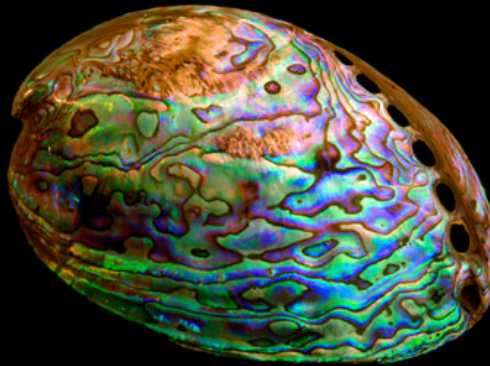


The End of the Line?

Patterns and Mechanisms of Resilience in Fisheries

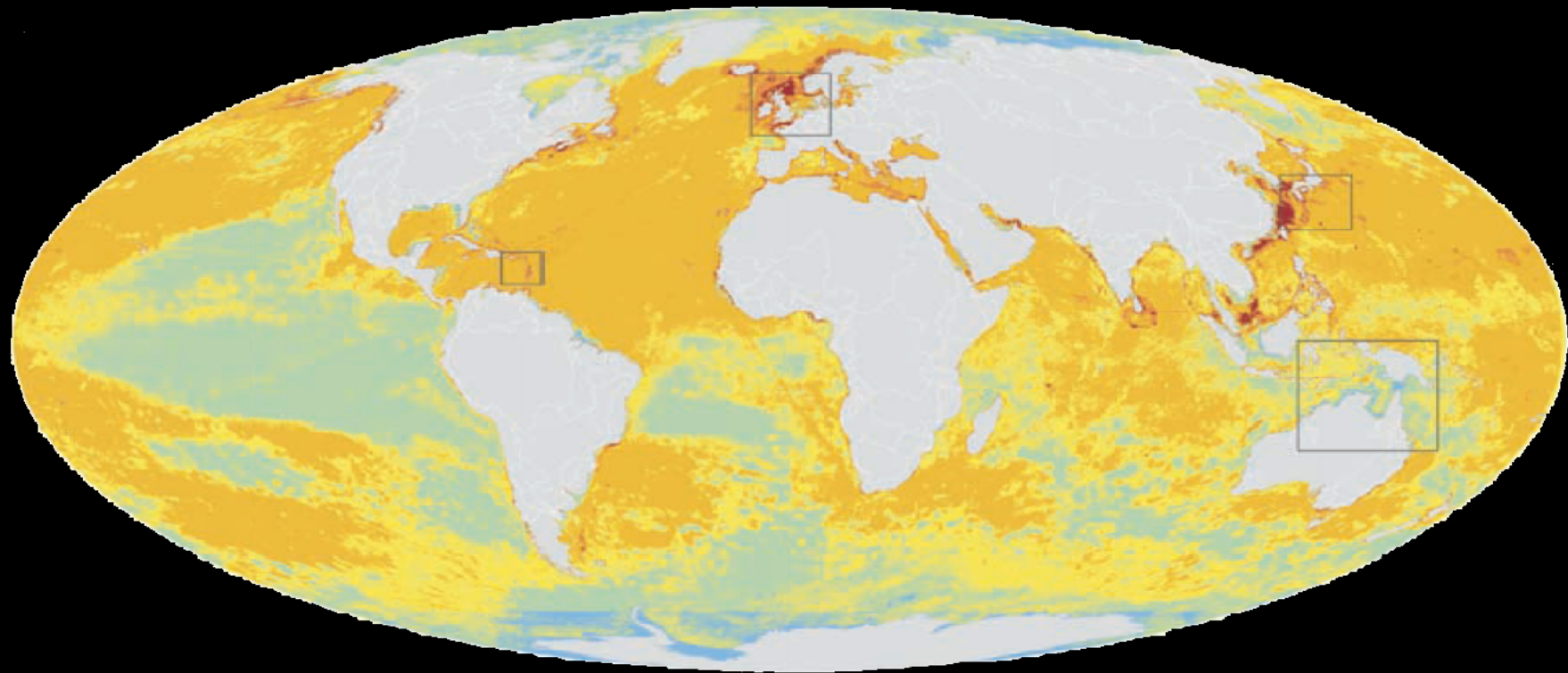


Philipp Neubauer

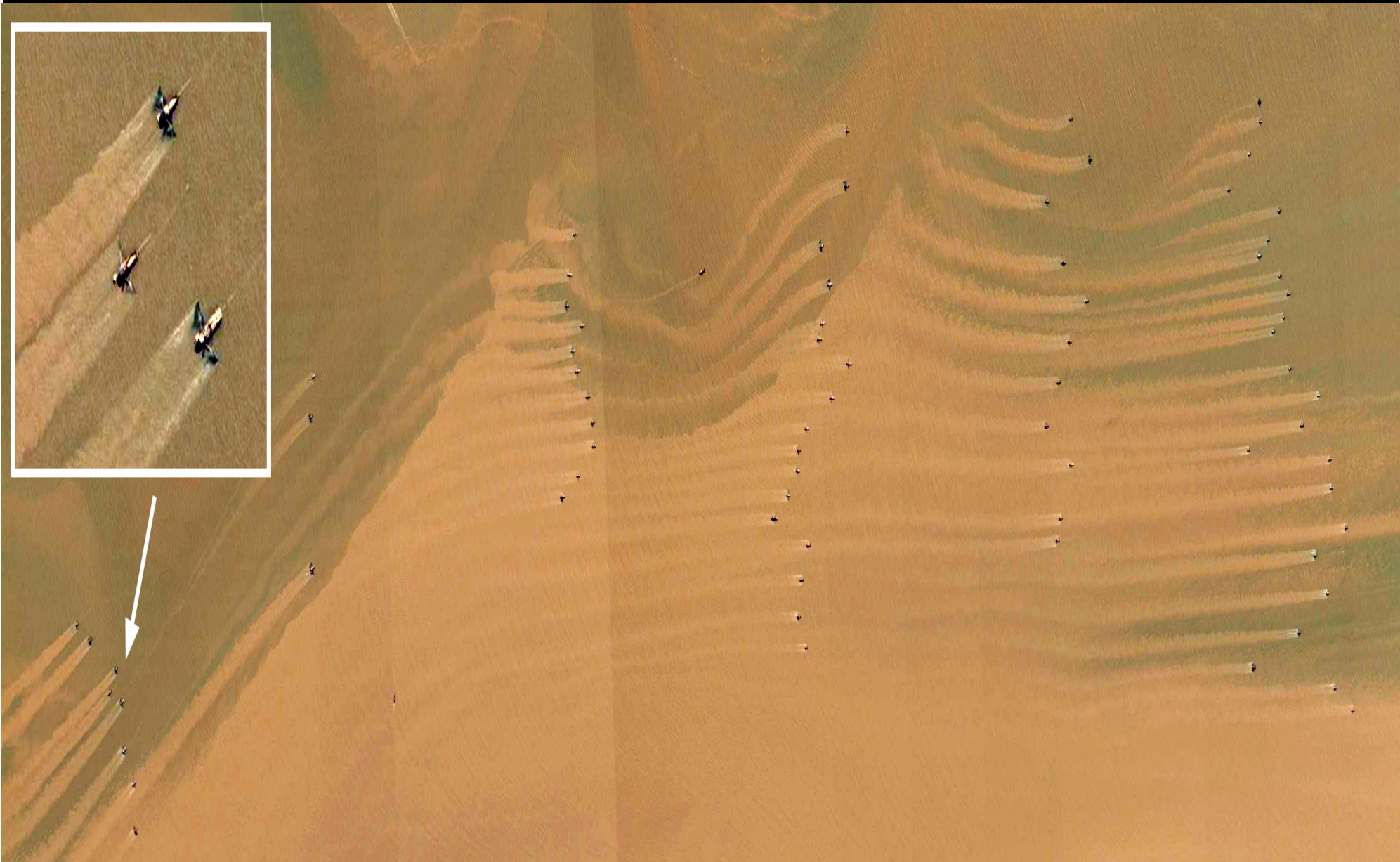
Rutgers University
Dragonfly Science



Global fisheries:
How bad is it really?



