Selective Fishing, Balanced Harvest and EAF

Presented by
Serge. M. GARCIA
Chair IUCN-CEM-FEG

Scientific Symposium Mitigating Impact of Fishing on Pelagic Ecosystems: Towards Ecosystem-based Management of Fisheries. 15-18 Octobre 2012. Montpellier, France

IUCN CEM FEG EBCD EUROPEAN BUREAU FOR CONSERVATION & DEVELOPMENT Convention on Biological Diversity CENSUS OF MARINE LIFE

Selective Fishing and Balanced Exploitation in Relation to Fisheries and Ecosystem Sustainability

Organized by the IUCN Fisheries Expert Group (FEG)
In Nagoya (Japan) 14-16 October 2010

Convened by: S.M. Garcia, J. Rice, J. Kolding, M-J. Rochet, S. Zhou

PARTICIPANTS

Arimoto, T. (Japan)	Graham, N. (Ireland)	Rice, J. (Canada)
Beyer, J. (Denmark)	Hall, M. (IATTC)	Rijnsdorp, A. D. (Netherl.)
Borges, L. (E.C.)	Heino, M. (Norway)	Smith, A.M.D. (Australia)
Bundy, A. (Canada)	Kolding, J. (Norway)	Simard, F. (IUCN)
Dunn, D. (USA)	Rochet, M-J. (France)	Makino, M (Japan)
Garcia, S.M. (France)	Law, R. (UK)	Symons, D. (EBCD)
		Zhou, S. (Australia)

This presentation is made on their behalf

Outline

1. Relevant norms for fisheries policy
2. The conventional selectivity concept
3. The food chain concept
4. Management implications

UNCLOS norm

«Stocks should be kept at biomass levels that can produce MSY»

UNCLOS (1982) – WSSD (2002) Declaration § 31 (a)

Criticized by scientists since early 1970s but recognized in all summits

CBD norm

«A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning»

CBD. 1998. Malawi principles for Ecosystem Approach:
FAO adopted EAF in 2001

Conservation concern

HOME PAGE | TODAY'S PAPER | VIDEO | MOST POPULAR | Edition: U.S. / Global

The New York Times

2 April 2012

Environment

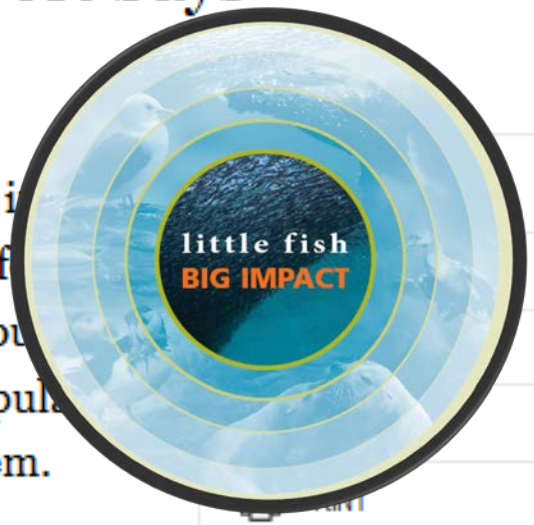
WORLD | U.S. | N.Y. / REGION | BUSINESS | TECHNOLOGY | SCIENCE | HEALTH | SPORTS | OPINION

ENVIRONMENT | SPACE & COSMOS

Too Many Small Fish Are Caught, Report Says

By HENRY FOUNTAIN
Published: April 2, 2012

An international group of marine scientists is calling for cuts i
commercial fishing for sardines, herring and other so-called f
fish whose use as food for fish farms is soaring. The catch shou
cut in half for some fisheries, the scientists say, to protect popul
of both the fish and the natural predators that depend on them.



Some discording voices

"In theory a food web could be maintained "in balance" by fishing each component in proportion to the rate of natural predation it is subjected to".

Caddy and Sharp (1986) optimal, albeit 'utopian' strategy

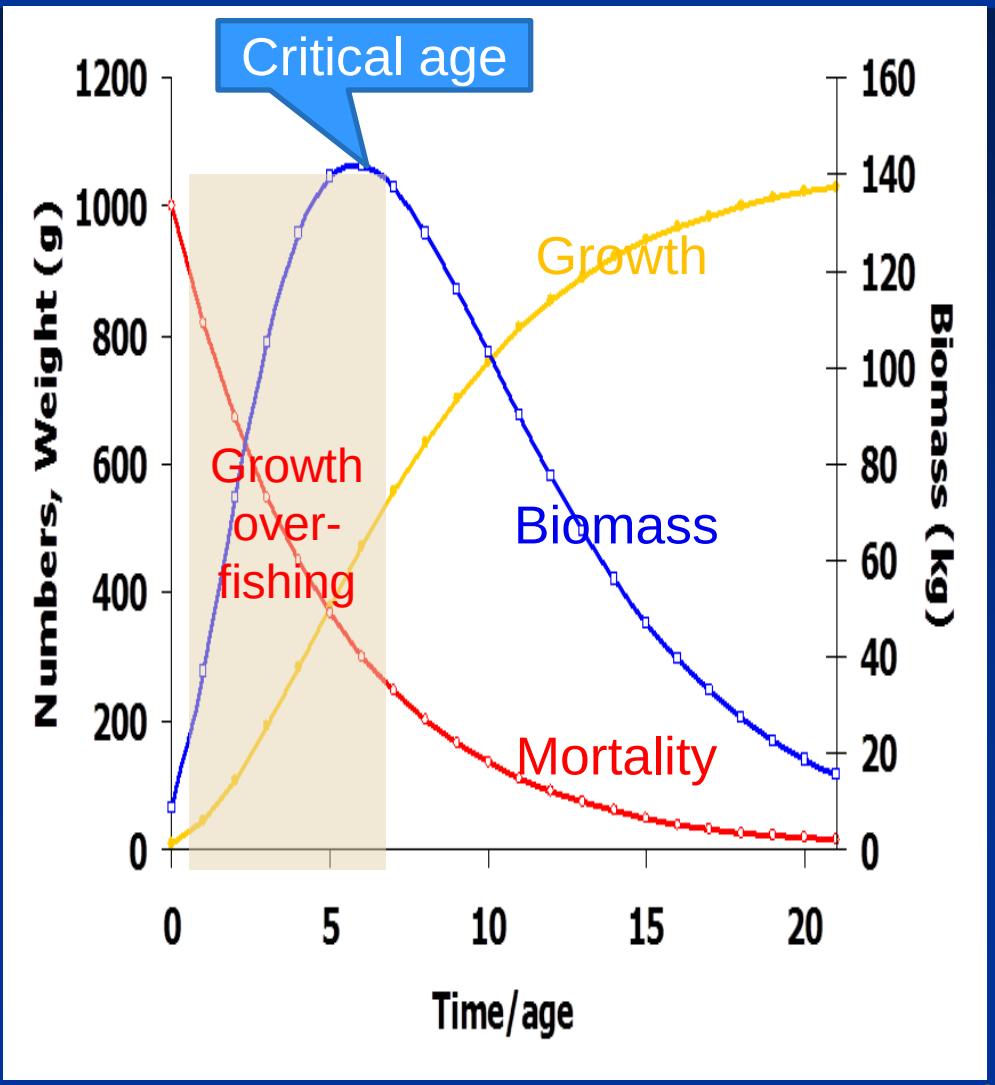
Outline

1. Relevant norms for fisheries policy
2. The selectivity issues

Selectivity concept

- Selectivity is the process through which fishing obtains a catch with a composition (in size, sex, or species) that differs from that of the natural habitat on which it operates.
- It is the probability of a species, sex, size or age to be caught.
- It results from the appropriate selection of: (i) the fishing area and depth, (2) the fishing season and time, and (3) the fishing gear, its characteristics and operation.
- Usually defined at gear level, it can be defined at vessel, fishery, community and ecosystem levels.
- It is conventionally regulated to: (i) maximize long-term yield from each recruit of the target species and (ii) reduce catch of unwanted or protected species.
- It is used by fishers to maximize short-term economic returns
- Conventional selectivity regulations ignore trophic relations and predation.

Dominant paradigm



".. a fishery will yield its maximum physical returns if all fish are allowed to grow to the point where the rate of

leave a breeding stock.

But we all know there are problems with that paradigm !!

Wildlife scientists have argued against it for decades in hunting reserves

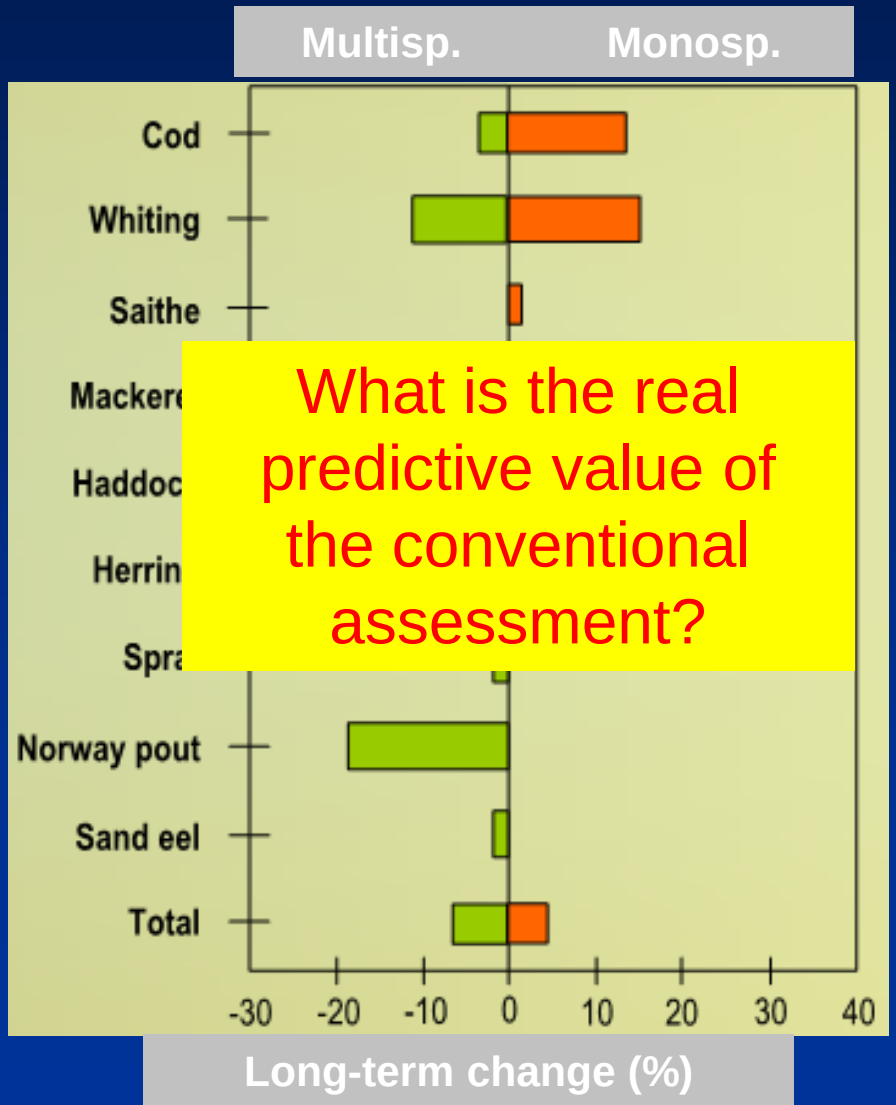
Hillis and Arnason 1995 Beverton and Holt, 1954

Multispecies problems: Cod

Long-term change in landings (in %) when passing from 80mm to 120 mm mesh for Cod.

