

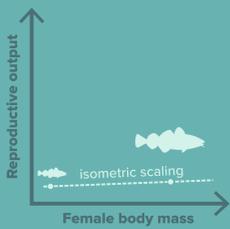
# BODY SIZE VS REPRODUCTIVE OUTPUT

## in marine fishes

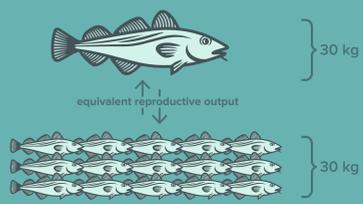
### ISOMETRY VS ALLOMETRY

Existing models of how organisms grow and reproduce are based on incorrect assumptions.

Most life-history models and theories assume that reproductive output scales proportionately with female body mass. This is an **isometric scaling model**.



Under an isometric assumption, a 30-kilogram Atlantic cod (*Gadus morhua*) would have the **same reproductive output** as 15 two-kilogram cods.



**Fisheries worldwide base their harvests on this assumption. But it's wrong.**

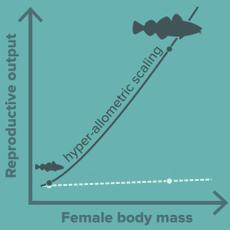
Researchers from Monash University's **Centre for Geometric Biology** compared:



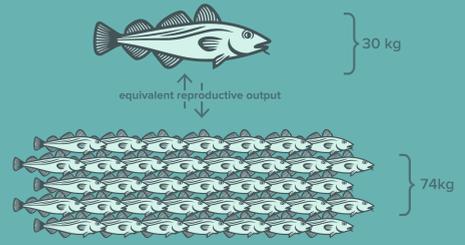
They found that in **95%** of species, reproductive output scaled **disproportionately** with body mass. Larger mothers reproduced **much, much more** than smaller ones.



They found that reproductive output (the product of fecundity, egg-volume and individual egg content) actually scales **hyper-allometrically** with female body mass.



The allometric model shows that the reproductive output of our 30-kilogram Atlantic cod is equivalent to **~37** two-kilogram cods. This represents a **2.5-fold increase** in biomass and a **147% underestimate** of the isometric assumption.



## CLIMATE CHANGE AND MARINE PROTECTED AREAS

The results also reveal the insidious cost of global change. Fish sizes are decreasing as the planet is warming.

For instance, a **1.5°C** increase in sea-surface temperature will decrease fish lengths by **~15%** in the Mediterranean.



Under the allometric model, this decrease in size would result in a **50%** per-capita reduction in fecundity for the Atlantic mackerel (*Scomber scombrus*).



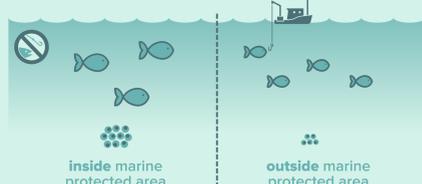
The impacts of global warming are compounded.



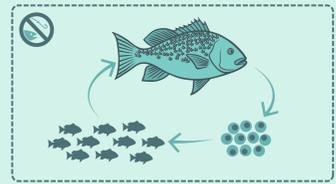
**But we can do something about it.**

The results suggest that the benefits of marine protected areas are grossly underestimated.

Marine protected areas increase fish size by **28%** on average. This has a much greater impact on overall reproductive output than previously thought.



Applying the revised allometric model to the widow rockfish (*Sebastes entomelas*) increases the benefits of marine protected areas to population replenishment by **74%**.



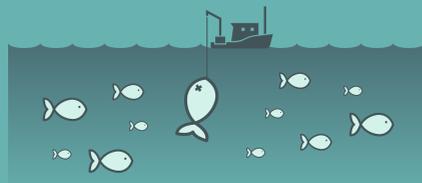
The benefits of marine protected areas are compounded too, and much more than previously thought.



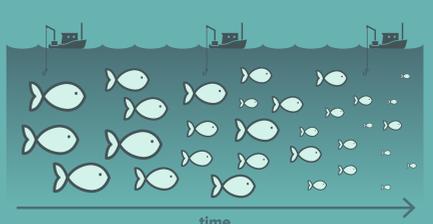
## THE IMPACTS OF OVERFISHING

Relying on outdated models and incorrect assumptions mean that many fisheries are dangerously overharvesting wild populations, without even realising it.

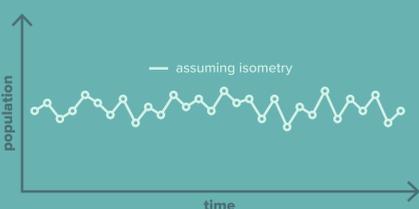
Most fisheries remove the biggest and oldest fish from a population. Bigger fish are more likely to be caught, and fishing pressure reduces the likelihood of fish ever growing to maturity.



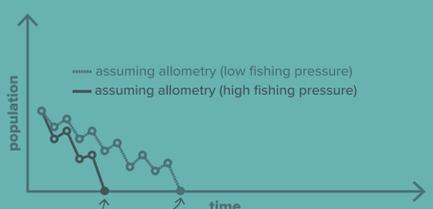
Over time, a harvested population will have fewer big fish, and an ever decreasing reproductive output, even at extremely low fishing pressure.



Fisheries managers assess stock and predict egg production to inform sustainable harvests. But assuming **isometry** drastically underestimates the impact on population replenishment.



Using the allometric model, we know that population replenishment is only **~40%** of previously predicted at low fishing pressure, and just **~20%** at high fishing pressure.



In other words...

**The world's fisheries are being dangerously overharvested.**

Relying on outdated models and incorrect assumptions gives us a false sense of security.

Uninformed overfishing will have calamitous consequences for fisheries worldwide and the **20%** of people globally that rely on fish for protein.

#### SOURCE

Barneche D, Robertson DR, White CR, Marshall DJ (2018) Fish reproductive-energy output increases disproportionately with body size. *Science*. 888 (8888) doi:10.1126/science.888.8888.88

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