Adapted from Halpern et al. 2008 Science

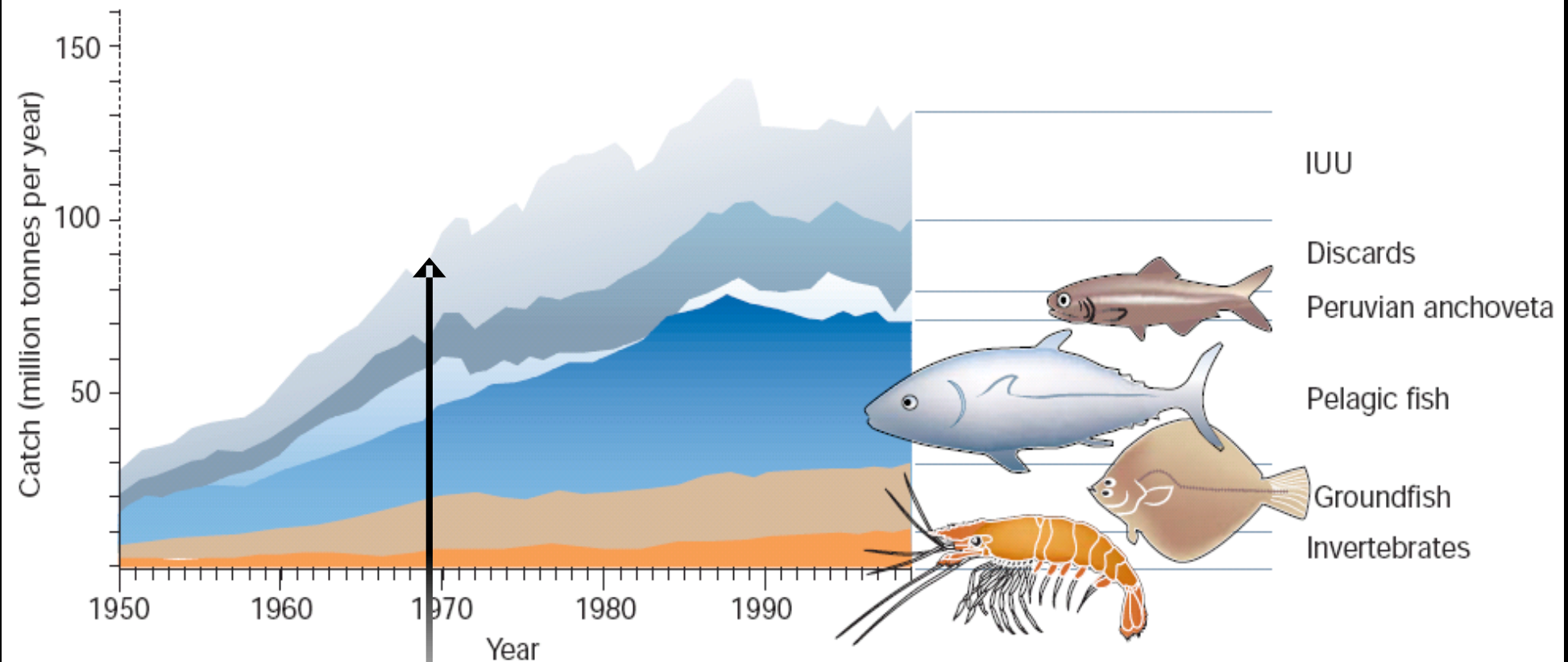




The
Economist

The 9 billion-people question

A special report on feeding the world | February 26th 2011



...it seems unlikely that the potential sustained yield of fish to man is appreciably greater than 100 million tons. - Ryther 1969, Science

FAO – The State of World Fisheries and Aquaculture

Where are we today?

Fishing mortality (F) is declining in many parts of the world, but often still too high.



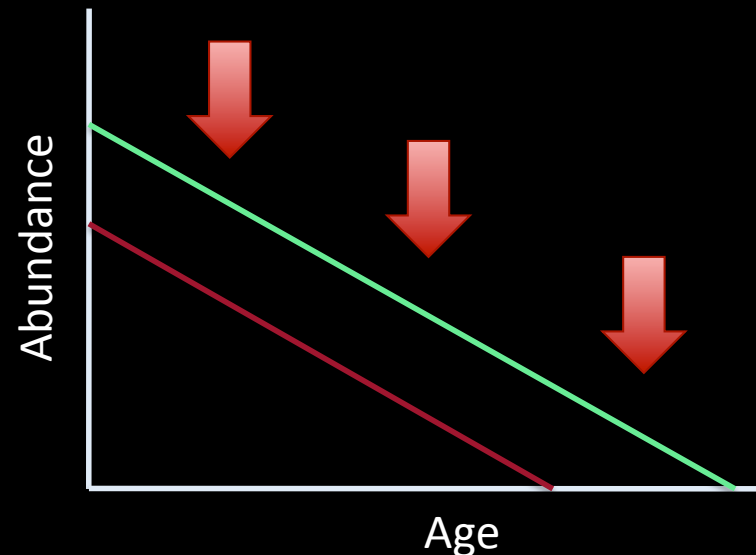
Around 2/3 of global fisheries are below target biomass levels¹

An estimated 15% of fished stocks are collapsed¹ ($<0.2 \times$ Target Biomass (MSY))

¹ Worm et al 2009 – Science

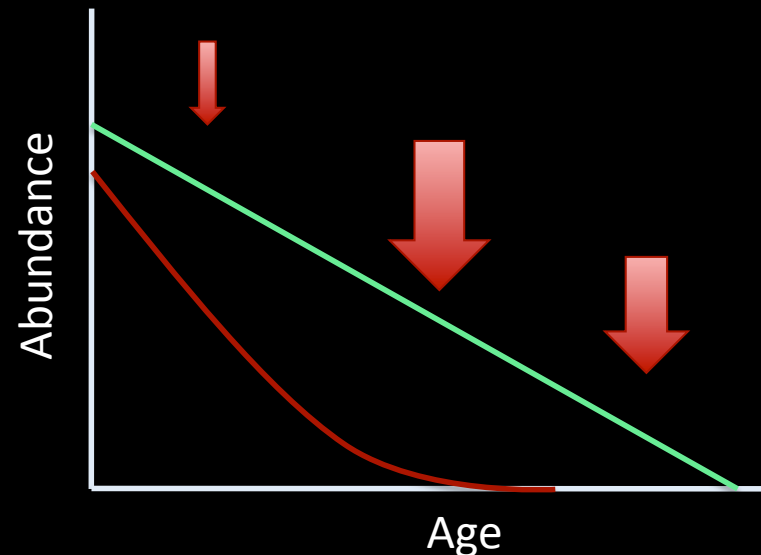
Impacts of fishing

- Fishing reduces biomass: 40% of virgin biomass is a common target
- Fishing alters the age structure of fished populations



Impacts of fishing

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Impacts of fishing

- Fishing reduces biomass: 40% of virgin biomass is a common target
- Fishing alters the age structure of fished populations
- Fished populations are more variable than unfished ones¹⁻³
- Fishing exerts selective pressure & reduces genetic diversity – a Darwinian debt?^{4,5}