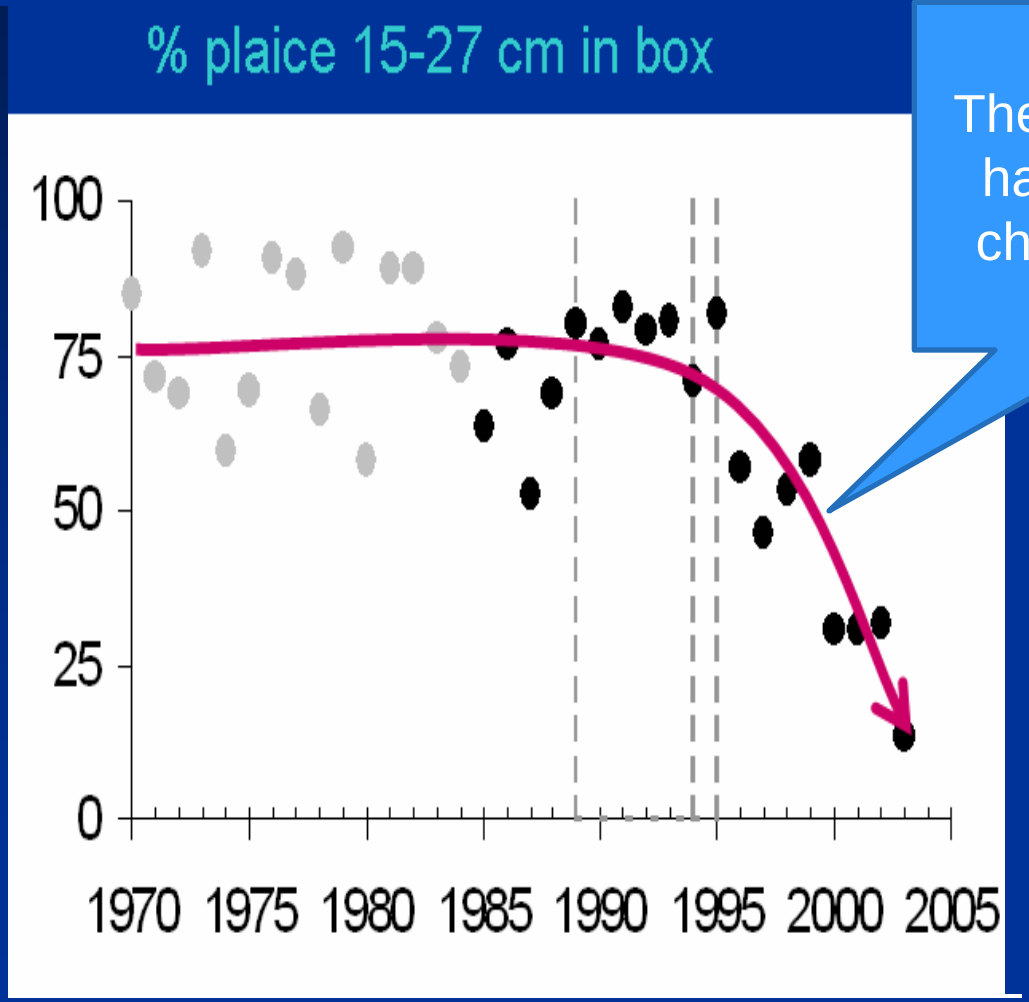
The difference is the result of the additional predation of large fish released by the larger mesh size.

Real results (since 2001) are different from both predictions (Graham, pers. Comm.)



Source: North Sea Cod. ICES 1989. Multispecies assessment working group

Natural uncertainty: Plaice



The young plaice had decided to change place!!!

But the fishery improved nonetheless because …increases in fuel cost reduced fishing mortality !

Rijnsdorf et al 2010. FEG Nagoya meeting The plaice box

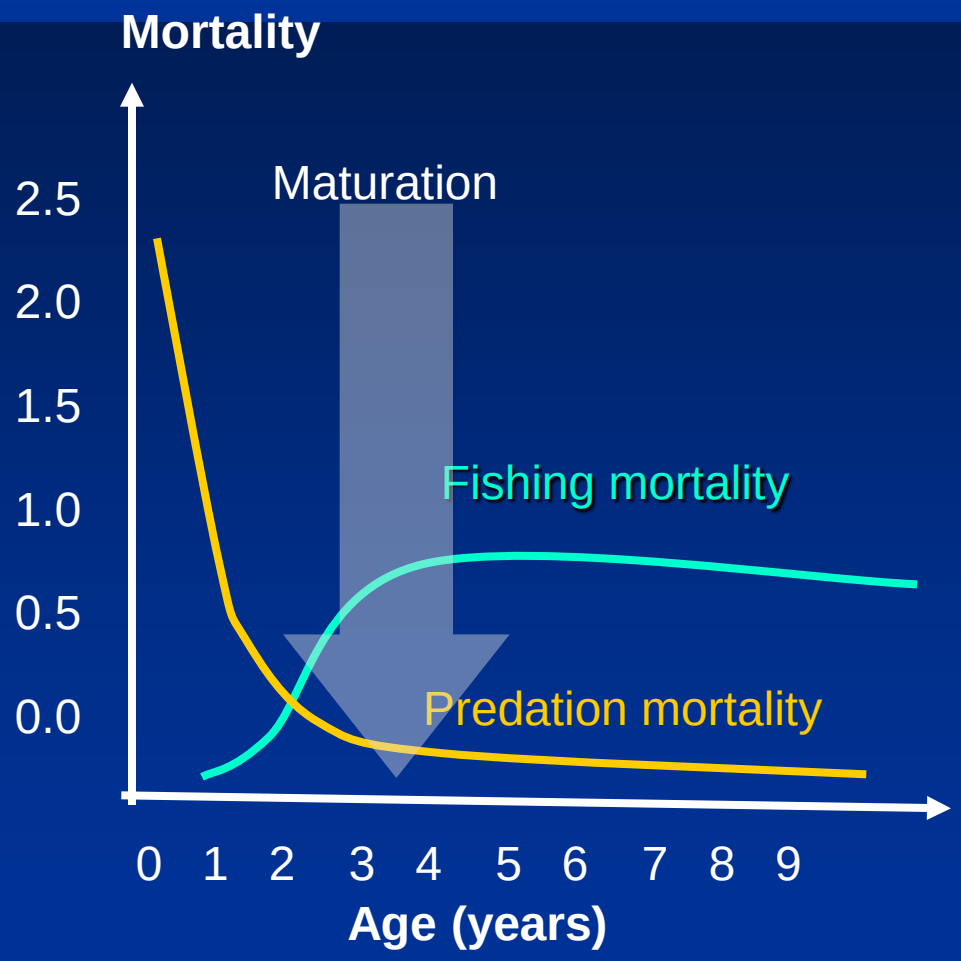
Fishery response: Tuna

East Pacific Tuna Purse seining

	Before dolphin protection	After dolphin protection
Yellowfin	18-22 Kg	3-6 Kg
Discard /set	0.1 t (1%)	4.6 t (10%)
Bycatch rate	1 dolphin 0.3 sailfish 0.2 manta ray	26 sharks 1.8 marlins 800 large bony fishes 1250 small fishes 0.04 turtles

This effect of selectivity was certainly not expected!

Change in mortality pattern…

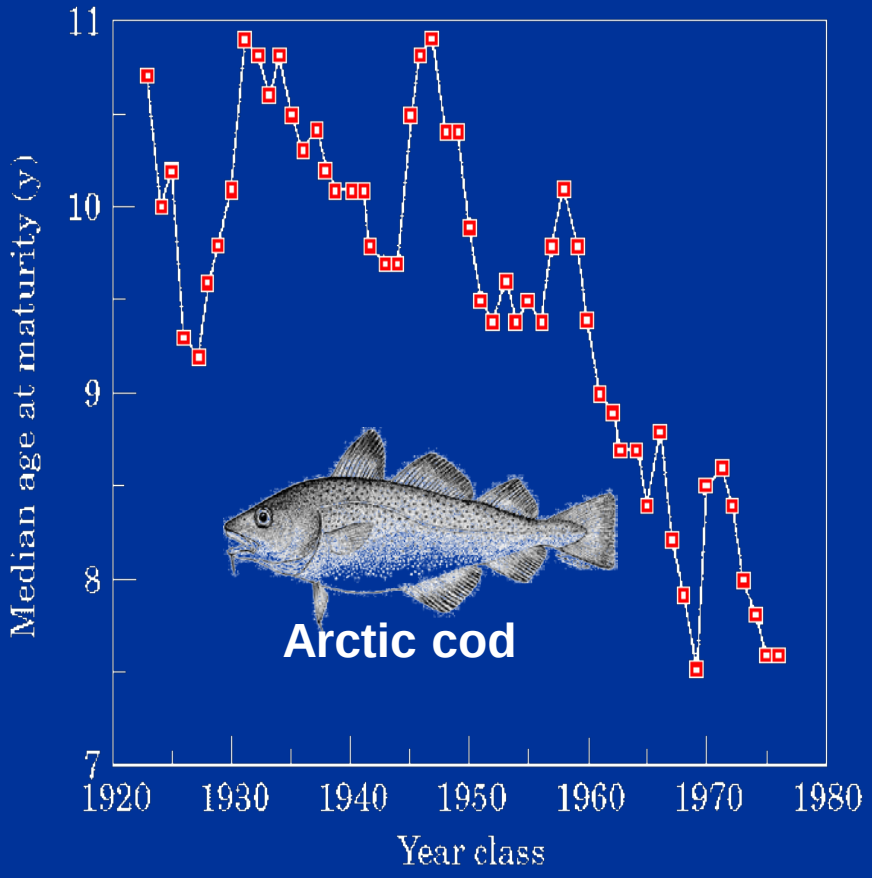


Example from Arctic Cod

Humans and natural predators "select" their targets differently !!

Growing big is not any more a good strategy!

… leads to changes in maturation

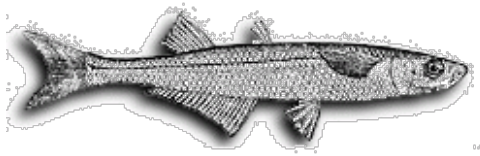


- Selection of phenotypes
  - Reduced age and size at maturity
  - Reduces maximum body size
- Increased reproductive investment
- Increased resilience to high fishing
- Decreased resilience to environment
- Reduced resource productivity
- Reduced N° of subpopulations
- Reduced genetic variability
  - Selection of genotypes

Modeling shows that a reduction of fishing pressure at both ends of the size spectrum reduces evolutionary response in a population

Source: Rijnsdorp. 2010; Mikko 2010. . FEG Nagoya meeting

… Changes in sizes at age …



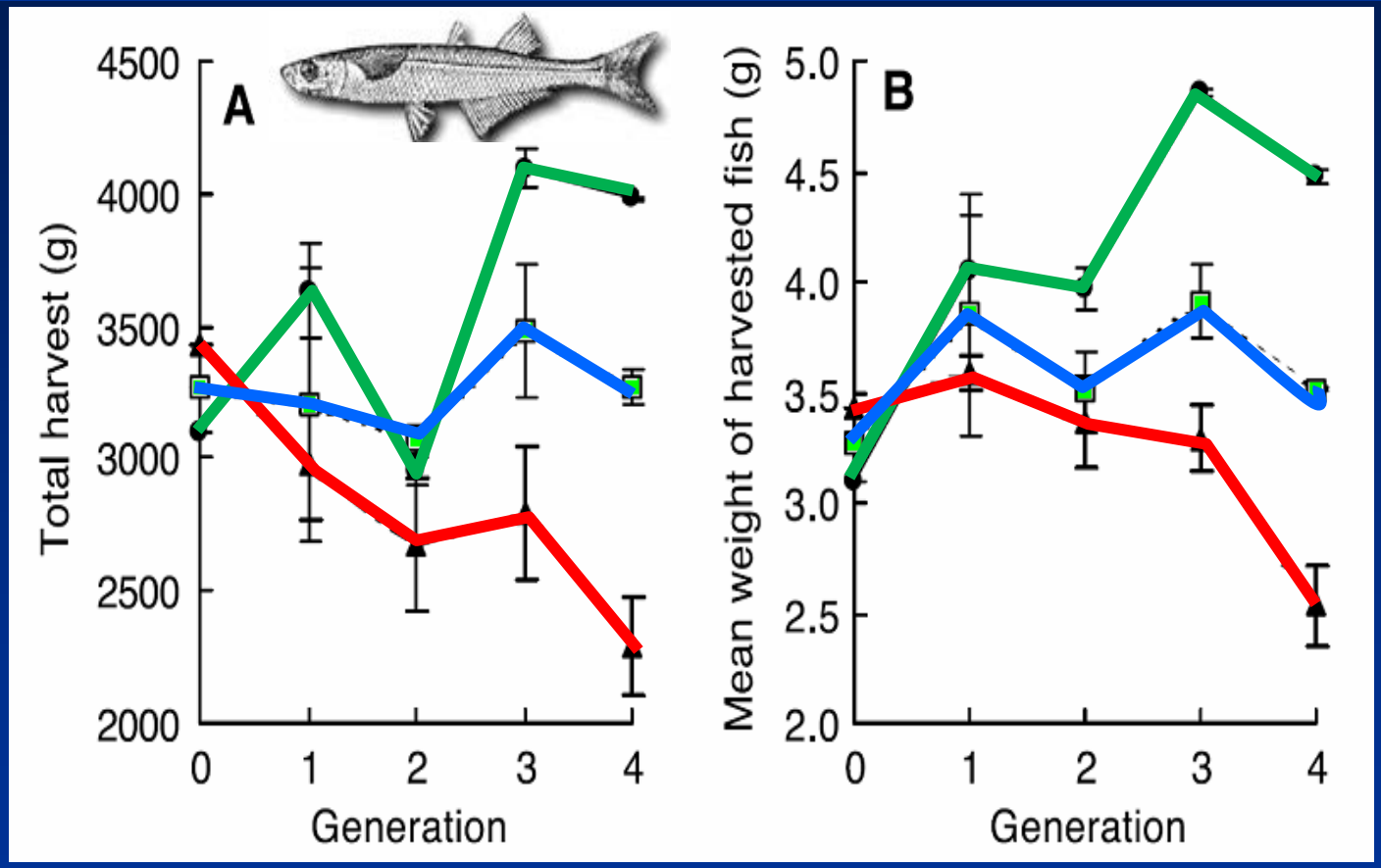
Growths slows down if only large fish are targeted

Mortality on

- Small
- Large
- Random

Conover and Munch 2002

… weight at age and yield



Mortality on

- Small
- Large
- Random

Conover and Munch 2002

Selectively removing large adults decreases mean size and total yields

Some conlusions

- The selectivity paradigm is 50-year old and non ecosystemic
- It ig
- The
- The
- By-
- The
- Mar
- But:
- But: com

Some questions

Are present practices making things better or worse for the ecosystem?

