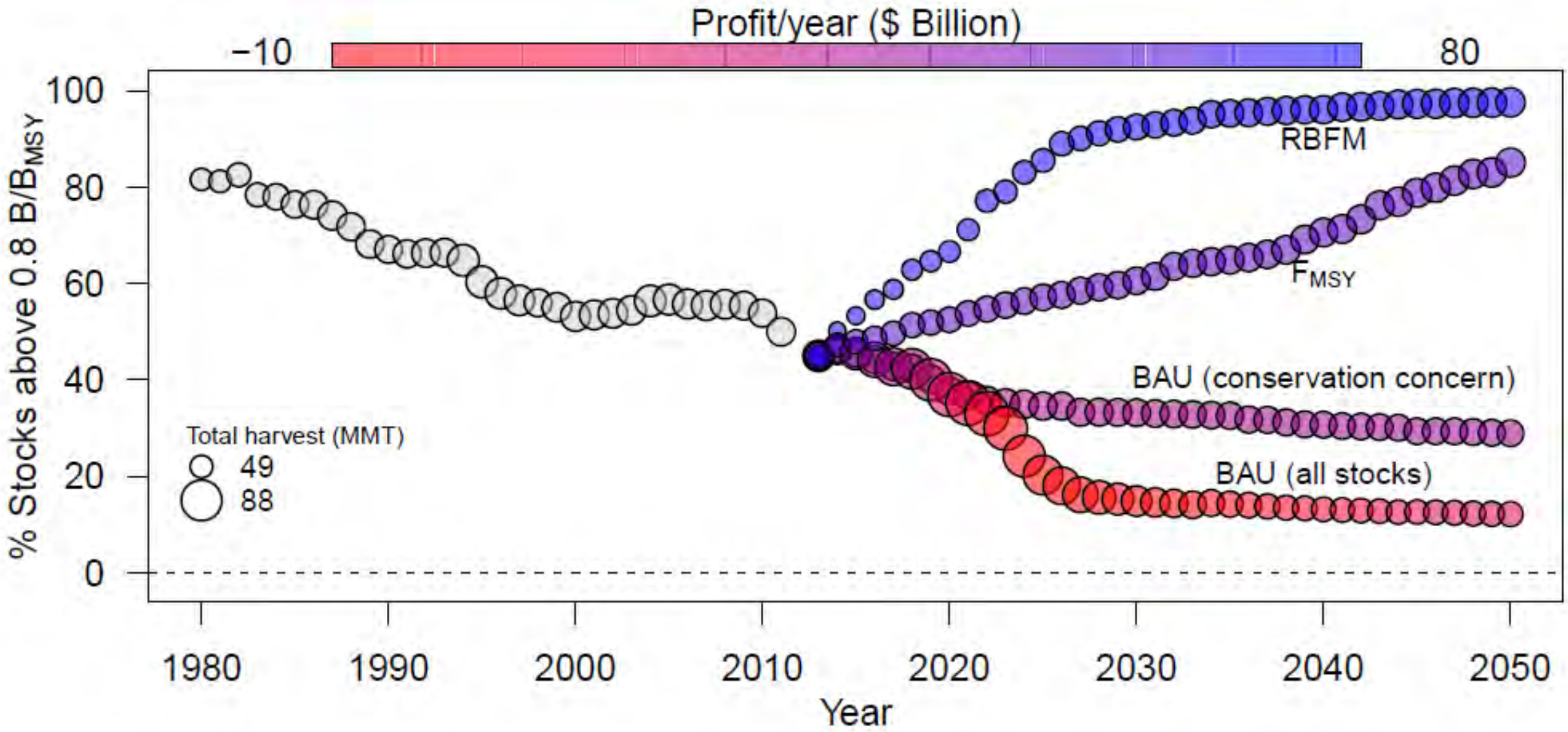
Trophic effects

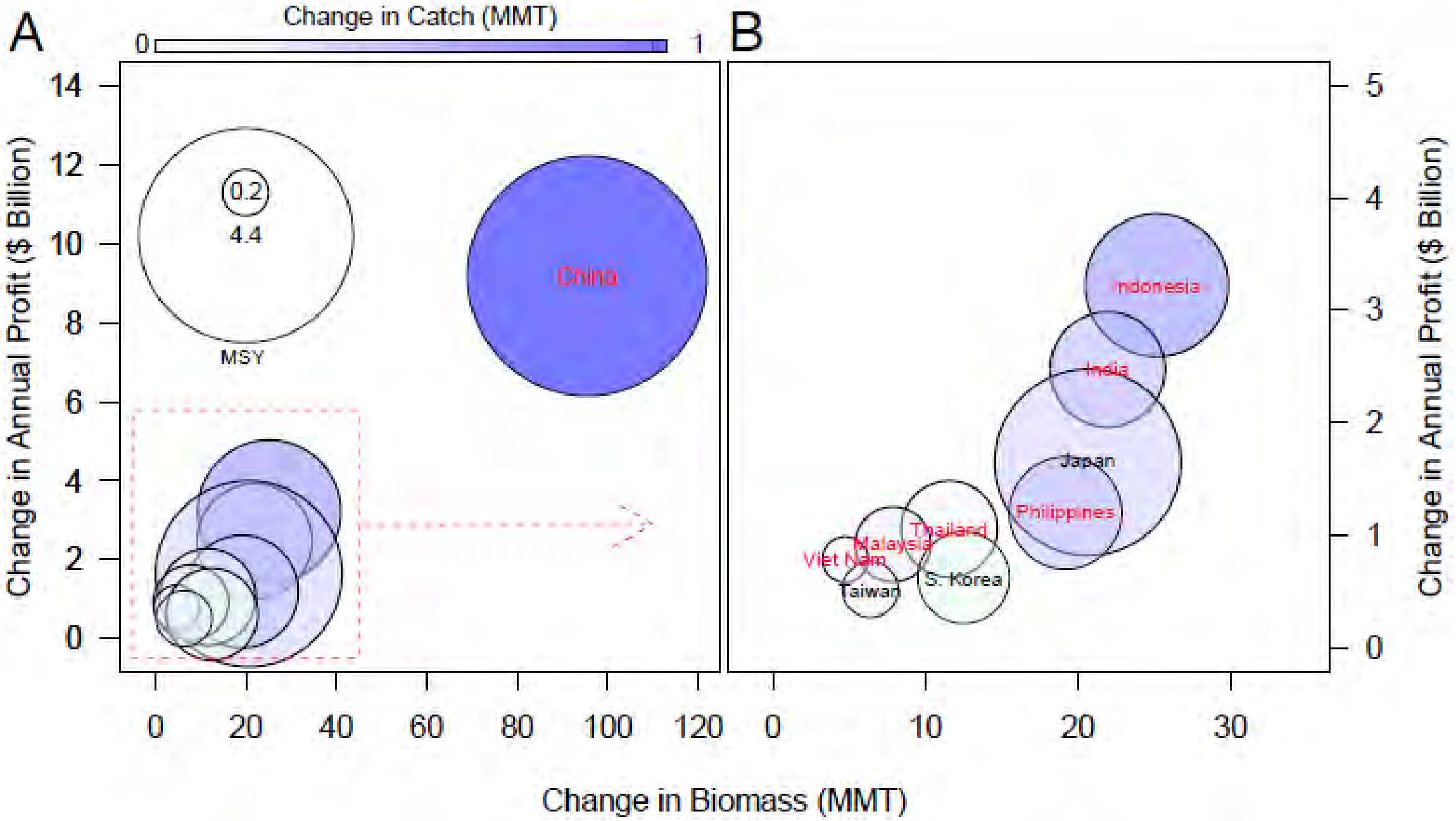
Implications for management

Global fishery prospects under contrasting management regimes

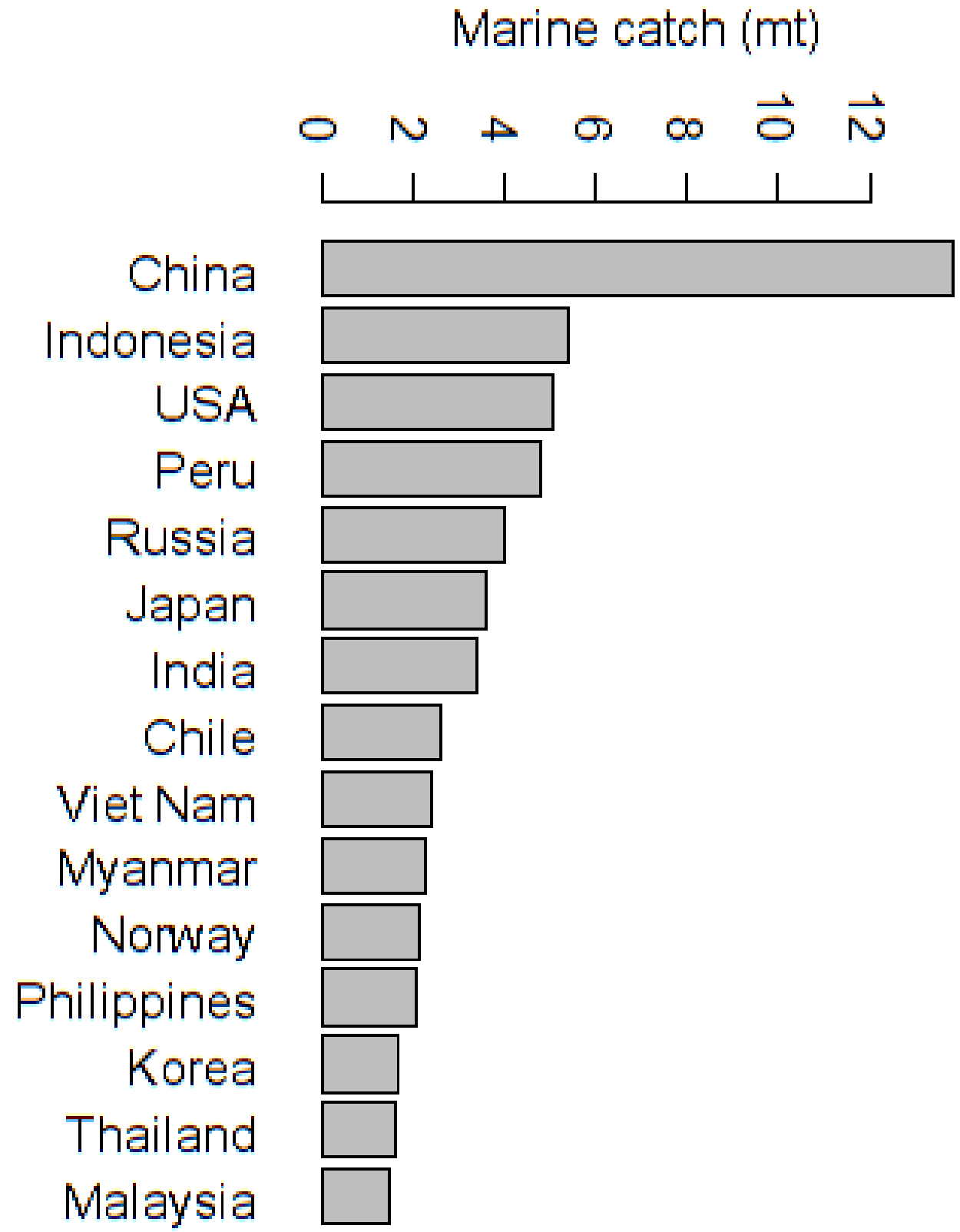
Christopher Costello[a,1], Daniel Ovando[a], Tyler Clavelle[a], C. Kent Strauss[b], Ray Hilborn[c], Michael C. Melnychuk[c], Trevor A. Branch[c], Steven D. Gaines[a], Cody S. Szuwalski[a], Reniel B. Cabral[a], Douglas N. Rader[b], and Amanda Leland[b]

