

Monkfish CPUE SSC Review

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Examining High-Resolution Monkfish CPUE Indices Across Gillnet, Trawl, and Scallop Dredge Fisheries

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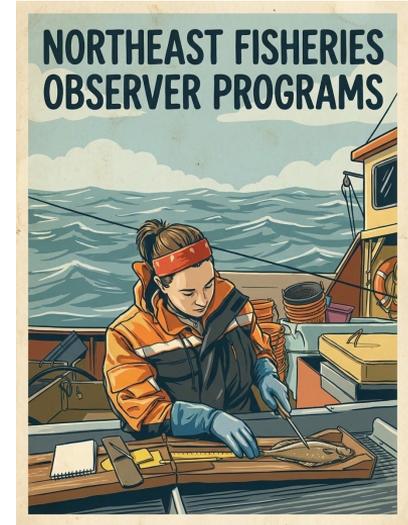
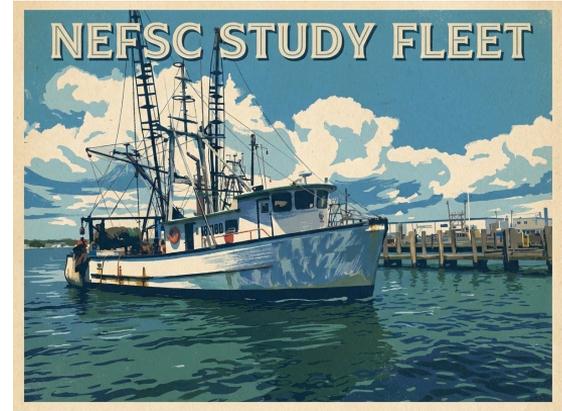
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Northeast Fisheries Science Center
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As Mel and Steve said...

- Exploring other monkfish data sets has been identified as a high priority by both the science and fishing communities
- Two RSA projects aimed to do this
- Goal was to complement SMAST/Cornell projects as well as research track
- Different methods, but some shared data
- Value in assessing how much perception of stock trajectory changes with fairly distinct methods
- Looking at broader set of gear/region combinations

Approach

- **Many decisions:**
- **First**, leverage extensive information on catch by commercial vessels (**Study Fleet, Observer**)
 - Similar resolutions among data sets (haul-level)
 - Distinct sampling frames
 - Observer is randomly assigned
 - Study Fleet is self-selected
- **Second**, use data from (**2000 - 2024**)
 - Period of high-quality and high-resolution data
- **Third**, explore in **three gears** of interest
 - **Gillnet, bottom trawl, and scallop dredge**



Other important choices:

- **Regions**

- North and south divided similar to assessments
- All regions combined

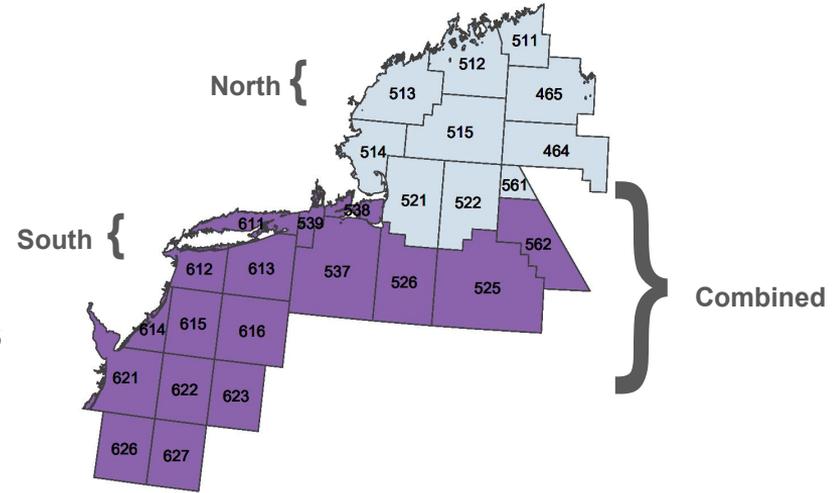
- **Catch-rate metrics (effort level)**

- Catch (kept + discards)
- Effort metrics

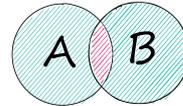
- **Gillnet:** soak time
- **Trawl:** tow time in hrs
- **Dredge:** tow time in hrs

- **Jaccard index used to generate data set**

- Includes fishing efforts with zero catch
- Similar to Jones et al. (2025)
- *Different than SMAST/CCCFA work*



$$\text{Jaccard} = \frac{\text{intersection}(A, B)}{\text{union}(A, B)}$$



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Original Article



Combining sources of high-resolution fishery-dependent data from the northeast United States to develop a catch rate time series

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Methods at a high level (details to follow)

- **Sample of full data set**
 - Proportional to the statistical area size
 - Average sized stat areas ~60 record/year
 - Allows us to fit simpler models, better estimate uncertainty
- **Patterns of spatial inequality in catches (Gini index)**
 - Understanding if catches are evenly distributed in space or if they are more concentrated
- **Nominal CPUEs**
 - Simple average catch rate in each year
 - Resampling observed hauls allows us to look at variability
- **Standardized CPUE**
 - Using a model that accounts for location, time of year, and depth



Methods at a high level (details to follow)

- **Comparison between the CPUE and traditional trawl survey indices**
 - Build understanding of monkfish stock by comparing survey and fishery data
- **Considered the potential impact of technology creep**
 - Using estimates of creep from the literature
- **Assessment relevant multiplier output**
 - Using two different terminal years