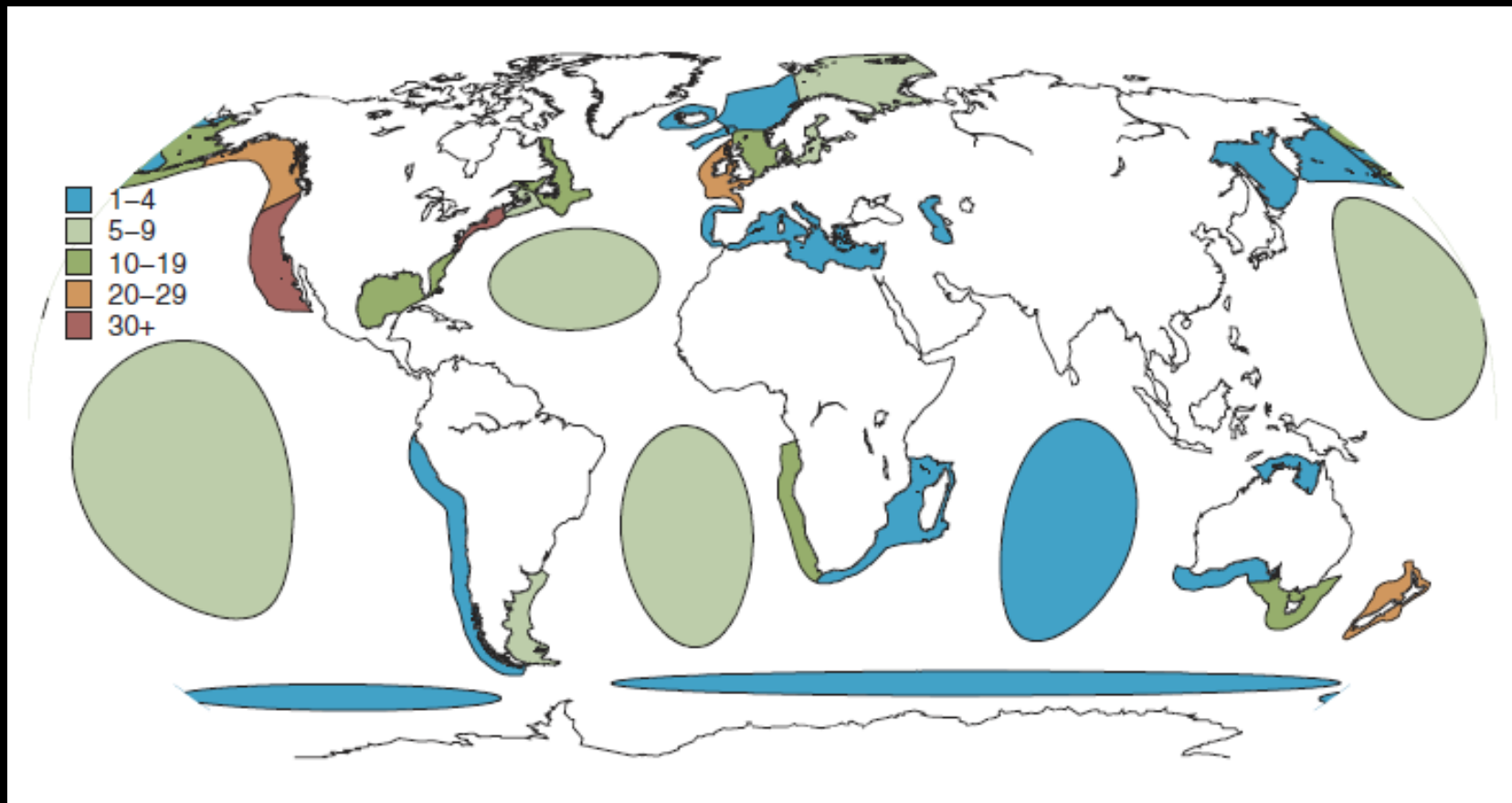
¹ Hsieh et al 2006 – Nature, ²Anderson et al 2008 – Nature, ³Shelton & Mangel 2011 – PNAS,

⁴ Jorgensen et al. 2007 – Science, ⁵ Pinsky & Palumbi, in press – Molecular Evolution

Do the impacts of fishing decrease
the resilience of fished populations?

Data

RAM Legacy Stock Assessment Database: over 360 stock assessments from around the globe



Data

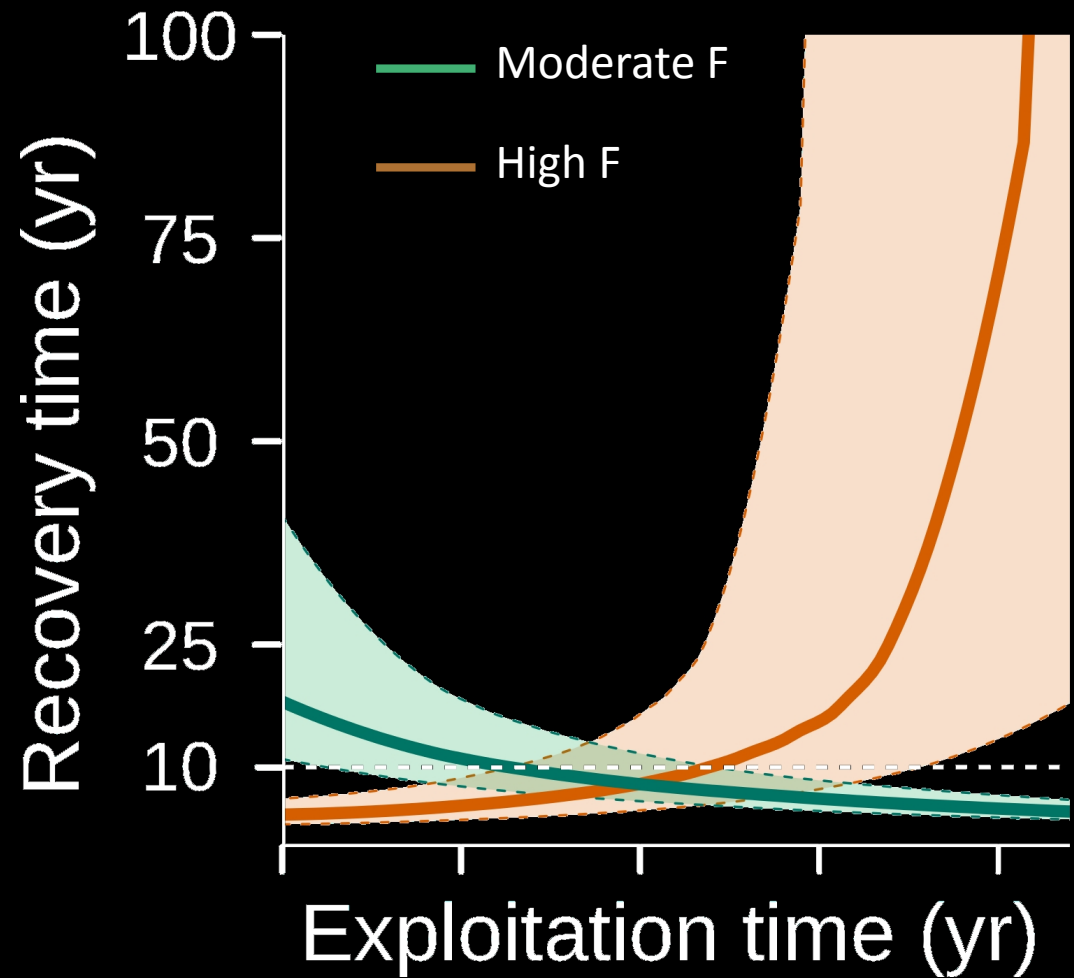
RAM Legacy Stock Assessment Database: over 360 stock assessments from around the globe

153 stocks that had been depleted at least once to below 0.5x target (MSY)

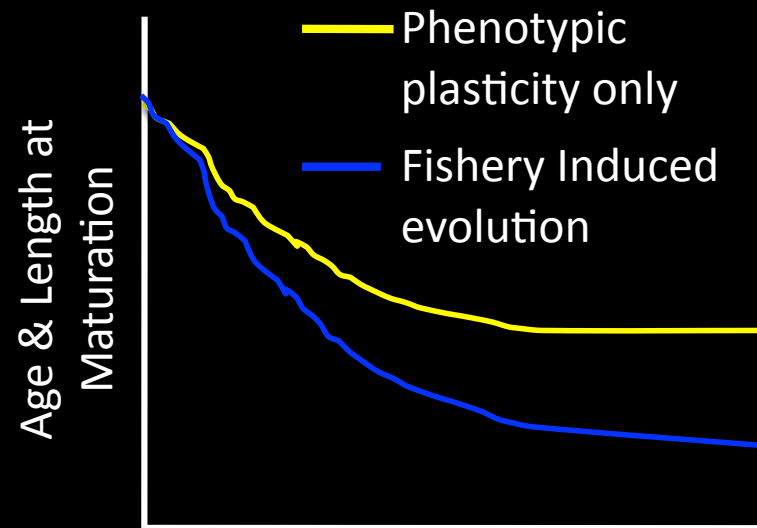
Survival analysis of overfished stocks: **Does overfishing reduce population resilience?**