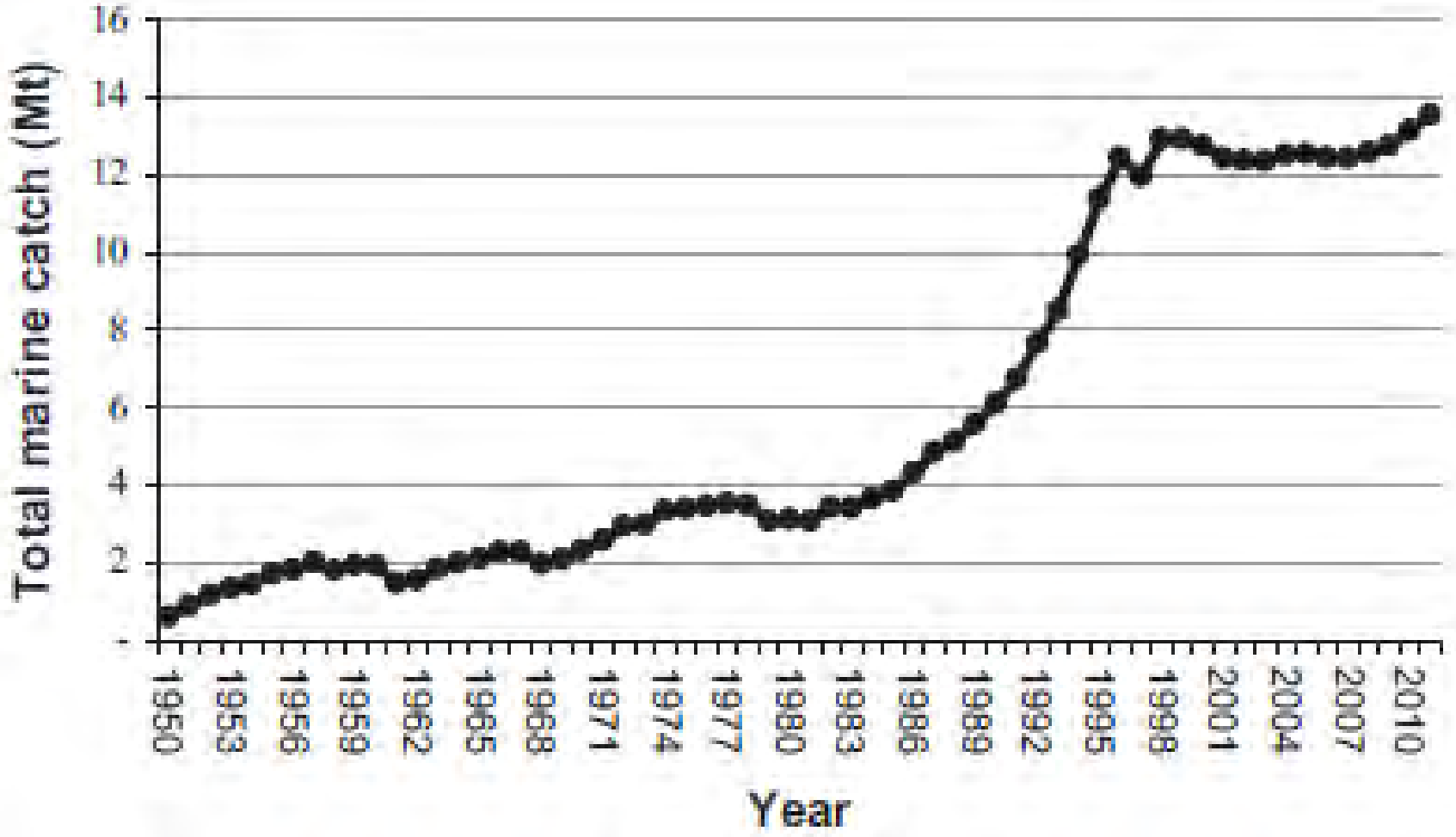


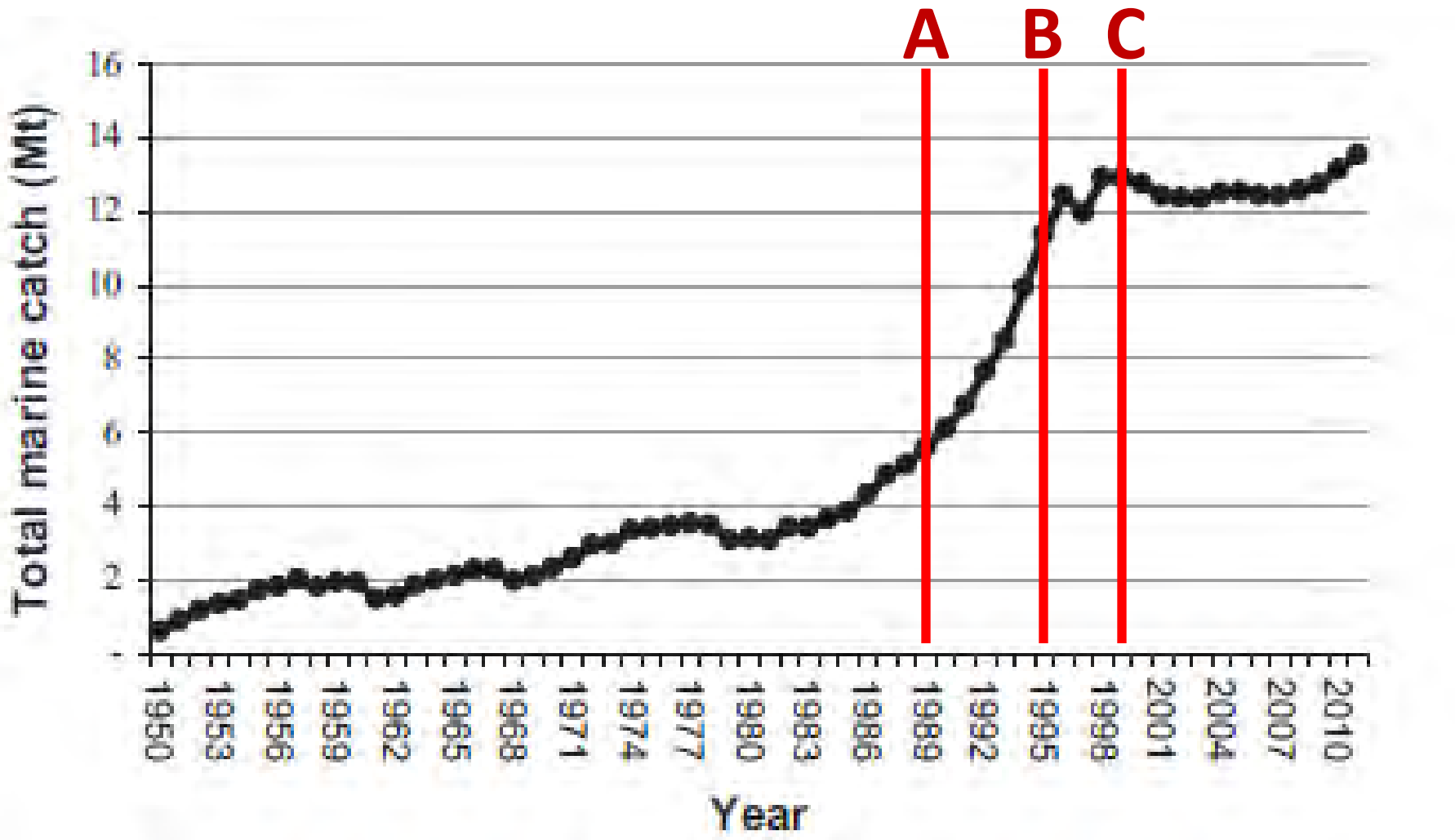

Profit/year ($ Billion)
−10
80
% Stocks above 0.8 B/B$_{MSY}$
100
80
60
40
20
0
RBFM
F$_{MSY}$
BAU (conservation concern)
BAU (all stocks)
Total harvest (MMT)
49
88
1980
1990
2000
2010
2020
2030
2040
2050
Year


A
Change in Catch (MMT)
0
1
B
Change in Annual Profit ($ Billion)
Change in Annual Profit ($ Billion)
Change in Biomass (MMT)
0.2
4.4
MSY
China
Indonesia
India
Japan
Philippines
Thailand
Malaysia
Viet Nam
Taiwan
S. Korea
0
2
4
6
8
10
12
14
0
1
2
3
4
5
0
20
40
60
80
100
120
0
10
20
30


China


Marine catch (mt)
0
2
4
6
8
10
12
China
Indonesia
USA
Peru
Russia
Japan
India
Chile
Viet Nam
Myanmar
Norway
Philippines
Korea
Thailand
Malaysia


Total marine catch (Mt)
16
14
12
10
8
6
4
2
-
1950
1953
1956
1959
1962
1965
1968
1971
1974
1977
1980
1983
1986
1989
1992
1995
1998
2001
2004
2007
2010
Year



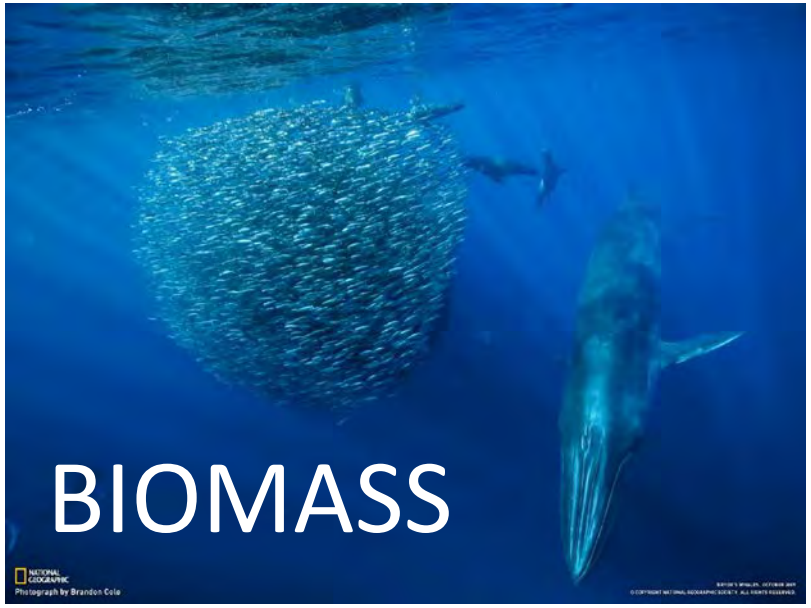
A. Minimum mesh size

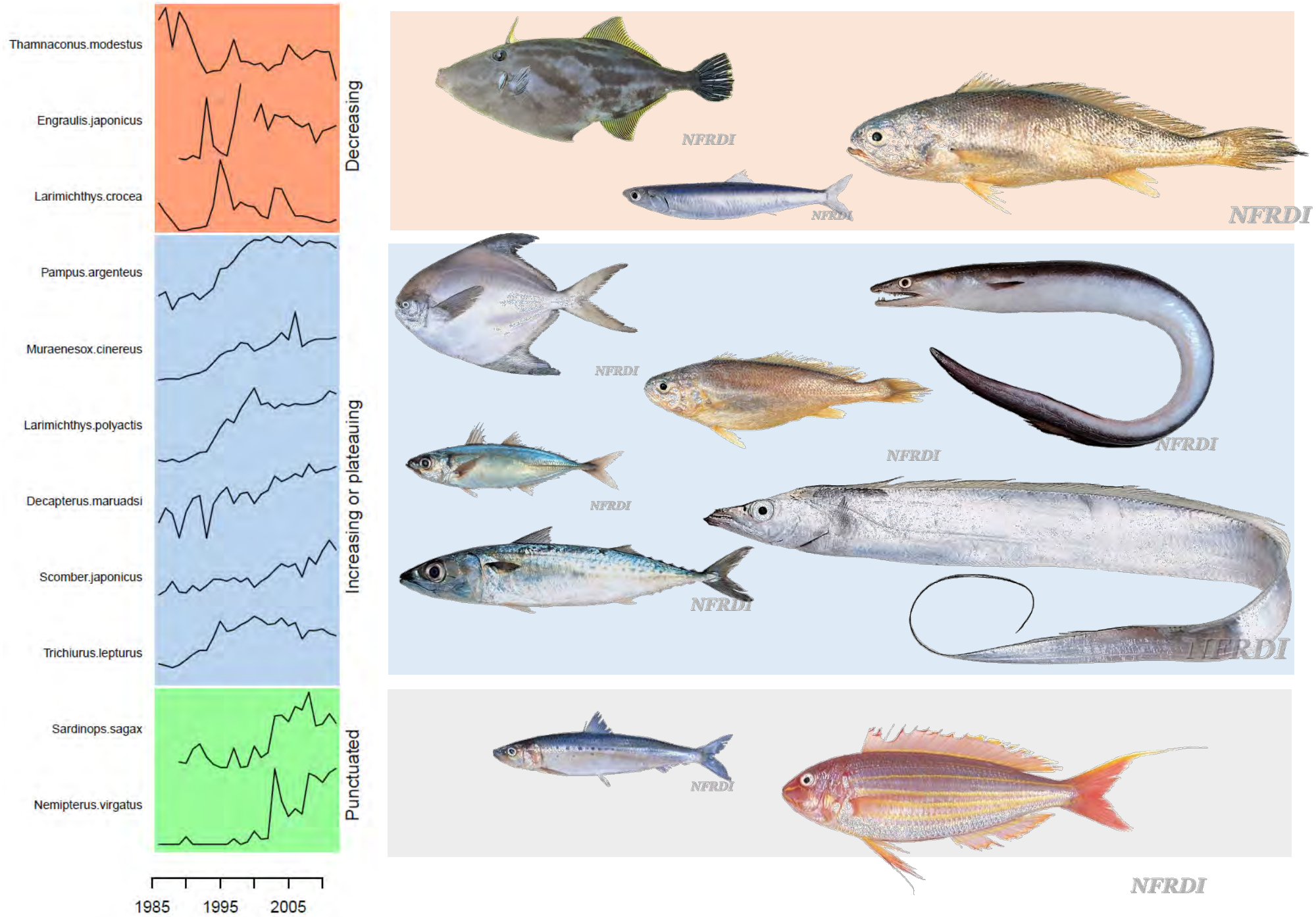
B. Summer fishing moratoria

C. Zero growth and then negative growth (2000)


North Korea
HEBEI
Bohai Sea
NINGXIA
SHANXI
SHAANXI
China
SHANDONG
South Korea
Yellow Sea
HENAN
JIANGSU
SICHUAN
HUBEI
ANHUI
East China Sea
ZHEJIANG
GUIZHOU
HUNAN
JIANGXI
FUJIAN
GUANGXI
GUANGDONG
Taiwan
South China Sea
HAINAN

How would management reform impact:




Thamnaconus.modestus
Engraulis.japonicus
Larimichthys.crocea
Decreasing
Pampus.argenteus
Muraenesox.cinereus
Larimichthys.polyactis
Decapterus.maruadsi
Scomber.japonicus
Trichiurus.lepturus
Increasing or plateauing
Sardinops.sagax
Nemipterus.virgatus
Punctuated
1985
1995
2005
NFRDI