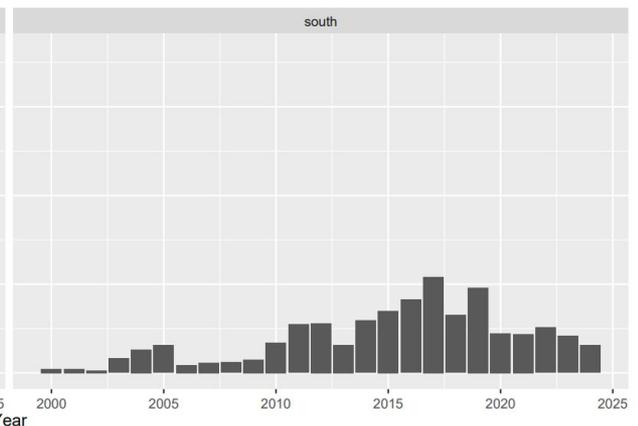
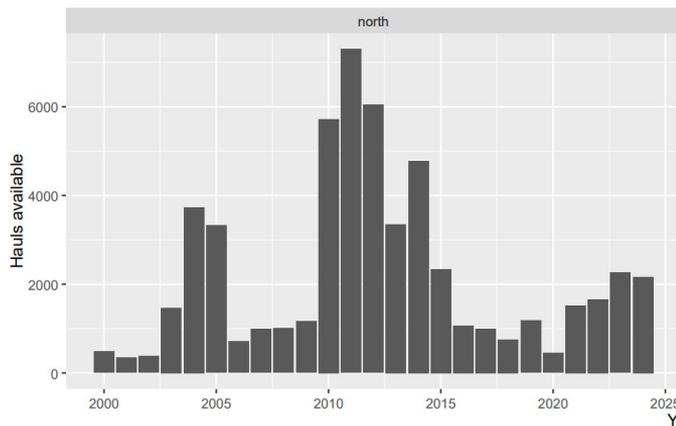
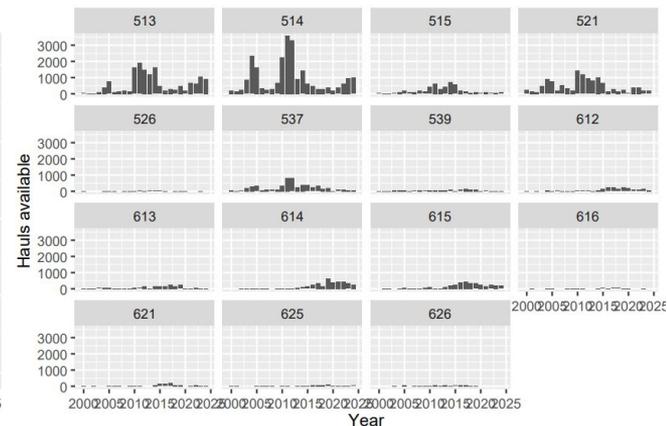
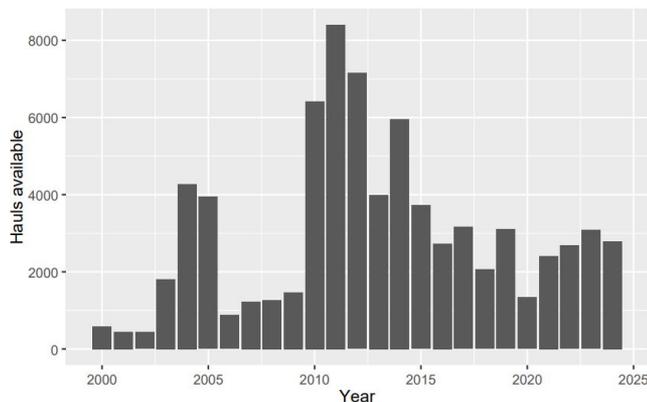
As an example: gillnet full data set

Available catch data for these programs using this gear type

Data limited from early in time series across both regions

A number of stat areas with limited info: 464, 512, 522, 525, 538, 541, 561, 611, 622, 631, 632, 635, 636