Recovery is accelerated for 'moderately high' historical fishing regimes

Negative impacts of fishing only for very long and intense fishing regimes

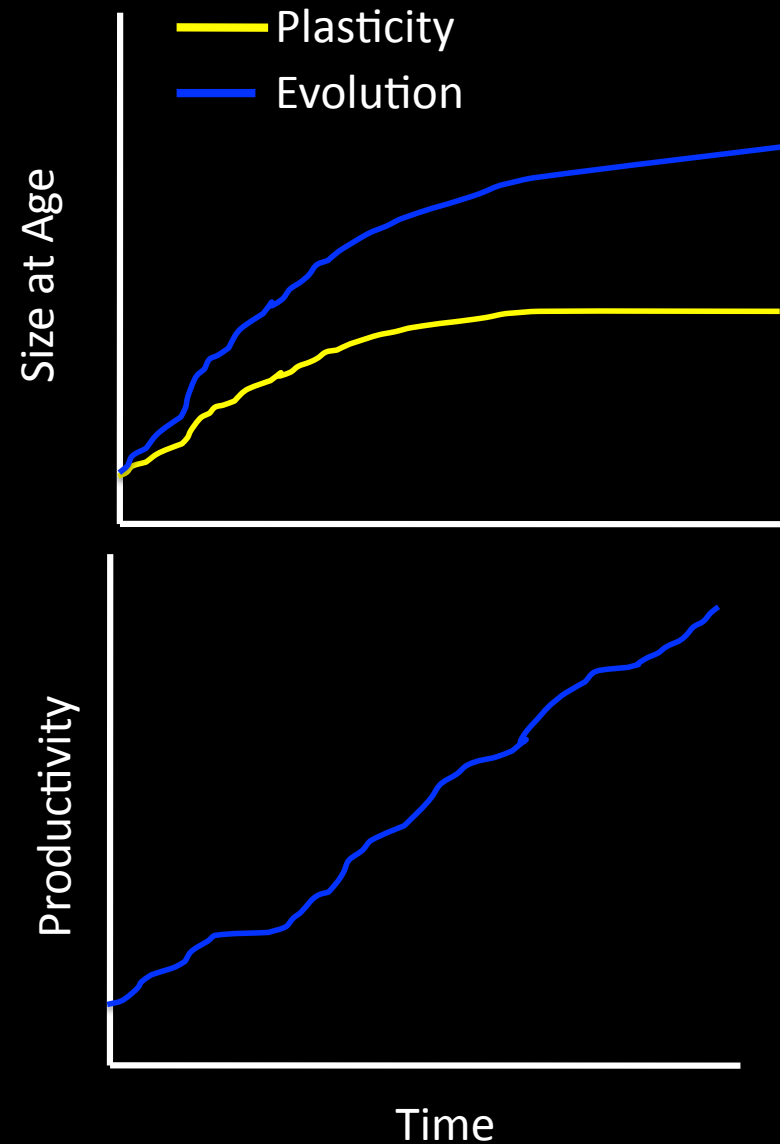


Phenotypic plasticity
and fishery induced
evolution can
increase the
productivity of
fished populations



See also Eikeset et al. 2013 – PNAS, Kuparinen & Hutchings 2012 - Proc.R.Soc.B , Enberg et al. 2009 – Evol. Appl.

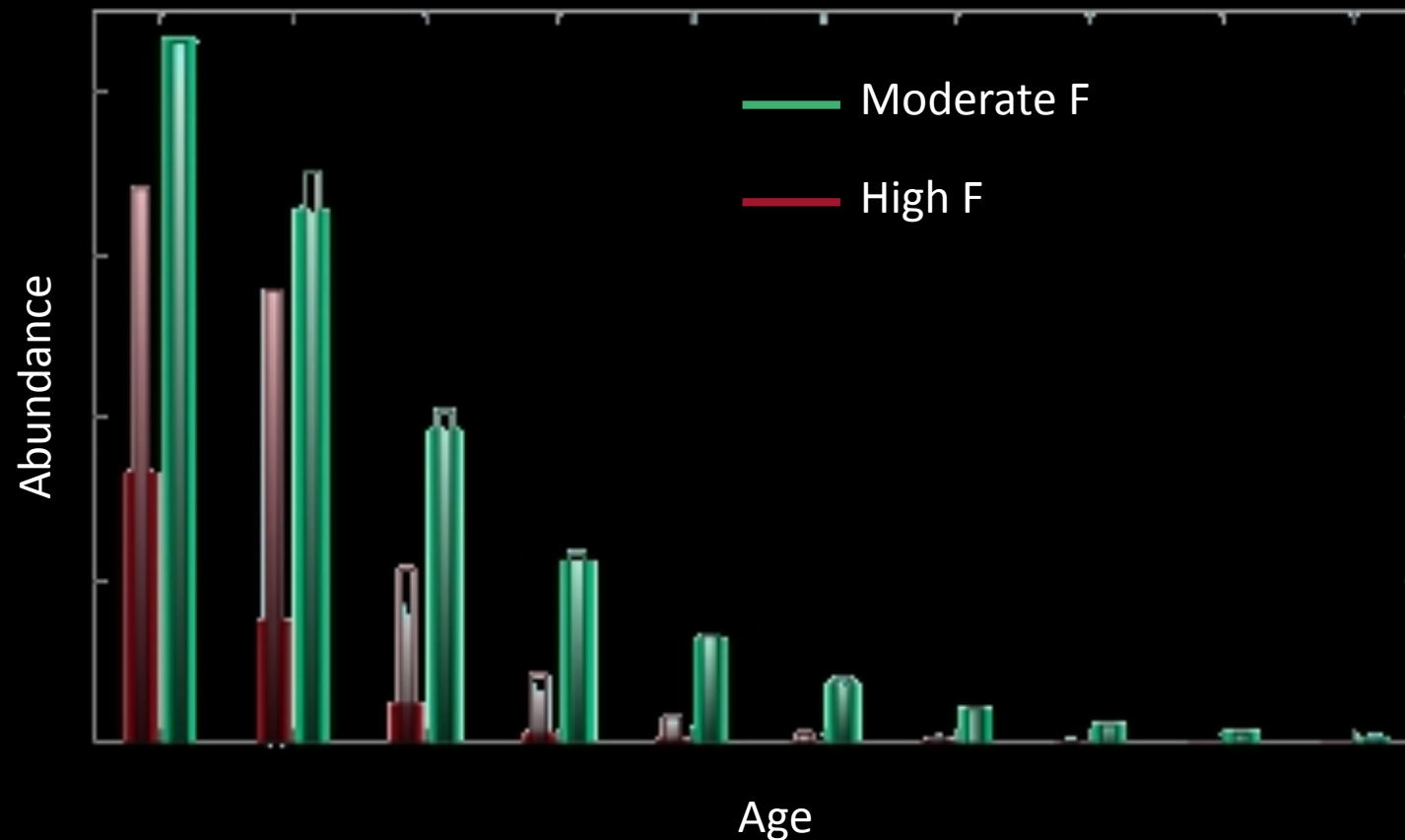
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Limits of resilience