Systematic distortions in world fisheries catch trends

Reg Watson* & Daniel Pauly*

* *Fisheries Centre, 2204 Main Mall, University of British Columbia, Vancouver, British Columbia V6T 1Z4, Canada*

Over 75% of the world marine fisheries catch (over 80 million tonnes per year) is sold on international markets, in contrast to other food commodities (such as rice)[1,2]. At present, only one institution, the Food and Agriculture Organization of the United Nations (FAO) maintains global fisheries statistics. As an intergovernmental organization, however, FAO must generally rely on the statistics provided by member countries, even if it is doubtful that these correspond to reality. Here we show that misreporting by countries with large fisheries, combined with the large and widely fluctuating catch of species such as the Peruvian anchoveta, can cause globally spurious trends. Such trends influence unwise investment decisions by firms in the fishing sector and by banks, and prevent the effective management of international fisheries

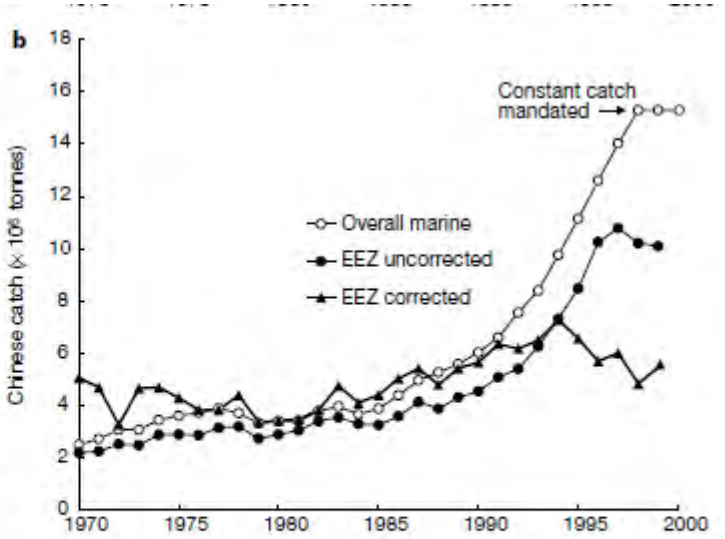
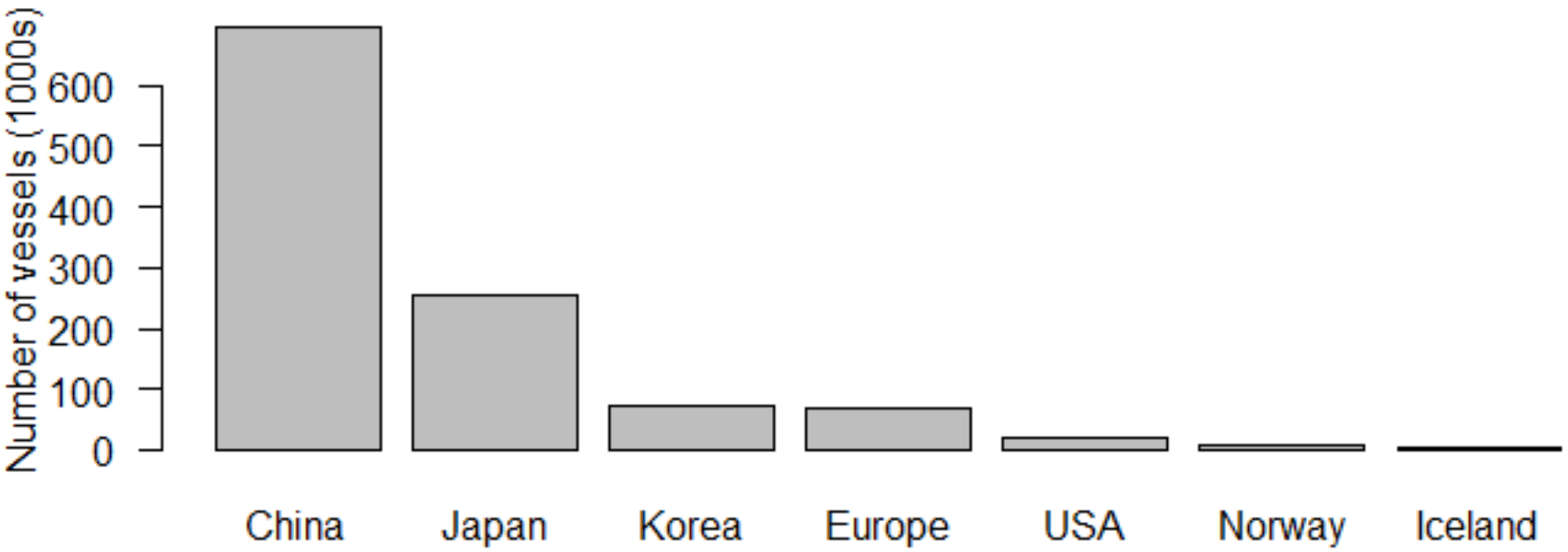


Figure 1 Time series of global and Chinese marine fisheries catches (1950 to present). **a**, Global reported catch, with and without the highly variable Peruvian anchoveta. Uncorrected figures are from FAO (ref. 3); corrected values were obtained by replacing FAO figures by estimates from **b**. The response to the 1982–83 El Niño/Southern Oscillation (ENSO) is not visible as anchoveta biomass levels, and hence catches were still

- Predicted catch based on depth, primary productivity, ice cover, SST, latitude, distance from shore, and upwelling with a GLM
- “Fishing effort was not used in the prediction and catches were assumed to be generally close to their maximum biologically sustainable limits.”
- China was an outlier

"Fishing effort was not used in the prediction and catches were assumed to be generally close to their maximum biologically sustainable limits."

1)



FAO. 2014. State of the world's fisheries.

2) "Biologically sustainable limits" are dependent upon the structure of the ecosystem.

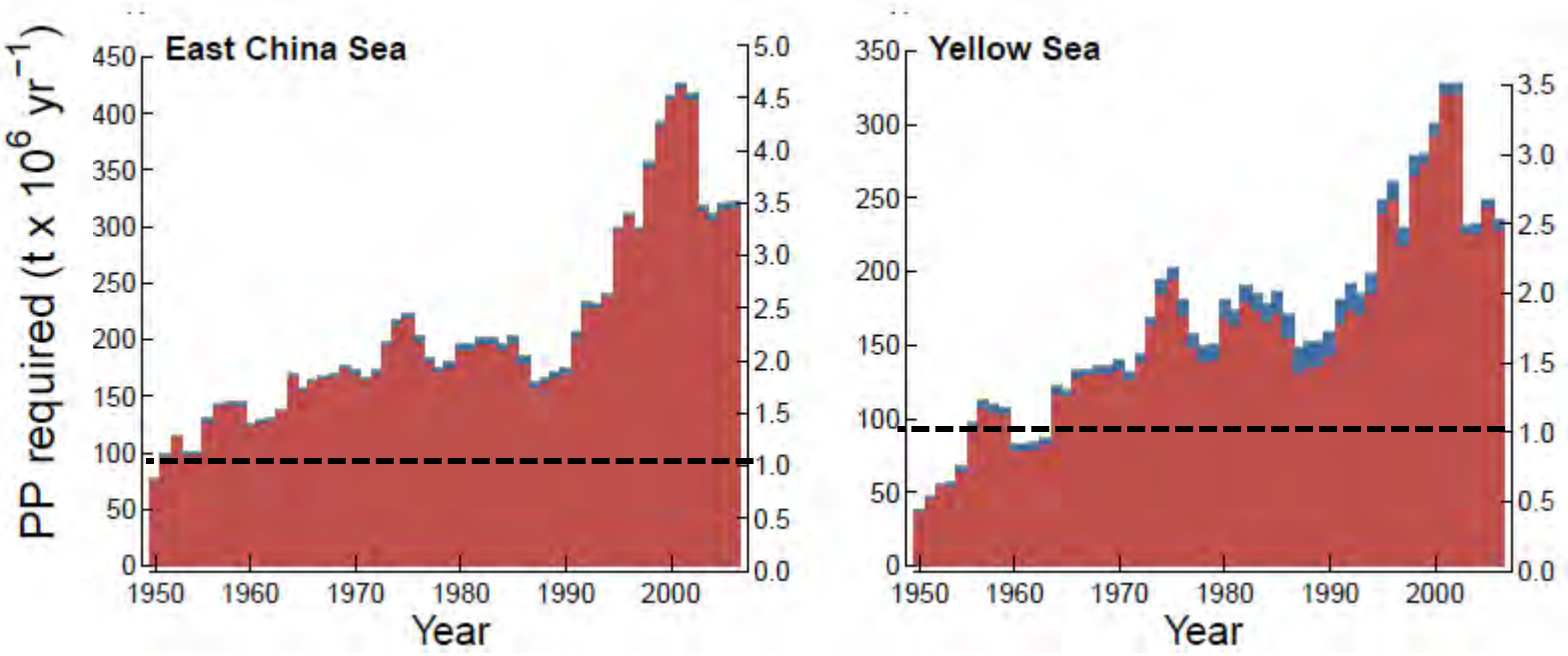
FISH and FISHERIES

FISH and FISHERIES, 2014, 15, 231–241

Primary productivity demands of global fishing fleets

Reg Watson[1,2], *Dirk Zeller*[1] & *Daniel Pauly*[1]

[1]Sea Around Us Project, Fisheries Centre, University of British Columbia, Vancouver, BC Canada, V6T 1Z4; [2]Institute of Marine and Antarctic Studies, University of Tasmania, Taroona, Tasmania, Australia



Journal of Marine Systems
Volume 67, Issues 3–4, 30 September 2007, Pages 304-311

Decadal-scale variations of trophic levels at high trophic levels in the Yellow Sea and the Bohai Sea ecosystem

B. Zhang, Q. Tang, X. Jin

- Trophic level declined from 4.06 in (1960) to 3.41 in (1998) in the Bohai Sea, and from 3.61 in (1985) to 3.40 in (2000) in the Yellow Sea.
- The percentage of planktivorous species increased and piscivorous or omnivorous species decreased.
- TL of the same prey got lower.
- Feeding habits of some species changed, such as largehead hairtail (*Trichiurus haumela*).

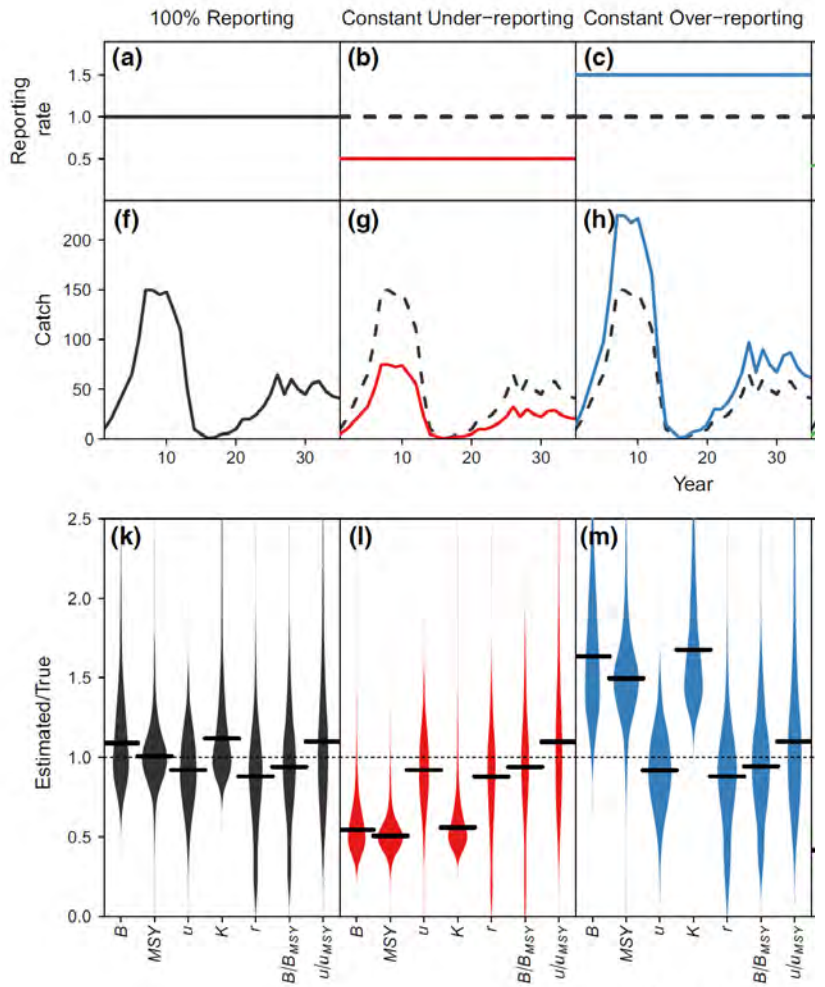
FISH and FISHERIES

FISH and FISHERIES, 2017, **18**, 313–323

Does unreported catch lead to overfishing?

