

# The dark side of the selectivity paradigm: fisheries-induced evolution

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This talk was given out of a sense of concern that the landing obligation of the EU Common Fisheries Policy is being implemented without considering its effects on evolution in fish assemblages

## **What has evolution got to do with fishing?**

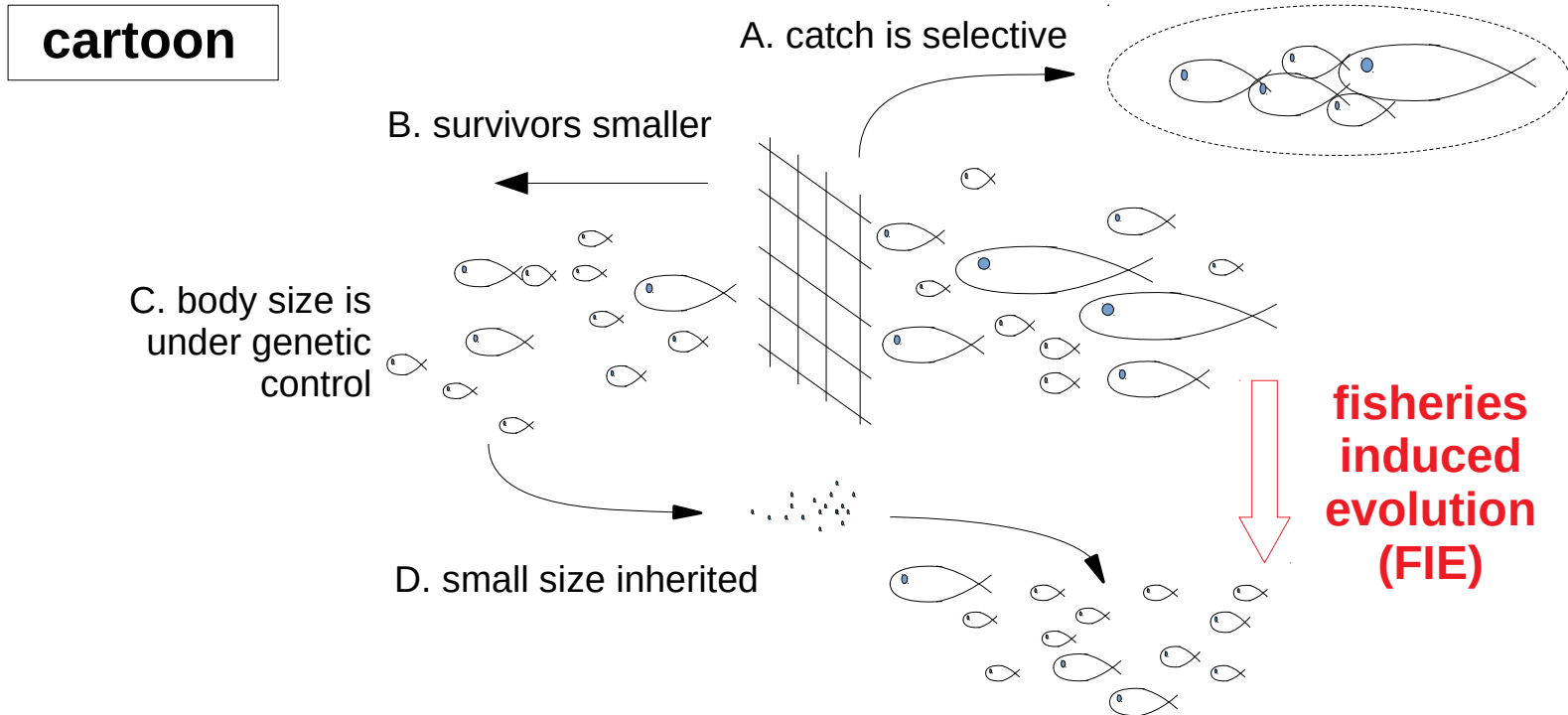
Surely evolution is the stuff of geological periods – changes that happen gradually over millions of years.

That's a misconception: you just need two things

- (1) directional selection
- (2) appropriate genetic variation in the trait(s) under selection

strong directional selection together with the genetic variation is enough to get evolution in a small number of generations.

# fisheries-induced evolution (FIE)



- this cartoon is simplified to make the basic point: obviously, fish grow! (could think of the trait as size-at-age)
- many traits can change through selective fishing, including the life-history (e.g. growth, maturation, reproduction, longevity), and behaviour

# evidence and time scales

## What we know about FIE:

- quantitative genetic variation exists for life-history traits; heritabilities  $\sim 0.2$   
reviewed by Law 2000: <https://academic.oup.com/icesjms/article/57/3/659/635953>
- molecular genetic markers associated with life-history traits exist, and can show evidence of selection caused by fishing  
Chebib et al. 2016 <https://link.springer.com/content/pdf/10.1007/s10592-015-0797-y.pdf>
- FIE can be demonstrated in experiments  
e.g. van Wijk 2013: <https://esajournals.onlinelibrary.wiley.com/doi/abs/10.1890/120229>
- fishing can generate directional selection on life-history traits  
e.g. Swain et al. 2009: <https://royalsocietypublishing.org/doi/10.1098/rspb.2006.0275>
- observed changes in exploited fish species match selection generated by fishing  
reviewed in Heino et al. 2015: [www.annualreviews.org/doi/10.1146/annurev-ecolsys-112414-054339](http://www.annualreviews.org/doi/10.1146/annurev-ecolsys-112414-054339)  
see also Swain et al. 2009: <https://royalsocietypublishing.org/doi/10.1098/rspb.2006.0275>
- **caveat:** hard to disentangle the signal of FIE from other changes in natural environments

Results suggest a detectable signal of FIE needs a time scale of tens of years  
e.g. unpublished results on Icelandic haddock by Thordason and Law

**too slow to be a priority for managers – though important in the long term**

# landing obligation and FIE

**So what? What has the landing obligation (LO) got to do with FIE?**

**solution to discarding:**

make fishing more selective

look for better ways to catch just the right fish for the market

rational solution: reduces potential waste

**rational** ... until you think about selection and evolution in fish stocks

if we increase directional selection on fish stocks,

we are also likely to increase the rate of FIE

**techno-fix dilemma** (Huesemann and Huesemann 2011)

we have a technological problem

we think of a technological solution

but ...

inadvertently, we have generated another technological problem

# downside: current path

## **Gear technology:**

- we are making fishing gear more selective
- but not considering the consequences for directional selection

## **Conservation NGOs endorse this solution:**

- “Regardless of the stock in question, all potential mitigation measures must be applied to minimise unwanted catches, such as using **the most selective gears and applying prescribed avoidance techniques.**” from:  
<http://image.pewtrusts.org/lib/fe8215737d630c747c/m/1/NGO+Position+Recovering+fish+stocks+and+fully+implementing+the+Landing+Obligation.pdf>
- this ignores FIE

## **Research on LO:**

- FIE appears not to be on the agenda for implementing the LO
- currently, the assumption is that exploited fish species are fixed, and will be immune to effects of selective fishing on the time scale of management
- this assumption is questionable, and at least needs checking

# upside

- (1) Reducing fishing mortality rate  $F$  will also reduce selection (all other things being equal)
- (2) Could do risk assessments on the new techniques, to get better informed about changes in directional selection, and to examine effects of LO on FIE  
Jørgensen, et al. 2007: <https://doi.org/10.1126/science.1148089>
- (3) Could investigate methods of fishing to prevent strong directional selection, to make fishing more sustainable in the long term.

Some ideas:

- Slot fisheries, e.g. gill nets, with carefully chosen slots, could generate disruptive, rather than directional selection on some traits  
Zimmerman and Jørgensen 2017 [www.int-res.com/abstracts/meps/v563/p185-195/](http://www.int-res.com/abstracts/meps/v563/p185-195/)
- The selection differential on some traits appears rather sensitive to removal of fish that are large for their species; this argues for protecting these fish when the LO is in place  
Law and Plank 2018 <https://onlinelibrary.wiley.com/doi/10.1111/faf.12313>
- The more that fishing mortality substitutes for natural mortality, the weaker the selection generated by fishing should be. Balanced harvesting (BH) has this substitutive property to some extent. Models suggest that selection differentials on certain traits would be reduced by moving towards BH.  
(Law and Plank 2018 <https://onlinelibrary.wiley.com/doi/10.1111/faf.12313>)