Could fishing selectivity be optimized at ecosystem level?

Could selective harvest and selective protection be co-optimized?

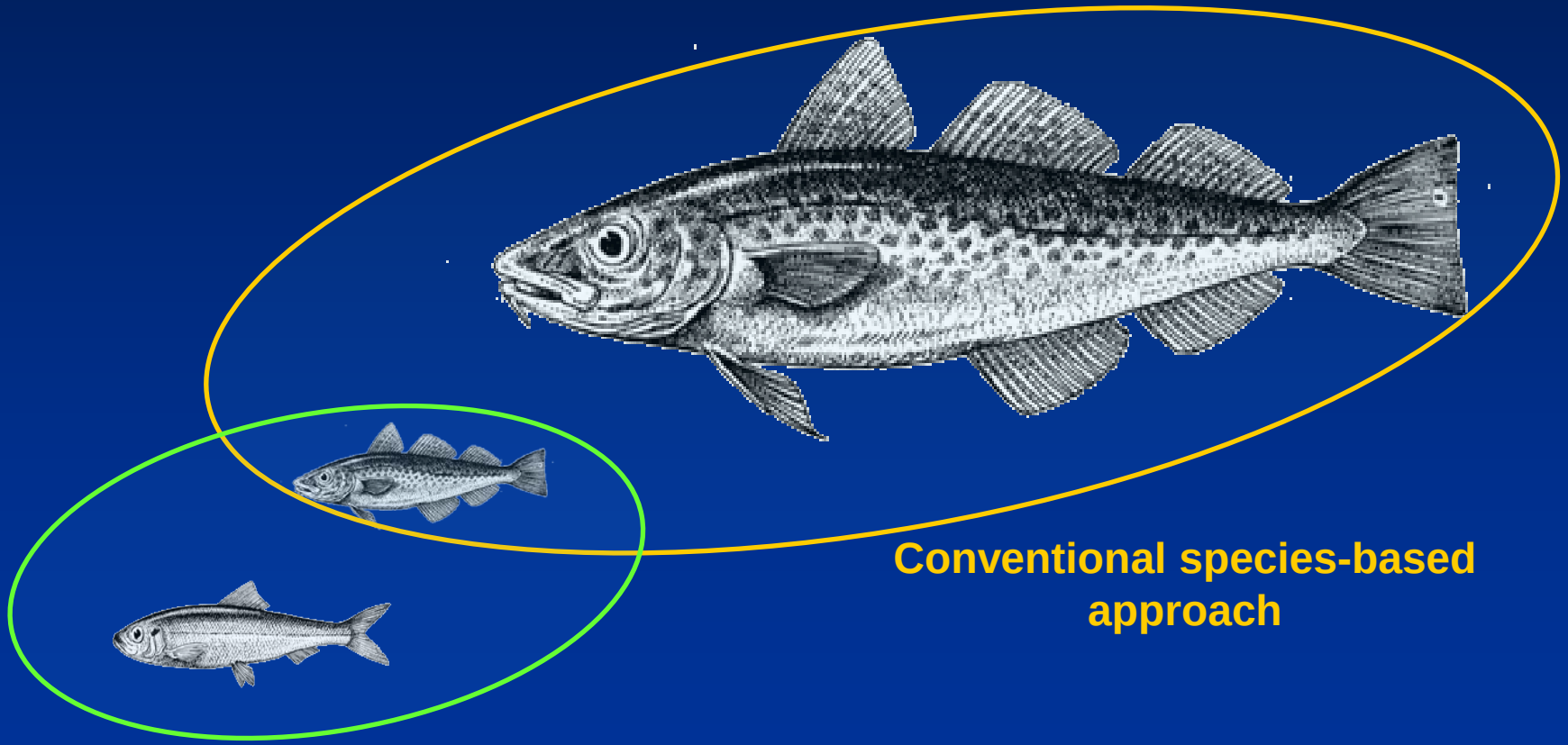
The selectivity paradigm needs to be reassessed in an ecosystem perspective!

Outline

1. Relevant norms for fisheries policy
2. The conventional selectivity concept
3. The food chain concept

The food chain

Which are the two most similar fishes?

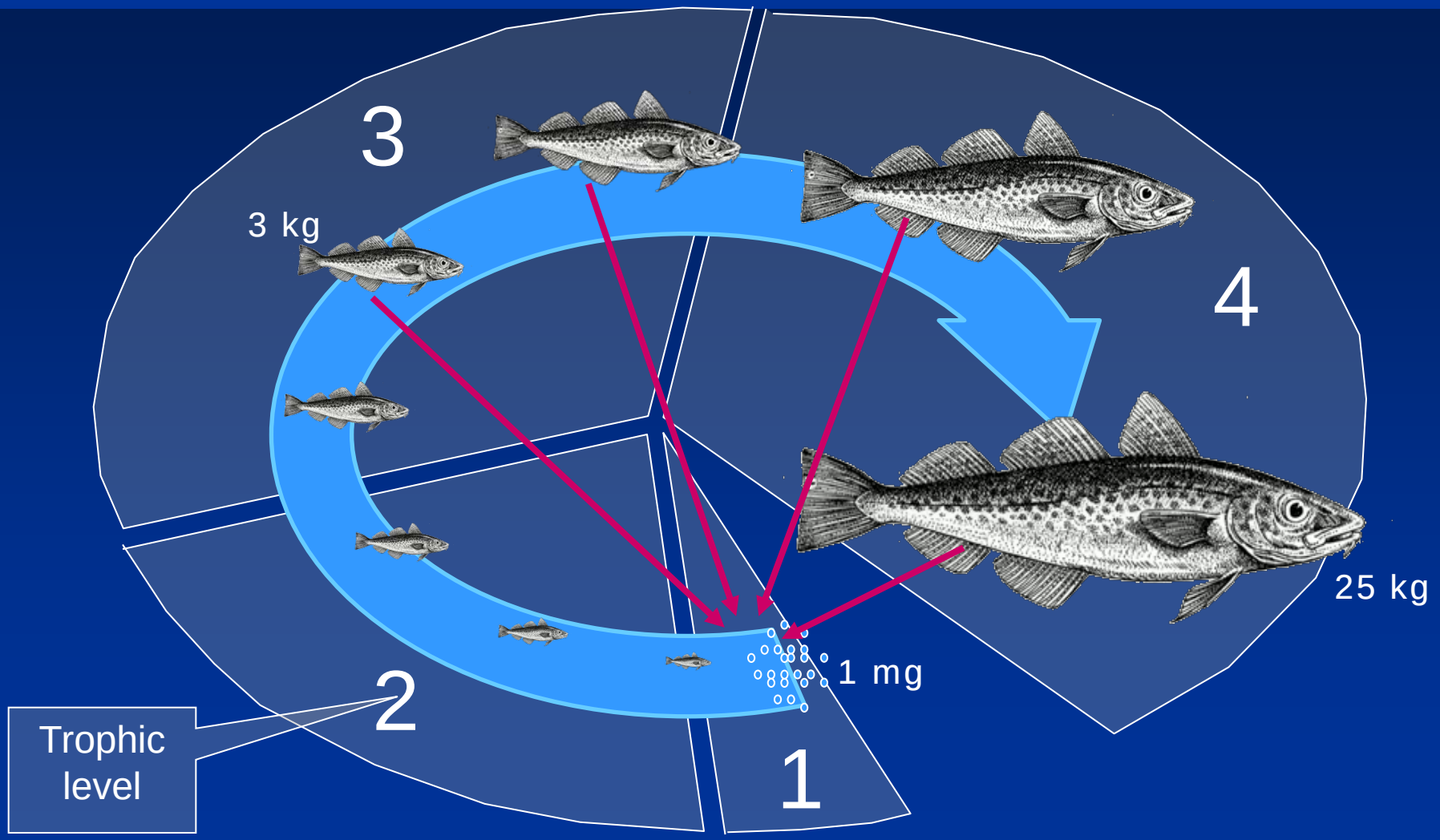


Conventional species-based approach

Ecosystem approach

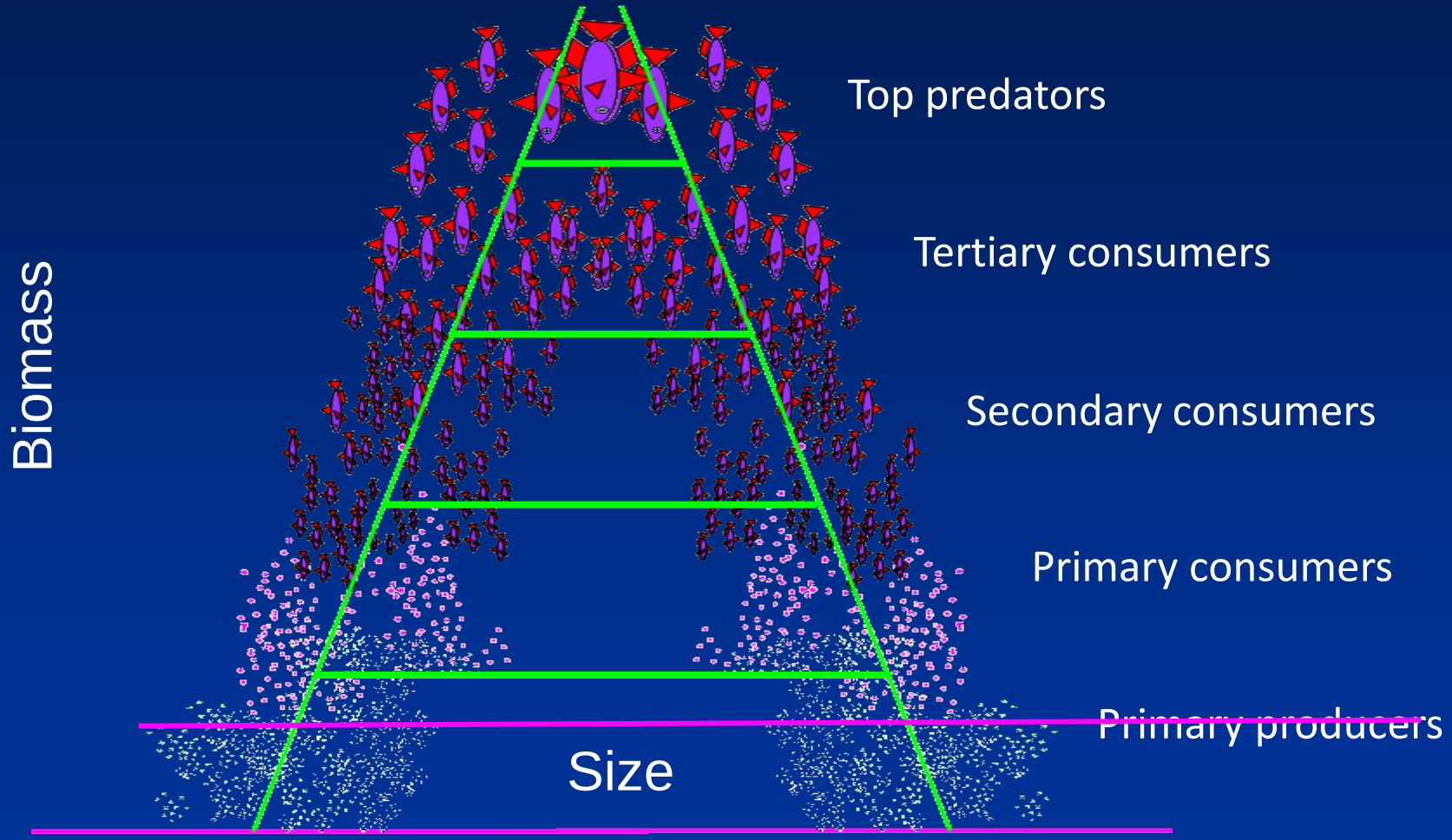
Source: Jan Beyer. Nagoya FEG meeting presentation 2010

4. The food chain: ontogenic shift



Source: Jan Beyer. Nagoya FEG meeting presentation 2010

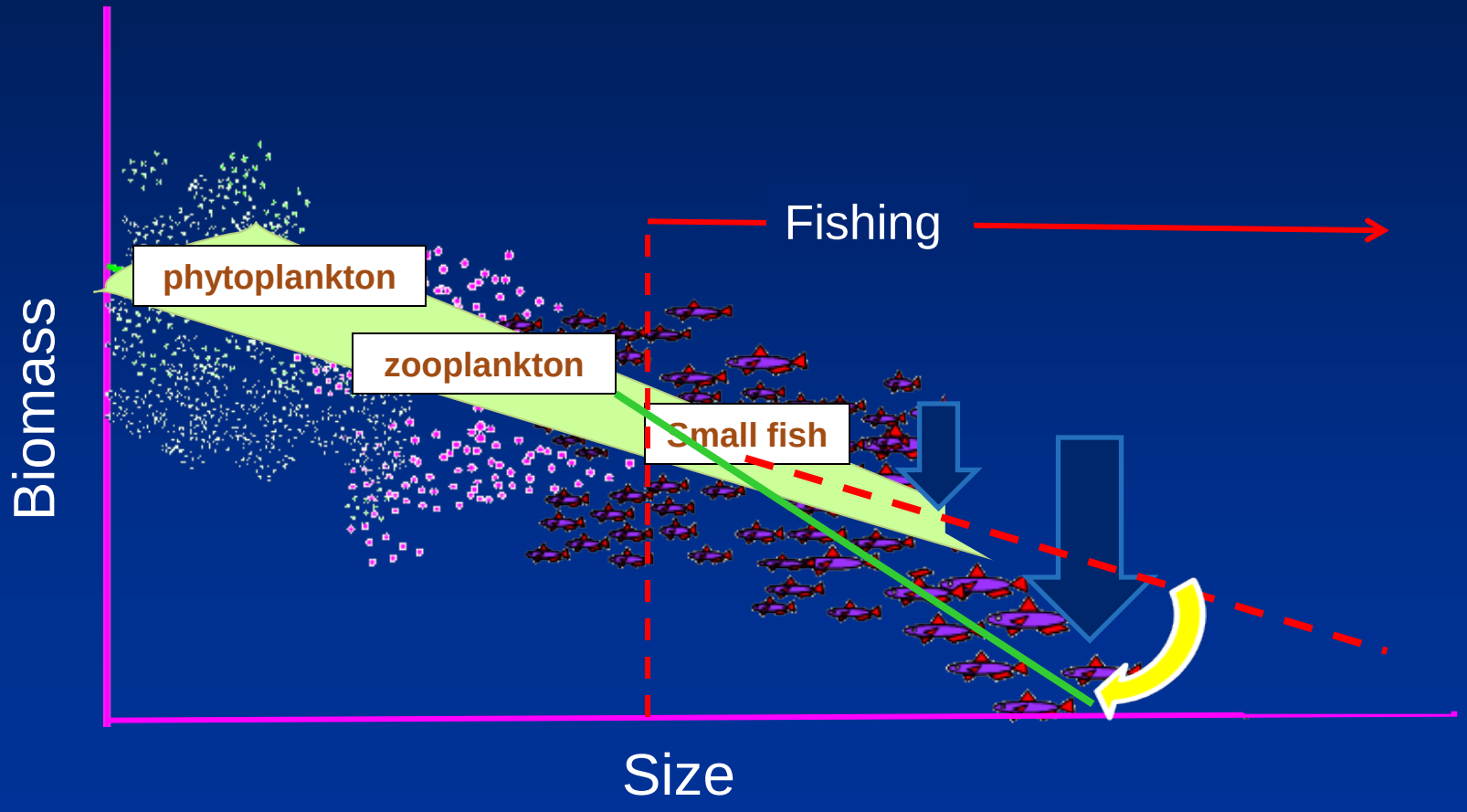
The food web is size structured…



… Abundance is inversely corelated with size

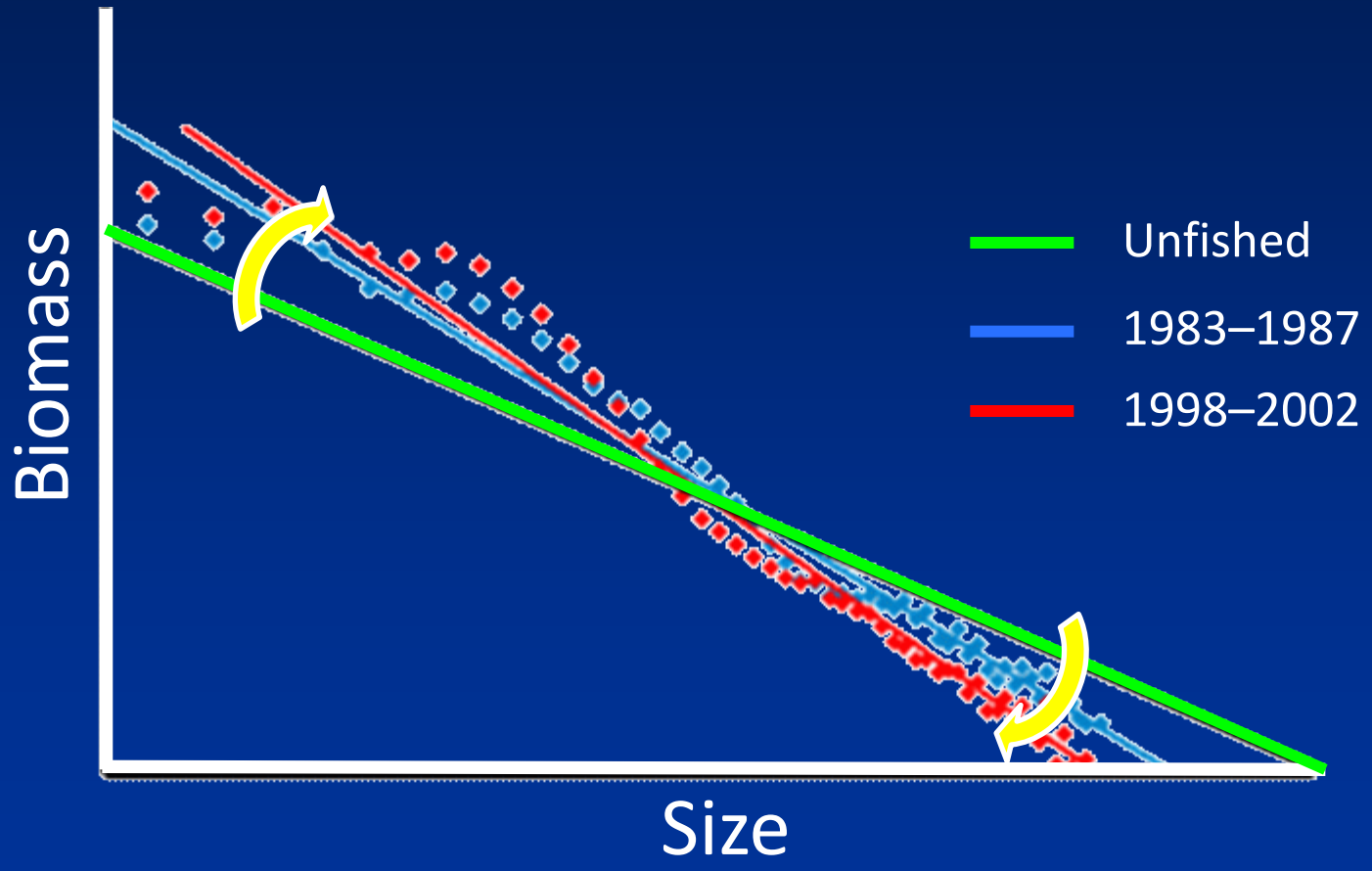
Community size spectrum

1. The distribution of biomass by body size follows regular patterns



2. Under conventional selective fishing slope and intercept will change

Changes in the North Sea

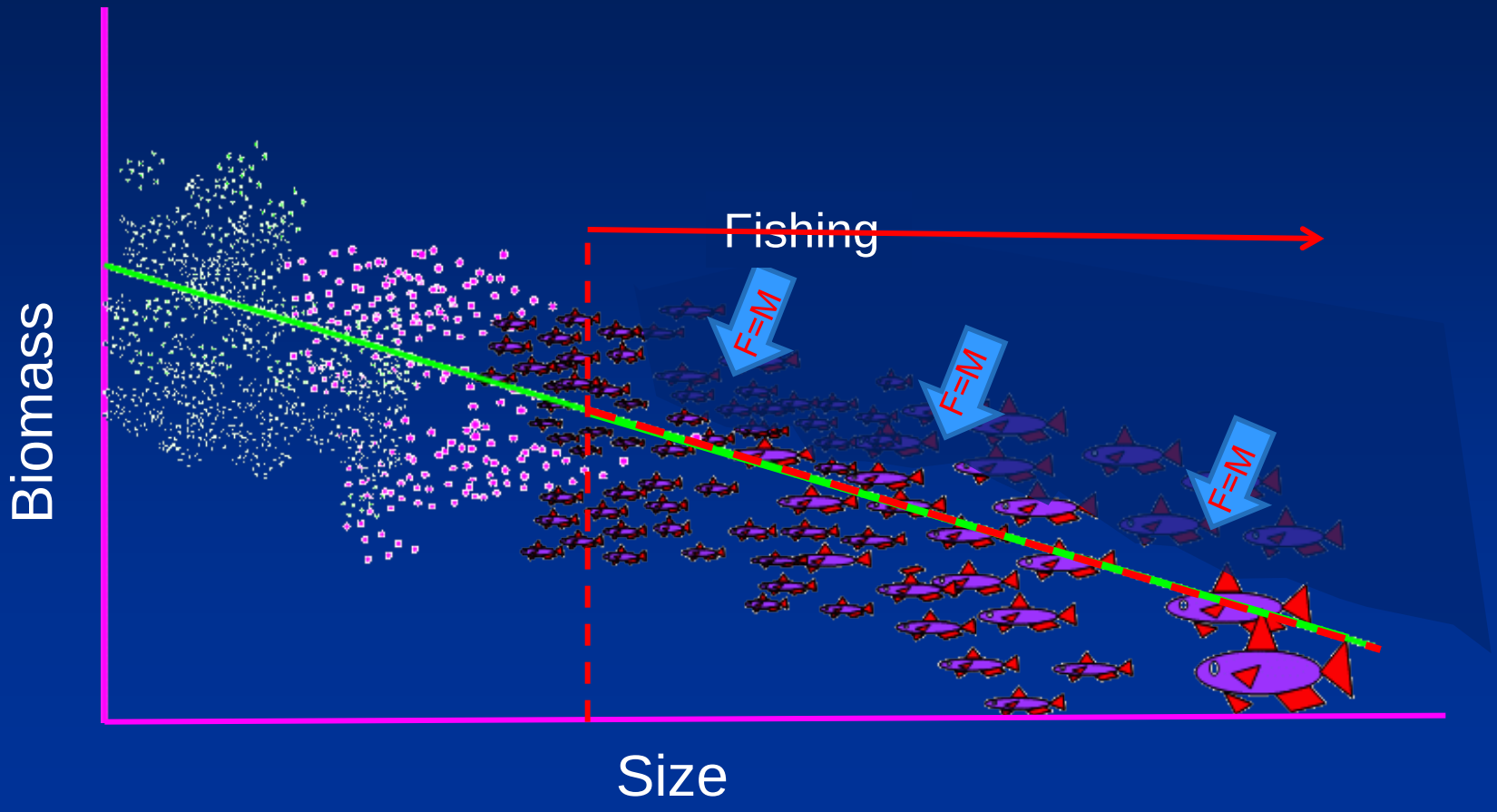


Rice, Gislasson, 1996, 1998

Garcia et al. 2012

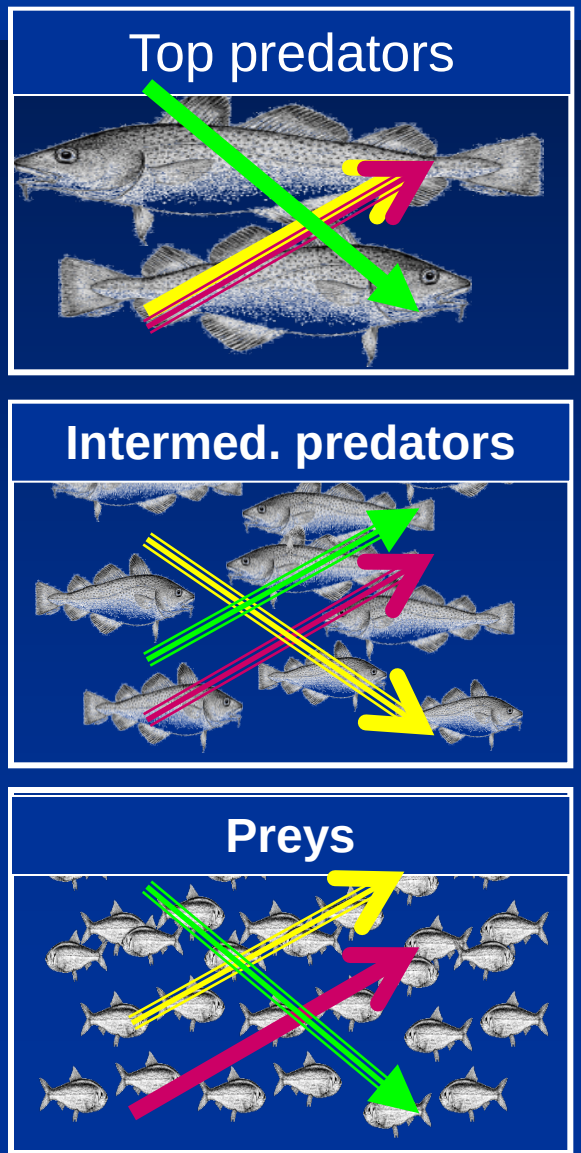
Balanced harvesting

Fishing “all” sizes and species in proportion to their natural productivity



Reconciles objectives: maintains community structure; returns highest yields

Trophic cascades



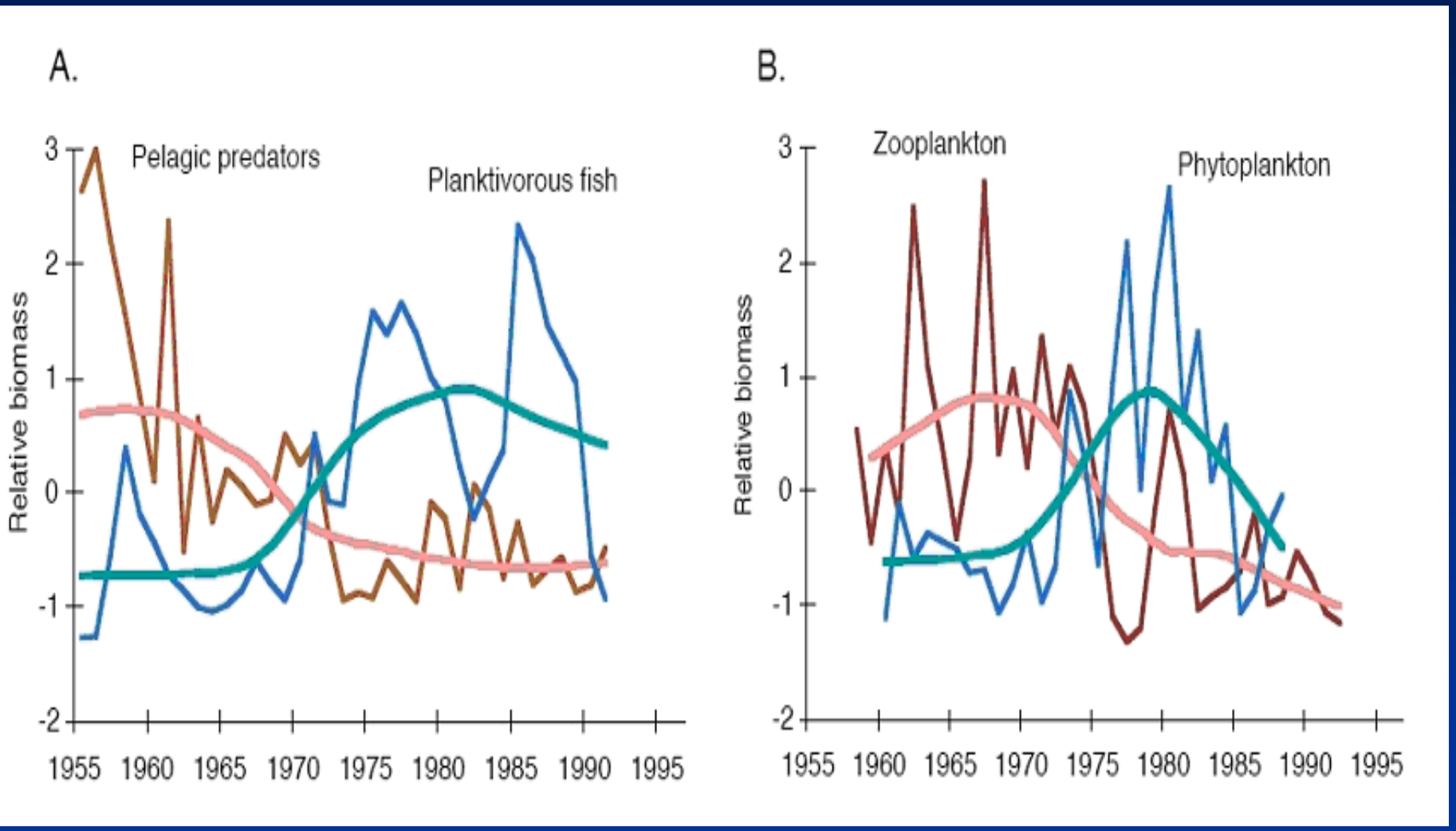
Any positive or negative change in any compartment generates a cascade of direct consequences upwards and/or downwards and feed-back responses

The end result is not easy to predict

Triggering change

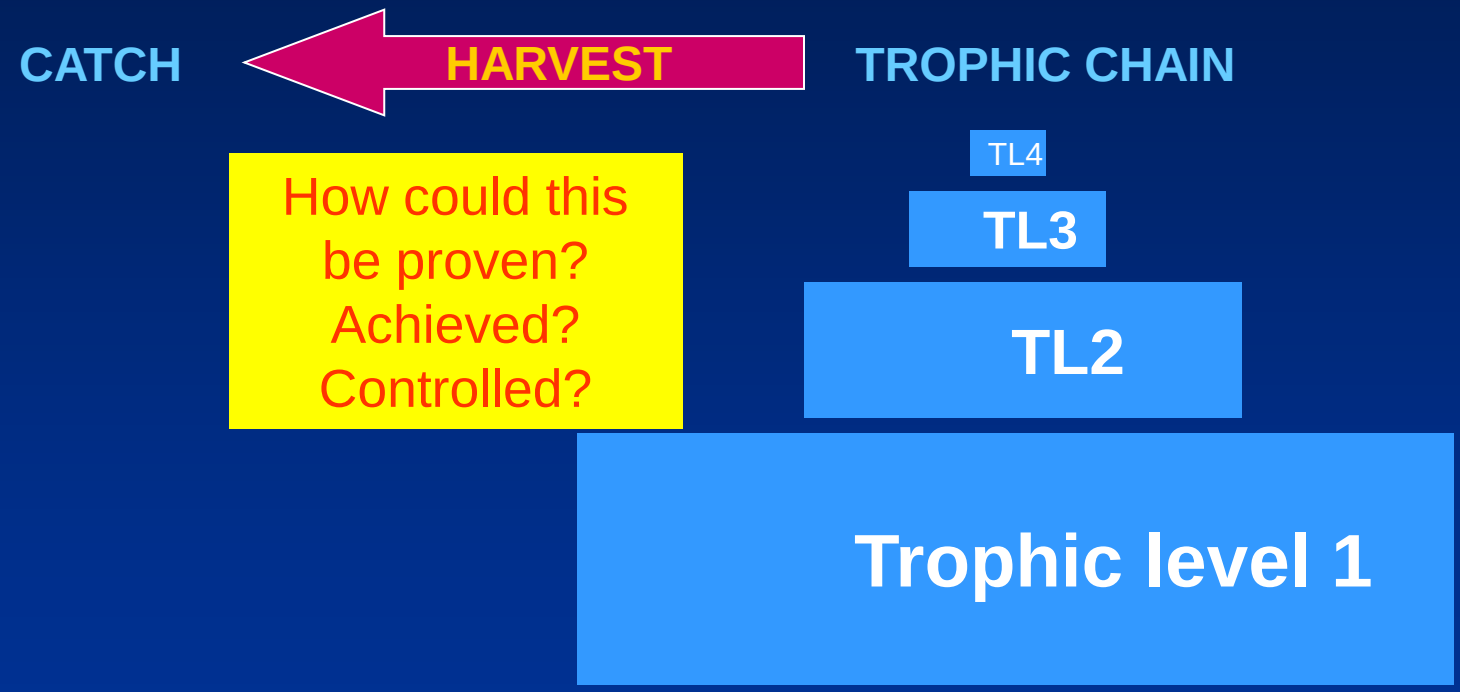
Induced change

4. The food chain: Trophic cascades



Source Daskalov 2010

The food chain perspective



Balanced harvesting: a fishing strategy that maintains ecosystem structure by keeping fishing pressure moderate and distributing it across ecosystem components (species, sizes, and trophic levels) in proportion to their productivities

Some comments

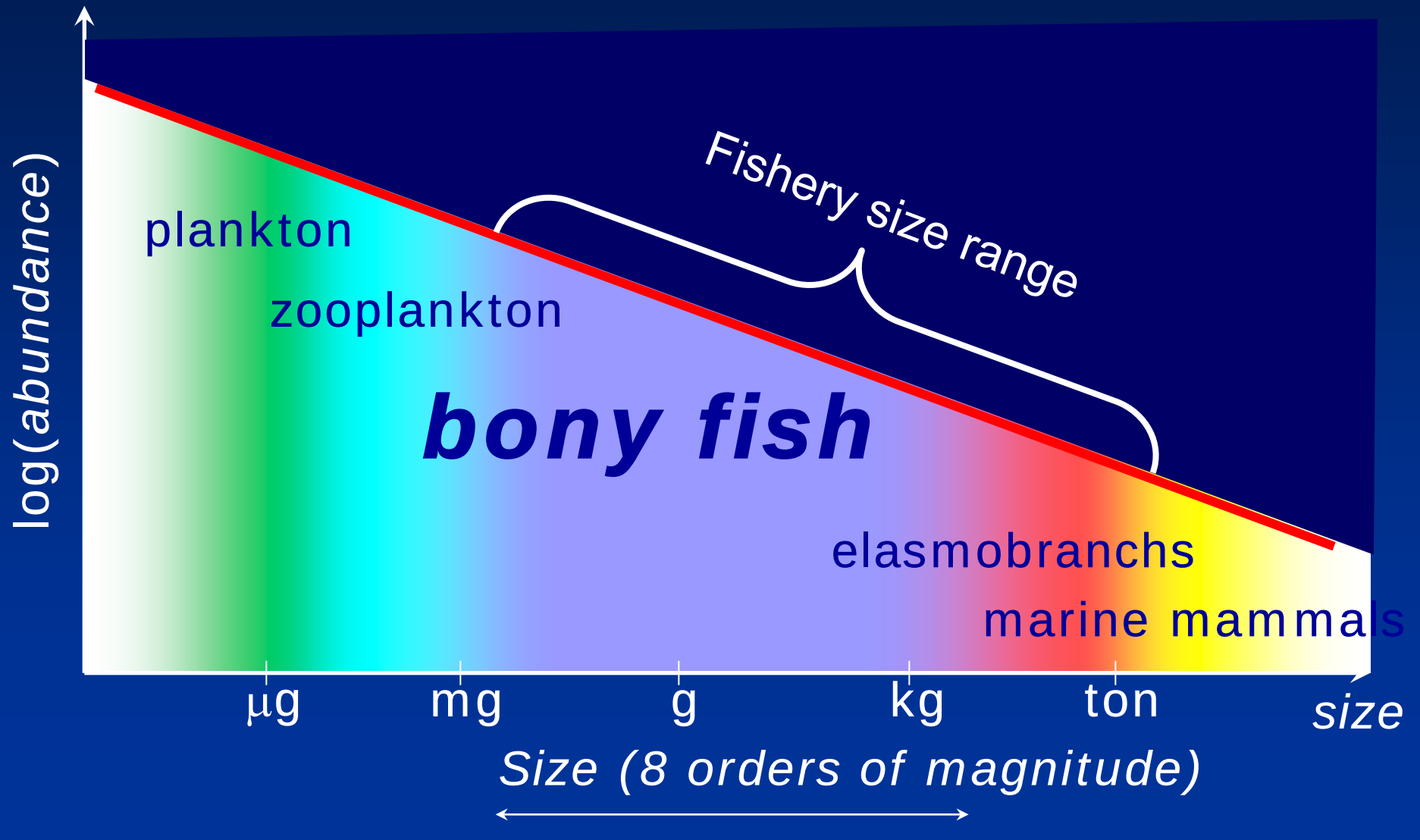
Balanced harvesting: a fishing strategy that maintains ecosystem structure by keeping fishing pressure moderate and distributing it across ecosystem components (species, sizes, and trophic levels) in proportion to their productivities

- It corresponds to Caddy and Sharp 1986 “Utopian management”
- I heard this from Garrod in the 1970s already
- Sydney Holt (pers. com.) considers it “intuitively obvious”
- Obtaining MSY from all stocks in the food chain would come close to it
- Ken Henderson: suggested to call it “Physiological Harvesting” as F is aimed to be proportional to M
- Wildlife scientist have already raised the issue (at population level) in conflict with hunters

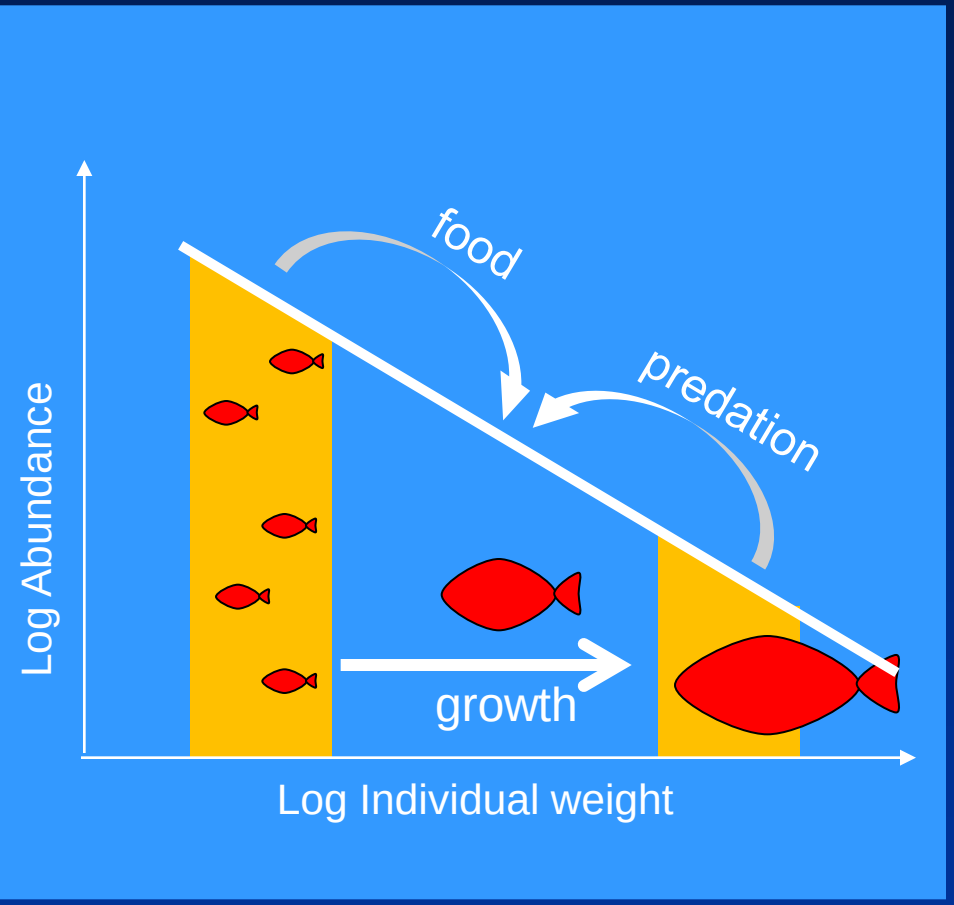
Outline

1. Relevant norms for fisheries policy
2. The conventional selectivity concept
3. The food chain concept
4. The modeling contribution

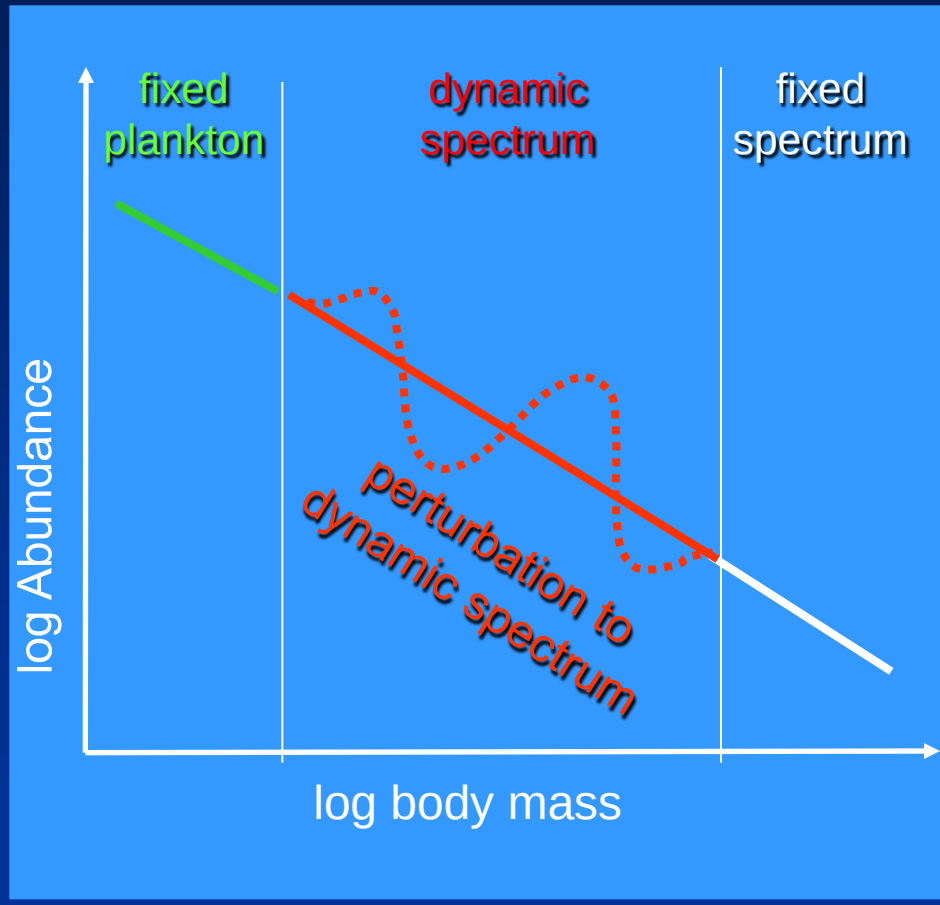
Biomass-Size spectra



Biomass-size spectra -2

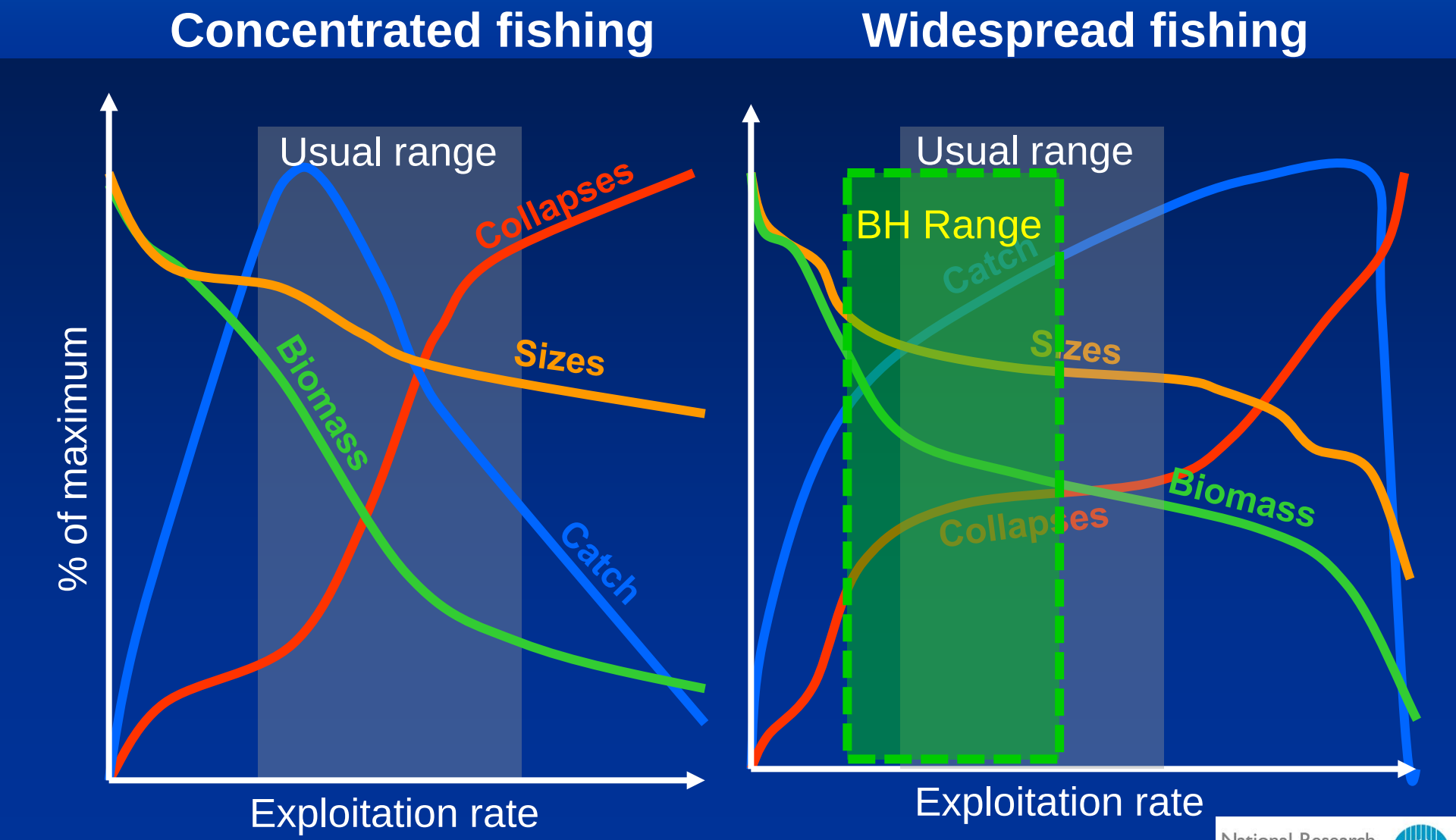


Beyer & Andersen 2010



Law et al. 2010

Ecosystem models



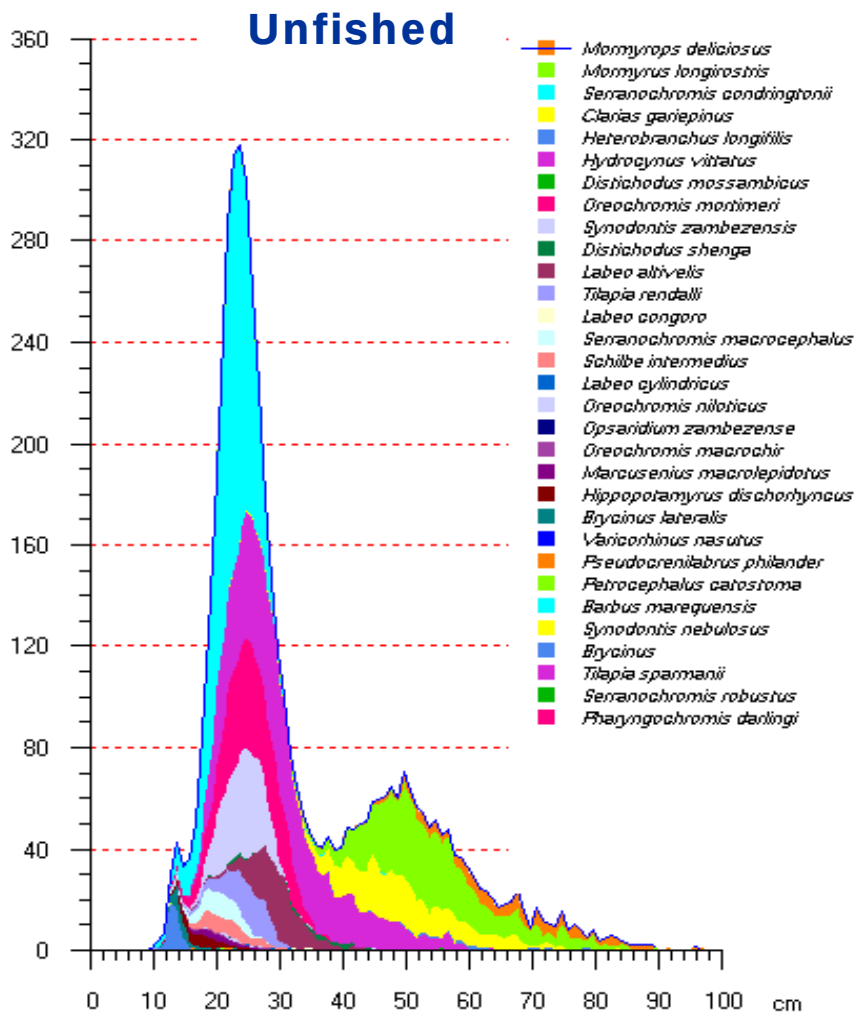
Source: Fulton et al.

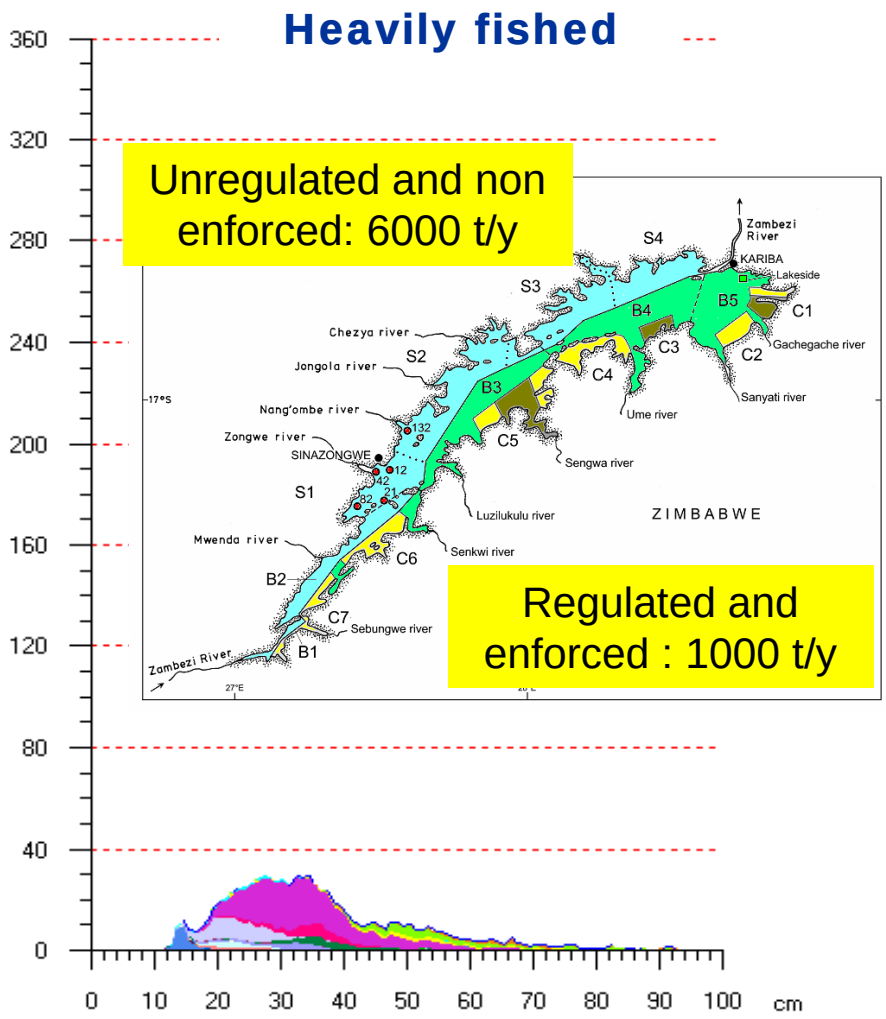
Outline

1. Relevant norms for fisheries policy
2. The conventional selectivity concept
3. The food chain concept
4. Modeling results
5. What empirical evidence ?

Empirical evidence: Lake Kariba

Lake Kariba ecosystem structure: 1980-1994

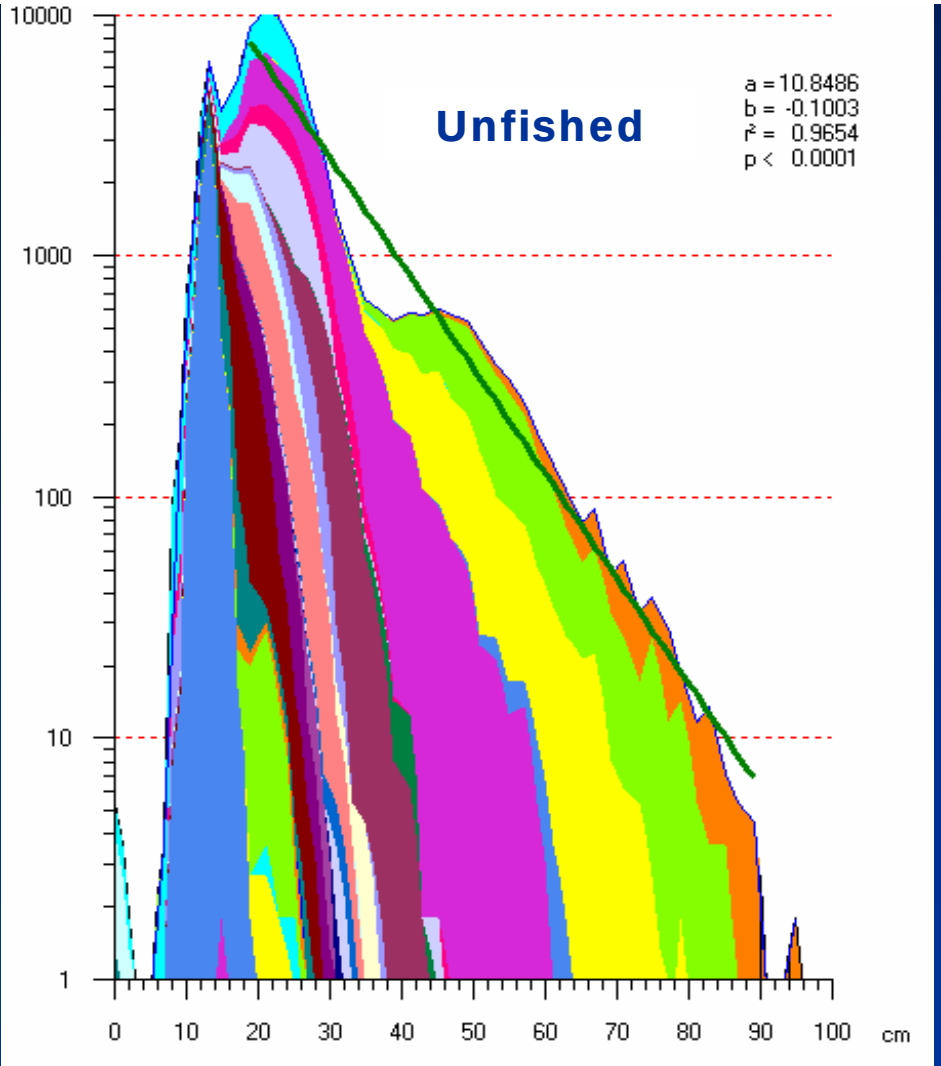


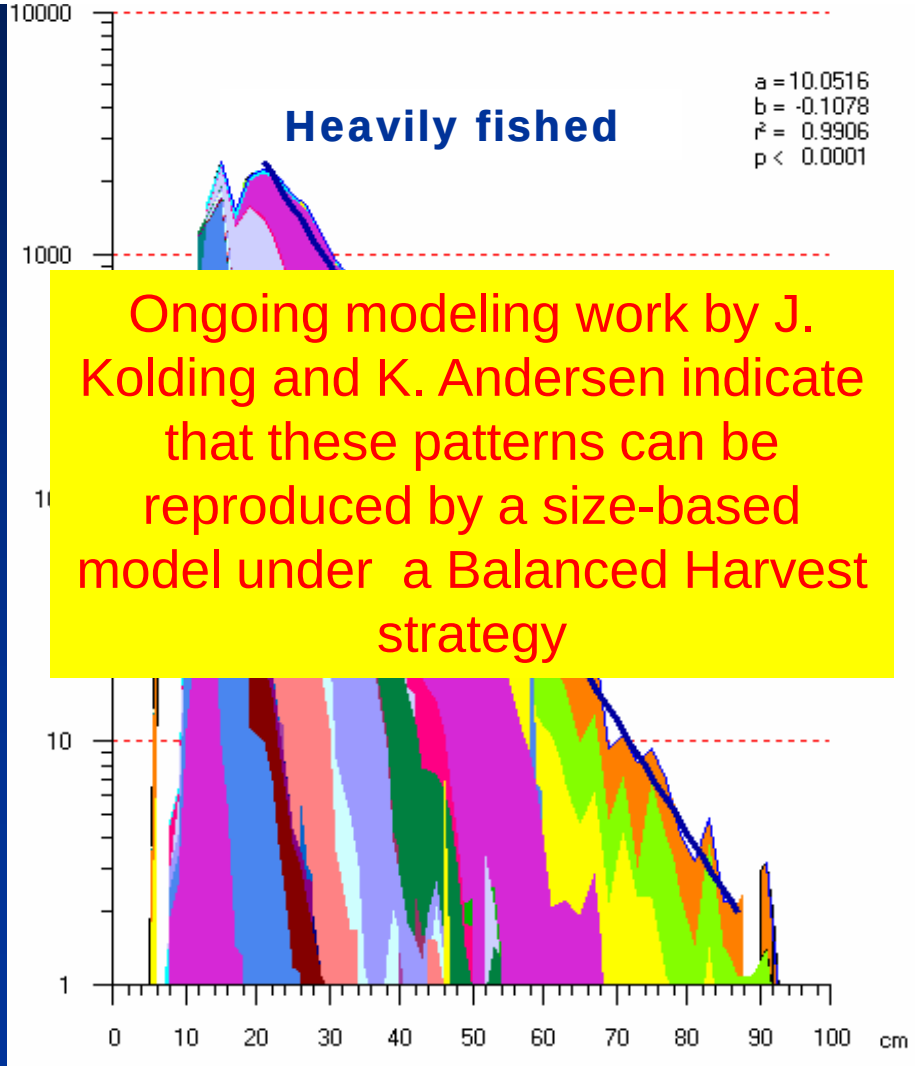


Source: Jeppe Kolding, 2011 (unpublished yet)

Empirical evidence: Lake Kariba

Lake Kariba ecosystem structure: 1980-1994

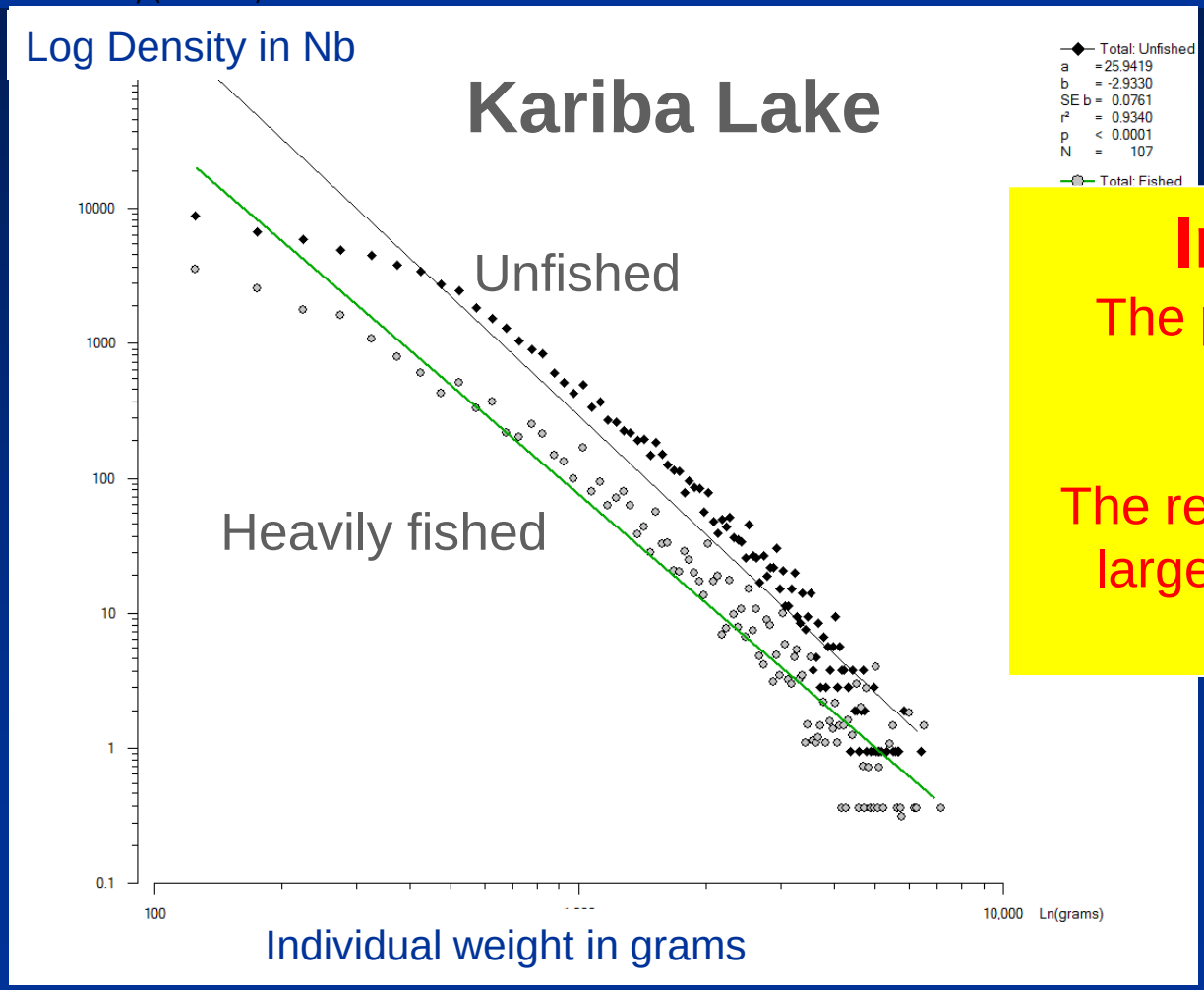




Ongoing modeling work by J. Kolding and K. Andersen indicate that these patterns can be reproduced by a size-based model under a Balanced Harvest strategy

Empirical evidence: Lake Kariba

Y as density (number)



Indirect proof

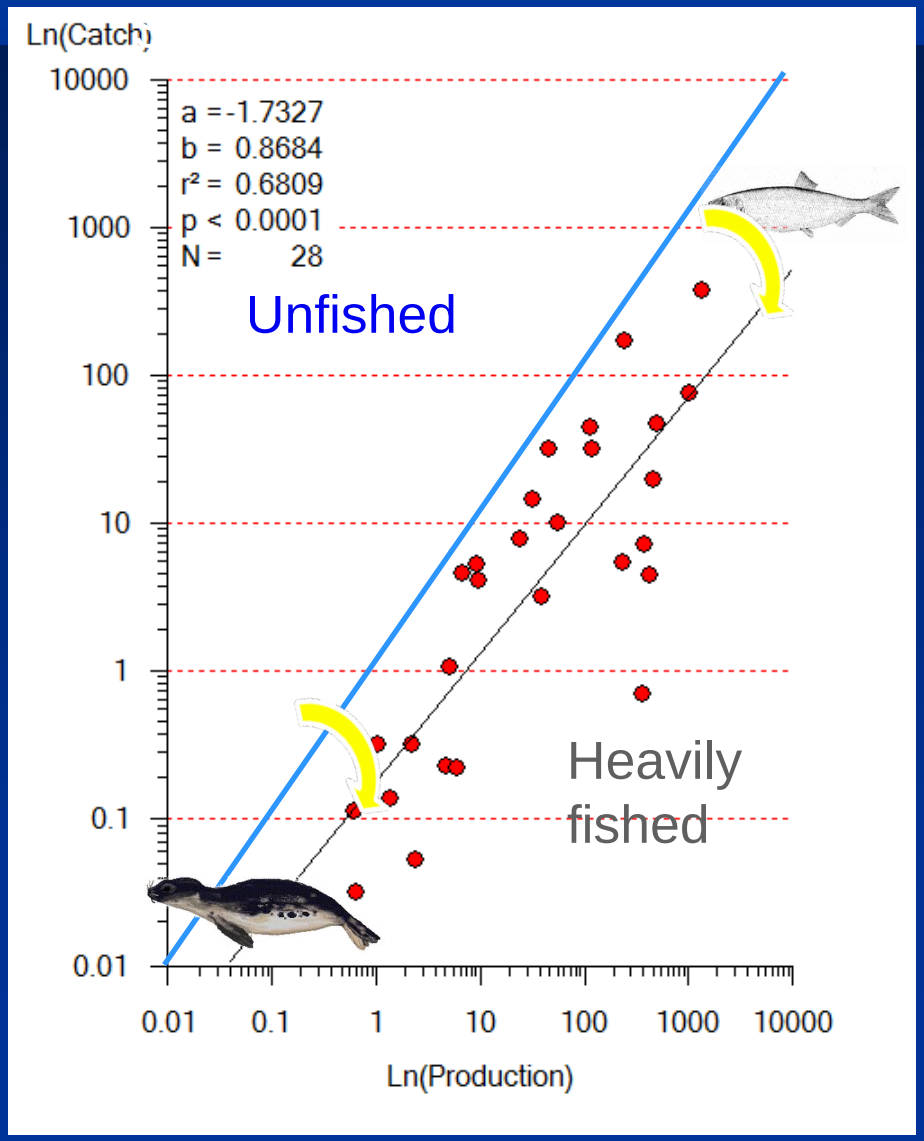
The patterns observed are easily simulated.

The results should be valid for large lakes and marine fish

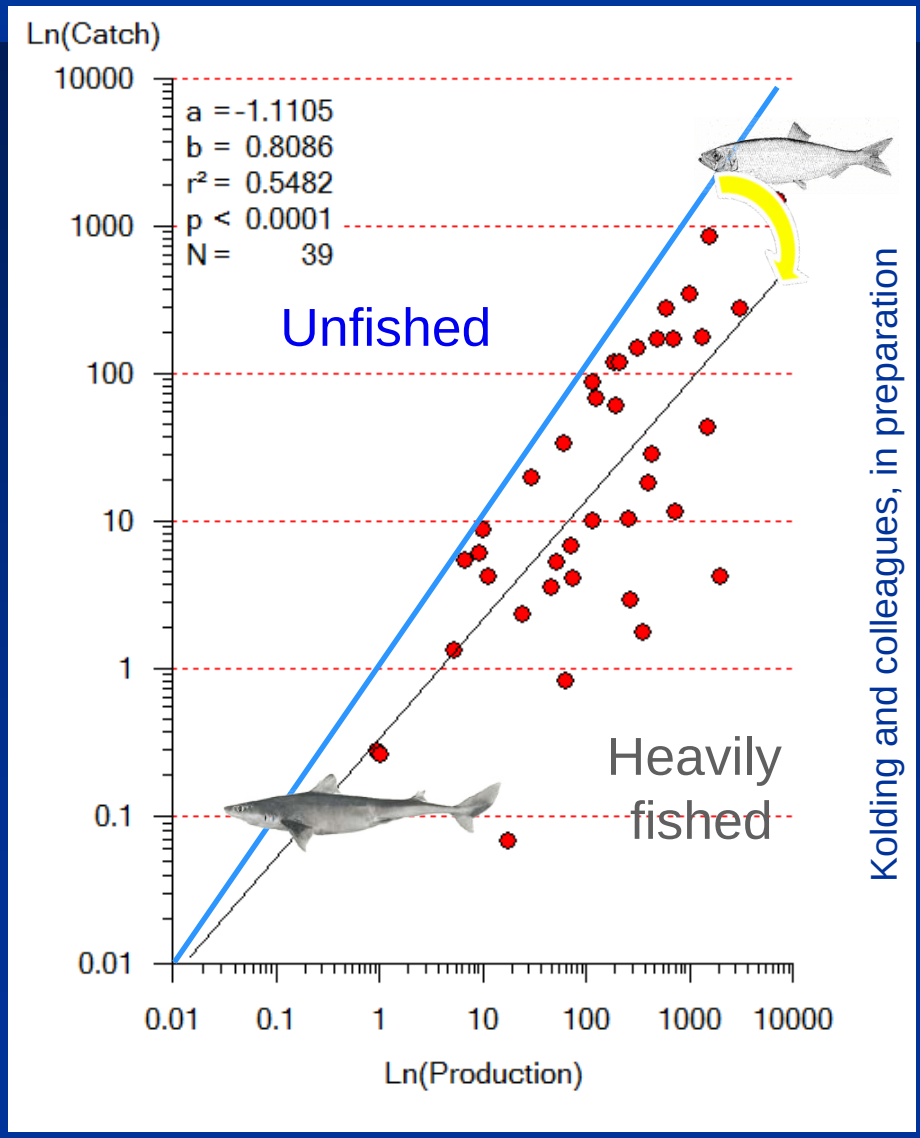
Source: Kolding, J.; Andersen, K. H.; Beyer, J.E. and van Zwieten, P.A.M. Maximizing fisheries yields while maintaining ecosystem structure (in preparation. Do not cite without permiss

BH in the North Atlantic

Norwegian and Barents



North Sea



Tentative conclusions

- In an ecosystem, there are robust relations between individual size (body mass, size, asymptotic size) and abundance that can be studied to analyze the impact of selective fishing on ecosystem structures and properties and develop appropriate indicators.
- Generally, models support the intuition that concentration of fishing on a narrow selection of species and sizes in an assemblage may not be the most sustainable way to use an ecosystem, maintaining its processes and properties.
- Spreading fishing pressure on the species and size spectrum appears theoretically preferable for ecosystem stability and, often, also for total yield.
- At population level, reducing pressure on both juveniles and old spawners, seems to stabilize the structure. To check!
- Conversely, the depletion of large sizes (old spawners) could have a destabilizing impact on the ecosystem structure and the species relationships.

Tentative conclusions

- It has been difficult, however to verify empirically the ecosystem impacts predicted by the models but there are apparently some examples of sustainable ecosystem structures with widespread fishing pressure
- Elements in favor of evolutionary forcing of stocks by fishing are slowly accumulating. Genetic evolution is likely but has not yet been proven. Applying a Dome-shaped fishing pressure vector on sizes may be beneficial. Sparing juveniles and old spawners seems promising.

How to combine all these conclusions in a coherent “balanced harvest” management strategy is not yet totally clear !

Outline

1. Relevant norms for fisheries policy
2. The conventional selectivity concept
3. The food chain concept
4. Management implications

CONSERVATION

Reconsidering the Consequences of Selective Fisheries

Balanced fishing across a range of species, stocks, and sizes could mitigate adverse effects and address food security better than increased selectivity.

S. M. Garcia,[1*] J. Kolding,[1,2*] J. Rice,[1,3*] M.-J. Rochet,[4*†] S. Zhou,[5*] T. Arimoto,[6] J. E. Beyer,[7] L. Borges,[8] A. Bundy,[9] D. Dunn,[10] E. A. Fulton,[11] M. Hall,[12] M. Heino,[2,13,14] R. Law,[15] M. Makino,[1,16] A. D. Rijnsdorp,[17] F. Simard,[18] A. D. M. Smith[11]

Concern about the impact of fishing on ecosystems and fisheries production is increasing (*1*, *2*). Strategies to reduce these impacts while addressing the growing need for food security (*3*) include increasing selectivity (*1*, *2*): capturing species, sexes, and sizes in proportions that differ from their occurrence in the ecosystem. Increasing evidence suggests that more selective fishing neither maximizes production nor minimizes impacts (*4*–*7*). Balanced harvesting would more effectively mitigate adverse ecological effects of fishing while supporting sustainable fisheries. This strategy, which challenges present management paradigms, distributes a moderate mortality from fishing across the widest possible range of species, stocks, and sizes in an ecosystem, in proportion to their natural productivity (*8*), so that the relative size and species composition is maintained.

which are not going to be used," i.e., by-catch (*13*). Fisheries worldwide have used species and size limits (*9*, *14*), gear technology (*5*, *15*), and spatial and temporal fishing restrictions (*16*) to reduce fishing impacts while pursuing human benefits.

But selective removals will inevitably alter the composition of a population or community and, consequently, ecosystem structure and biodiversity. Old individuals contribute the most to reproduction (*17*). Even moderate fishing reduces the proportion of large and old fish in a population. Selectively

species and individuals in the North Sea (*22*) (fig. S1). By contrast, in several African small-scale inland fisheries, the fish size spectrum (*23*) has been maintained under intense and diverse fishing activities that cause high mortality with low selectivity (*5*, *24*) (fig. S1).

Results from models suggest that moderating fishing mortality across a wide range of species and sizes maximizes overall catch summed across species while better conserving biodiversity. Multispecies fishery models show that increased mesh sizes may reduce

Balanced harvesting … distributes a moderate mortality from fishing across the widest possible range of species, stocks, and sizes in an ecosystem.

Management implications

Ecosystemic target: How to slice the pyramid?

- Strategies to be built around cumulative selectivity
- Evaluate performance of strategies already in place
- Define “Balance”: in relation to trophic levels? Sizes? Assemblages?
- Selection tool box: gear, time, area, market controls, rights, ecosystem tax, incentives, ecolabelling, novel food technology
- Strategy depends on starting point (ecological, economic conditions)
- Strategy depends on scale (small, large), area (coastal, offshore, high seas), domain (pelagic, demersal); culture (Asia, Africa, Europe)

Discuss use and protection strategies TOGETHER

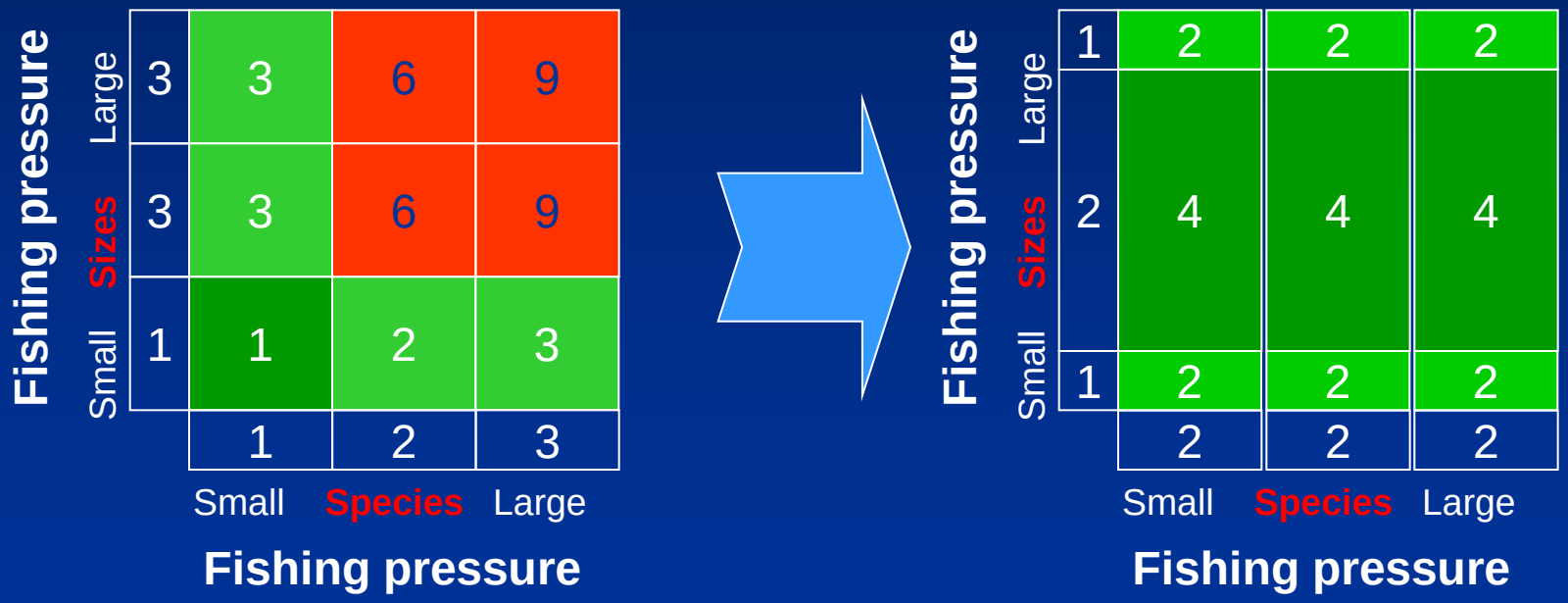
- Role of MPAs and reserves

Management implications

- Need to add ecosystem-based strategic (long time) regulations to single-species (shorter time) regulations.
- Increase focus on diversity and diversification of harvest. Better distribute the impact across species and sizes. But also protect juveniles and old spawners
- Reduce overall impact by eliminating overfishing as a prerequisite for implementing and benefiting from balanced harvest
- Carefully examine modern management strategies that tend to increase target specialization and selectivity and, eventually, look for implementation or alternatives strategies to better balance overall pressure across the wider spectrum of species and sizes.
- Use incentives to convince fishers to broaden harvest diversity when appropriate

Management implications

A tentative interpretation of “balance”



Present: excessive & selective

Future: Right & balanced harvest ?

Thanks for your attention