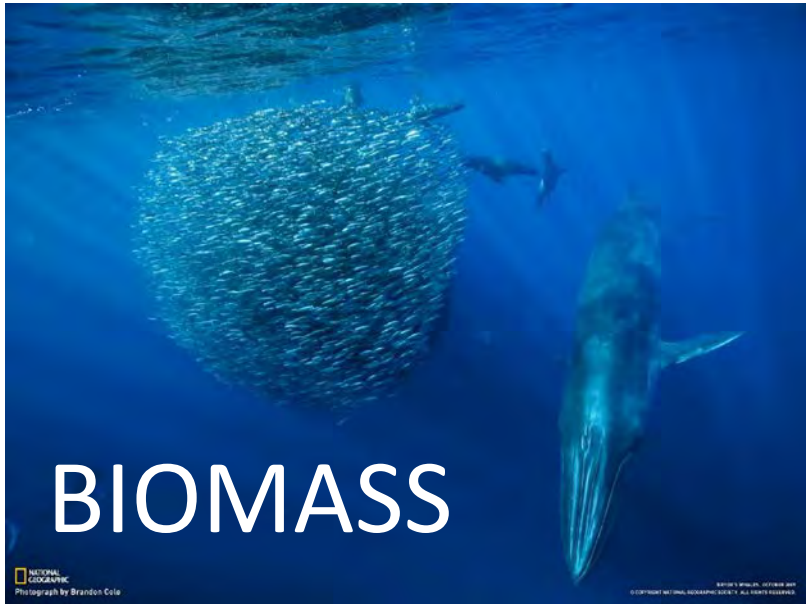
Merrill B Rudd & Trevor A Branch

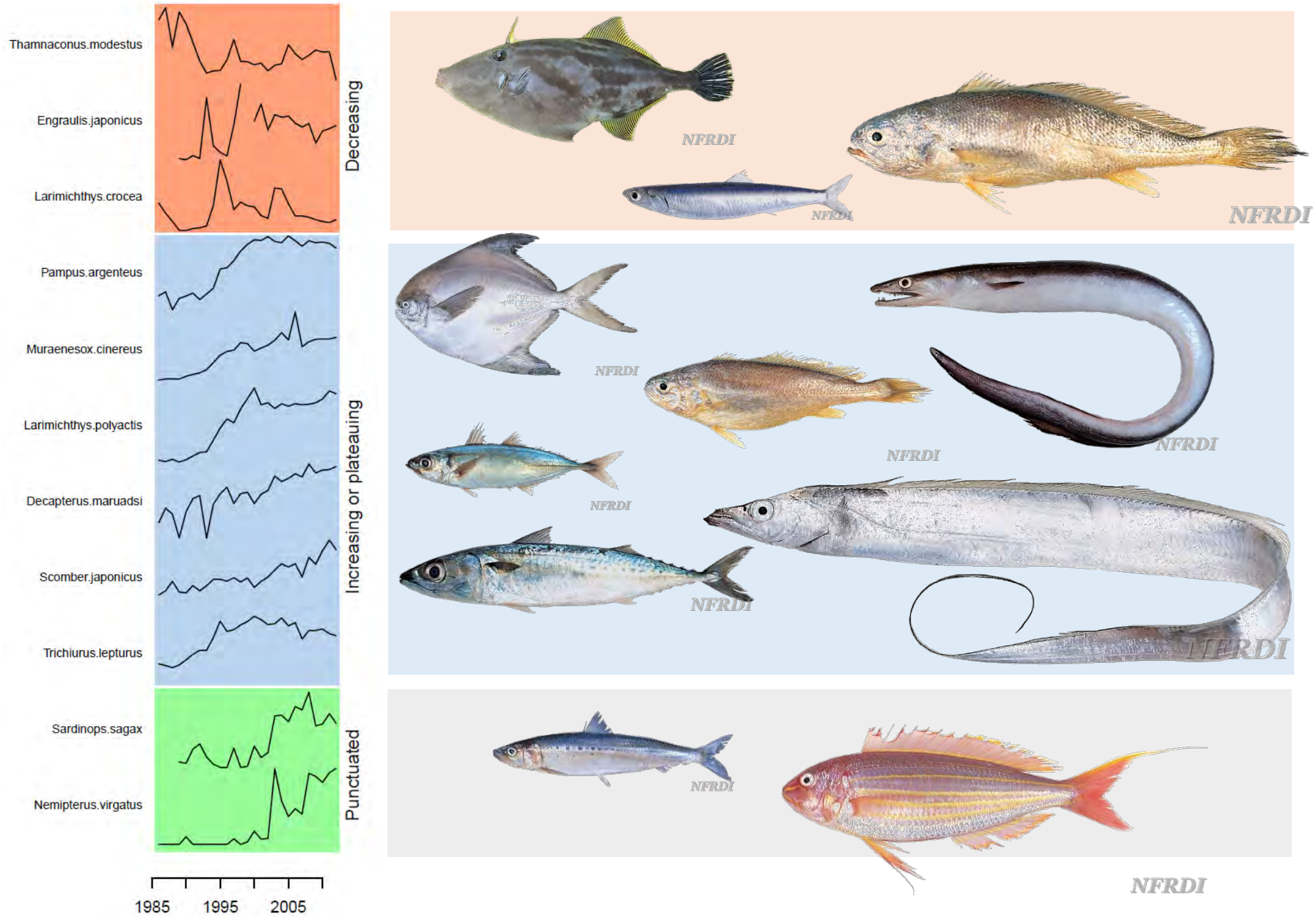
- Over- or under-reporting of catches results in biased estimates of biomass.
- BUT, estimates of status remain unbiased.

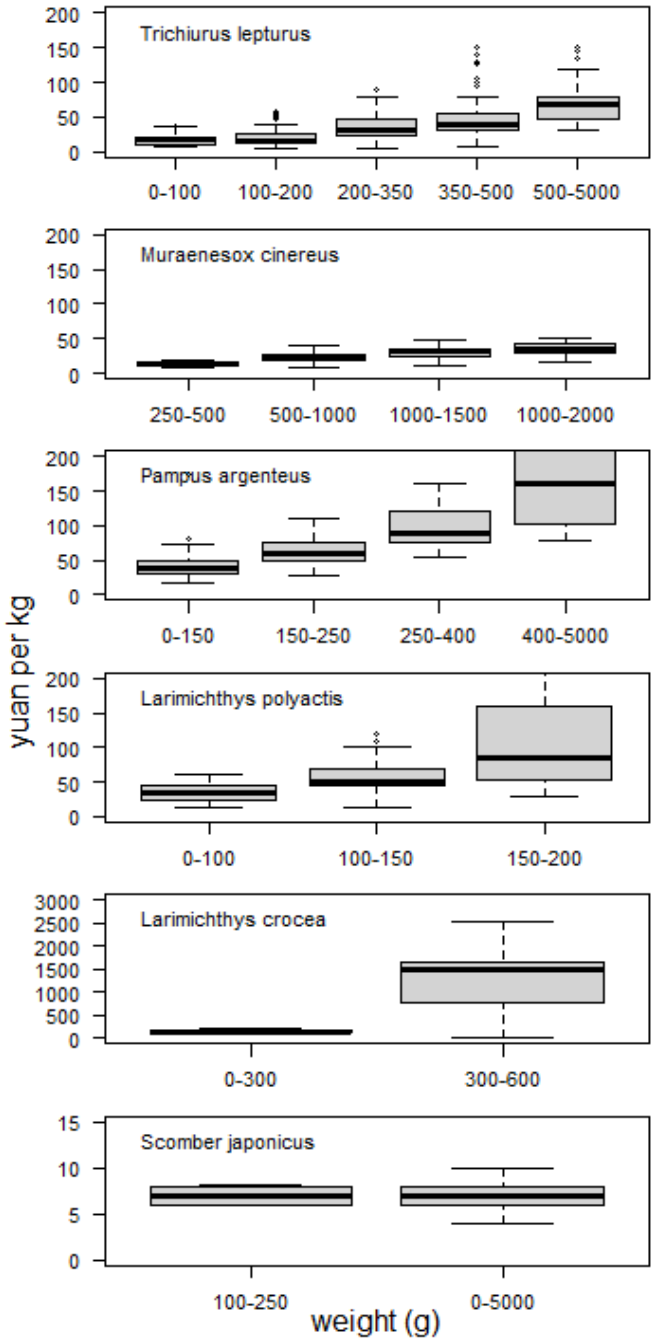


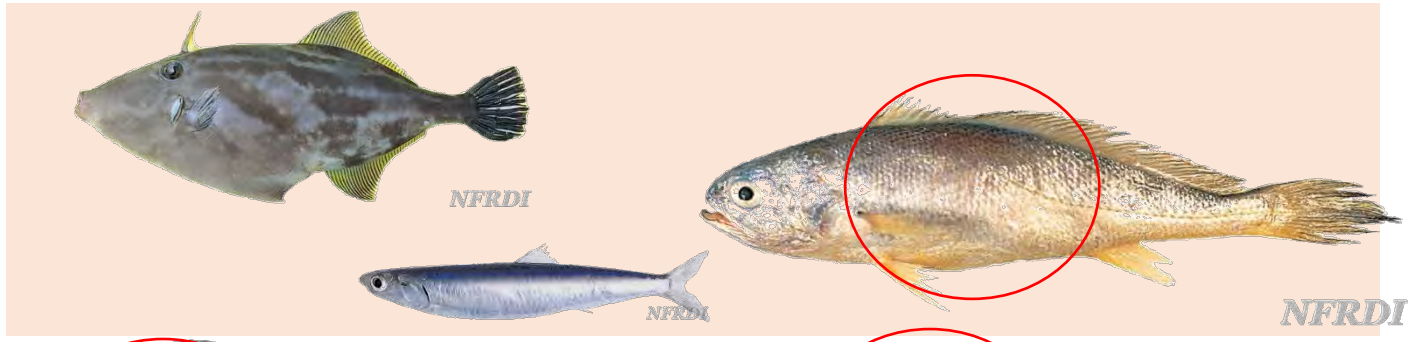

North Korea
HEBEI
Bohai Sea
NINGXIA
SHANXI
SHAANXI
China
SHANDONG
South Korea
Yellow Sea
HENAN
JIANGSU
SICHUAN
HUBEI
ANHUI
East China Sea
ZHEJIANG
GUIZHOU
HUNAN
JIANGXI
FUJIAN
GUANGXI
GUANGDONG
Taiwan
South China Sea
HAINAN

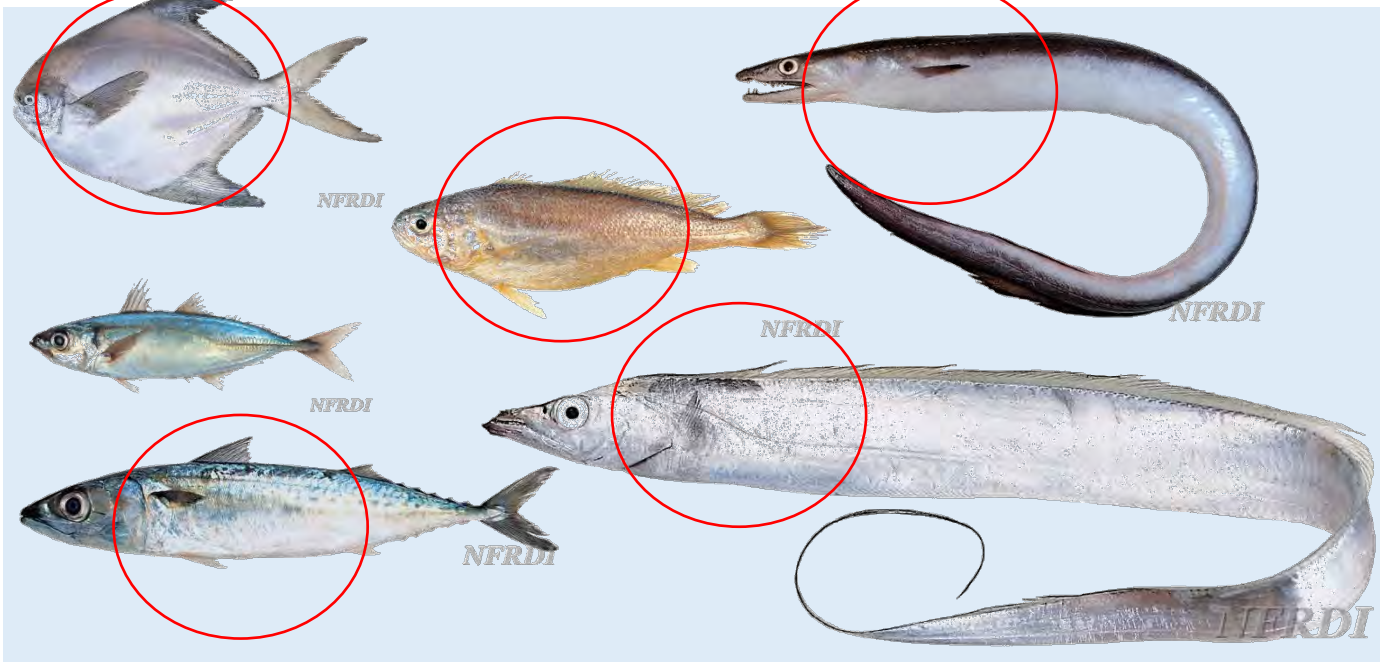
How would management reform impact:




Thamnaconus.modestus
Engraulis.japonicus
Larimichthys.crocea
Decreasing
Pampus.argenteus
Muraenesox.cinereus
Larimichthys.polyactis
Decapterus.maruadsi
Scomber.japonicus
Trichiurus.lepturus
Increasing or plateauing
Sardinops.sagax
Nemipterus.virgatus
Punctuated
1985
1995
2005
NFRDI