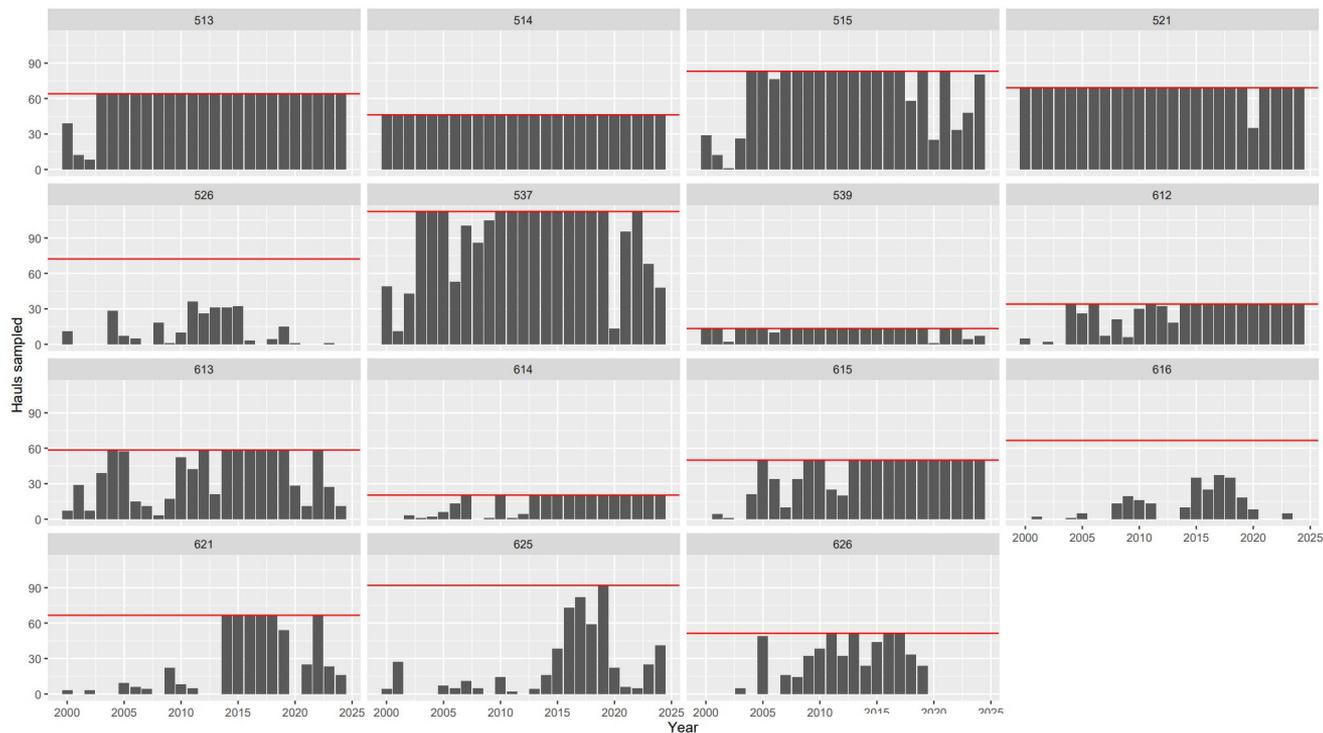
~78,000 efforts/hauls



Compared to gillnet subset sampling coverage

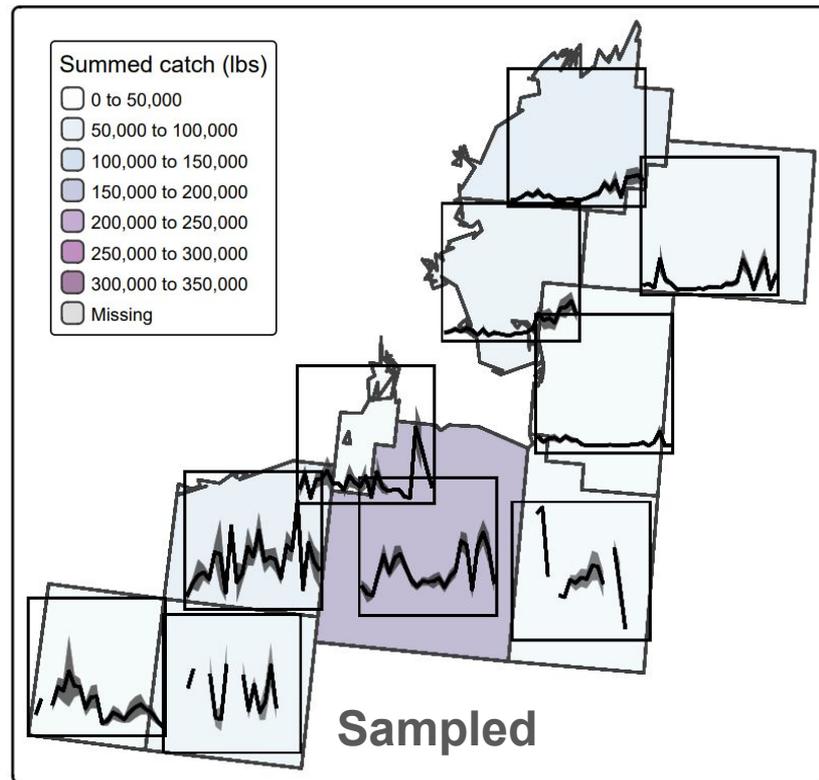
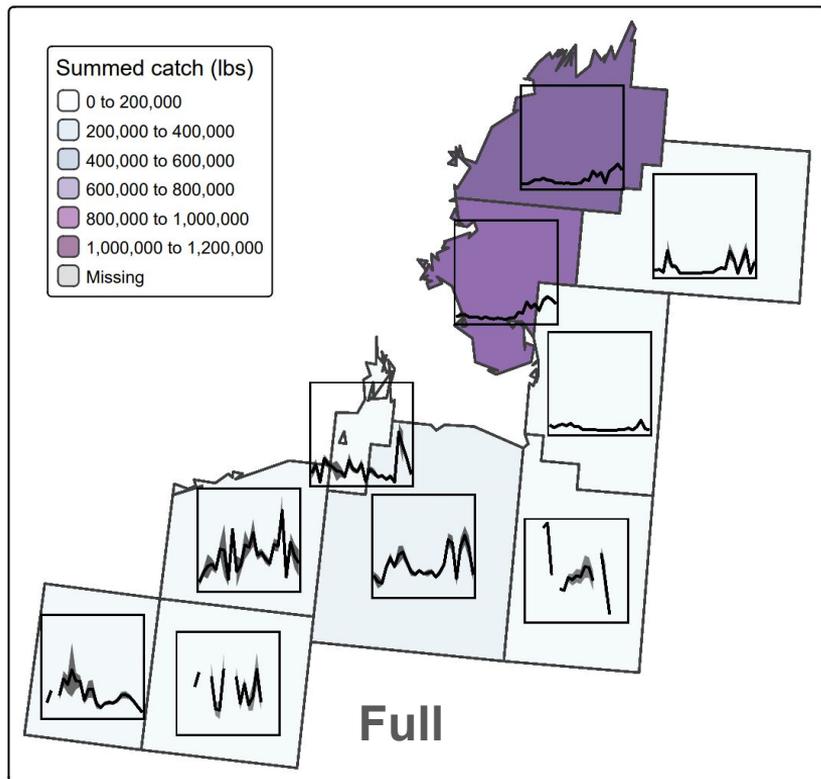
~13,300
efforts/hauls

- More spatial balance in samples
- Weights sampling by stat area size
- Mean sized stat area contributed ~60 efforts per year
- Similar to survey station allocation, with some holes



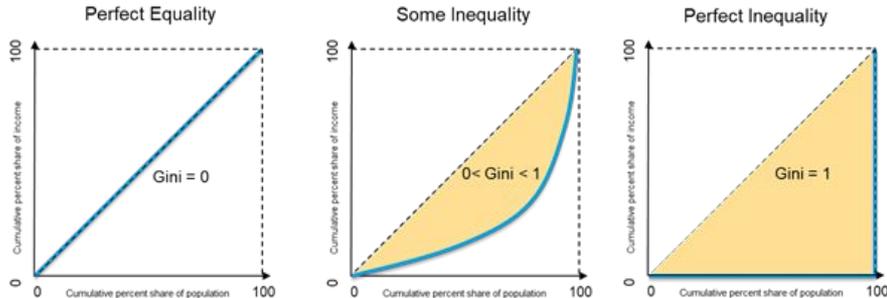
Red line shows the target n based on area size

Spatial comparison of full vs sampled for gillnet



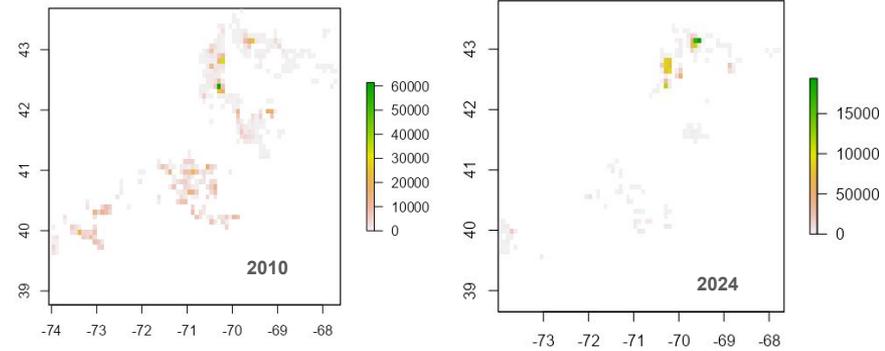
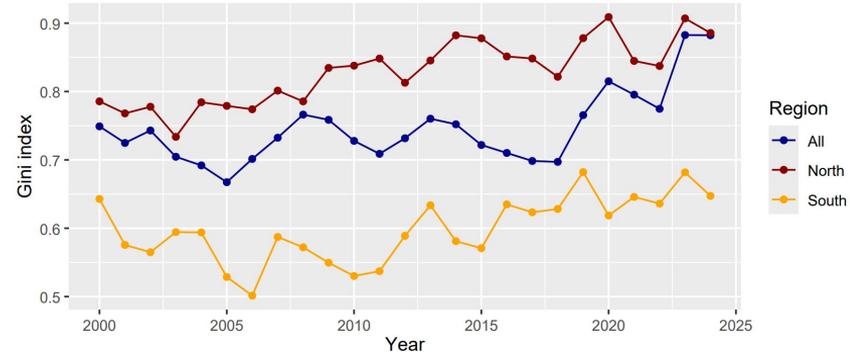
Gini index (spatial clumping)

- Grid lat lon into $\sim 65 \text{ km}^2$ cells for each year
- Calculating a gini index
- Some concentration in full data sets