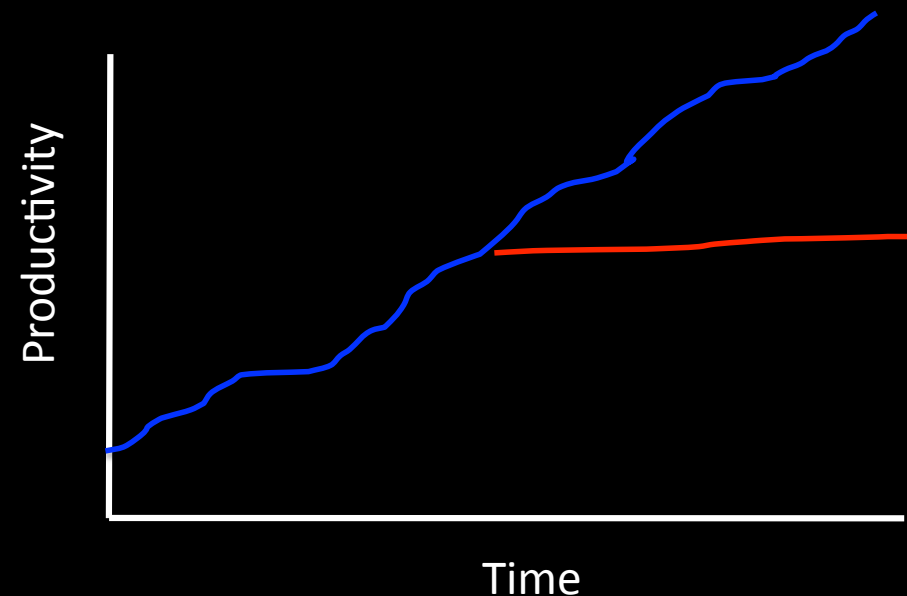
Age composition needs to 'fill in' again after very intense harvest



Limits of resilience

Age composition needs to 'fill in' again after very intense harvest

Limits to adaptive capacity?



Limits of resilience

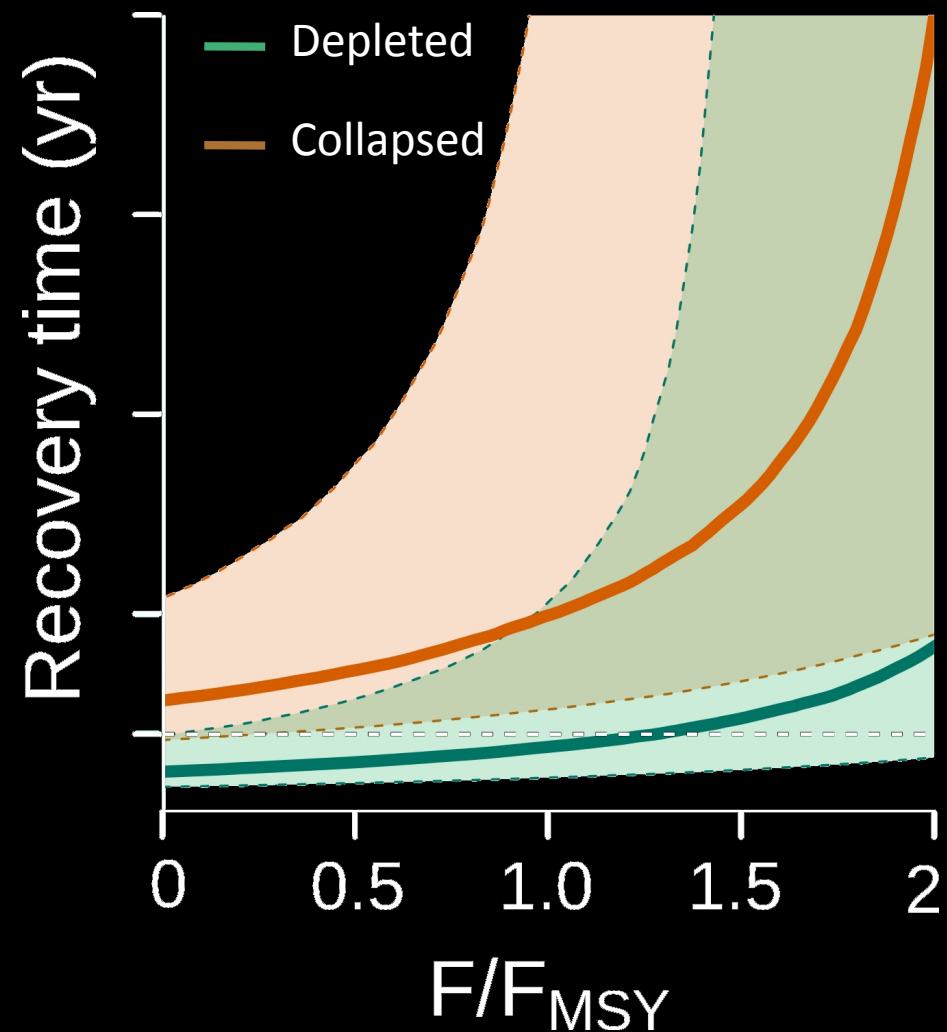
Age composition needs to 'fill in' again after very intense harvest

Limits to adaptive capacity?

Increases in productivity can lead to unstable (nonlinear) population dynamics¹

¹Anderson et al 2008 – Nature

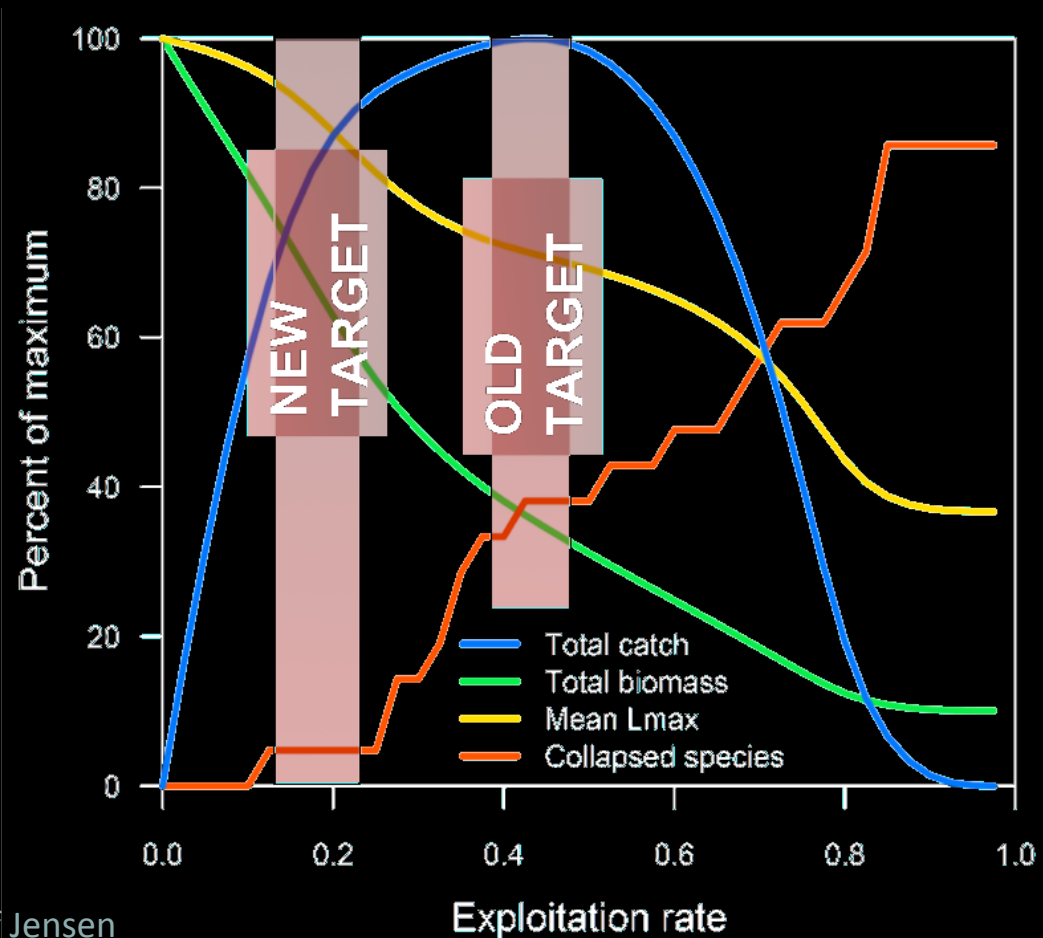
Responsible and responsive management is key to building resilience and recovering overfished populations