Trichiurus lepturus
0-100
100-200
200-350
350-500
500-5000
Muraenesox cinereus
250-500
500-1000
1000-1500
1000-2000
Pampus argenteus
0-150
150-250
250-400
400-5000
Larimichthys polyactis
0-100
100-150
150-200
Larimichthys crocea
0-300
300-600
Scomber japonicus
100-250
0-5000
yuan per kg
weight (g)


NFRDI


NFRDI

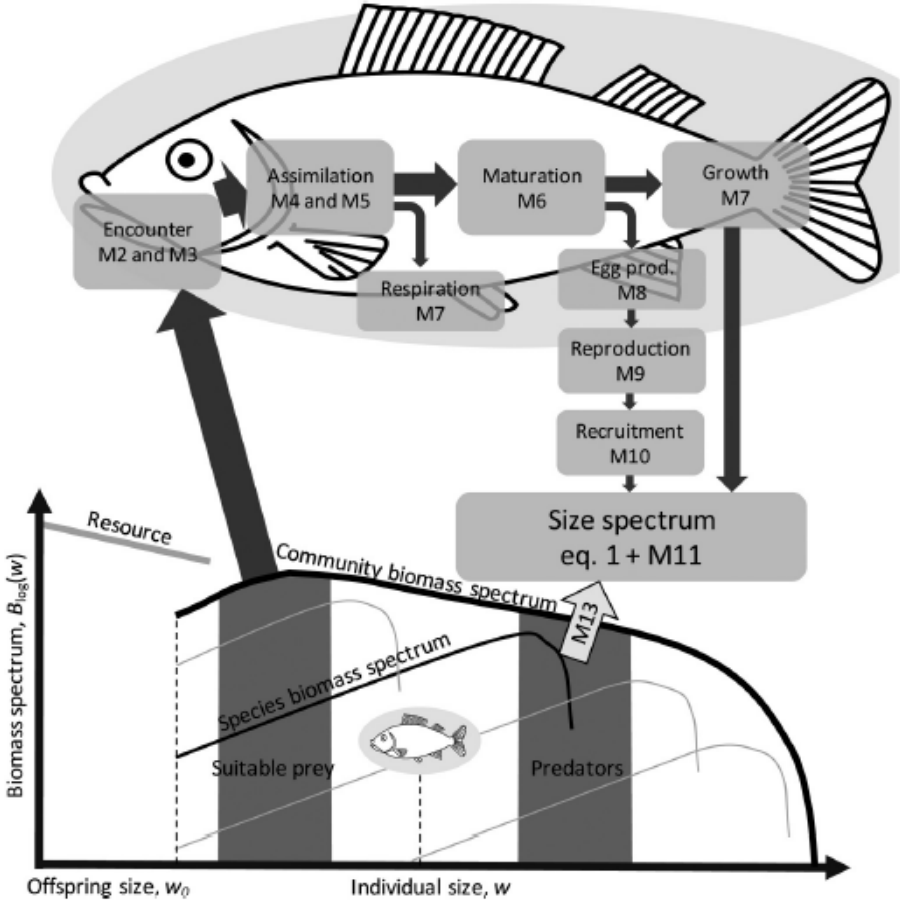

NFRDI

Size-spectrum models

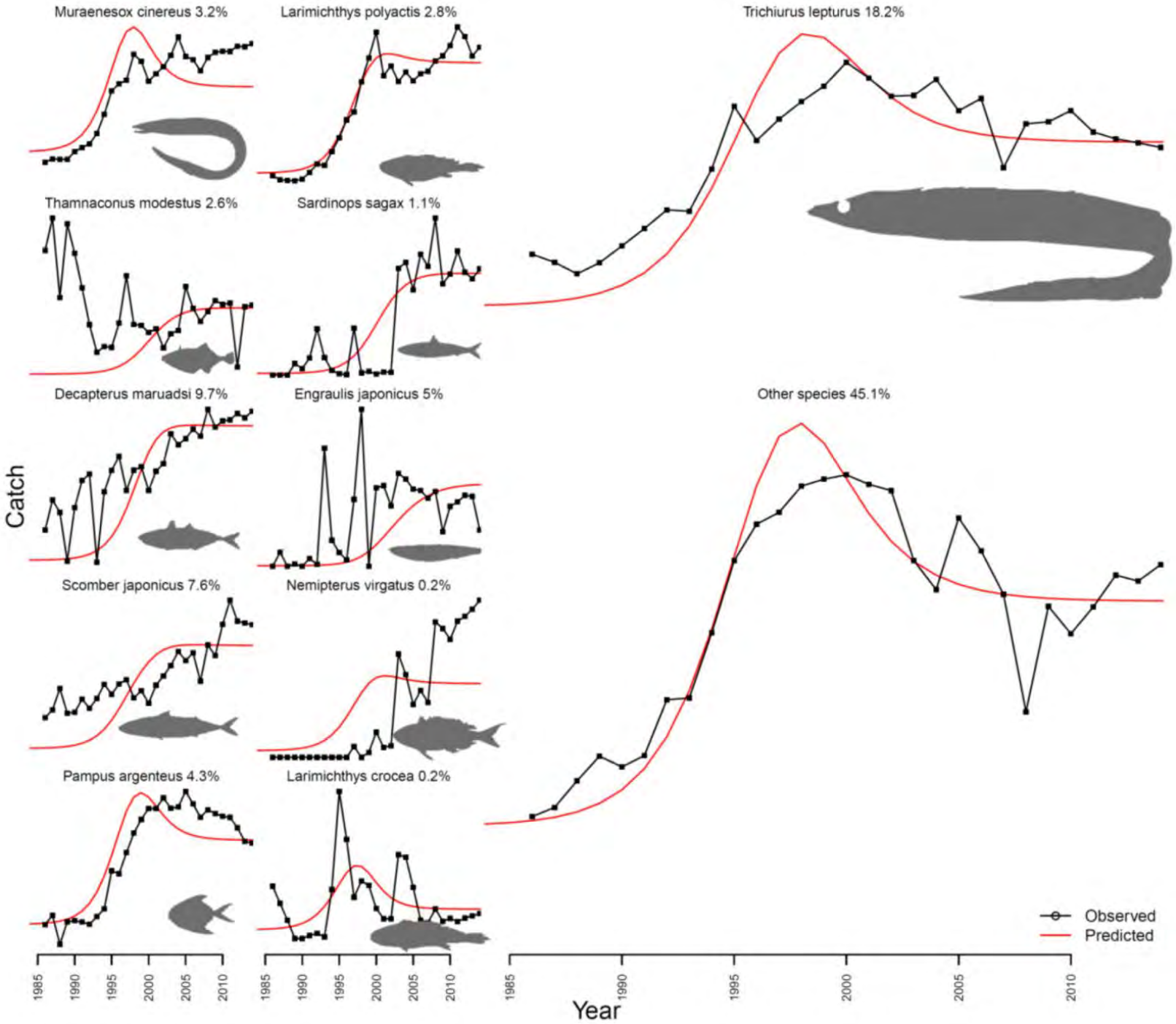
- Community dynamics
- Food consumption
- Somatic growth and reproduction
- Mortality (predation, background, starvation, fishing)
- Background resource

MIZER (R package, Scott et al. 2014)

- Maximum weight
- Weight at maturity
- Weight at length parameters
- Von Bert K
- Preferred predator/prey weight ratio
- Fishery selectivity parameters
- Maximum recruitment
- Background resource



Anderson, KH, et al. 2014. Theoretical foundations for size spectrum models of fish communities.. CJFAS.

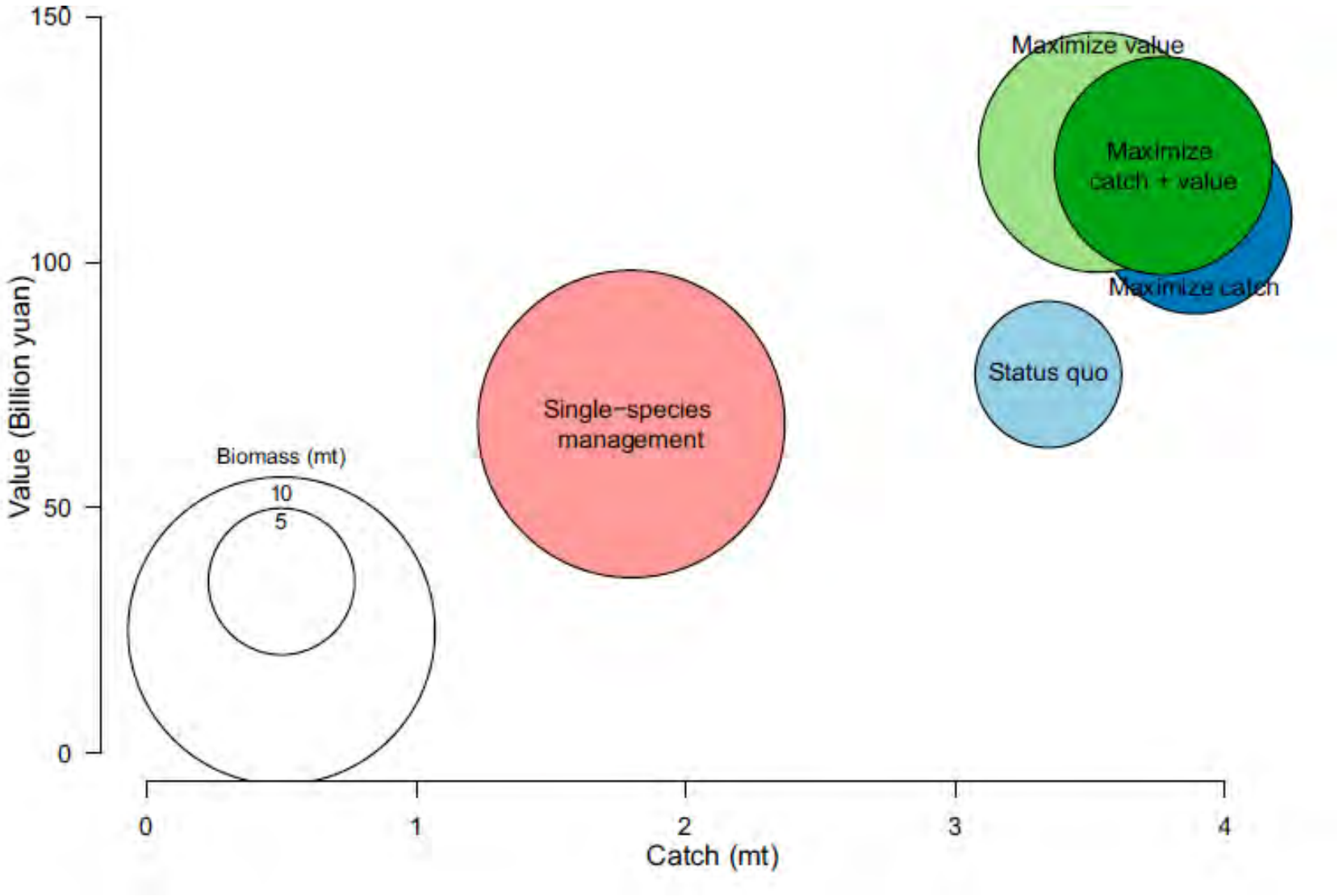

Muraenesox cinereus 3.2%
Larimichthys polyactis 2.8%
Trichiurus lepturus 18.2%
Thamnaconus modestus 2.6%
Sardinops sagax 1.1%
Decapterus maruadsi 9.7%
Engraulis japonicus 5%
Other species 45.1%
Scomber japonicus 7.6%
Nemipterus virgatus 0.2%
Pampus argenteus 4.3%
Larimichthys crocea 0.2%
Catch
1985
1990
1995
2000
2005
2010
Year
Observed
Predicted