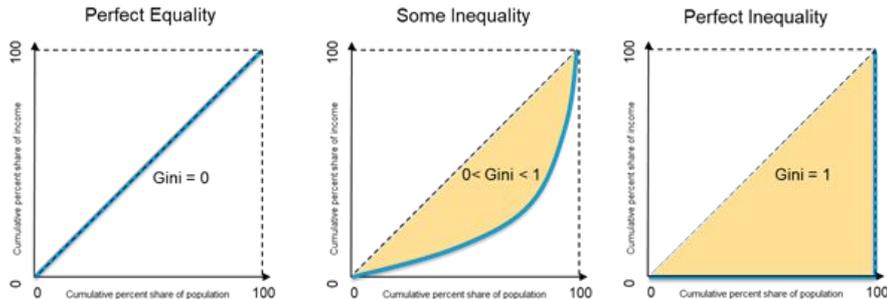
Full

Gillnet

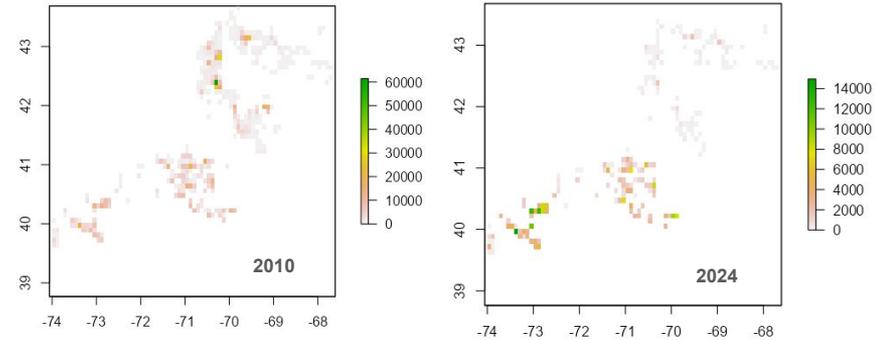
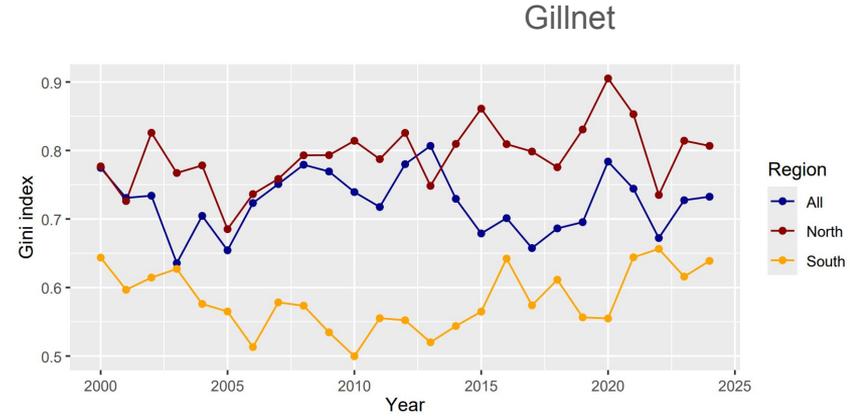


Gini index (spatial clumping)

- Grid lat lon into $\sim 65 \text{ km}^2$ cells for each year
- Patterns generally flat in sampled data sets



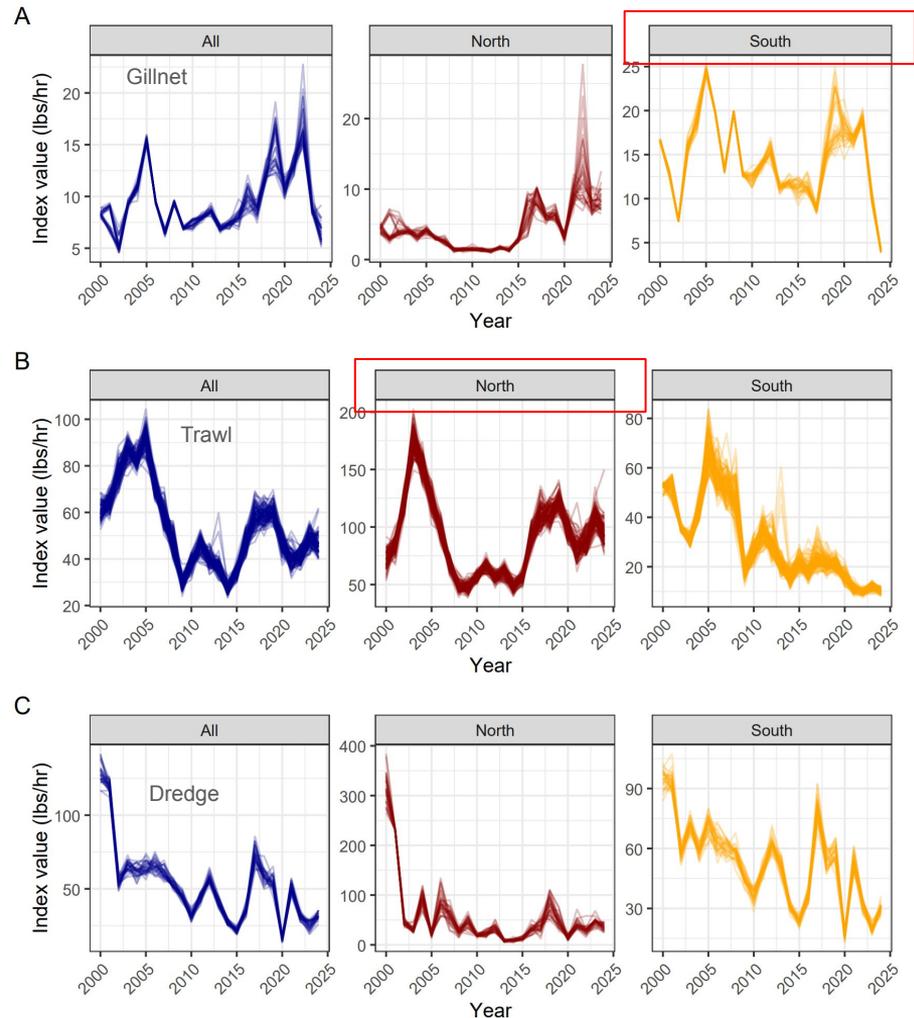
Sampled



Nominal CPUE

 Gear regions also used by SMAST/CCCFA

- Explorations led us to decide to move forward with sampled data sets
- 30 data sets sampled using stat area size to determine the number of records
- Averaged CPUE per year, looking at consistency
- Generally similar patterns among samples across gears and regional configurations
- A few outliers potentially due to large catches, small effort values, or small sample sizes