Adapted from Neubauer et al. 2013 Science

Resilient fisheries

Fished stocks and communities are surprisingly resilient if fished responsibly



Adapted from Worm et al 2009 – Science, by Olaf Jensen

Frontiers

Dynamic life history parameters (i.e., evolution of intrinsic growth rates) challenge the paradigm of stable population dynamics and fisheries targets

Robust and responsive management of fishing mortality

Age structure is likely key to avoiding negative impacts and retaining resilience – a new selectivity paradigm is needed¹

Acknowledgements

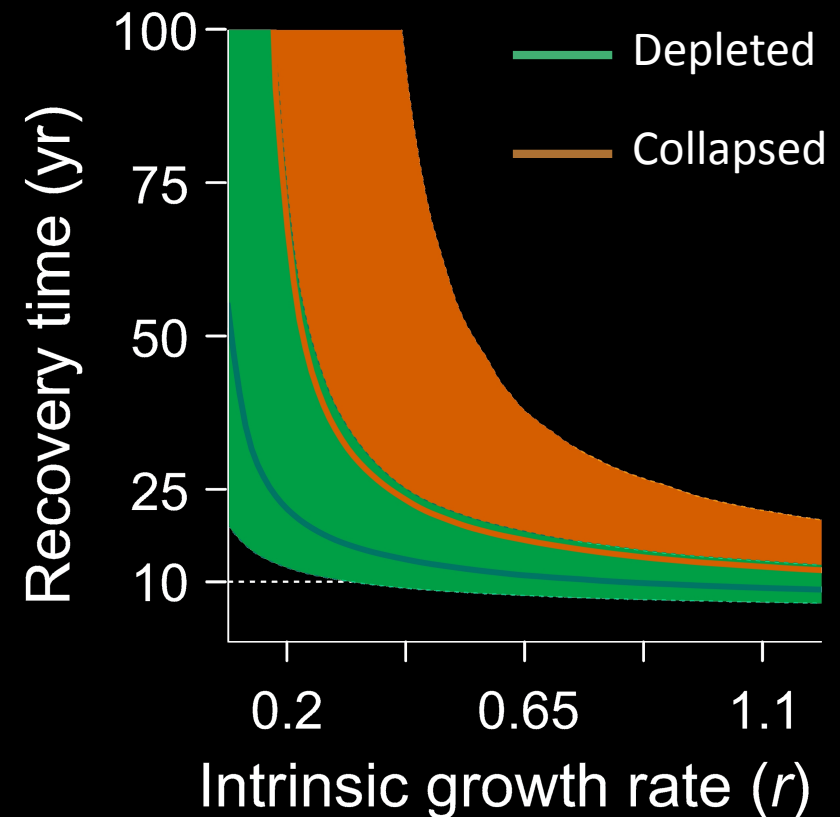
- NSF/NOAA CAMEO grant



- Olaf Jensen, Malin Pinsky
- Ed @ Dragonfly Science

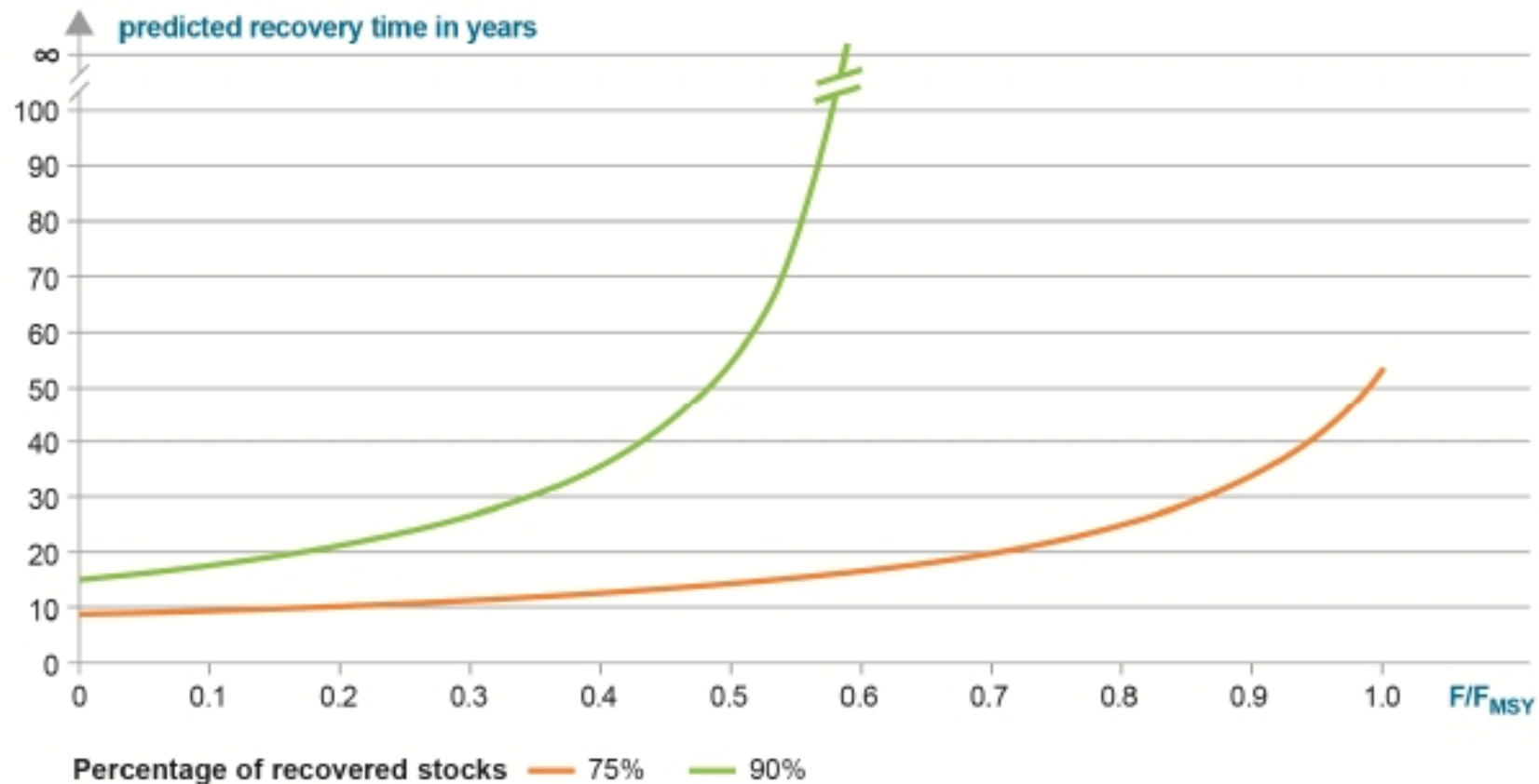
We know that life history is no predictor of collapse.¹

But recovery is conditional on life history



¹ Pinsky et al. 2011 - PNAS

Predicted recoveries in Europe



Two rules of thumb that don't work... and three that generally do

Two that don't work

- Wild is better than farm raised
- Countries with better environmental records have more sustainable fisheries