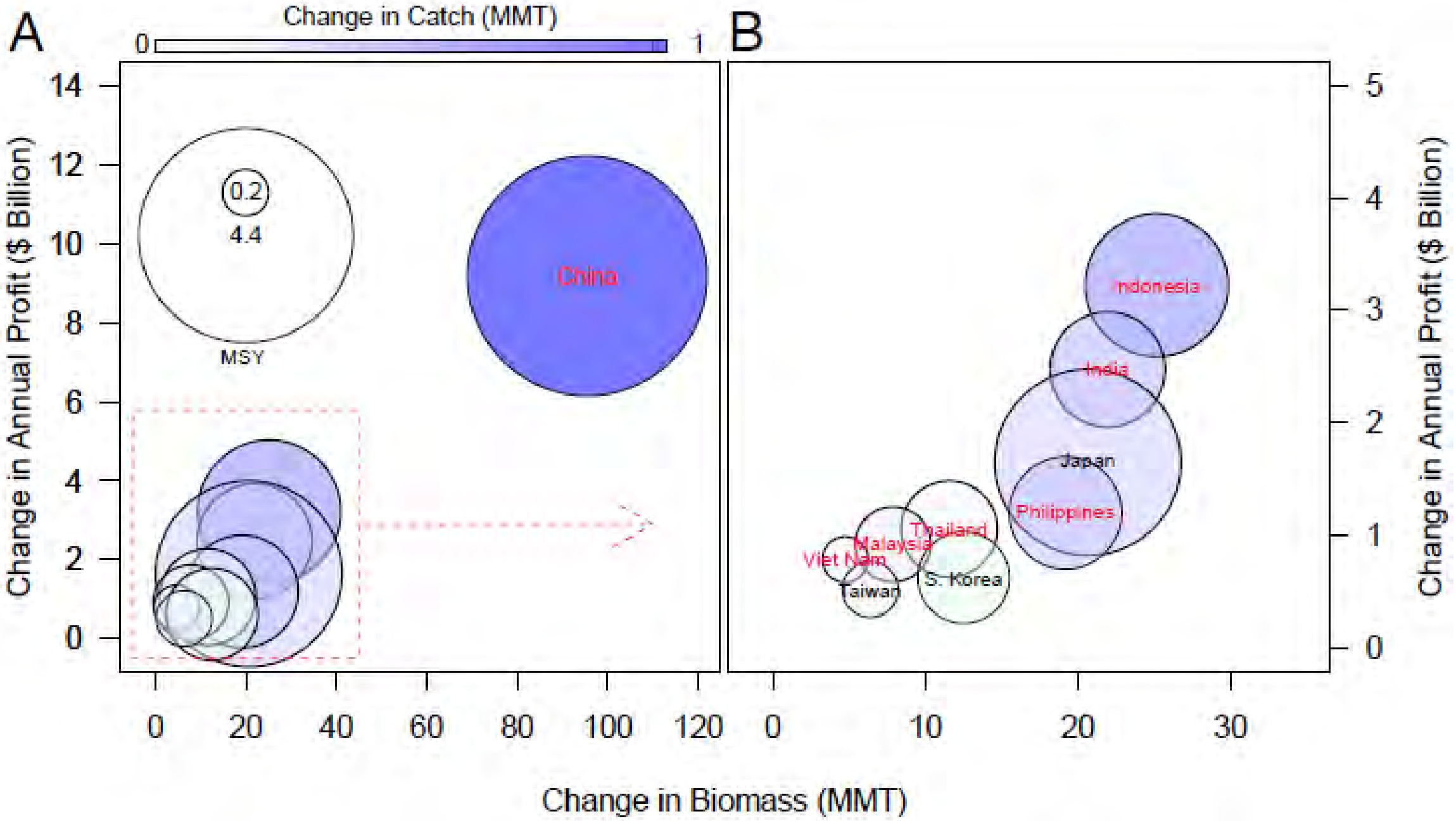
Set

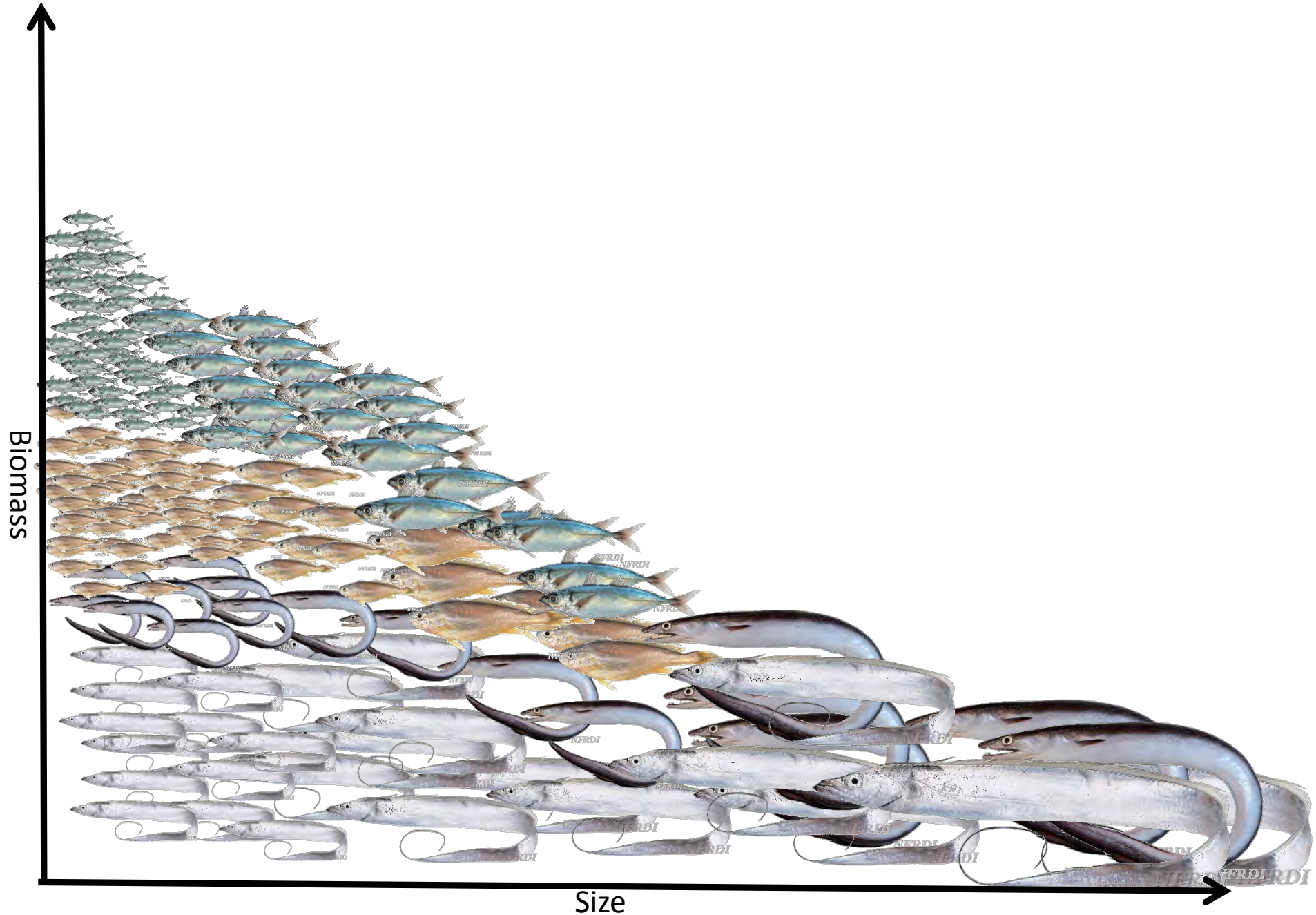
High fishery catches through trophic cascades in China

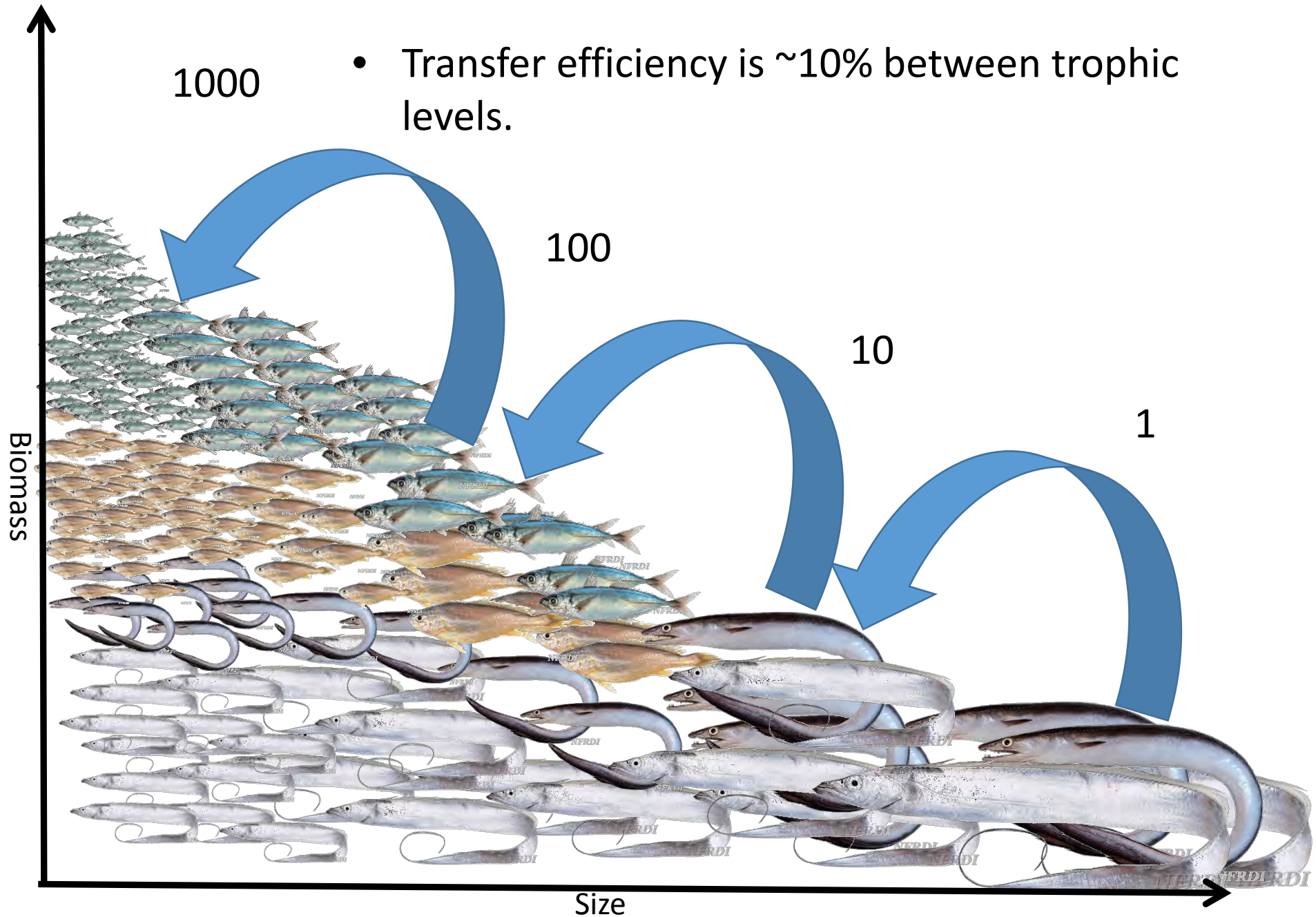
Cody S. Szuwalski[a,b,c,1], Matthew G. Burgess[a,b,c], Christopher Costello[a,b,c], and Steven D. Gaines[a,b,c]

[a]Sustainable Fisheries Group, University of California, Santa Barbara, CA 93106; [b]Bren School of Environmental Science and Management, University of California, Santa Barbara, CA 93106; and [c]Marine Science Institute, University of California, Santa Barbara, CA 93106



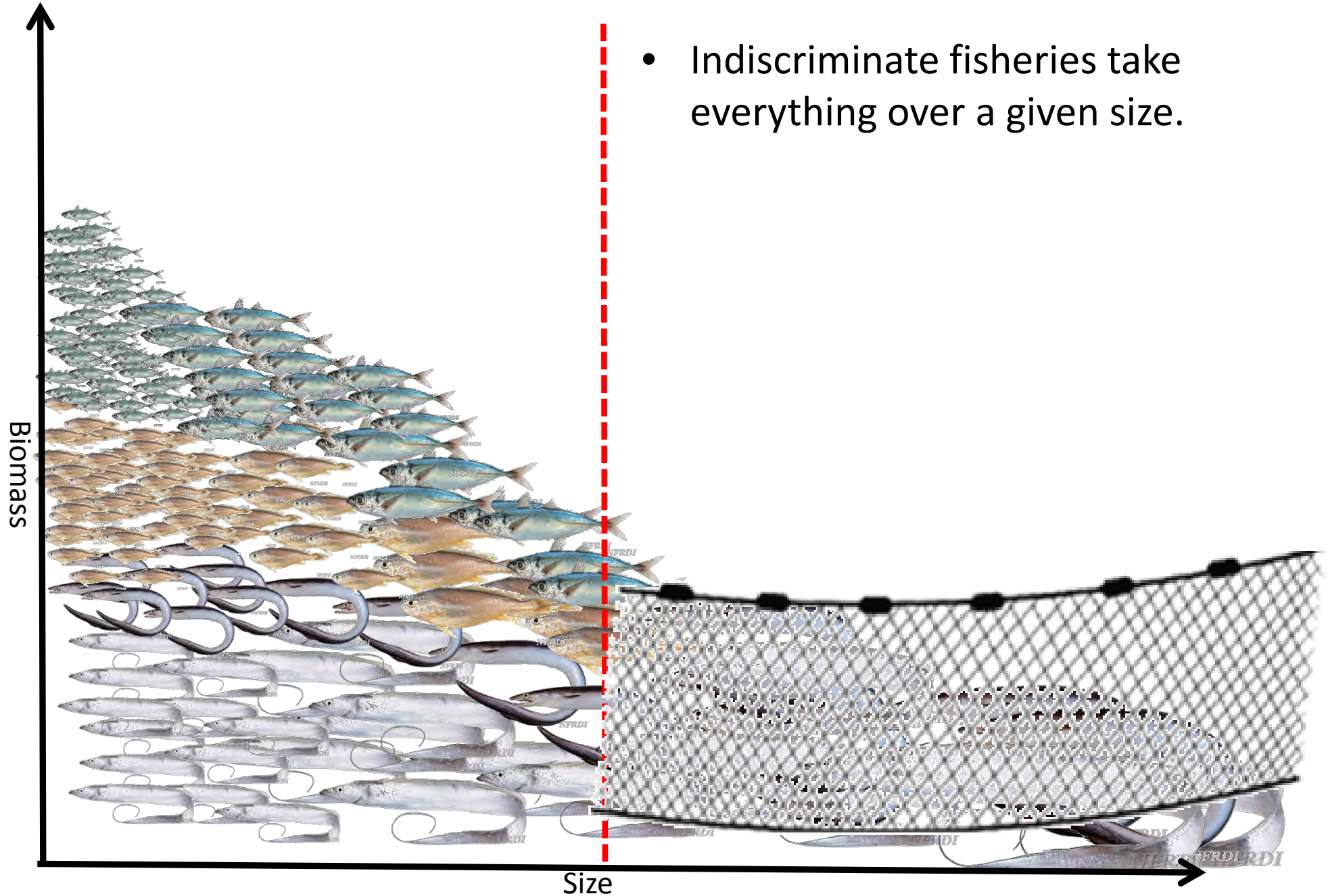

A
Change in Catch (MMT)
0
1
B
Change in Annual Profit ($ Billion)
Change in Annual Profit ($ Billion)
Change in Biomass (MMT)
0.2
4.4
MSY
China
Indonesia
India
Japan
Philippines
Thailand
Malaysia
Viet Nam
Taiwan
S. Korea
0
2
4
6
8
10
12
14
0
1
2
3
4
5
0
20
40
60
80
100
120
0
10
20
30