Standardized CPUE

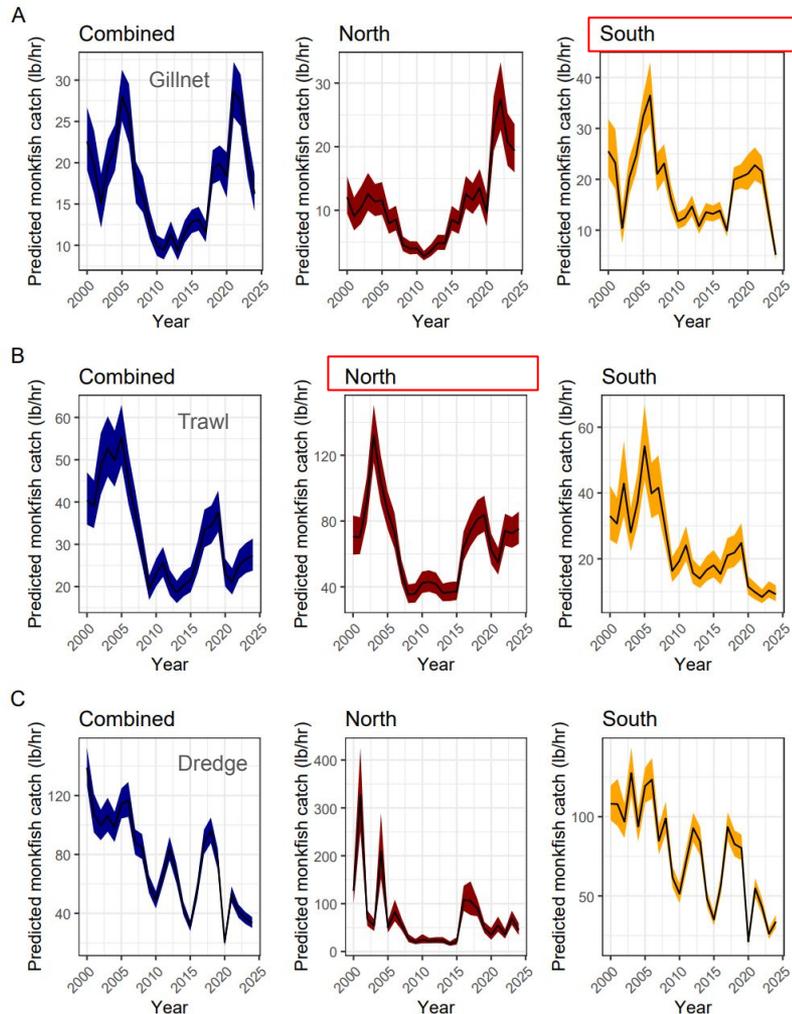
 Gear regions also used by SMAST/CCCFA

- Using a single sampled data set for each gear/region we then:
- Standardized with gams and a small set of parameters and Tweedie distribution

$$Catch \sim \text{Tweedie}(\mu, \phi, p)$$

$$\ln(\mu) = \text{Offset}(\ln(\text{Effort})) + \text{Area} + \text{Year} + s(\text{Depth}) + s(\text{Day})$$

- **Offset(ln(Effort))** = log-transformed offset for effort
- **Area** = Statistical area of the catch
- **Year** = Annual deviations
- **s(Depth)** = A thin-plate regression spline for the non-linear effect of bottom depth.
- **s(Day)** = A cyclic cubic regression spline for the day of the year that is continuous from year end to the start.
- **Interesting to note:** the 95% CI are similar in spread to the variation in the nominal CPUEs

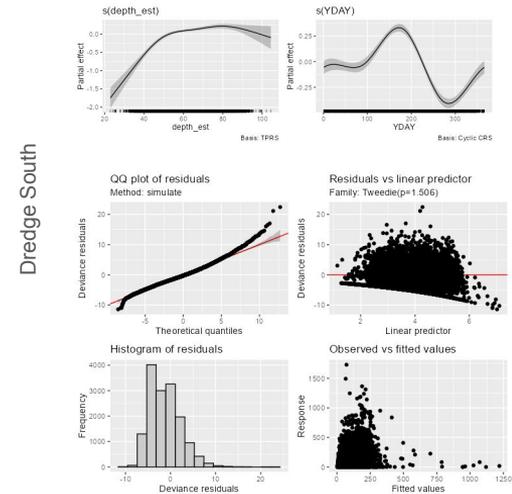
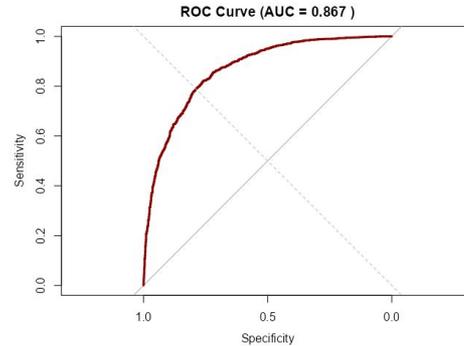
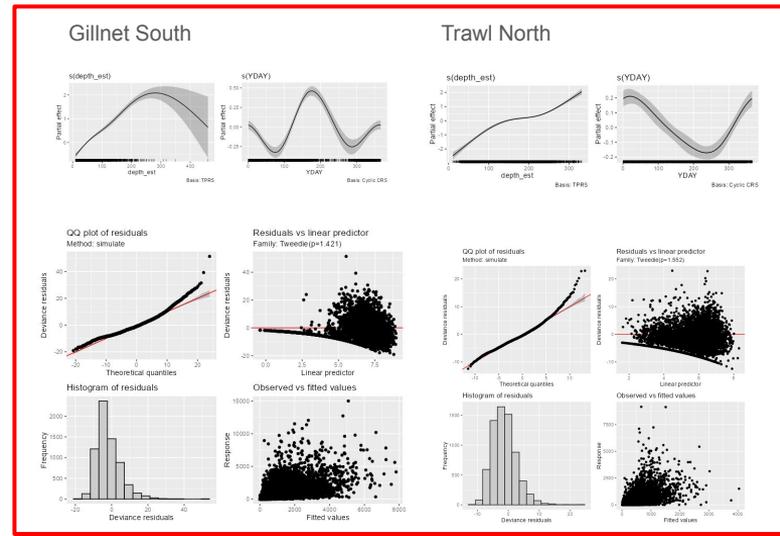


Standardized CPUE diagnostics

- Checked standard diagnostics
- Lots of informal explorations of modeling alternatives
- Explained deviance ~ 25% to ~ 40%
 - With only year and effort models explain ~5%
- AUC high (> 70%) if catches treated as binary outcome
 - Models know where catches occur, but not fantastic at predicting the size of catches
- Some patterning in residuals
 - Likely due to the inclusion of zeros



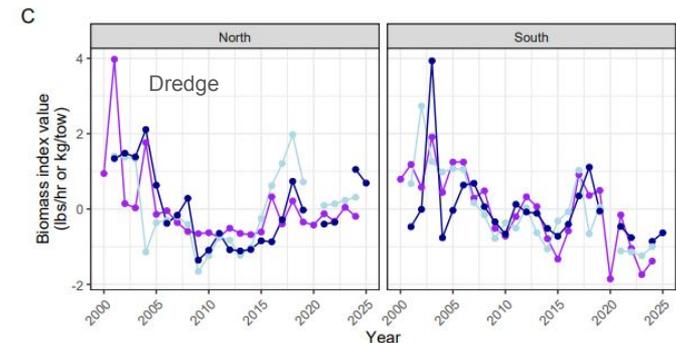
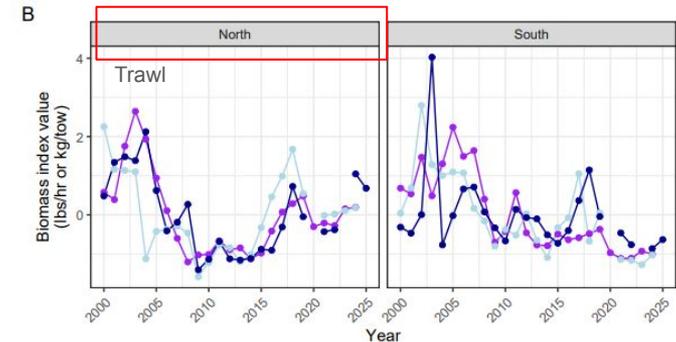
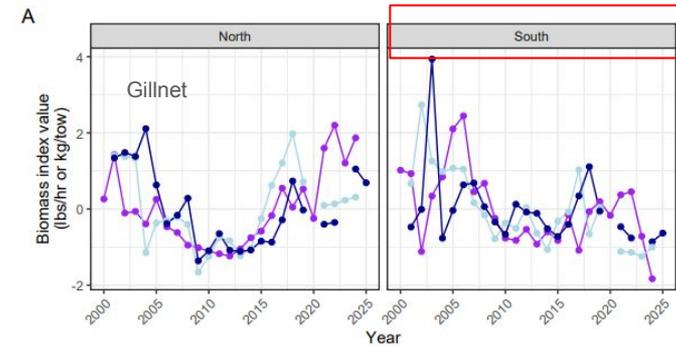
Gear regions also used by SMAST/CCCFA