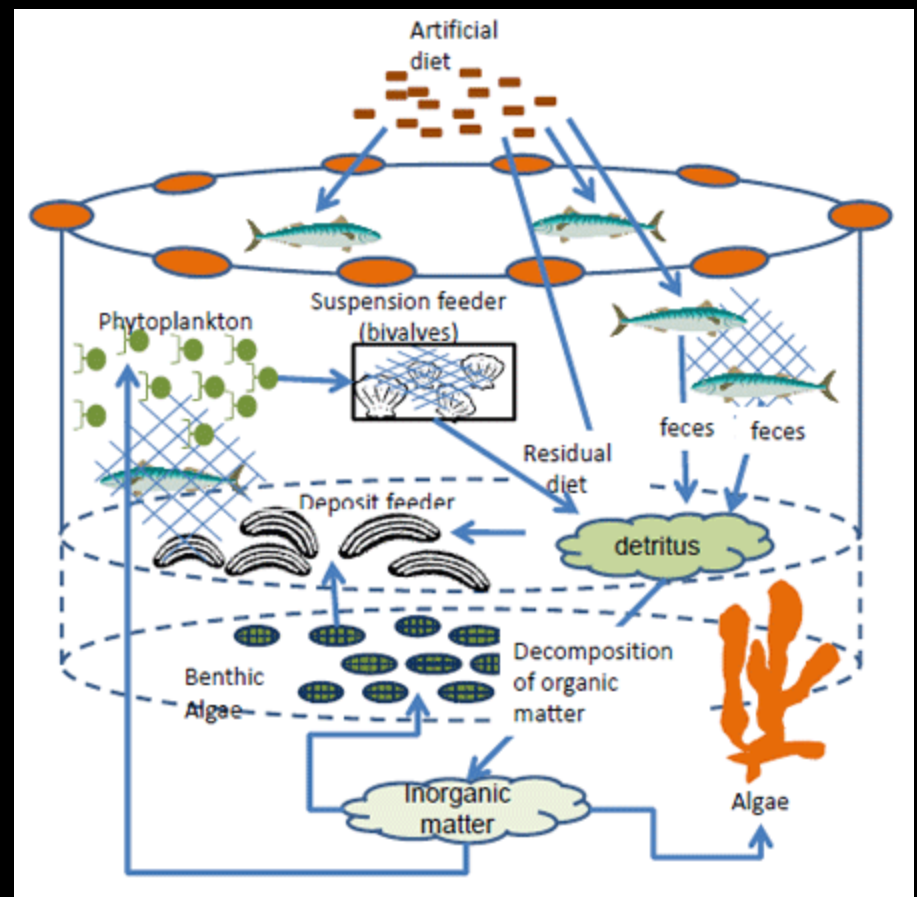
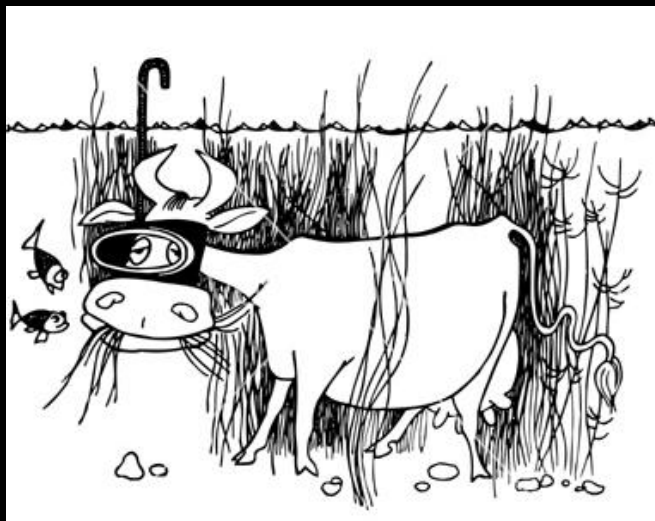
Three that generally do

- Buy local
- Buy lower trophic level (lower on the food chain)
- Buy Marine Stewardship Council (MSC) certified

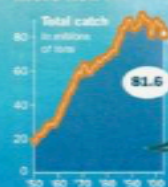
Where will the protein come from?

Unless we cut down more forests for beef and soy, it will have to be:

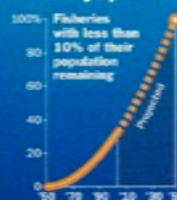
- Well managed fisheries
- Aquaculture of Herbivorous fish



The world is consuming more fish ...



... which could lead to the extinction of many species



A LOOK AT WHO DOES THE MOST FISHING

Total marine harvest '84 '04
In millions of tons



SPECIES DIVERSITY
LOW RISK High diversity
HIGH RISK Low diversity

Analyzing more than 50 years of data, researchers found that collapses in ecosystems occur faster and recovery is slower in areas with low species diversity (red) than in areas with high diversity (light yellow).

STURGEON

This ancient fish was around at the time of the dinosaurs. Its eggs (true caviar) are a gourmet delicacy, but sturgeons of the Caspian Sea are nearing extinction.

SWORDFISH

It was overfished in the late 1990s, but public pressure led to tighter regulations, which helped the species rebound. Today most of the swordfish Americans eat is imported.

ATLANTIC COD

Its abundance attracted European settlers to America, but recent overfishing has altered the ecosystem. Scientists say we are fishing the last 10% of this species.

CHILEAN SEA BASS

The trendiness of this fish, also called the Patagonian toothfish, could be its downfall. The fish is often caught illegally, especially in the remote waters of the Antarctic.

PACIFIC SALMON

Nearly 30 runs of salmon in Washington and Oregon are endangered due to construction of dams and habitat loss. However, Alaska's salmon population thrives.

GROUPER

These sedentary, long-living fish dwell in deep waters and reproduce for short periods. They're overfished in the Gulf of Mexico near Florida's west coast and in Hawaii.

RED SNAPPER

Not to be confused with "Pacific red," they are heavily fished in the Gulf of Mexico, exported by Mexico and Brazil and listed as overfished by the U.S. since 1980.

BLUEFIN TUNA

One of the world's most valuable fish, these 300-lb. giants are favored for sushi. The Atlantic population has declined almost 90% since the 1970s.

SHARKS

Almost all are in trouble in part because they mature slowly and bear few offspring. They are being hunted to extinction, often to make traditional delicacies like shark-fin soup.

OCEANS OF NOTHING

A study says overfishing will soon destroy the seafood supply

By UNMESH KHER

FISHERMEN ON THE HIGH seas have plenty of worries, not the least of which are boat-tossing storms, territorial squabbles and even pirates. Now Boris Worm, a marine biologist at Dalhousie University in Halifax, Canada, has added another. After studying, among other things, global catch data over more than 50 years, he and a team of 13 researchers in four countries have come to a stunning conclusion. By the middle of this century, fishermen will have almost nothing left to catch. "None of us regular working folk are going to be able to afford seafood," says Stephen Palumbi, a Stanford University marine biologist and co-author of the study published in *Science*. "It's going to be too rare and too expensive."

Don't tell that to your local sushi chef. Over the past three decades, the fish export trade has grown fourfold, to 30 million tons, and its value has increased ninefold, to \$71 billion. The dietary attractiveness of seafood has stoked demand. About 90% of the ocean's big predators—like cod and tuna—have been fished out of existence. Increasingly, fish and shrimp farms are filling the shortfall. Though touted as a solution to overfishing, many of them have—along with rampant coastal development, climate change and pollution—devastated the mangroves and seagrass beds where many commercially valuable fish hatch.

Steven Murawski, chief scientist at U.S. National Marine Fisheries Service, fishery's headlining prediction far too pessimistic. Industry experts are even more skeptical. "There's now a global effort to phase out or eliminate fishing practices that are unsustainable," says industry analyst Howard Johnson. "With that increased awareness, these projections just aren't realistic."

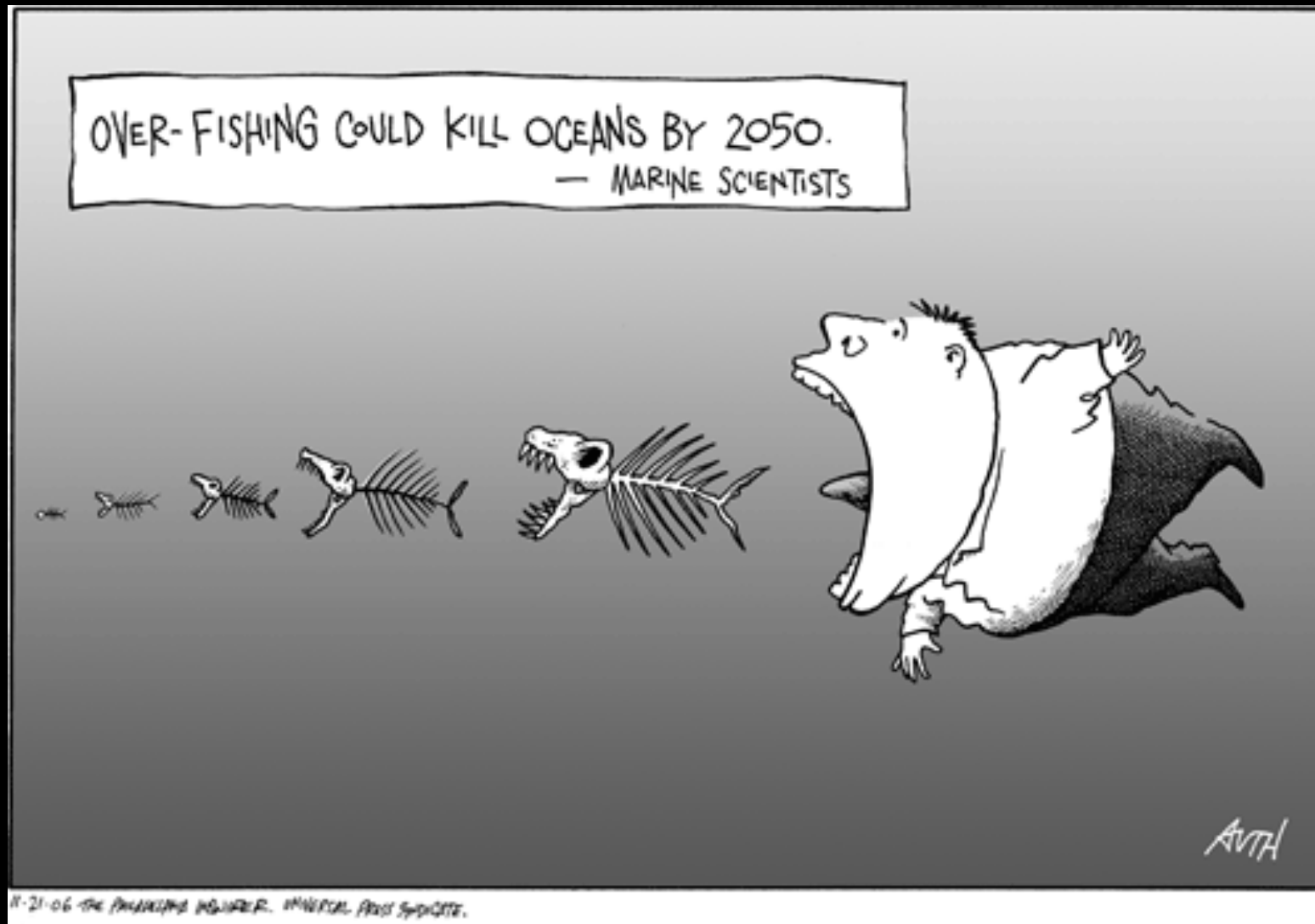
Perhaps. Still, the destructive fishing practices that have decimated tuna and other fish have not declined worldwide, as Johnson suggests. Up to half the marine life caught by fishers is discarded, often dead, as is catch, and vibrant coral reefs are still being stripped bare by draggers. Worm argues that fisheries based on ecosystems strip of their biological diversity are especially prone to collapse. At least 29% of fish species have already collapsed, according to the study, and the trend is accelerating.

So what's a fish eater to do? "Vote with your wallet," says Michael Sutton, who runs the Monterey Bay Aquarium's Seafood Watch program in California. Since 1999, the aquarium has handed out pocket guides listing sustainably harvested seafood. The Marine Stewardship Council has partnered with corporations to similarly certify wild and farm-raised seafood. Some 370 products in more than two dozen countries bear the British group's "Fish Forever" label of approval. Wal-Mart and Red Lobster, among others, have made commitments to sell sustainably harvested seafood.

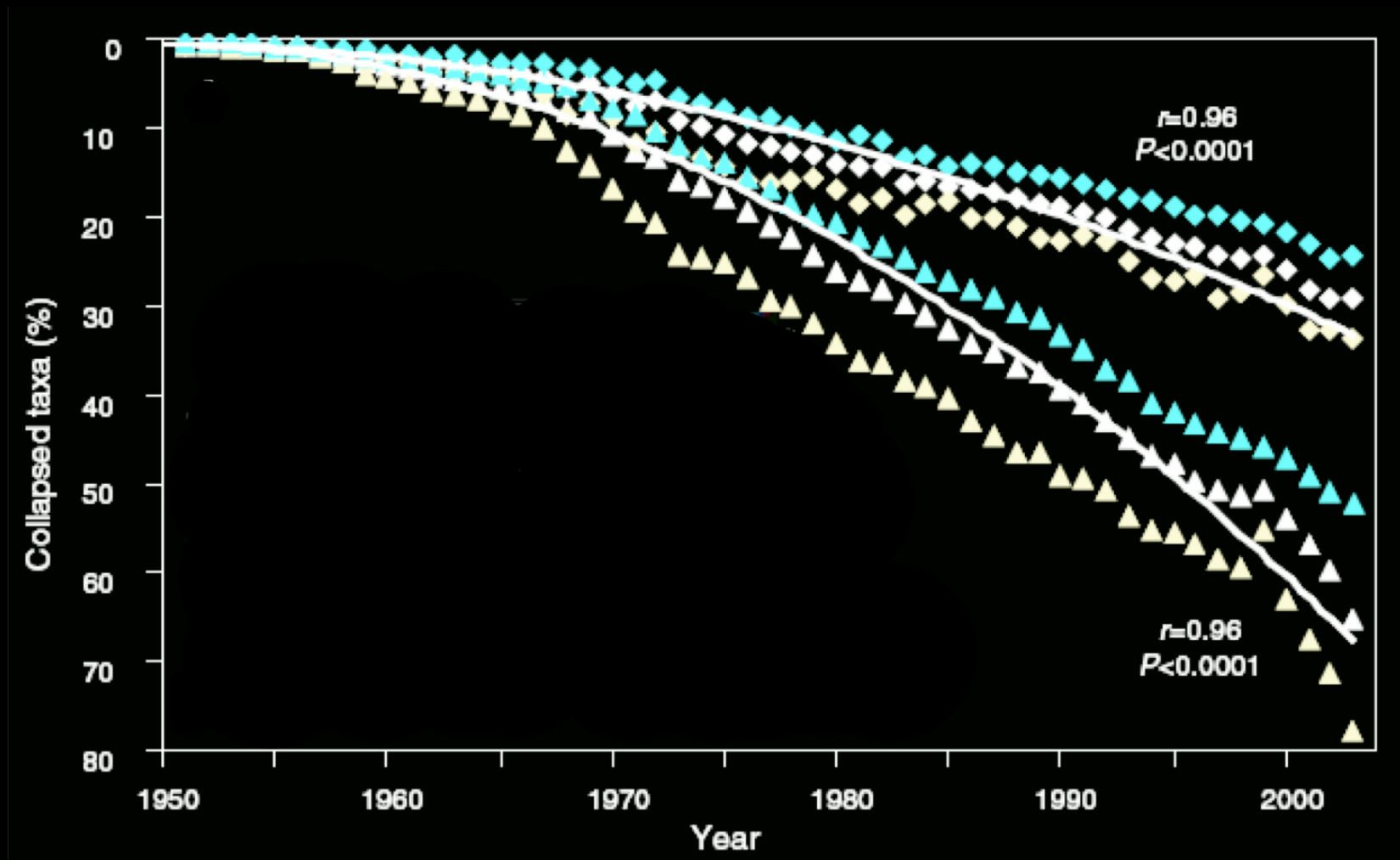
But that's just a spit in the ocean unless consumers in Japan, India, China and Europe join the chorus for change. "Everyone in the U.S. started eating sustainable seafood," says Worldwatch Institute senior researcher Brian Halweil. "It would be wonderful, but it wouldn't address the global issues. We're at the very beginning of this."

—With reporting by Kathleen Kingsley

By 2006 the perception had changed quite a bit...



Biodiversity loss in the ocean?



Adapted from Worm et al. 2006 Science