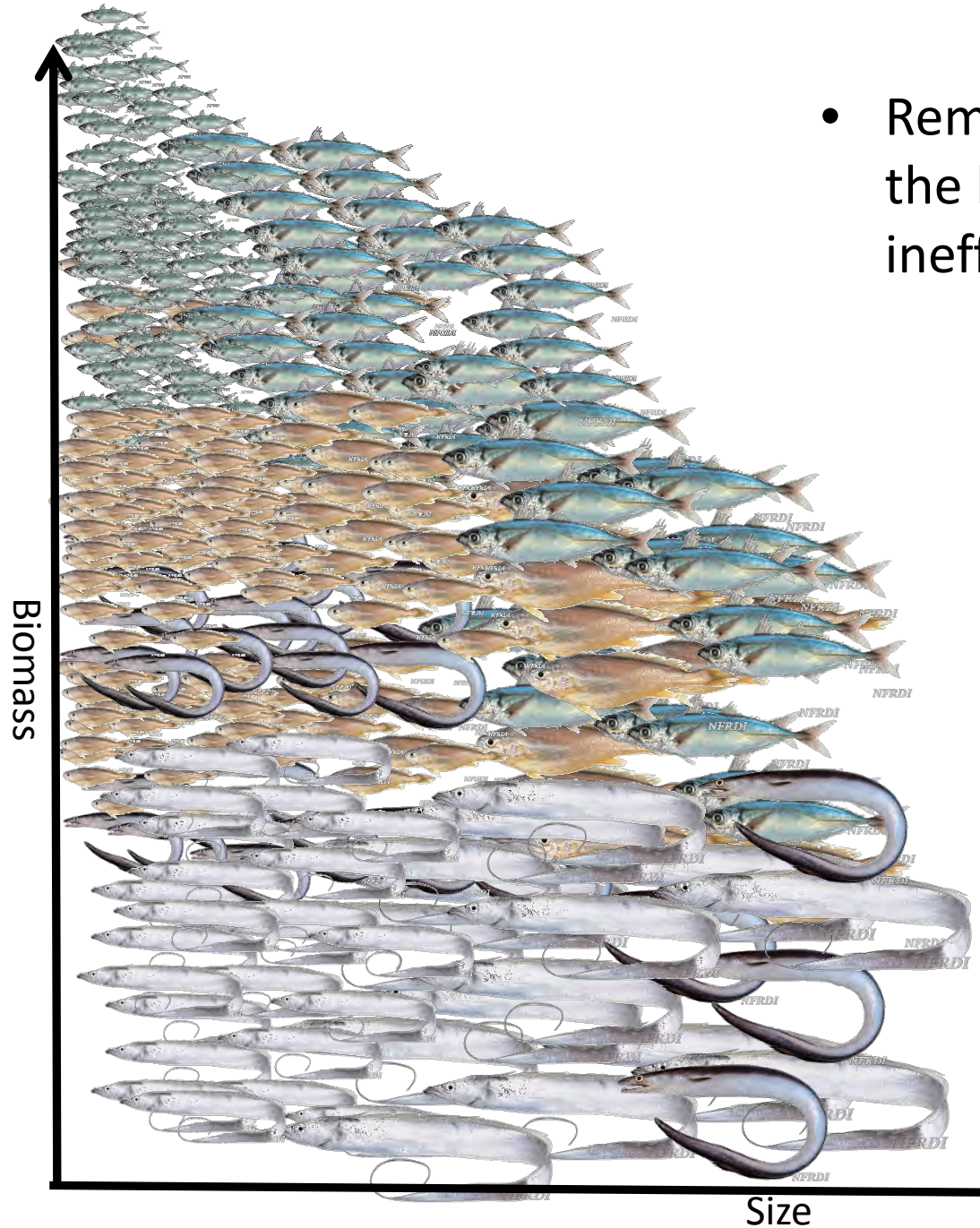

Biomass
Size



- Transfer efficiency is ~10% between trophic levels.

- Indiscriminate fisheries take everything over a given size.





- Removing large fish conserves the lost energy by eliminating inefficiencies of transfer.

- Markets and culture matter
- Discards are non existent

THEORY

MAXIMAL YIELDS FROM MULTISPECIES FISHERIES SYSTEMS:
RULES FOR SYSTEMS WITH MULTIPLE TROPHIC LEVELS

HIROYUKI MATSUDA[1,3] AND PETER A. ABRAMS[2]

[1]*Faculty of Environment and Information Sciences, Yokohama National University, 79-7, Tokiwadai, Hodogaya-ku, Yokohama, Kanagawa 240-8501 Japan*
[2]*Department of Zoology, University of Toronto, 25 Harbord Street, Toronto, Ontario M5S 3G5 Canada*

Trade-offs between objectives for ecosystem management of fisheries

KEN H. ANDERSEN,[1,3] KEITH BRANDER,[1] AND LARS RAVN-JONSEN[2]

[1]*Centre for Ocean Life, National Institute of Aquatic Resources, Technical University of Denmark, Jægersborg Allé 1, DK-2920 Charlottenlund, Denmark*
[2]*Department of Environmental and Business Economics, University of Southern Denmark, DK-6700 Esbjerg, Denmark*

PRACTICE

Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean

Ransom A. Myers,[1] Julia K. Baum,[1*] Travis D. Shepherd,[1] Sean P. Powers,[2] Charles H. Peterson[3*]

Trophic Cascades in a Formerly Cod-Dominated Ecosystem

Kenneth T. Frank,[1*] Brian Petrie,[1] Jae S. Choi,[1,2] William C. Leggett[2]

MALTHUSIAN OVERFISHING AND EFFORTS TO OVERCOME IT ON KENYAN CORAL REEFS

TIM R. MCCLANAHAN,[1,4] CHRISTINA C. HICKS,[2,5] AND EMILY S. DARLING[3]

Trophic cascades triggered by overfishing reveal possible mechanisms of ecosystem regime shifts

Georgi M. Daskalov*[,1], Alexander N. Grishin[2], Sergei Rodionov[3], and Vesselina Mihneva[1]

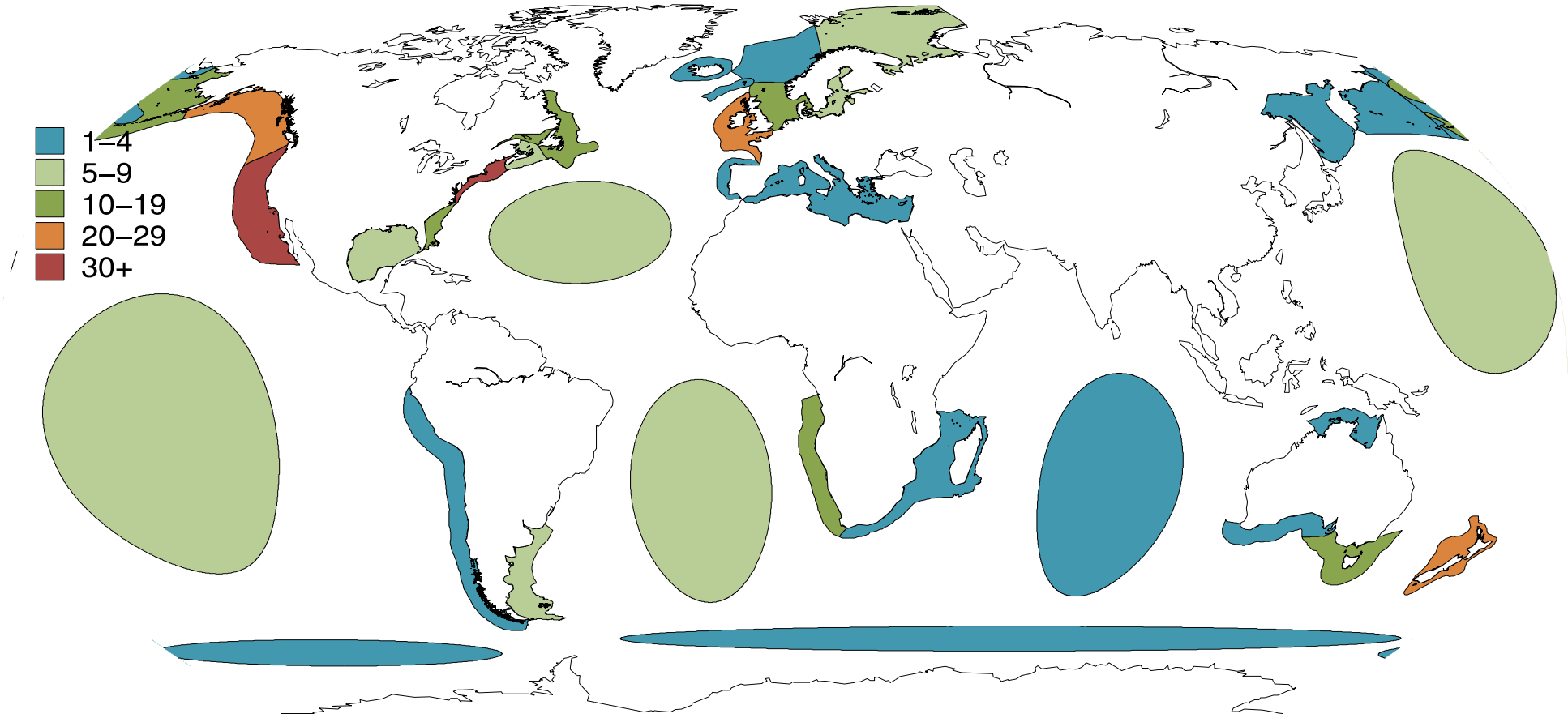
Conservation Biology

Unintended Cultivation, Shifting Baselines, and Conflict between Objectives for Fisheries and Conservation

CHRISTOPHER J. BROWN* AND ROWAN TREBILCO†

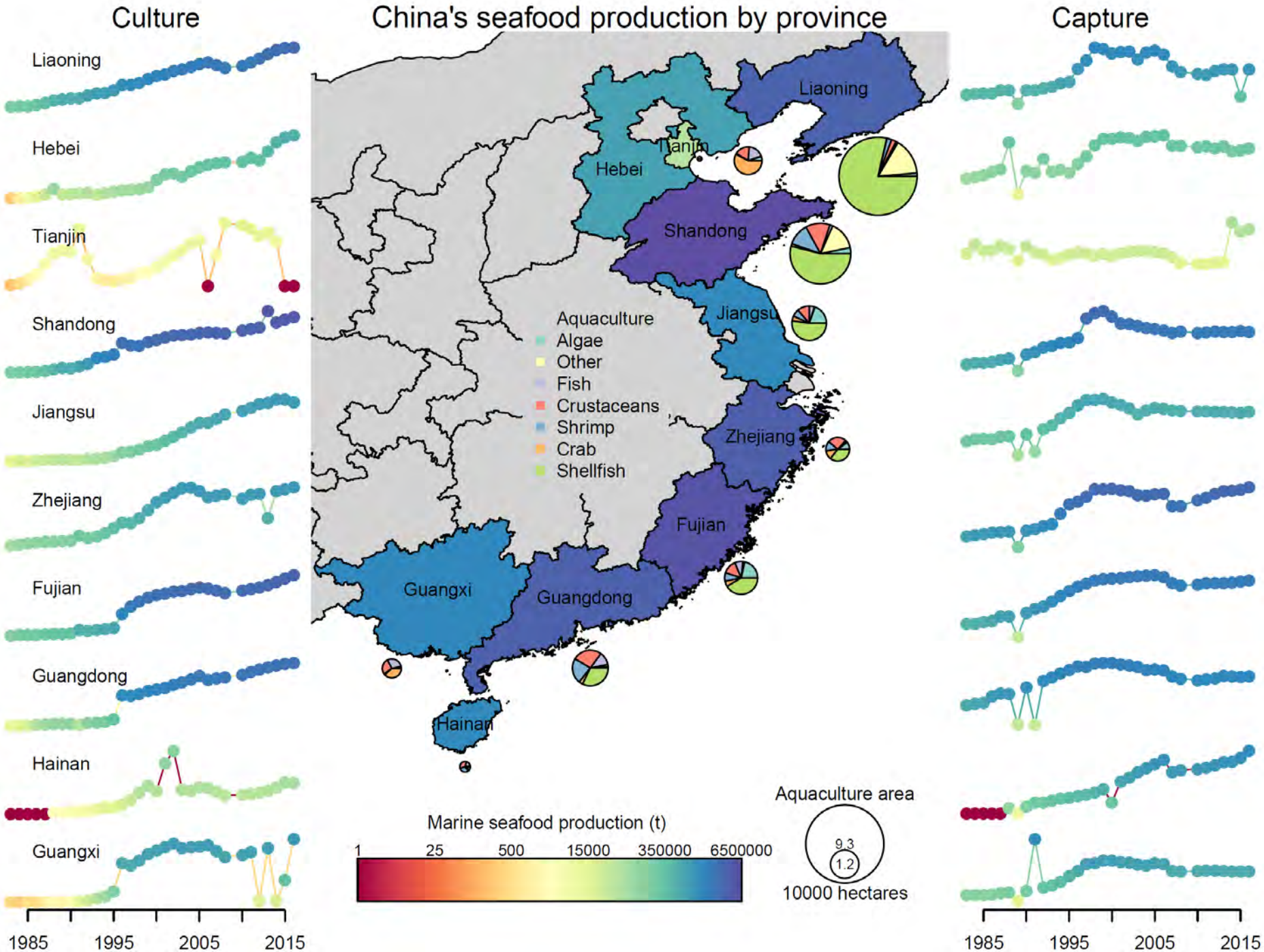
Table 1. Examples of fishing-induced ecosystem change benefitting fishery production of another species.