Stand. CPUE and traditional trawl survey indices

- Many similarities to NEFSC surveys
- Lower correlation for gillnet could be because of selectivity (larger fish - see tech memo), need to lag

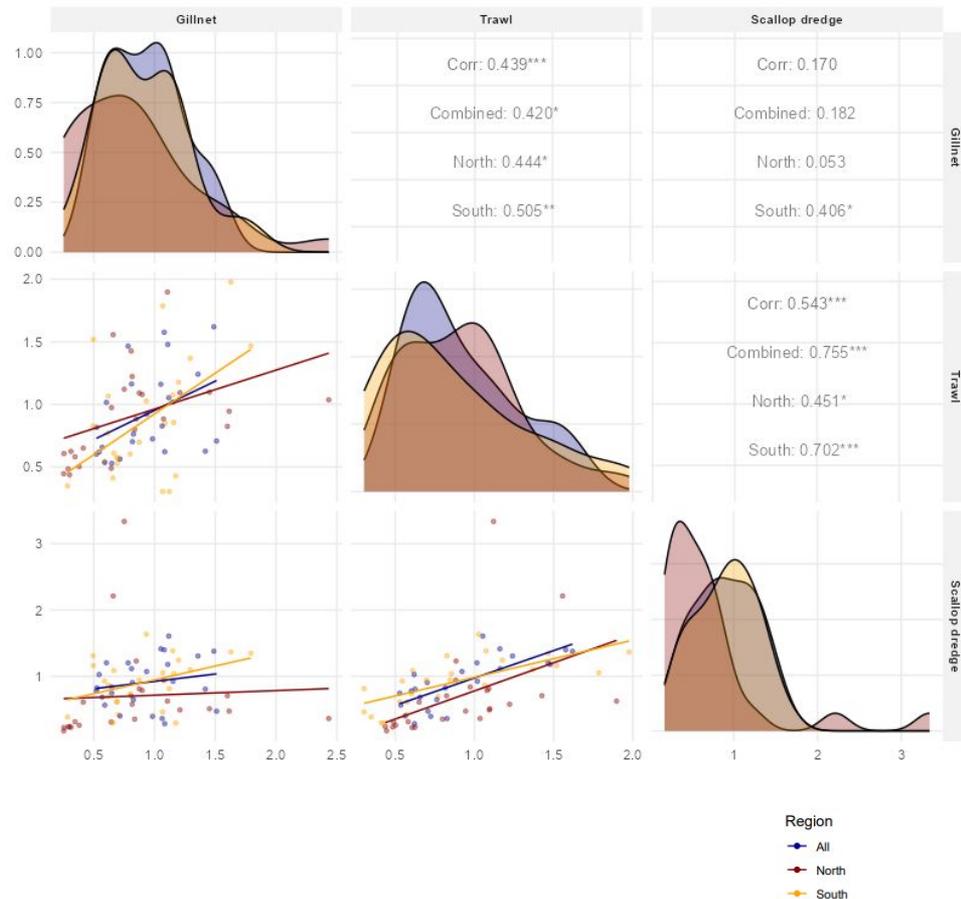
Region	Gear	r (CPUE vs. NMFS fall BTS)	r (CPUE vs. NMFS spring BTS)	r (NMFS fall BTS vs. NMFS spring BTS)
North	Gillnet	0.41	0.34	0.54
South	Gillnet	0.27	0.20	0.37
North	Scallop dredge	0.60	0.79	0.54
South	Scallop dredge	0.78	0.27	0.37
North	Trawl	0.40	0.58	0.54
South	Trawl	0.76	0.61	0.37



Correlations among CPUEs

- Correlation among gears

Region	Gear 1	Gear 2	$r(\text{CPUE vs CPUE})$
South	Trawl	Scallop dredge	0.70
South	Gillnet	Trawl	0.51
South	Gillnet	Scallop dredge	0.41
North	Trawl	Scallop dredge	0.45
North	Gillnet	Trawl	0.44
North	Gillnet	Scallop dredge	0.05



Considered the potential impact of technology creep

- Tech. creep is a potential pitfall for the application of CPUE methods
- Lit. review suggests 0 - 4% per year
- CPUE standardization can help

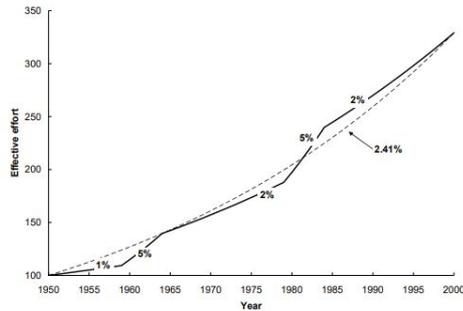


Figure 1. Simulation of increase in effective effort over a 50 year period consisting of a mixture of background rates (C% = 1 and 2%) and rapid increases (5%) due to technological improvements. The average rate (2.41%; dotted line) is obtained by comparison of the beginning and end estimates of effective effort, but can be approximated by an average rate of increase weighted by the number of years (2.42%).

scientific reports

OPEN Technological creep masks continued decline in a lobster (*Homarus gammarus*) fishery over a century

Aif Ring Kleiven^{1,2}, Sigurd Heiberg Espeland^{1,2}, Stian Stiansen¹, Kotaro Ono¹, Fabian Zimmermann¹ & Esben Moland Olsen^{1,2}

Fishery-dependent data are frequently used to inform management decisions. However, inferences about stock development based on commercial data such as Catch-Per-Unit-Effort (CPUE) can be severely biased due to a phenomenon known as technological creep, where fishing technology improves over time. Here we show how trap improvement over nine decades has driven technological creep in a European lobster (*Homarus gammarus*) fishery. We combined fishing data, experimental fishing with contemporary and older trap types, and information on seasons. The resulting standardized CPUE time series indicates a 92% increase between 1928 and 2018 compared to 70% if technological creep is not accounted for. An uncorrected CPUE index suggests an 8% increase in lobsters while the corrected CPUE index declined by 57%. We conclude that to

improve and largely improve designs to include management of data

Fisheries Centre
The University of British Columbia

Working Paper Series

Working paper # 2010-07

An empirical equation to predict annual increases in fishing efficiency

Daniel Pauly and M.L. Deng Palomares

Year: 2010
email: d.pauly@fisheries.ubc.ca

This working paper is made available by the Fisheries Centre, University of British Columbia, Vancouver, BC, V6T 1Z4, Canada.
www.fisheries.ubc.ca

Original Article

Quantifying the increase in fishing efficiency due to the use of drifting FADs equipped with echosounders in tropical tuna purse seine fisheries

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Wain, G., Guiry, L., Kaplan, D. M., and Gaertner, D. Quantifying the increase in fishing efficiency due to the use of drifting FADs equipped with echosounders in tropical tuna purse seine fisheries. – ICES Journal of Marine Science, 78, 235–245.

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Numerous pelagic species are known to associate with floating objects (FOs), including tropical tunas. Purse seines use this behaviour to facilitate the capture of tropical tunas by deploying artificial drifting fish aggregating devices (dFADs). One major recent change has been the integration of echosounders in satellite-tracked CPUE tows attached to FADs, allowing fishers to remotely estimate fishable biomass. Understanding the effects of this new technology on catch of the three main tuna species (yellowfin tuna, *Thunnus albacares*, bigeye tuna, *Thunnus obesus*, and skipjack tuna, *Katsuwonus pelamis*) is important to accurately correct for changes in catch-per-unit-effort (CPUE) indices used for stock assessments. We analysed catch data from the French purse seine fleet for the period 2010–2017 in the Indian Ocean to assess the impact of this fleet switch to echosounder tows around 2012. Results indicate that echosounders do not increase the probability a set will be successful, but they have a positive effect on catch per set, with catches on average increasing by +2.1–2.5 tonnes per set (+107%) when made on the vessels' own dFADs equipped with an echosounder buoy. Increases were due to a decrease in sets below +2.5 tonnes and an increase in those greater than +2.5 tonnes, with a non-linear transition around this threshold. This increase explains the considerable investment of purse seines in echosounder buoys, but also raises concerns about bias in stock size estimates based on CPUE if we do not correct for this fishing efficiency increase.

Keywords: catch per unit effort, hyperstability, Indian Ocean, standardization

Original Article

Regulation strength and technology creep play key roles in global long-term projections of wild capture fisheries

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Scherrer, K. and Galbraith, E. Regulation strength and technology creep play key roles in global long-term projections of wild capture fisheries. – ICES Journal of Marine Science, 77, 2518–2528.

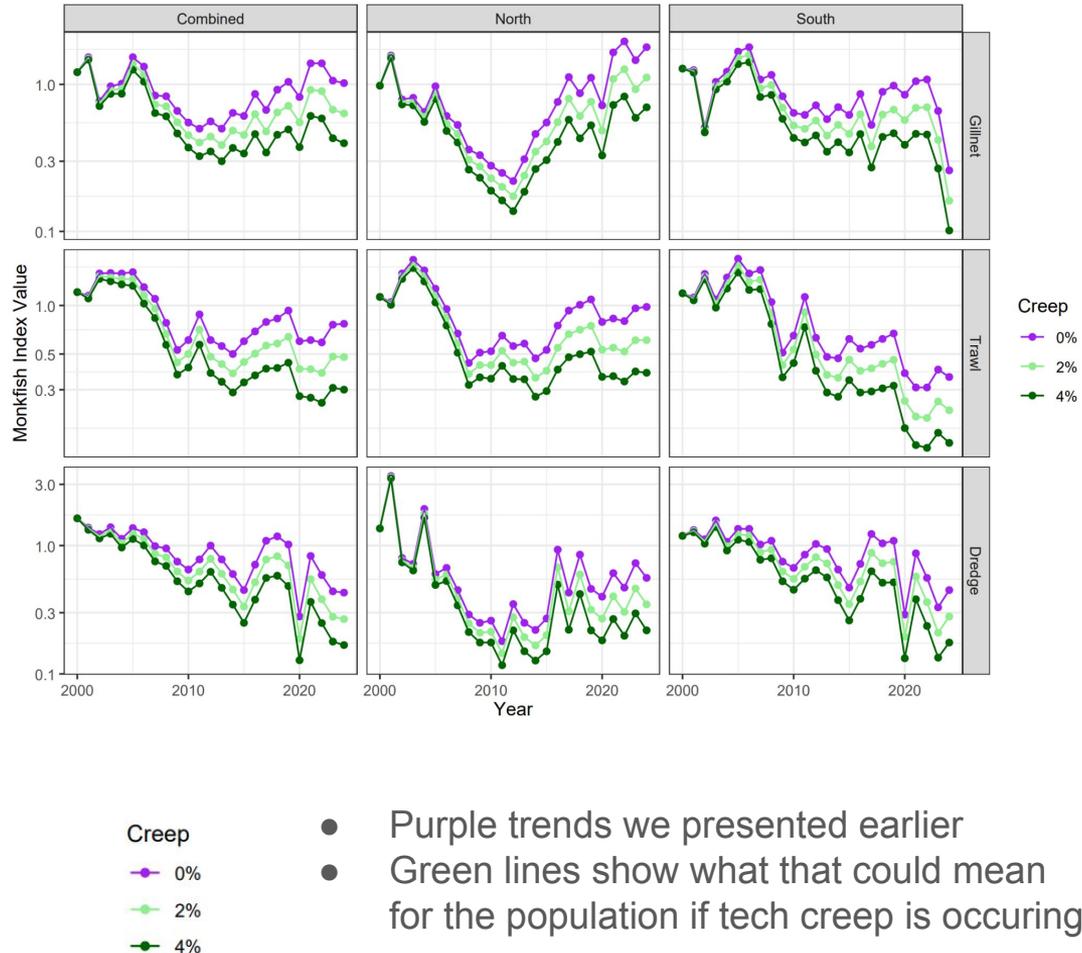
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Many studies have shown that the global fish catch can only be sustained with effective regulation that remains overfishing. However, the persistence of weak or ineffective regulation in many parts of the world coupled with changing technologies and additional stresses like climate change, renders the future of global catches uncertain. Here, we use a spatially resolved, bio-economic, size-spectrum model to shed light on the interactive impact of three globally important drivers over multidecadal timescales: imperfect regulation, technology-driven catchability increase, and climate change. We implement regulation as the adjustment of fishing mortality to a target level with some degree of effectiveness and project a range of possible trajectories for global fisheries. We find that if technological progress continues apace, increasingly effective regulation is required to prevent overfishing, akin to a 3rd Queen Ice. Climate change reduces the possible upper bound for global catches, but its economic impacts can be offset by strong regulation. Driven by technological progress under weak regulation, despite a progressive erosion of fish biomass by lowering profits and generating a temporary stabilization of global catches, our study illustrates the large degree to which the long-term outlook of global fisheries can be improved by continually strengthening fisheries regulation, despite the negative impacts of climate change.

Keywords: catchability, climate change, collective action, fisheries management, future fisheries, management effectiveness, marine ecosystem modeling

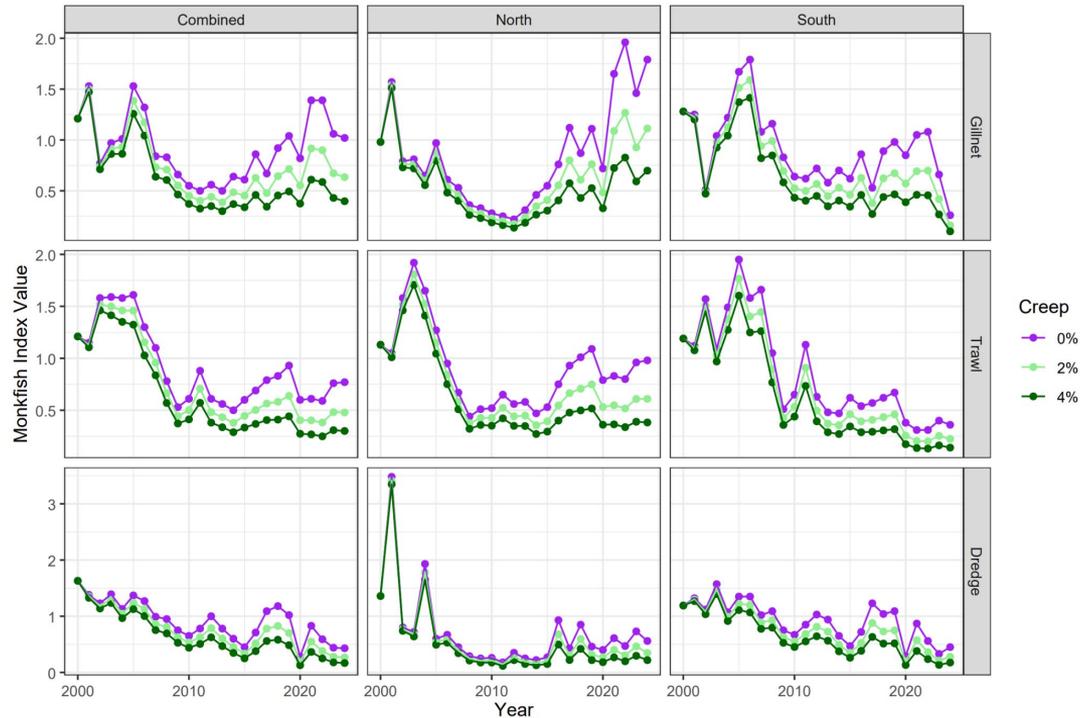
Considered the potential impact of technology creep

- Applied this to the CPUE series we generated (**note log scale**)
- What would that mean for the population trend if CPUE was capturing trends, but this was occurring?
- Trend has similar peaks but distinct (lower by sig. amount)



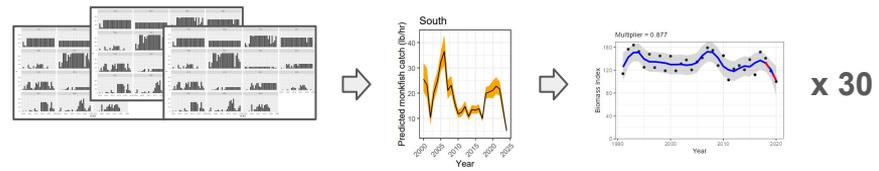
Considered the potential impact of technology creep

- Here without the log scale for the y axis
- **Take away: potentially impactful if occurring**

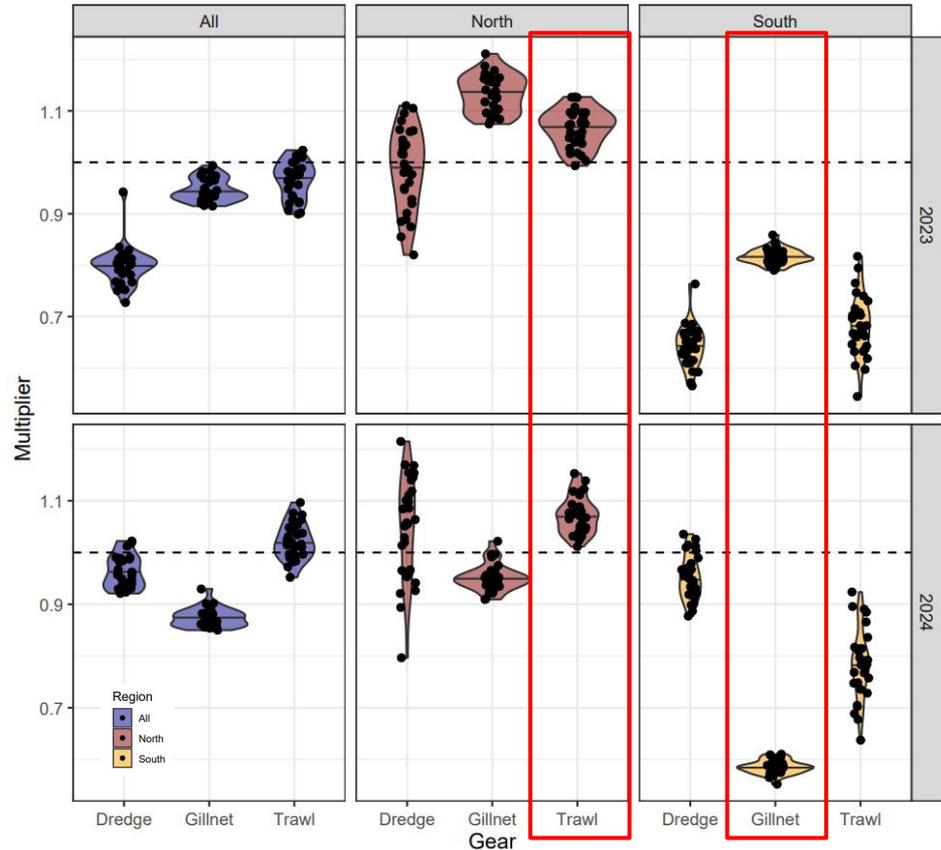


- Purple trends we presented earlier
- Green lines show what that could mean for the population if tech creep is occurring

Looked at assessment relevant Ismooth multipliers



- Repeated standardization on 30 'samples' for each gear type
- Two terminal years 2023 and 2024
- Sampling produces fairly tight groupings (with four exceptions)
- Southern gillnet lower with 2024 terminal year



Gear regions also used by SMAST/CCCFA

• = Multiplier from standardization fit to a sampled data set

Takeaways

1. Sampling seems to be beneficial (flatter gini index, more even spread of catches)
 - As Steve showed, these CPUEs are similar to non-sampled, so it may not be essential
2. Simple standardization models fit relatively well
3. Good correspondence between standardized CPUEs and trawl survey indices
4. Good correspondence among CPUEs for different gears
5. However, with a few options it's important to appropriately select CPUE series that is most reliable when comparing gear types (not one with highest multiplier currently)
6. Consistent tech creep could be a problem
 - Might take additional investigation to rule out or quantify, characterize impact to multipliers from lsmooth
7. Multipliers based on repeated 'sampling' are fairly consistent