Region	*Benefitting fishery*	*Evidence*	*Ecosystem*	*Mechanism*	*Cause and consequence*	*Ecological features*	*Reference*
Great Barrier Reef	Prawns, *Metapenaeus endeavourt*, *Penaeus* spp.	Model	Tropical, demersal reefs	Predation release	Reduced abundance of predatory fish because of bycatch by prawn trawlers may increase prawn abundance.	Invertebrate prey, vertebrate predators	Gribble (2003)
Gulf of Mexico	Menhaden, *Brevoortia patronus*; red drum, *Sciaenops*	Model	Subtropical, demersal	Predation release	Reduced abundance of predatory fish because bycatch	Predation on juveniles, bycatch mortality of predator	Walters et al. (2008)


1–4
5–9
10–19
20–29
30+

Take aways

- When the ecosystem is considered, triple wins disappeared.
- Trade offs must be communicated to stake holders.
- Reference points are conditional quantities; changes in trophic structure change reference points.

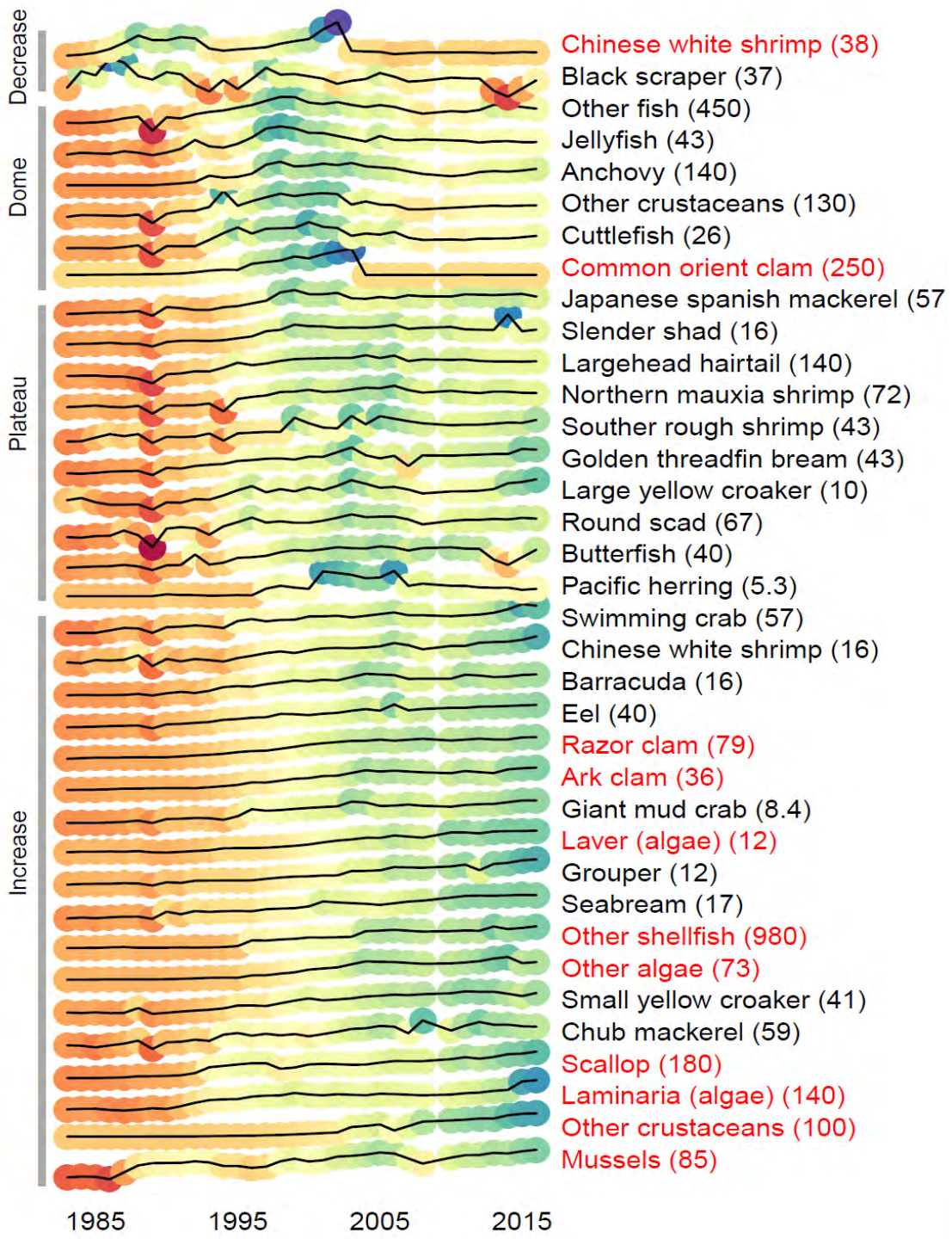

Culture
China's seafood production by province
Capture
Liaoning
Hebei
Tianjin
Shandong
Jiangsu
Zhejiang
Fujian
Guangdong
Hainan
Guangxi
Aquaculture
Algae
Other
Fish
Crustaceans
Shrimp
Crab
Shellfish
Marine seafood production (t)
1
25
500
15000
350000
6500000
Aquaculture area
9.3
1.2
10000 hectares
1985
1995
2005
2015

Decreasing

Dome-shaped

Plateau

Increasing



Research questions

- What have been the outcome of different strategies of seafood production among provinces?
- What portfolio of aquaculture and wild-capture fisheries can balance the needs of China's people and its marine ecosystems?
- How has aquaculture influenced wild-capture fisheries in China? Do different types of aquaculture produce different effects? Are there MPA-like effects of aquaculture?
- How resilient are different strategies for seafood production to environmental change?

If tradeoffs exist, how can we manage ocean resources?

FISH and FISHERIES

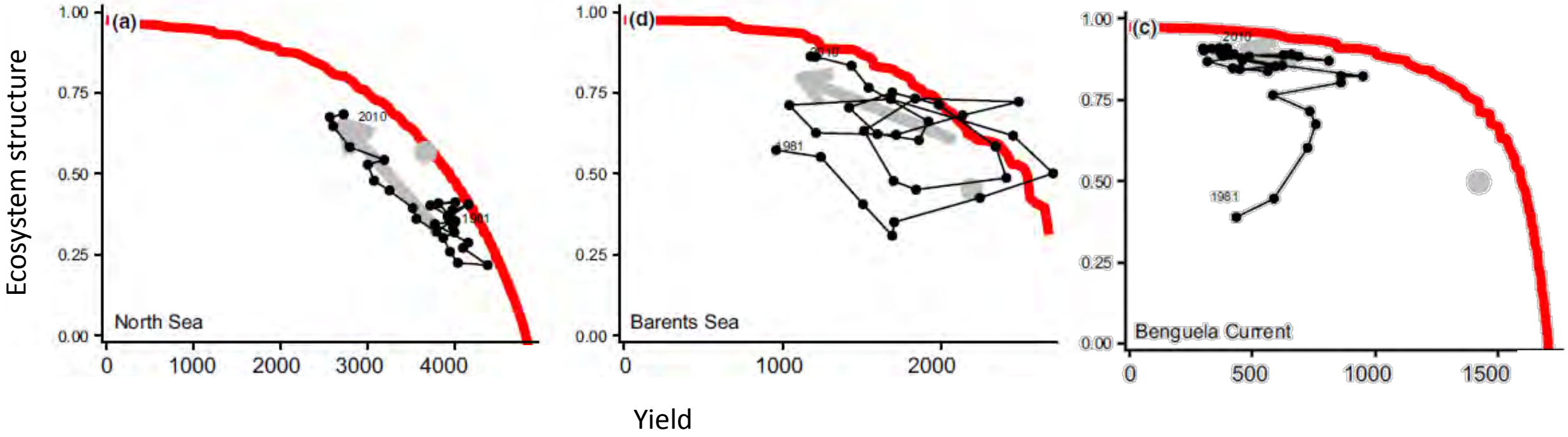
FISH and FISHERIES, 2017, 18, 199–211

Efficiency of fisheries is increasing at the ecosystem level

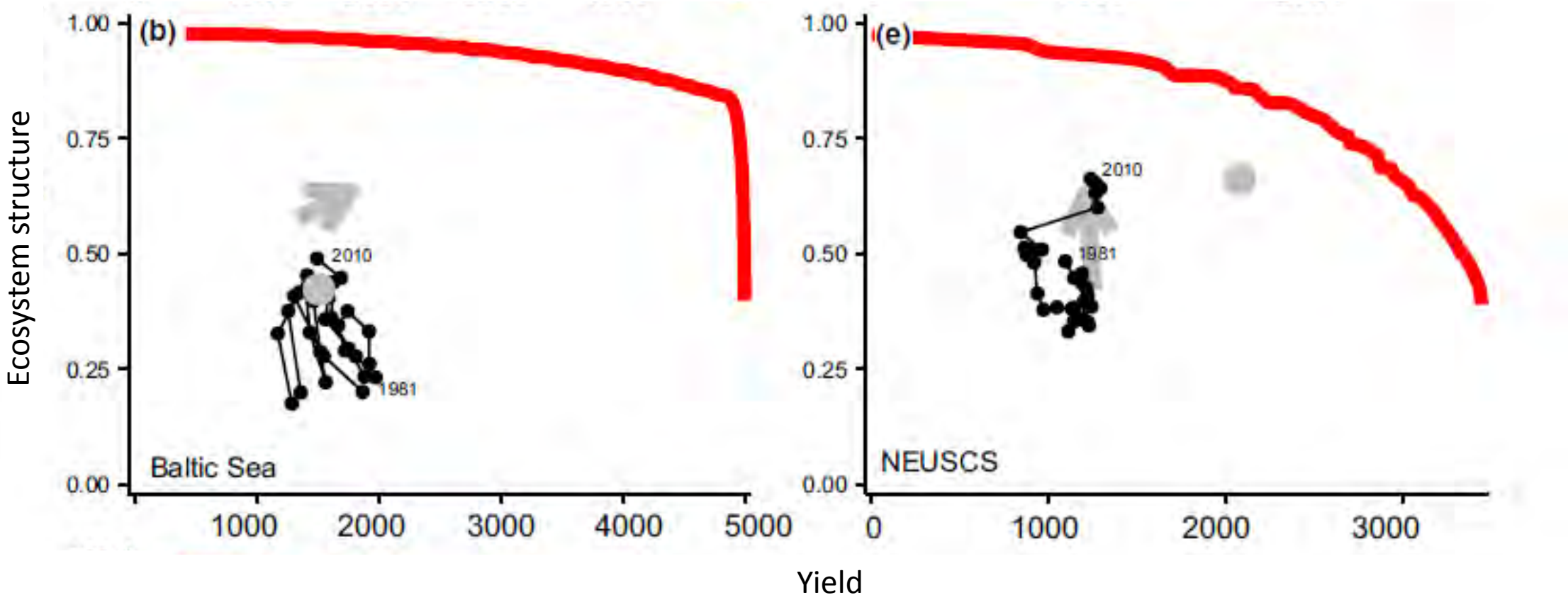
Nis S Jacobsen[1,2], *Matthew G Burgess*[3,4,5] & *Ken H Andersen*[1]

- Tradeoffs between conservation and protein production exist in fisheries management.
- Pareto efficiency : a state from which it is impossible to improve with respect to any objective without regressing at least one other.
- Jacobsen's results suggest:
  - (i) a trend towards ecosystem-level efficiency of fisheries;
  - (ii) ecosystem-scale win–wins may still be common;
  - (iii) single-species assessment approaches may overestimate the availability of win–wins by failing to account for trade-offs across interacting species.

- Fishing patterns in North Sea, Barents Sea and Benguela Current are nearly efficient with respect to long-term yield and ecosystem impact and that efficiency has improved over the last 30 years.



- In Baltic Sea and North East US Continental Shelf, fishing is inefficient and win–wins remain available.



If tradeoffs exist, how can we manage ocean resources?

- Model the trade-off space
- Identify wins-wins—move toward the efficiency frontier
- Have serious conversations with stakeholders about what tradeoffs are acceptable.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Collaborators and funding sources: