Online Appendix

A.1 The Rebuilding of the Atlantic Spiny Dogfish

To better clarify the variables, definitions and thresholds, as well as how they interact, we plot the regulatory and stock health history of the Atlantic spiny dogfish in Figure A1. The stock was doing well in the early 90s, then increased fishing mortality led to reductions in biomass. The stock was designated as overfished in 1999. The rebuilding plan was implemented in 2002. The plan reduced fishing mortality, which reversed the trend in declining biomass and led to the stock being declared rebuilt in 2010. It is important to note that there is a lag between the stock being declared overfished and entering rebuilding. There is another lag before we observe declining fishing mortality, and another lag before observing biomass recovery.

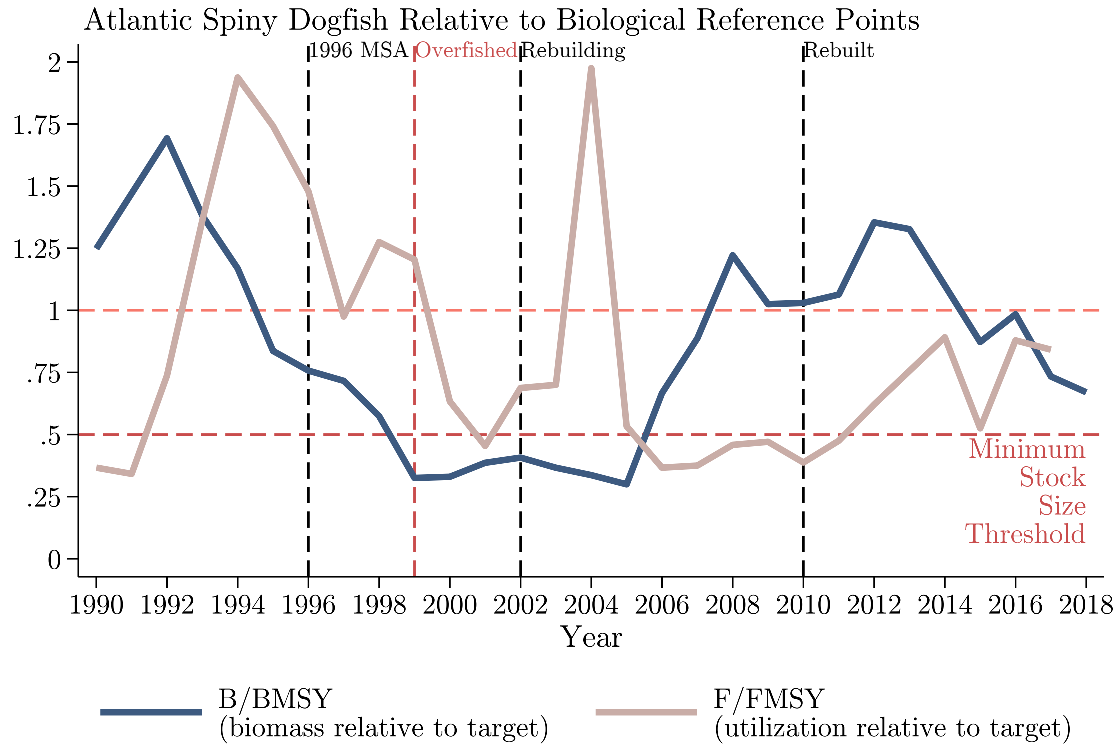
At face value, this appears to be a successful case study for the policy. A stock's biomass declined below healthy levels (B_{MSY}), and then declined below the regulatory threshold that considers it overfished (MSST). The stock received treatment by entering a rebuilding plan where management lowered catch. Finally the stock successfully rebuilt to sustainable levels (B_{MSY}). However, interpreting the changes to the stock as a causal treatment effect of the rebuilding plan assumes that in the absence of rebuilding plans, the stock would have either continued to decline or stagnate around its MSST.

This example also clarifies the causal inference challenge of attributing the recovery of the fishery to the rebuilding plan. We cannot rule out other explanations such as natural variability in a stock's population dynamics. Causal inference can be especially challenging when variability is combined with measurement error in the estimated size of the stock. As the stock approaches a low value in its cycle, even small measurement error could end up determining that the stock is below its MSST. It will be hard to disentangle how much of the observed increase is due to the rebuilding plan and how much is simply driven by natural variability.

A.2 Validating Stock Assessment Data

Fish stock assessment reports are developed by NOAA fish scientists. They use peer-reviewed models to estimate fish populations and reference points. NOAA's website describes stock assessments as conceptually similar to their National Weather Service dynamic atmospheric models: "Even though fish stock assessments operate on much longer time scales than

Figure A1: MSA Management Example: Atlantic Spiny Dogfish



Notes: Plotting the the biomass relative to the target biomass (B/B_{MSY}), and the fishing mortality relative to the target fishing mortality (F/F_{MSY}). When the stock is meeting both its targets, for biomass and fishing mortality, the values of B/B_{MSY} and F/F_{MSY} should be centered around one. When biomass drops below the Minimum Stock Size Threshold (50% of its B_{MSY} target), the Atlantic spiny dogfish is considered to be overfished (below the red dashed line). When the fishing mortality is above F_{MSY}, the stock is considered to be experiencing overfishing (above the coral dashed line).

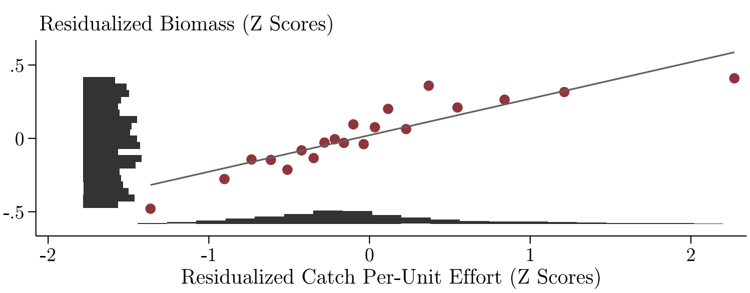
weather models—months and years rather than hours and days—they similarly combine and incorporate many different complex observations into a holistic picture of the situation." The data that we use for this analysis come from the retrospective components of stock assessments. Their higher fidelity to historic observations makes them more reliable than the predictions that managers use to make decisions. They benefit from the availability of full catch records and survey data, and are not affected to the same degree by the uncertainties that managers face in real time regarding the management of the stock (see Section 2).

Stock assessment models are calibrated using observed data from NOAA abundance surveys and catch data from fishers. Survey data are reported in units of catch-per-unit-effort (CPUE). Catch data include landings that are sold at the dock, discards at sea, and bycatch, which is accidental catch of a species that fishers were not targeting. A network of monitoring programs is used to enforce quality control of this data, including third-party dockside and boat observers, log books, and recreational sampling. Abundance surveys employ fishing methods, but they are statistically designed, run by NOAA, and use standardized sampling methods (same boat, gear, ocean sampling grid, and time of year).

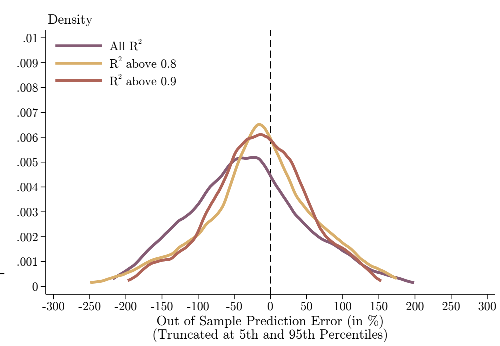
To verify that the stock assessments are consistent with the observed data, we perform two empirical validation exercises. First, we examine the in-sample fit by estimating a simple regression model linking the stock assessment output (biomass) to the key inputs (NOAA abundance sampling survey data and catch). We obtain the survey data records from NOAA's Distribution Mapping and Analysis Portal, and we standardize the biomass, catch, and survey data by stock. Then we residualize the standardized biomass as a function of lagged standardized survey data and contemporaneous and lagged standardized catch, along with stock and year fixed effects. We repeat this residualization for the standardized survey data. We plot the relationship between the residuals of biomass and survey data (in z scores) in Figure A2a. There is a strong linear fit between the survey data and the assessed biomass. In other words, the survey data, which provides a proxy for stock abundance, is a strong predictor of assessed biomass.

Figure A2: Validating the Stock Assessments Using Survey and Catch Data

(a) In-Sample Fit



(b) Out-of-Sample Fit



Notes: Results from running two sets of tests to verify that the stock assessments are capturing features that appear in their raw data inputs instead of generating patterns that do not agree with the catch and survey data.

In the second validation exercise, we run a regression on each stock, excluding one year at a time, using the same model as above. For each omitted year of data, we generate a predicted value for the assessed biomass. Because we are running the regression for each stock separately, we keep the data in levels and do not transform it into z-scores. In Figure A2b, we report the distribution of prediction errors. While some prediction errors are large, they are centered and concentrated around zero, especially for the models with high R-squared values. Overall, we find a strong in-sample and out-of-sample fit of biomass to survey and catch data, even though we are using a very simple regression specification that does not incorporate any biological theory, which the stock assessments do include. We interpret these results as evidence that the stock assessments are not generating artifacts that are not observed in the raw data inputs.

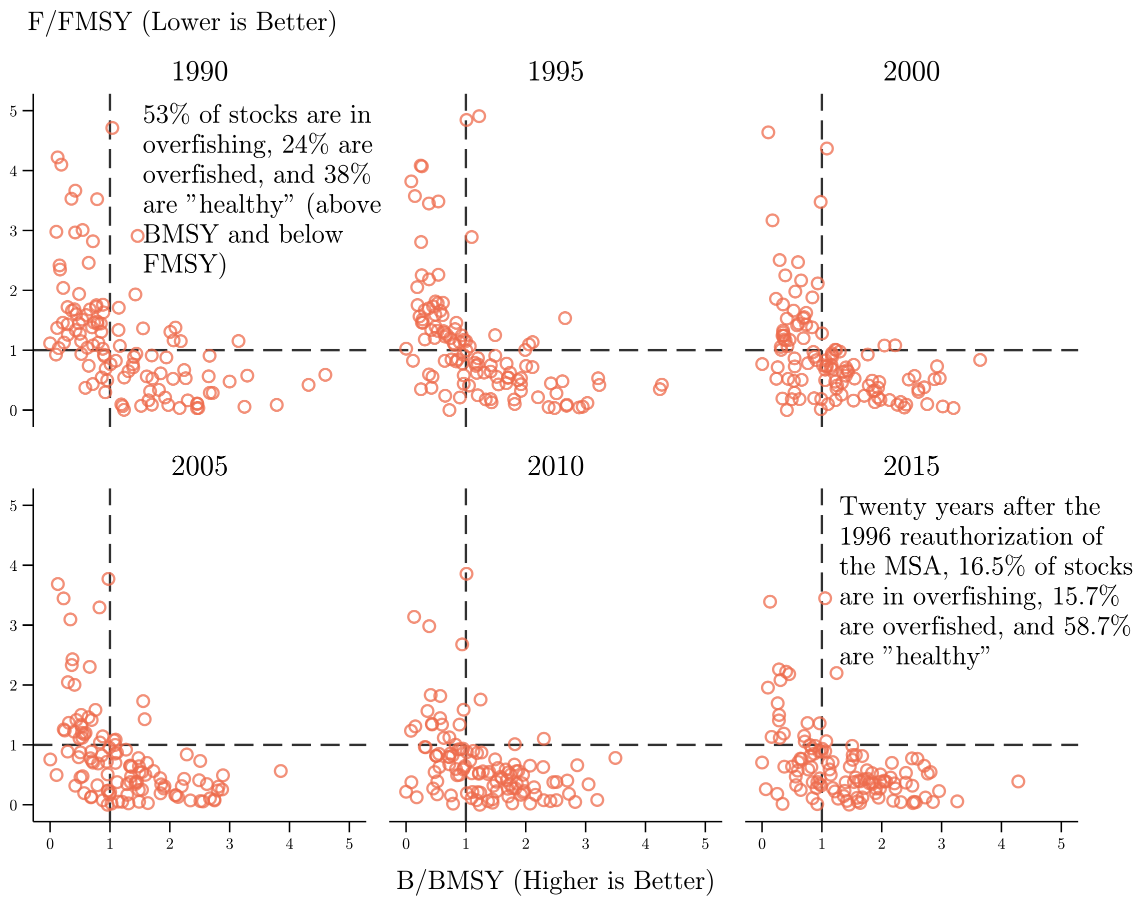
A.3 Summarizing Fishing Mortality & Biomass Relative to Targets Over Time

To summarize the raw data on the status of fisheries in the years before and after the 1996 reauthorization of the MSA, we plot the two key metrics relative to their reference points: fishing mortality and biomass. In Figure A3, we present scatter plots for six time periods, two before 1996, and four after. Across all six panels, we restrict the sample to 121 stocks that have balanced data (i.e. no missing data on F/FMSY and B/BMSY in all six periods). From 1990 to 2015, we observe a reduction in the number of stocks that are in the top left area of the plot where fishing mortality is above its target (F/FMSY above 1) and where the biomass is below its target level (B/BMSY is below 1). The percent of stocks that are meeting their targets (F/FMSY is below 1 and B/BMSY is above 1) increases from 40.3 to 58.7 between 1990 and 2015.

A.4 Descriptive Data on Changes to Catch & Biomass Around MSA Events

Figure A4 plots the mean levels of biomass (Panels a-b) and catch (Panels c–d) in event time, standardized by their levels in the event year. For treated stocks, the events are the first year the stock experiences overfishing, falls below its MSST, is declared overfished, or enters a rebuilding plan (Panels a and c). For control stocks, we use EU stock biomass declining below its SBL, and US stock biomass declining below its MSST in the pre-MSA period (Panels b and d). Because official stock status (overfishing, overfished) and regulatory responses (entering rebuilding) often lag behind a stock falling below its MSST, biomass may begin to recover earlier as the harvest control rule reduces catch and promotes recovery. This is more likely when the lag between biomass falling below its MSST and an overfished determination or rebuilding plan is longer (see Figure A5 for a summary of such delays). By contrast, declines in catch around event timings are more similar because they reflect both reduced stock availability and policy-imposed harvest reductions.

Figure A3: Stocks' Statuses Relative to Biological Reference Points



Notes: Summarizing the status of stocks relative to their target reference points in five-year intervals, for stocks that have data reported in each time period (n=121). The y-axis shows the fishing mortality (catch over biomass) relative to the target level (F_{MSY}), while the x-axis shows the biomass relative to the biomass target level (B_{MSY}). Stocks with F/F_{MSY} above one are experiencing overfishing. Stocks with low B/B_{MSY} values, generally below half of their B_{MSY} value (below 0.5 on the x-axis), are considered overfished. We truncate the axes at 5 to allow for easier visual inspection of the data.

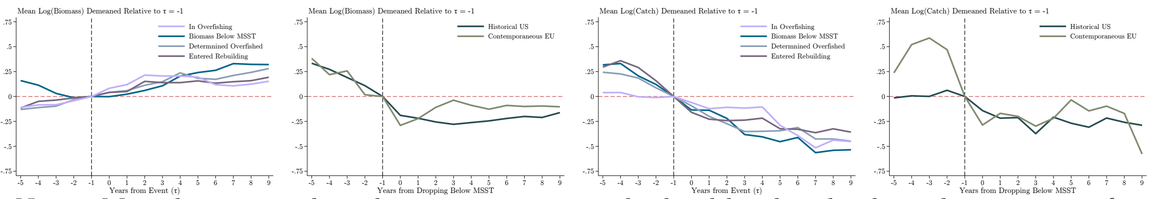
A.5 Delay Between Overfished Determination & Rebuilding Plan

Under the MSA, regional management must develop and implement a rebuilding plan for stocks designated as overfished. Historically, many stocks experienced long delays between being declared overfished and entering a rebuilding plan. There can also be delays between when a stock's biomass declines below its MSST and when it is declared overfished.

We summarize these delays in Figure A5. Before the 2006 reauthorization of the MSA—which introduced the requirement to implement a rebuilding plan within two years of an overfished designation—delays were substantial. After 2006, fewer stocks were declared overfished, or entered rebuilding, and those that did saw mostly short delays. After 2006,

Figure A4: Changes in Key Outcomes Around MSA Events

Biomass		Catch	
(a) With Reb.	(b) Without Reb.	(c) With Reb.	(d) Without Reb.



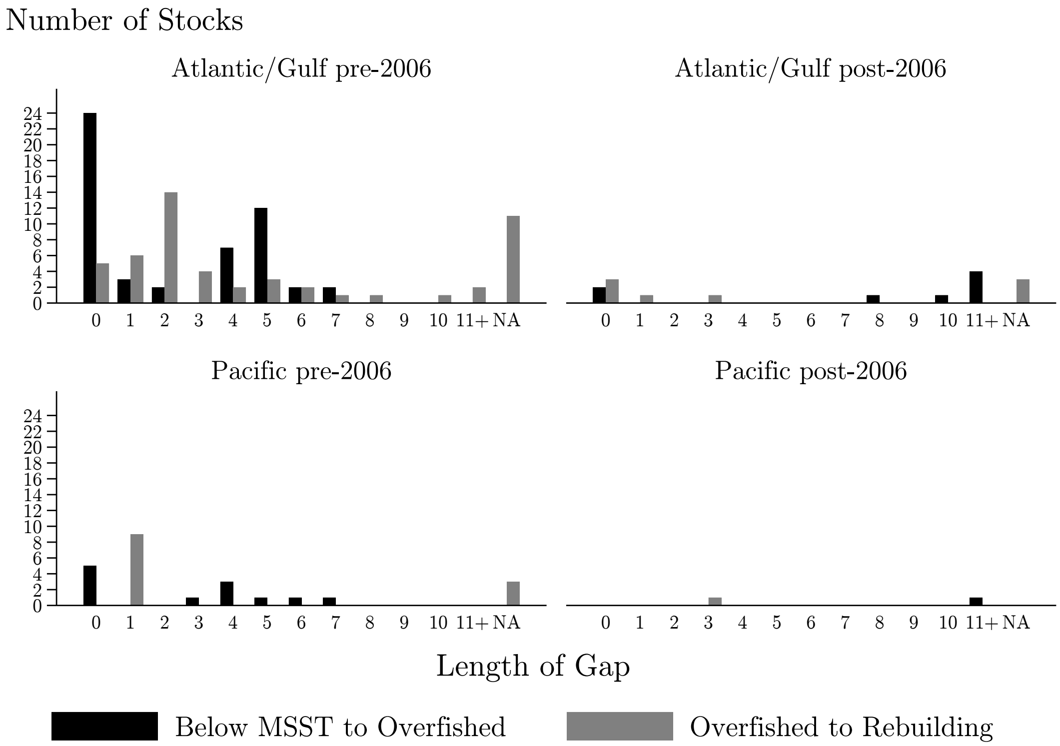
Notes: Mean biomass and catch in event time, standardized by their levels in the event year for stocks with (a-b) or without (c-d) rebuilding plans.

the longer delays happened between the year a stock declined below its MSST and the year it was declared overfished. These delays could be due to changes in the science. At the time, the stock may not have even been considered overfished, but based on improved, scientific estimates of the MSST, we now consider the stock to have been overfished (see the Online Data Appendix for more details on scientific changes to reference points over time). Stocks that have not yet received a rebuilding plan have either rebuilt prior to the implementation of a rebuilding plan, do not have sufficient data to design a rebuilding plan, or are listed under the Endangered Species Act where their recovery plans would be governed by this Act.

A.6 Historical Comparison of US and EU Policy

US and EU fisheries policies share many features, although EU policy has lagged behind the US. Both jurisdictions adopted fishery laws in the 1970s, but the EU required international agreement among member states, making coordination more difficult than passing national legislation in the US. In 1970, the European Economic Community (EEC) assumed responsibility for conserving member states' fish stocks, granting reciprocal access to territorial waters. However, member states could not agree on a common fisheries policy (Hegland and Raakjaer 2020; Battista et al. 2018). At the same time, US Congress debated two competing 1975 bills, both extending the EEZ to 200 nm. One proposed creating a new federal Fisheries Management Council, while the other—backed by New England fishermen—favored state management. The compromise became the 1976 Magnuson–Stevens Act (MSA), which established regional councils guided by national standards, including sustaining optimum yield (Walsh 2014). The following year, the EEC extended its Exclusive Fisheries Zone (EFZ) to 200 nm, but the first Common Fisheries Policy (CFP) was not adopted until 1983. The CFP introduced total allowable catches (TACs), allocated under the "relative

Figure A5: Years From Below MSST to Overfished to Rebuilding Plan



Notes: Summarizing the time, in years, between either the first year we observe the stock below its MSST and the first year it was declared overfished, as well as the number of years between a stock being declared overfished and and the first year it entered a rebuilding plan, if any.

stability" principle, which promoted stability in national shares rather than sustainability. Regional advisory councils were only introduced with the 2003 CFP reform (Hegland and Raakjaer 2020; Battista et al. 2018). Both US and EU regional councils are composed of stakeholders, but EU councils serve in an advisory capacity to the EU commission on fisheries management, whereas US councils create and implement fisheries management under national guidelines (Hegland and Raakjaer 2020; Battista et al. 2018; Walsh 2014).

The goals of maintaining optimum yield in the 1976 MSA and relative stability of catch in the 1983 CPA were not stringent. The US and EU experienced rising overfishing throughout the end of century. The 1996 MSA reauthorization (the Sustainable Fisheries Act) required the rebuilding of overfished stocks (*Sustainable Fisheries Act* 1996). Some US fisheries had already adopted MSY-based management with TACs, landing obligations, limited entry, gear restrictions, days-at-sea limits, and fishery management plans—for example, New England sea scallops had TACs by 1994. Similarly, some EU fisheries adopted MSY-based measures and effort restrictions (e.g. North Sea herring) using the same tools (Table 1, Hegland and

Raakjaer (2020)) before the 2013 CFP reform, which aimed to restore fish stocks to levels capable of producing maximum sustainable yield (*Common Fisheries Policy* 2013). Our study is limited to stocks with an established MSST or SBL, indicating sufficient data, scientific knowledge, and management to define biological reference points (see Data Appendix).

The 1996 MSA and 2013 CFP share similarities: both aimed to rebuild stocks through MSY-based fishery management plans developed or advised by regional councils[26], using catch quotas (ACLs in the US; TACs in the EU). Both also struggled with loopholes and compliance, particularly TACs set above scientific advice (*Natural Resources Defense Council, Inc. v. Daley, 62 F. Supp. 2d 102 (D.D.C. 1999);* Battista et al. 2018). The US addressed these gaps through the 2006 MSA reauthorization and the subsequently revised National Standard 1 Guidelines that were implemented in 2010 (*Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006* 2007). The 2013 CFP required full implementation by 2020 and arguably still has loopholes to address (Battista et al. 2018). The period 1996 to 2016 offers a valuable counterfactual: how US fisheries might have evolved without legally binding rebuilding requirements.

A.7 Summarizing Information on Stocks Included in the Analysis

Tables A1 and A2 provide details on the stocks that are included in the contemporaneous and historical analyses in the main text.

A.8 DD Results Centered Around Overfished Determination & Rebuilding Plan Implementation

In the main text, we define the year a stock declines below its MSST as the event of interest. In Figure A6, we report results for the same specification in Equation (1), centering around the year a stock is declared overfished or entered a rebuilding plan. Overall, we recover qualitatively similar results to those we report in the main text. However, under the MSA, treatment starts before the implementation of a rebuilding plan. In other words, increases in biomass can be observed before these alternative events of interest. We summarize these re-centered estimations in Table A3. The results for biomass (columns 1 to 3) demonstrate how the full effect we estimate is attenuated as some of the early gains in biomass are excluded from the treatment period, and instead become part of the pre-treatment trends. We also see that in the one to five years after the event, the biomass increases more than it does in

[26] Mediterranean and Black Sea stocks are excluded from our main analysis.

Table A1.
Summarizing Information About US Stocks Included in the Analysis

Stock Name	FMC	Order	Included in Comparison			Long Rebuilding Plan	Determined Rebuilt
			C. DD	H. (Pre)	H. (Post)		
Acadian redfish	NE	Scorpaeniformes	Y	Y	Y	Y	Y
American plaice	NE	Pleuronectiformes	Y	N	Y	N	Y
Atlantic cod	NE	Gadiformes	Y	Y	Y	N	N
Atlantic mackerel	MA	Scombroidei	Y	N	Y	N	N
Atlantic wolffish	NE	Zoarcoidei	Y	N	Y	N	N
Barndoor skate	NE	Rajiformes	Y	Y	Y	Y	Y
Black grouper	SA	Percoidei	N	Y	Y	N	N
Black sea bass	MA	Percoidei	Y	Y	Y	N	Y
Black sea bass	SA	Percoidei	Y	N	N	N	Y
Bluefish	MA	Percoidei	Y	Y	Y	N	Y
Bocaccio	P	Scorpaeniformes	Y	N	Y	Y	Y
Butterfish	MA	Stromateoidei, Anabantoidei	Y	N	N	N	Y
Canary rockfish	P	Scorpaeniformes	Y	N	Y	Y	Y
Cowcod	P	Scorpaeniformes	Y	Y	N	Y	Y
Darkblotched rockfish	P	Scorpaeniformes	Y	N	Y	Y	Y
Gag	SA	Percoidei	Y	Y	Y	N	N
Gag	GM	Percoidei	Y	Y	Y	N	Y
Gray triggerfish	GM	Tetraodontiformes	N	N	Y	N	N
Greater amberjack	GM	Percoidei	N	Y	Y	N	N
Haddock	NE	Gadiformes	Y	Y	Y	N	Y
Haddock	NE	Gadiformes	Y	Y	Y	N	Y
King mackerel	SA	Scombroidei	Y	Y	Y	N	Y
Lingcod	P	Scorpaeniformes	Y	Y	Y	N	Y
Lingcod	P	Scorpaeniformes	Y	N	Y	N	Y
Ocean pout	NE	Zoarcoidei	Y	Y	Y	N	N
Pacific hake	P	Gadiformes	Y	N	N	N	Y
Pacific ocean perch	P	Scorpaeniformes	Y	N	N	Y	Y
Petrale sole	P	Pleuronectiformes	Y	Y	Y	N	Y
Pollock	NE	Gadiformes	Y	N	N	N	Y
Red grouper	GM	Percoidei	Y	N	N	N	Y
Red grouper	SA	Percoidei	N	Y	Y	N	N
Red hake	NE	Gadiformes	Y	N	Y	N	N
Red porgy	SA	Percoidei	Y	Y	Y	Y	N
Red snapper	SA	Percoidei	N	Y	Y	N	N
Scup	MA	Percoidei	Y	Y	Y	N	Y
Sea scallop	NE	Bivalvia	Y	Y	Y	N	Y
Silver hake	NE	Gadiformes	Y	N	Y	N	Y
Silver hake	NE	Gadiformes	Y	N	Y	N	Y
Smooth skate	NE	Rajiformes	Y	Y	Y	N	Y
Snowy grouper	SA	Perciformes	Y	Y	Y	Y	N
Spiny dogfish	NE / MA	Squaliformes	N	N	Y	N	N
Summer flounder	MA	Pleuronectiformes	Y	Y	Y	N	Y
Thorny skate	NE	Rajiformes	Y	Y	Y	Y	N
Tilefish	SA	Perciformes	Y	N	Y	N	N
Tilefish	MA	Perciformes	Y	Y	Y	N	Y
Vermilion snapper	SA	Percoidei	Y	N	N	N	N
White hake	NE	Gadiformes	Y	Y	Y	N	N
Widow rockfish	P	Scorpaeniformes	Y	N	N	Y	Y
Windowpane	NE	Pleuronectiformes	Y	N	N	N	Y
Winter flounder	NE	Pleuronectiformes	Y	N	Y	N	N
Winter flounder	NE	Pleuronectiformes	Y	N	Y	N	Y
Winter skate	NE	Rajiformes	Y	Y	Y	N	Y
Yelloweye rockfish	P	Scorpaeniformes	Y	N	Y	Y	N
Yellowtail flounder	NE	Pleuronectiformes	Y	Y	Y	Y	N
Yellowtail flounder	NE	Pleuronectiformes	Y	N	Y	N	Y

Notes: A list of the US stocks included in the biomass and catch analyses including treated stocks in the contemporaneous DD comparison (C. DD), treated (H. Post) and control stocks (H. Pre) in the historical double event study comparison. For each stock, we report the common name, the fishery management council (FMC), the taxonomic order the species belongs to, which comparison the stock is included in, whether the stock has a long rebuilding plan, and whether they were determined rebuilt.

Table A2.
Summarizing Information About EU Stocks Included in the Analysis

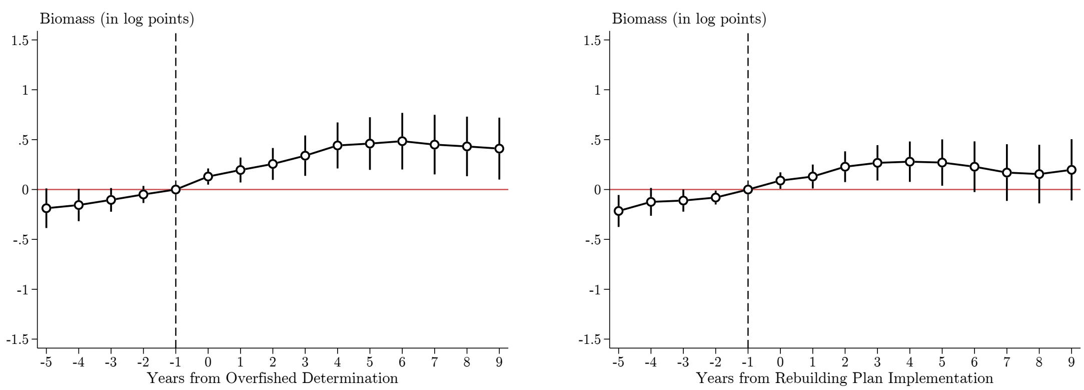
Stock Name	Region	Ecological Region	Order	Has MSST
Angler	Northeast Atlantic	BBIC	Lophiiformes	Y
Atlantic cod	Northeast Atlantic	CS , GNS , ONA	Gadiformes	Y
Atlantic cod	Northeast Atlantic	F	Gadiformes	Y
Atlantic cod	Northeast Atlantic	CS	Gadiformes	Y
Atlantic cod	Northeast Atlantic	GNS	Gadiformes	Y
Atlantic cod	Northeast Atlantic	CS	Gadiformes	Y
Atlantic herring	Northeast Atlantic	CS	Clupeiformes	Y
Atlantic herring	Northeast Atlantic	CS , F , ONA	Clupeiformes	Y
Atlantic herring	Northeast Atlantic	BS	Clupeiformes	Y
Atlantic mackerel	Northeast Atlantic	AC , A , BBIC , BaS , CS , F , GS , IS , GNS , NS , ONA	Scombroidei	Y
Capelin	Northeast Atlantic	AC , BaS , F , GS , IS , NS	Salmoniformes	Y
Common sole	Northeast Atlantic	CS	Pleuronectiformes	Y
Common sole	Northeast Atlantic	BS , GNS	Pleuronectiformes	Y
Common sole	Northeast Atlantic	GNS	Pleuronectiformes	Y
European anchovy	Northeast Atlantic	BBIC , ONA	Clupeiformes	Y
European anchovy	Mediterranean and Black Sea	CM	Clupeiformes	N
European anchovy	Mediterranean and Black Sea	WM	Clupeiformes	N
European flounder	Northeast Atlantic	GNS	Pleuronectiformes	N
European hake	Northeast Atlantic	BBIC , CS , F , GNS , ONA	Gadiformes	Y
European hake	Northeast Atlantic	BBIC	Gadiformes	Y
European pilchard	Mediterranean and Black Sea	CM	Clupeiformes	N
European pilchard	Northeast Atlantic	BBIC	Clupeiformes	Y
European plaice	Northeast Atlantic	CS	Pleuronectiformes	Y
European plaice	Northeast Atlantic	GNS	Pleuronectiformes	Y
European seabass	Northeast Atlantic	CS , GNS	Percoidei	Y
European sprat (27.4)	Northeast Atlantic	GNS	Clupeiformes	Y
European sprat (27.3A)	Northeast Atlantic	GNS	Clupeiformes	N
Four-spot megrim	Northeast Atlantic	BBIC	Pleuronectiformes	Y
Golden redfish	Northeast Atlantic	AC , CS , F , GS , IS , NS , ONA	Scorpaeniformes	Y
Haddock	Northeast Atlantic	F	Gadiformes	Y
Haddock	Northeast Atlantic	CS , GNS	Gadiformes	Y
Megrim	Northeast Atlantic	BBIC	Pleuronectiformes	Y
Norway pout	Northeast Atlantic	GNS	Gadiformes	Y
Picked dogfish	Mediterranean and Black Sea	Black Sea	Squaliformes	N
Red mullet	Mediterranean and Black Sea	Black Sea	Percoidei	N
Sandeel (1R)	Northeast Atlantic	GNS	Perciformes	Y
Sandeel (3R)	Northeast Atlantic	GNS	Perciformes	Y
Sandeel (2R)	Northeast Atlantic	GNS	Perciformes	Y
Whiting	Northeast Atlantic	GNS	Gadiformes	Y
Whiting	Northeast Atlantic	CS	Gadiformes	Y

Notes: A list of the EU fishery stocks included in the analysis. We report stocks that are included in the contemporaneous DD comparison. For each stock, we report the common name, the FAO fishery region, the taxonomic order the species belongs to, the ecological region the stock resides in, and whether the stock has an MSST value, or we calculate a pseudo MSST for it. We abbreviate the ecological regions using the following: Azores, A; Arctic Ocean , AO; Baltic Sea, BS; Barents Sea, BaS; Bay of Biscay and the Iberian Coast, BBIC; Celtic Seas, CS; Central Mediterranean, CM; Faroes, F; Greater North Sea, GNS; Greenland Sea , GS; Iceland Sea, IS; Norwegian Sea, NS; Oceanic Northeast Atlantic, ONA; Western Mediterranean, WM.

the one to five years after the stock falls below the MSST. The results for catch demonstrate a similar pattern, where once the stock has started to recover, we see catch levels increasing relative to one year before the event. Finally, the number of stocks in the sample slightly declines in columns 2, 3, 5, and 6 because we have fewer stocks with a 10-year balanced time window after these events.

Figure A6: The Effect of Rebuilding Plans on Stock Biomass Using Different Treatment Onsets

(a) Centered Around Overfished (b) Centered Around Rebuilding



Notes: Panels (a) and (b) report estimation results showing coefficients and 95% CIs for the DD specification in Equation (1). Standard errors are clustered at the stock level.

A.9 Including Order-by-Year Fixed Effects in the Contemporaneous Comparison

In the main text, when reporting results for the contemporaneous comparison of US to EU stocks, we include year fixed effects that pool together common shocks to all stocks (e.g. technological changes, shifts in demand, development of aquaculture, etc.). Here, we use the taxonomic data on the order that each fish species belongs to in order to narrow down the residual variation to stocks within the same order. First, we include order-by-year fixed effects (instead of the year fixed effects, but in addition to the fishery stock fixed effects). Second, we narrow the sample to the taxonomic order group that has stocks in both the US and the EU. We report the results in Figure A7. On average, we recover a nearly identical evolution of biomass for the treated US stocks relative to the untreated EU stocks. We do not observe a pre-trend in the years leading to stocks dropping below their MSST, and we estimate larger coefficients for the biomass recovery, yet those fall well within the 95% CIs we report in Figure 3. For catch, we estimate a similar imprecisely estimated trajectory of

Table A3.
Contemporaneous Comparison Results When Centering Around Different Events

	Logged Biomass			Logged Catch		
	(1)	(2)	(3)	(4)	(5)	(6)
Event Time 1-5	0.10	0.27	0.20	-0.18	0.05	0.18
	(0.07)	(0.07)	(0.07)	(0.14)	(0.13)	(0.16)
Event Time 6-10	0.42	0.45	0.20	-0.06	0.50	0.35
	(0.14)	(0.13)	(0.13)	(0.27)	(0.26)	(0.22)
Within R^2	0.134	0.143	0.095	0.058	0.034	0.042
Observations	2,214	2,106	2,025	2,214	2,106	2,025
Clusters	82	78	75	82	78	75
Centered On:						
Biomass Below MSST	X			X		
Determined Overfished		X			X	
Entered Rebuilding			X			X

Notes: Estimation results from the DD specification in Equation (1). We report the linear combinations for the event time dummies after the stock drops below the MSST (columns 1 and 4), is determined to be overfished (columns 2 and 5), and enters rebuilding (columns 3 and 6), for the average of the first to fifth lags, and the sixth to tenth lags, excluding the top-coded lag coefficient. Columns 1-3 report results for biomass, in log points, while columns 4-6 report results for catch, in log points. All regressions include stock and year fixed effects. Standard errors are clustered at the stock level.

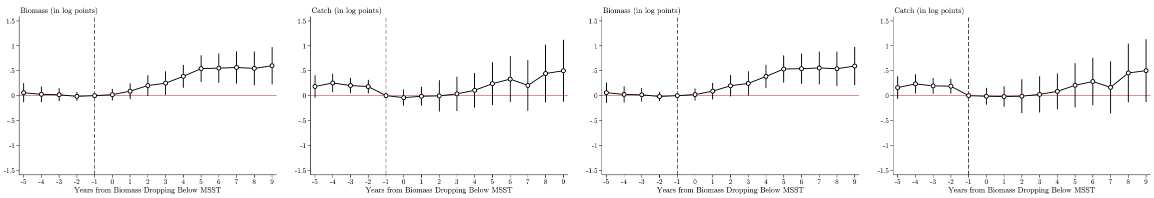
an initial estimated decline with a later recovery. The key difference here is that while there is no pre-trend in catch (leads -5 to -2 are all similar to each other), when controlling for order-by-year fixed effects, US stocks experience a drop in catch relative to EU stocks one year before dropping below their MSST.

A.10 Using Normalized Biomass Instead of Logged Biomass

In the main text, we use logged values for all the outcomes. In Figure A8, we report the same estimation as in Figure 3, only using normalized instead of logged biomass. We recover the same patterns, and similar magnitudes. However, the results are less precisely estimated in the contemporaneous comparison.

Figure A7: Contemporaneous Comparison, US to EU, With Order-by-Year FEs

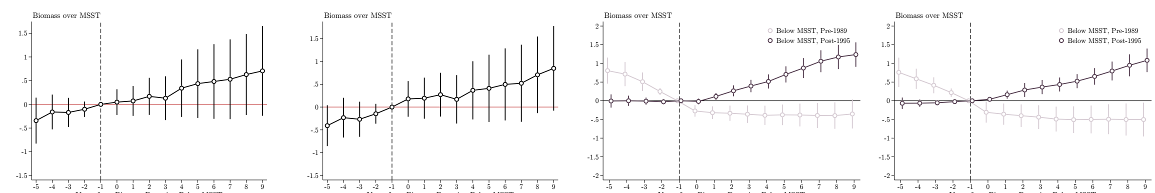
Full Sample		*Order Present in both US & EU*	
(a) Biomass	(b) Catch	(c) Biomass	(d) Catch



Notes: Same as in Figures 3 and 4, for the contemporaneous comparison, only here we include order-by-year fixed effects (a-d), and narrow the sample to orders with stocks in both the US and the EU (c-d).

Figure A8: Evidence for the Policy's Outcome: Fish Biomass Recovery

Contemporaneous Comparison		*Historical Comparison*	
Including All US Stocks	Excluding New England Stocks	Including All US Stocks	Excluding New England Stocks
(a)	(b)	(c)	(d)



Notes: Panels (a) and (b) report estimation results showing coefficients and 95% CIs for the DD specification in Equation (1). Panels (c) and (d) report estimation results from two separate regressions showing coefficients and 95% CIs for the specification in Equation (2). Standard errors are clustered at the stock level.

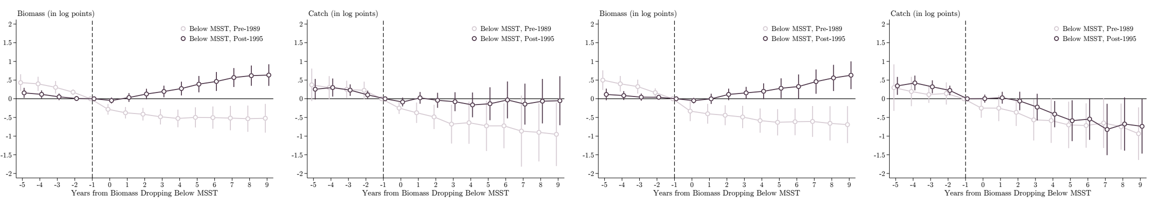
A.11 Historical Comparison Results With Fuel Prices and Climate Indices

In the main text, in the historical comparison event study analysis, we include quadratic trends. Here, we also add fuel prices and climate indices (see Online Data Appendix for more details) as additional time-varying controls. The results in Figure A9 show similar patterns and magnitudes as the results in the main text. This means that costs, proxied by diesel fuel costs, and environmental conditions, proxied by climate indices, fail to explain the results we report in the main text.

Figure A9: Historical Comparison Biomass Results with Fuel & Climate Controls

Historical Comparison, Present-US to Past-US

Including All US Stocks		Excluding New England Stocks	
(a) Biomass	(b) Catch	(c) Biomass	(d) Catch



Notes: Versions of Figures 3 and 4 (Panels c and d) with controls for fuel prices and climate indices.

A.12 Historical Comparison Results Without Quadratic Time Trends

In the main text, results for the historical comparison include quadratic time trends. In Figure A10, we repeat the estimation reported in the main text, but only include unit fixed effects without time trends. Overall, we recover similar trajectories for the outcomes after stocks enter rebuilding.

A.13 Stock-Specific Estimation Results

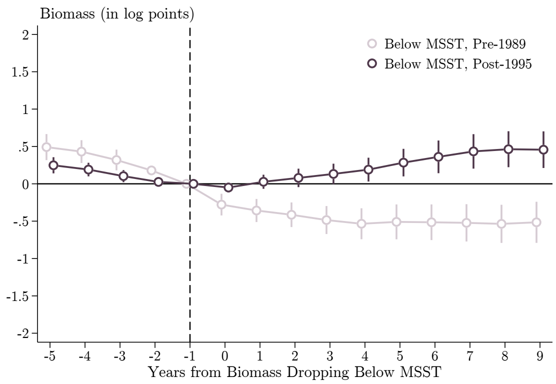
In the main text, we report results for the historical comparison that examines stocks whose biomass declines below their MSST pre-1989 as well as post-1995. Here, we report separately estimated regressions for the same set of stocks to fully describe the heterogeneity in Figures 3c and 4c. We use the same sample, but estimate a single regression for each stock. Each regression includes a dummy variable for being one to five years after declining below its MSST, and another dummy variable for being six to 10 years after declining below its MSST. These two coefficients are estimated relative to the omitted category of years before declining below its MSST. For each stock, we estimate four regressions: for biomass and catch outcomes, and for biomass declining below its MSST before 1989, and after 1995.

In Figure A11, we report the separately estimated coefficients for each stock on the effect of being six to 10 years after being below the MSST. One immediate observation that arises from the figure is that nearly all stocks that dropped below their MSST, pre-1989, were still below their MSST six to 10 years after dropping below that threshold. However, the results from after rebuilding plans were required show that several stocks increased in biomass in

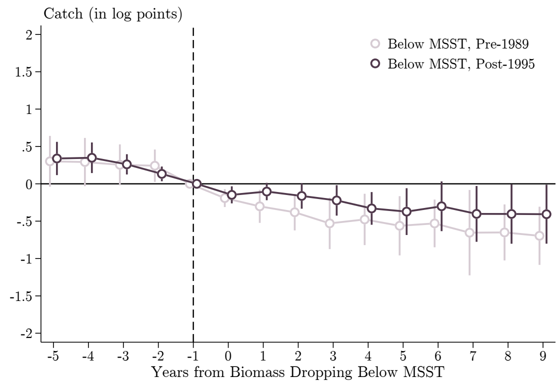
Figure A10: Estimation Results for the Historical Comparison Group With Unit FEs Only

All Stocks That Were Below Their MSST Either Pre- or Post-SFA

(a) Biomass: Double-Event-Study

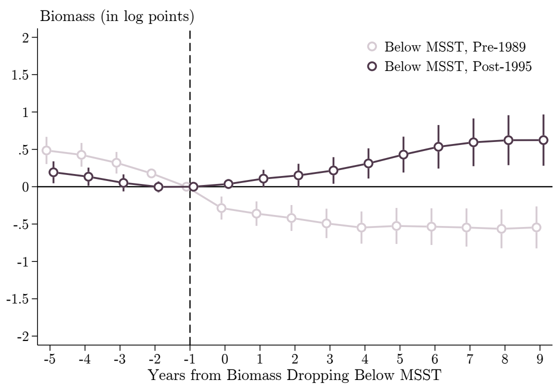


(b) Catch: Double-Event-Study

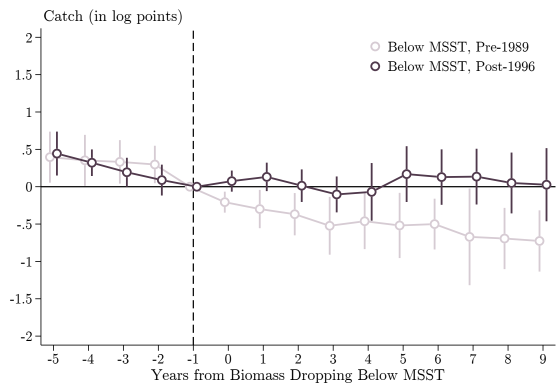


Holding Stock Composition Constant

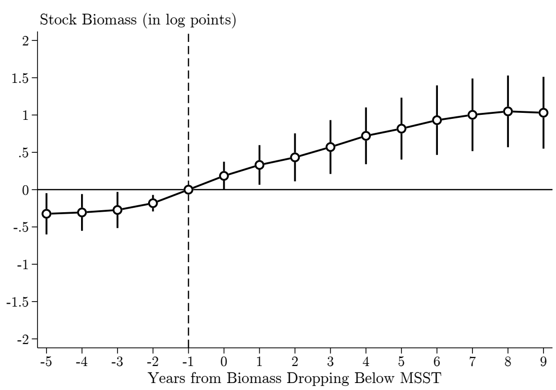
(c) Biomass: Double-Event-Study



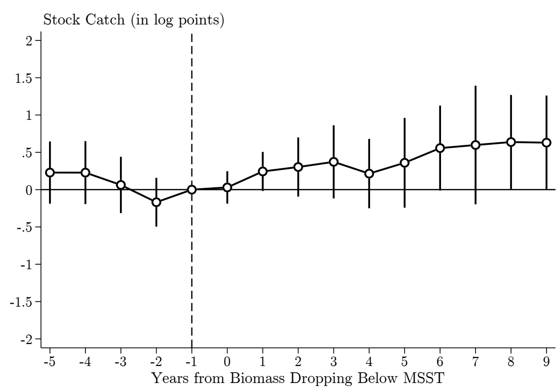
(d) Catch: Double-Event-Study



(e) Biomass: Paired-Differences



(f) Catch: Paired-Differences



Notes: Estimation results showing coefficients and 95% for the specification in Equation (2), excluding the quadratic time trends. Standard errors are clustered at the stock level.

the six to 10 years after having biomass below the MSST. Results for catch are more mixed. Some stocks experience lower catch in both pre-1989 and post-1995 periods, while others switch from continued low catch to higher catch, or vice-versa.

For visual inspection of the stock-specific estimation results, we summarize them using kernel densities for the biomass and catch outcomes in Figures A11b and A11c. The distribution for both the effects on biomass and catch in the post-1995 are shifted to right relative to the results from pre-1989. More importantly, the pre-1989 distributions are centered around negative values, highlighting that with falling biomass levels, catch levels declined as well. The same stocks, however, experienced growth in biomass, as well as higher levels of catch, once harvest control rules and rebuilding provisions were put in place as part of the 1996-reauthorization of the MSA.

A.14 Contemporaneous Comparison Using US Stocks That Never Entered Rebuilding

In the main text, the contemporaneous analysis uses EU stocks as the control group. We emphasize the importance of using a control group that is less likely to be affected by restrictions on catch on US stocks. Here, we report the results of the contemporaneous analysis that compares how the treated stocks to the untreated US stocks as the control group.

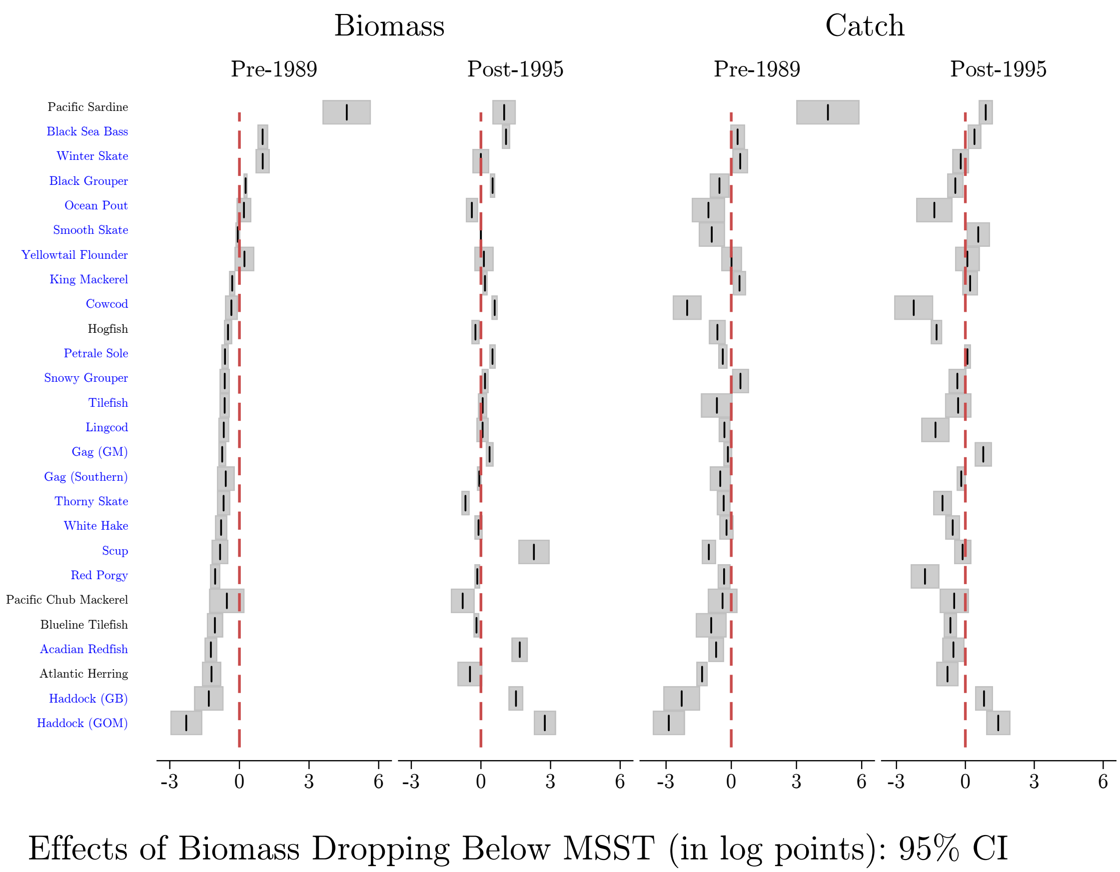
We find slight evidence of pre-trends in Figure A12, unlike the results for the contemporaneous comparison in Figures 3 and 4. For biomass, we observe that treated stocks experienced a larger depletion trend four and five years before dropping below their MSST. We still observe a large and meaningful gain in biomass for the treated stocks in the years after they drop below the MSST. For catch, we estimate a similar decline in catch that starts five to four years before the stock drops below the MSST. After stocks drop below their MSST, we estimate small and noisy declines in catch. The results remain nearly identical whether we include or exclude NEFMC stocks.

A.15 Documenting Inaccuracies in Alternative Fishery Revenue Data

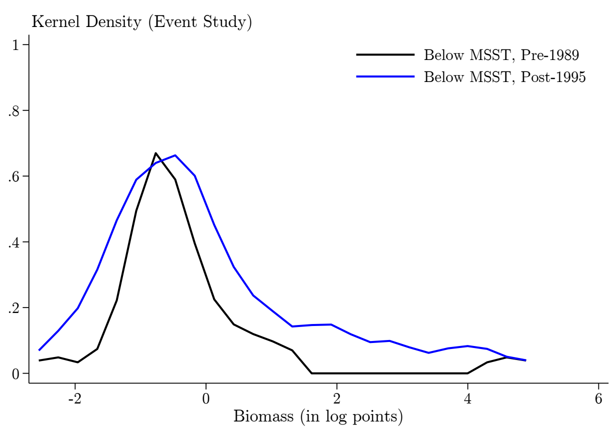
In the main text, we discuss how revenue data for the EU is widely available only after 2006. We explored using an alternative data set on prices and revenue for fisheries made available by the Sea Around Us (SAU) organization. However, upon inspecting the quality of the

Figure A11: Changes in Biomass & Catch Following Decline Below MSST, by Stock

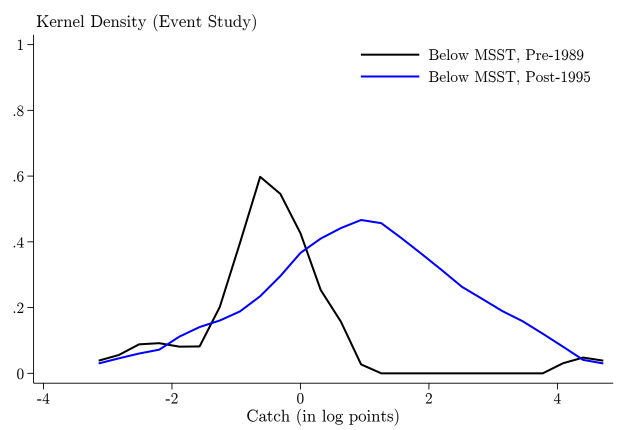
(a) Biomass & Catch, by Stock, Six to 10 Years Post-Event



(b) Biomass



(c) Catch

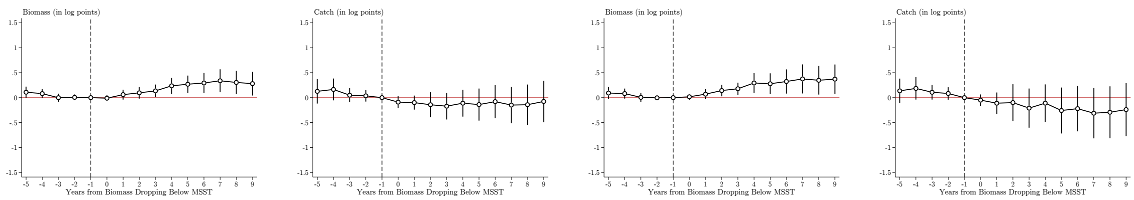


Notes: We report the estimates from a stock-by-stock regression, where we report the coefficient on a dummy variable for being six to 10 years after the event of dropping below the MSST. We repeat the estimation in pre-1989 and post-1995 periods, capturing the historical comparison when holding the composition of stocks constant (see Figure A17). Stock that are highlighted in blue are those that also entered a rebuilding plan post-1995. In Panels (b) and (c), we summarize the distribution of the coefficients by the time period for each outcome.

Figure A12: Contemporaneous Comparison, Treated US to Untreated US

Including All US Stocks | Excluding New England Stocks

(a) Biomass | (b) Catch | (c) Biomass | (d) Catch

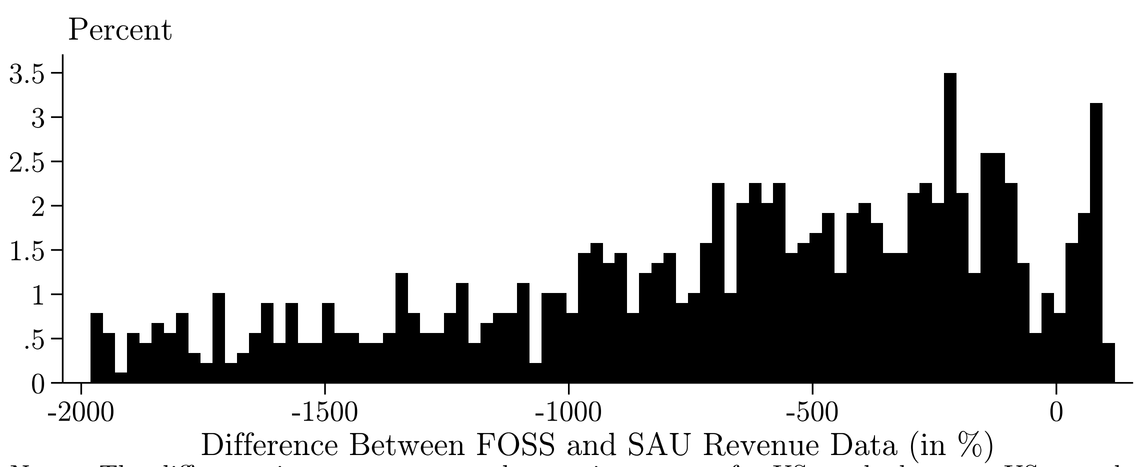


Notes: Same as in Figures 3 and 4, but using US stocks that did not enter rebuilding as the controls instead of EU stocks that did not enter rebuilding.

data we discovered serious discrepancies that we think invalidate any use of the data for the purpose of our analysis.

The key flaw of the SAU data is that it fails to reproduce the revenue data we have for the US. We compare for each US stock the revenue we obtain from US sources, the FOSS, (see Section 3 for more details) to that in the SAU data. In Figure A13 we plot the distribution of the percentage difference between the FOSS and SAU revenue data for the stocks that enter rebuilding. Even with truncating the data at the 25th percentile, the distribution reveals massive discrepancies between the sources of data we expected to align very closely. The distribution extends up to 10th, 5th, and 1st percentile values of -32,105.31, -12,6525.7, -2,154,961 percent, respectively. For this reason alone, we consider the data unusable. This prevents us from running a contemporaneous cohort-weighted DD comparison as we do not have a valid source of EU data across the 1990 to 2016 period.

Figure A13: Differences in FOSS and SAU Revenue Data



Notes: The difference in revenue per stock-year, in percent, for US stocks between US records (FOSS) and non-US record (SAU).

A.16 Additional Details on Potential Revenue Counterfactuals Approximations

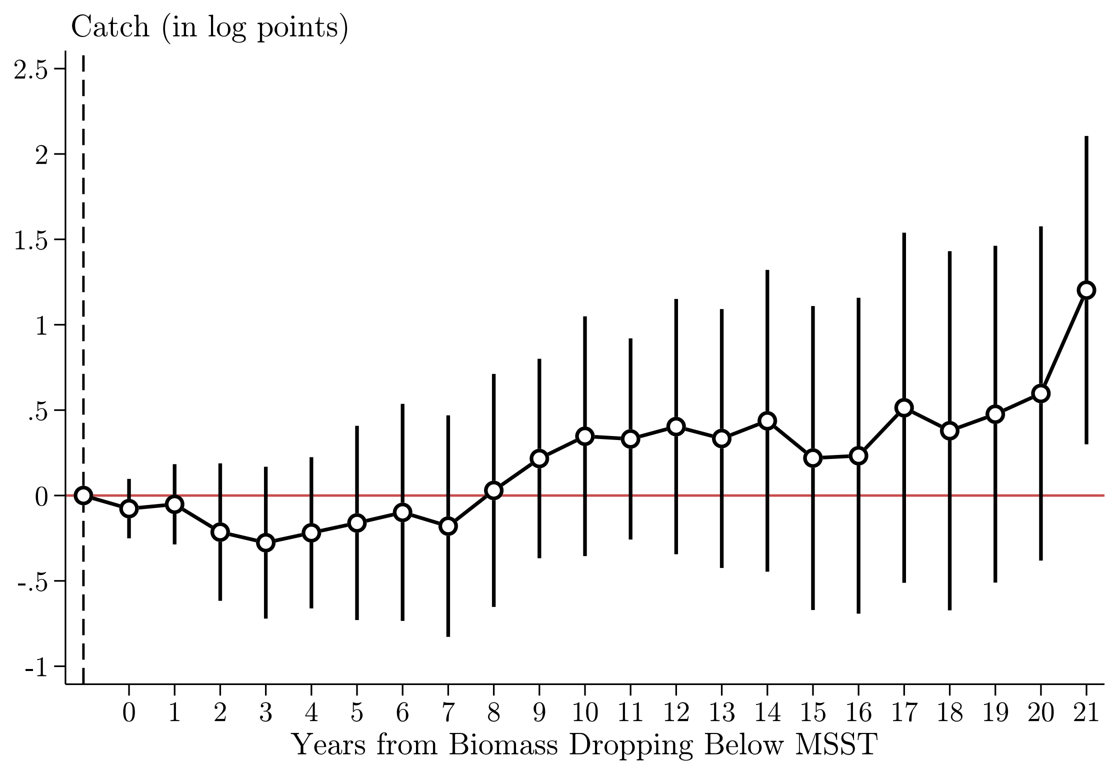
In the main text, in lieu of EU revenue data, we use three approaches to produce potential counterfactual revenue flows for each US fishery. Here, we provide additional details on how we produce each one.

For the exponential extrapolation approach, we regress the logged revenue on a time trend for each stock, from 1986 until the stock drops below their MSST. We used the estimated time trend coefficient as the average growth rate in revenue up to that point. If the coefficient is positive, we calculate an exponential decay function by using the following equation: $R_t = e^{(t-\tau)\lambda} R_{\tau=0}$. Where $R_{\tau=0}$ is the revenue at the time the biomass dropped below the MSST by, t is the year, τ is the time from the biomass dropping below the MSST, and λ is the estimated growth rate for the stock-specific regression. If instead, the growth rate is positive, then we calculate a logarithmic growth function. If we were to use an exponential growth function, revenue values would increase by orders of magnitude in just a few years. We use the following equation for the logarithmic growth function: $R_t = R_{\tau=0} + (1 - e^{-(t-\tau)\lambda}) R_{\tau=0}$.

For the simulated volatility approach, we first calculate the year-on-year changes in revenue, in relative terms: $\Delta_t = \frac{R_t - Rt-1}{R_{t-1}}$. We the calculate the mean and the standard deviation of these changes. We use those parameters and calibrate a normal distribution. Then, for each year following the biomass dropping below the MSST, we use the following equation to simulate the evolution of revenue: $R_t = \frac{R_t + R_{t-1}}{2} + \zeta_t \min\left\{\frac{R_{t-1}}{\overline{R}}, 1\right\}$. The first term is the moving average of revenue, to which we add the random draw from the normal distribution ζ_t. We multiply the random draw by a dampening effect that prevent the revenue from becoming negative. The dampening factor is either the revenue in the previous period divided by the mean revenue used to calibrate the normal distribution, if that fraction is smaller than one, or one if the revenue at time $t-1$ is larger than the mean revenue. This simply attenuate the random draw as the revenue starts to substantially decline below its historic level.

For the approach that uses the cohort-weighted DD comparison, we first estimate a modified version of Equation (1) where we estimate all lags, and combine all the leads prior to the omitted category (one year before the biomass dropped below the MSST) into one dummy variable. We plot the results from this estimation in Figure A14. Coefficients are imprecisely estimated, but suggest a decline in catch in the first eight year after the biomass fall below the MSST. In the nine years after the biomass falls below the MSST, catch begin to increase for US stocks relative to EU stocks. We use each coefficient as the inverse effect on revenue (effectively holding prices constant). This means that if we estimate that on average, five years after the biomass fall below the MSST, catch is 20 percent lower, we would assign counterfactual revenue that is 20 percent higher than what the revenue was when the in the year before the biomass dropped below the MSST (the omitted category in the regression).

Figure A14: Contemporaneous Comparison, US to EU, All Lags



Notes: A modified specification to that in Equation (1) where we include all lags, and combine all leads up to one year prior to the omitted category as one dummy variable. The regression includes stock and year fixed effects. The sample include all US stocks that got determined as rebuilt. Standard errors are clustered at the stock level.

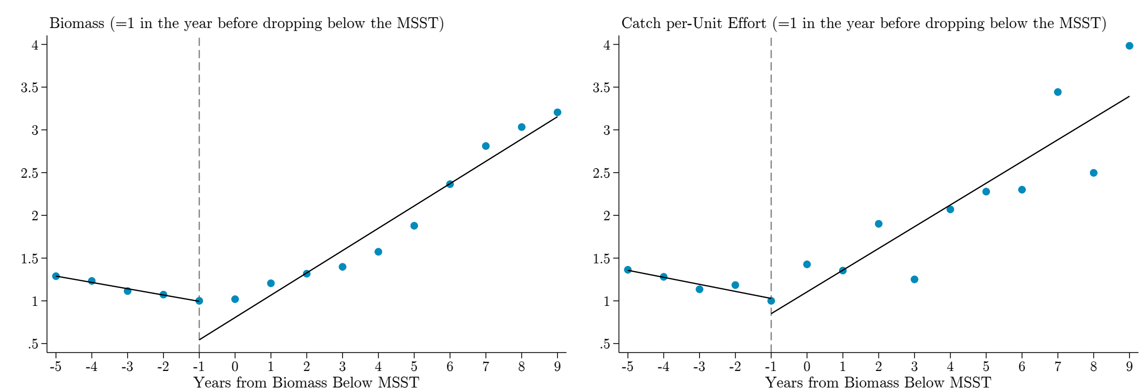
A.17 Validating Fishery Recovery is Not Driven by Assessed Biomass Modeling

Throughout the main text we use biomass to measure the policy's efficacy. One concern is the possibility that stock assessments may be somehow manipulated to create the appearance that populations are being successfully rebuilt. In part, we address this in Section A.2, where we use catch data and survey data on fish abundance to demonstrate that there is strong agreement between the inputs to a stock assessment and its output of assessed biomass (see Figure A2). A second concern is that the assessed biomass might be higher simply due to a mechanistic relationship in the population biology model between lower catch levels and higher biomass. In other words, we want to reject that the higher biomass levels are simply a product of the theoretical model used to estimate biomass. We want to ensure that they are instead capturing a true signal about the status of the fishery.

The survey data, measured as catch per unit effort (CPUE), are designed to estimate the abundance of fish in the fishery. We compare these raw data, a proxy for biomass, to biomass after a stock declines below its MSST. Our comparison focuses on the 34 stocks that have received a rebuilding plan, and for which we have balanced data on both biomass and CPUE during the 1990 to 2016 period. To simplify interpretation and comparison between biomass and CPUE, for each stock, we normalize its biomass or CPUE data to be equal to one in the year just before it drops below its MSST. In Figure A15, we plot the binned means of either biomass or CPUE, re-centered around the year of dropping below the MSST.

Figure A15: Fishery Recovery Observed in Biomass & Survey Proxy for Biomass

(a) Biomass (b) Survey Proxy for Biomass



Notes: Binscatters for scaled biomass and CPUE data for 34 balanced stock during 1990 to 2016, that dropped below their MSST and subsequently entered rebuilding. CPUE acts as a proxy for fish abundance and is used in the assessment process as a key input in order to assess the stock's biomass.

Both biomass and CPUE exhibit a strong recovery, preceded by a slight downward trend prior to falling below the MSST (Figure A15). The fact that CPUE also increases suggests the increase in assessed biomass is not simply an artifact of the assessment process. On average, biomass increases threefold, while CPUE almost quadruples, in the 10 years after the event. These increases in magnitudes are meaningful; potentially highlighting the importance of using additional inputs (such as catch) as well as population biology to determine the stock's status (its biomass).

A.18 Addressing Changes in Environmental Conditions

Environmental conditions are in constant flux in both the Pacific and Atlantic oceans due to known climatic oscillations, as well as stochastic perturbations (Chavez et al. 2003; Vert-pre et al. 2013; Overland et al. 2010).[27] A key concern for our study is that more beneficial environmental conditions could be increasing fish populations. If the main reason stocks declined below their MSST was poor environmental conditions, caused by either long-term climatic oscillations or short-term shocks, then a reversal of the oscillations or return to baseline would lead to higher levels of biomass. If these conditions are more common today, and more common in the US than in the EU, then these variables could be driving our results.

The full interaction of environmental conditions with each stock is a complex function, however, we can observe an important proxy of stocks' recovery: productivity of the stock, also referred to as recruitment.[28] Explicitly, we can calculate the recruitment per-unit of fish biomass (hereafter, recruitment per-biomass). If recruitment per-biomass is increasing over time, especially after 1996, then it could be the main mechanism responsible for the observed improvement in biomass.

We do not observe an increase in recruitment per-biomass over time. Instead, we observe the opposite—recruitment is declining on average. Lower recruitment per-biomass in recent years suggests it should be harder for stocks to recover after being overfished. In Figure A16a, we plot the recruitment per-biomass over time for each of the 133 stocks for which we have both recruitment and biomass data. We include the average across stocks in each year (orange line), as well as linear fits before MSA reauthorization (1976-1996) and after reauthorization (after 1996), with or without residualizing on stock fixed effects (green and dark purple line, respectively).

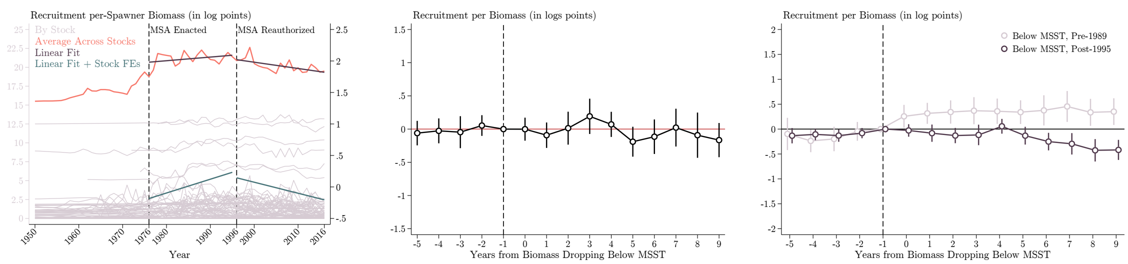
We repeat the contemporaneous and historical analysis with recruitment-per-biomass as our outcome variable. In both cases, we find that the recruitment-per-biomass ratio remains stable around the event of interest until biomass begins to recover, overtaking any growth

[27] Examples for known oceanic oscillations in the northern hemisphere are El Niño–Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), and the Arctic Oscillation (AO).

[28] Recruitment is often measured as a quantity of juvenile fish within a particular fish stock during a given year. Changes to habitat, upwelling, primary productivity, food availability, predators and temperature can all impact recruitment.

Figure A16: Assessing Changes in Stock Growth Dynamics

(a) Trends in Recruitment Dynamics (b) Contemporaneous Comparison (c) Historical Comparison



Notes: In Panel (a), each gray line (left y-axis) corresponds to recruitment per-biomass of one stock over time. The coral line (right y-axis) is the average across stocks in each year. The linear fit lines (right y-axis), in dark purple and dark teal, are estimating a simple linear trend model either between 1976 and 1996, and post-1996. The dark teal line fits the recruitment per-spawning biomass after residualizing them on stock fixed effects. Panel (b) repeats the contemporaneous DD estimation as in Figure 3a, and Panel (c) repeats the paired differences between the same stocks in the historical comparison group as in Figure 3c.

in total recruitment (Figures A16b and A16c). In other words, more beneficial environmental conditions are not driving increases in biomass because recruitment-per-biomass it not differentially higher for stocks in the US relative to the non-US stocks or historical US stocks.

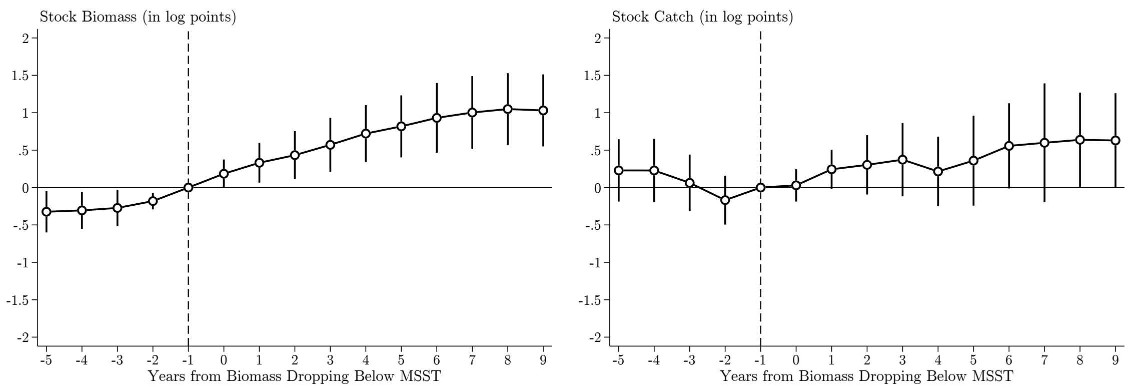
Potential explanations to the finding that recruitment declines for treated stocks are outside the scope of this paper to evaluate. One explanation could be due to a permanent decline in productivity due to changing environmental conditions (Free et al. 2019; Pershing et al. 2015), especially for US New England stocks. Another explanation could be due to fishers' behavioral responses that lower stock productivity. When a stock goes into rebuilding, the annual quota is reduced, potentially creating a "race to fish" before the total allowable catch (TAC) for the fishery is reached, compressing the fishing season. This short-term compression of fishing effort has been empirically documented in US fisheries, and "the race to fish" is linked to detrimental fishing practices that destroy habitat and increase bycatch (Birkenbach et al. 2017; Costello et al. 2008; Essington 2010; Gordon 1954; Huang and Smith 2014).

A.19 Event-Study Results for the Paired Differences Estimation

In the main text, we report a summary of the paired difference results in Table 2. Here, we present the full event-study coefficients for biomass and catch. The results for biomass (Figure A17a) show that compared to the years before rebuilding plans were required, stocks have more than doubled in biomass in the years after falling below the MSST. For catch, we note that in the pre-event period, catch levels are not systematically different, suggesting that that are no large changes to the demand for those stocks that might explain the recovery following the event.

Figure A17: Paired-Differences Event Study Estimation Results

(a) Biomass (b) Catch



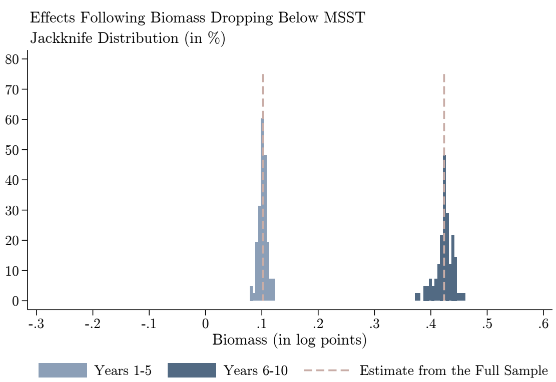
Notes: Estimation results showing coefficients and 95% CIs for the specification in Equation (2). Standard errors are clustered at the stock level.

A.20 Examining Sensitivity to Outliers by Using Leave-One-Out Estimation

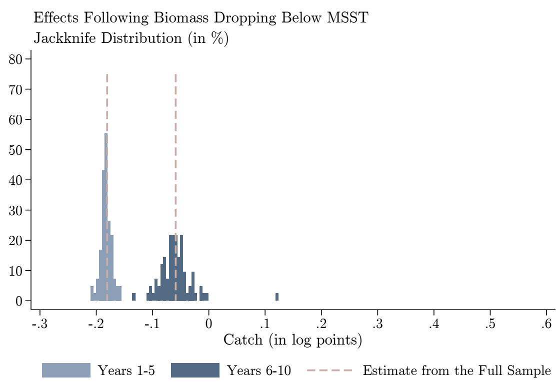
Extreme outliers in either the treated sample or the comparison sample could have a large influence on the results. In Figure A18, we repeat the estimation by leaving one stock out of the sample each time. Overall, the jackknifing distributions are narrowly centered around the estimated coefficient from the full sample (those reported in Table 1).

Figure A18: Contemporaneous Comparison Jackknifing Estimation Results

(a) Biomass



(b) Catch

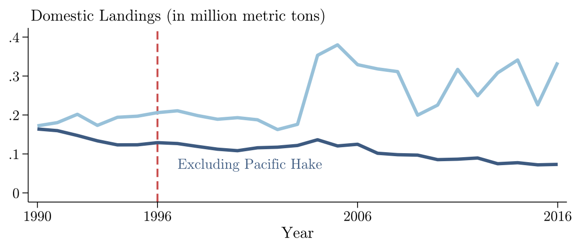


Notes: Repeating the estimation reported in Table 1, column 2, while excluding one stock from the sample in each iteration.

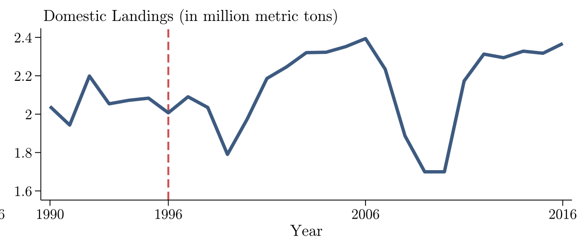
Figure A19: Substitution Through Increased Imports

Domestic Landings of Stocks, by Rebuilding Status

(a) Ever in Rebuilding Stocks

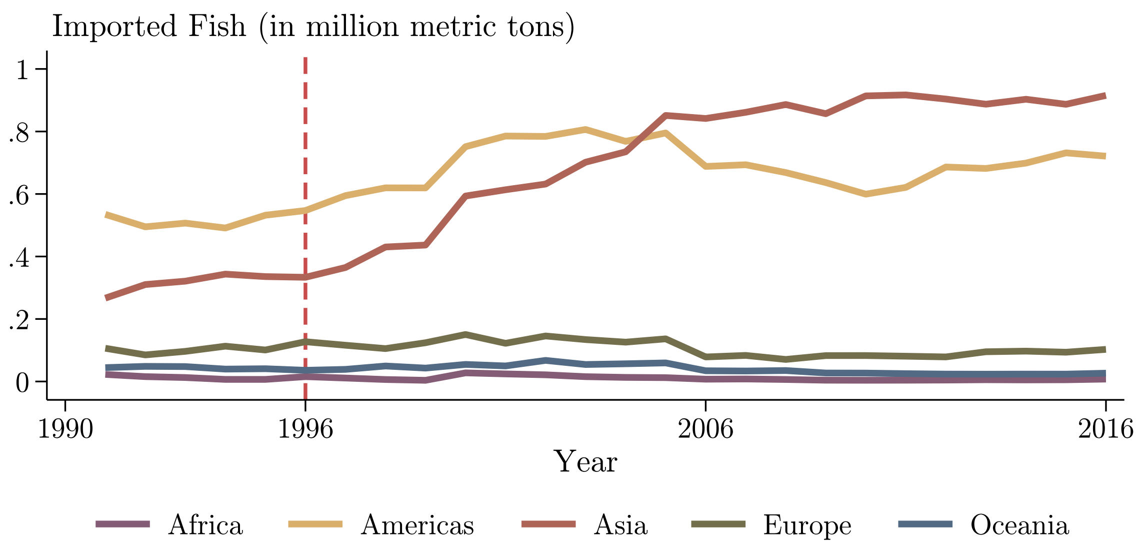


(b) Never in Rebuilding Stocks

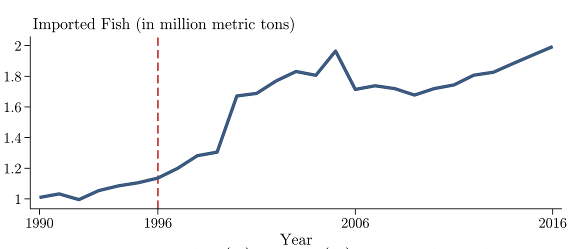


Imports of Fish to the United States

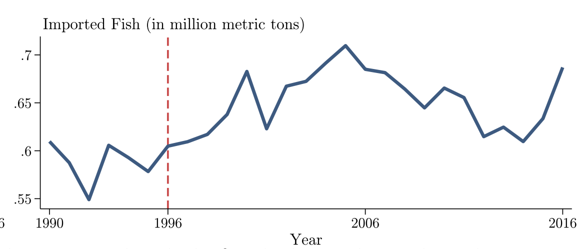
(c) Imported Fish (COMTRADE) by Continent



(d) Imported Fish (COMTRADE)



(e) Imported Fish (FishStats)



Notes: In Panels (a) and (b), we plot the total amount landed, for balanced stocks, that ever or never entered rebuilding during our sample period. In Panel (c), we plot the total amount of imported fish, as recorded in the COMTRADE database ,by different regions. In Panel (d), we aggregate all fish imports in the UN-COMTRADE database, and compare those to imports of specific fish species, which more closely align with the species that we focus on in the analysis, as recorded in the FAO FishStats database.

Online Data Appendix

B.1 US Data

B.1.1 Times Series and Reference Point Data

We sourced US stock biomass, catch, fishing mortality, and recruitment (productivity) data from NOAA's Stock SMART (Status, Management, Assessments, & Resource Trends) database. Stock SMART collects its data from stock assessments. As of October 2021, Stock SMART contained data for 311 stocks.

Stock SMART's database is incomplete, resulting in stocks with missing time series, missing biological reference points, and mismatched units between the time series and reference point data. To fill in these gaps in data, we performed the following steps when encountering a stock with one or more of these issues. First, we would search through the stock assessment report published by the responsible scientific agency for the missing data. If the missing data was not found in the assessment report but the report alluded to its existence, we would then contact the stock assessors and request the missing data. Once the data was found or provided, we would populate the missing values in our dataset (see "Stock documentation and data cleaning.csv" for all manual entries and unit conversions). When a stock's biological reference point did not match the units of its time series data, such as a stock's MSST and its biomass time series, we would convert the reference point to match the units of the time series data.

A single stock can have multiple stock assessments over time, where each new stock assessment may supplement or completely update the time series and reference point data from the previous stock assessment. Stock SMART collects the data from stock assessments as far back as 2005. However, stock assessments do exist prior to 2005. In this study, we used the most recent stock assessment to use for each stock, unless it had limited data availability. In some cases, we chose an older assessment if it had a longer time series of data or possessed a variable (such as catch) that the newer assessment lacked. See "Stock documentation and data cleaning.csv," in the supplementary files for the specific assessment year's data we used for each stock in the study.

Choosing one stock assessment also means we are using the set of reference points (MSY, B_{MSY}, MSST, and F^{MSY}) that were calculated and reported in that assesssment, and applying them to the time series of the stock. This decision leaves reference points constant for the entirety of a given stock's time series. The implication is that the MSST reference point may not reflect whether the MSST was crossed in an earlier period of a stock's time series, due to changes in fishery selectivity, weight at age, maturity at age, or natural mortality.

Constructing a dataset that reflects annual changes in reference points over a stock's entire time series is currently not viable due to a lack of readily available data, especially prior to 2005. In some cases, reference points are reported in different units that cannot be easily converted from one type to another. For example, one assessment could report a B_{MSY} value in kilograms per tow (reflecting reliance on survey data and potentially no population biology model), whereas a subsequent assessment might report B_{MSY} in metric tons. In more extreme examples, one assessment can report the reference point in eggs, and another assessment in the number of individuals or in metric tons.

In addition to time series data from Stock SMART, we compile a time series dataset of stock survey data from NOAA's Distribution Mapping and Analysis Portal. Biomass time series data reported from Stock SMART are typically the output of a model used in a stock assessment to estimate a stock's biomass. An input of these models is, among other collected data, survey data. Survey data are gathered via bottom trawl surveys, where a research boat (a trawler) will go fishing. Researchers use the same boat and gear and will fish at the same time every year. They also grid off the ocean and trawl the same number of times in each grid. They will catch, identify, measure, and dissect the fish. Bottom trawl surveys provide data for stocks such as length, age, gender, and diet. The total amount of a particular stock captured during these surveys is a preliminary measure of its abundance, typically measured in kilograms per tow. We use survey data to validate that the stock assessment data does not deviate significantly from observed data.

B.1.2 Landings and Revenue Data

US landings and revenue data were collected from NOAA's Fisheries One Stop Shop (FOSS) Landings System database. FOSS reports annual commercial and recreational landings and revenue data at the stock-region and stock-state levels sourced from regional partners that collect these data. Landings are the amount of fish of a particular species that are sold. Landings data is required to be reported by permitted dealers who buy the fish. This is different from catch, which includes landings, bycatch, and discards, and is estimated from the stock assessments. For some fisheries, third-party observers are placed with dealers and on fishing boats to verify landing and catch data, including discards and bycatch.

B.1.3 Management Determination Data

We compiled data on when stocks were declared overfished or entered a rebuilding plan primarily from NOAA's Status of Stocks (SOS) reports. These annually released reports list changes in determination statuses for stocks across each fishery management council, namely, experiencing overfishing, approaching overfished, overfished, entering rebuilding, currently in rebuilding, and determined rebuilt. We convert these SOS reports into a time series for each of these statuses, then merge this dataset with the stock data we collected from Stock SMART. In addition, we verified our stock status data with internal documents obtained from NOAA, specifically for the earliest SOS reports, which used the overfishing and overfished determinations interchangeably. These documents also allowed us to verify the original rebuilding plan lengths for stocks which were determined overfished and required a rebuilding plan. These original rebuilding plan lengths may differ from the length the actual rebuilding plan had. It is worth noting that our data on stock status is more accurate than what is available in public records. Our quality assurance process resolved several inaccuracies that were never corrected in publicly available records.

B.1.4 Catch Limit Data

We use annual catch limit (ACL) data to examine fishers' compliance with these annual quotas of each stock, as well as management's setting of precautionary buffers between MSY and ACL. We recorded ACL data by stock and year from each FMC. North Pacific ACL data was sourced from NOAA's Alaska Catch Accounting System, which provides values for groundfish stocks in the Bering Sea/Aleutian Islands and Gulf of Alaska. Regional fishery management councils and science centers provided ACL data for Pacific groundfish stocks and ACL data for both New England and Mid-Atlantic stocks. ACL data for South Atlantic and Gulf of Mexico stocks were taken directly from the NOAA Fisheries Southeast Region Annual Catch Limit (ACL) Monitoring website, which provided ACL data along with each stock's commercial and recreational landings data.[29] Lastly, we verified and filled gaps in the dataset using ACL data obtained through from a FOIA request to NOAA.[30]

[29] https://www.fisheries.noaa.gov/southeast/sustainable-fisheries/southeast-region-annual-catch-limit-acl-monitoring. Accessed: 10/31/2022

[30] FOIA request number is DOC-NOAA-2022-001089

B.1.5 Observer Coverage & Violations Data

We collected data via the Freedom of Information Act for NOAA's Office of Law Enforcement (OLE) and various observer programs. Unfortunately, individual citation data was not available before 2014, and most of the 2014-2016 data was spotty, and could not match it to a particular stock.

We found it was impossible to match observer programs to specific stocks for most stocks. Methods for allocating observers changed from year-to-year and realized observer coverage was even harder to collect. The only complete dataset we were able to collect was the annual total number of vessel observers and total funding (from federal and industry sources) from 2005 to 2016. During this time period, the number of observers doubled, and funding increased by 39 percent (not reported here).

B.1.6 Fuel Prices and Climate Indices Data

Fuel data comes from the US Energy Information Administration (EIA) database, which has retail prices of diesel fuel in dollars per gallon from 1978-2020. Climate data includes climate indices from three sources covering different regions. For the US Atlantic coast, we use monthly North Atlantic Oscillation (NAO) values from 1951-2021. To merge the NAO with our yearly time series, we take the average from December to March for each year. For the Pacific coast, we use the El Niño/Southern Oscillation (ENSO) index by taking the annual average of its monthly index values from 1980-2021. Lastly, for the North Pacific US, we use yearly averages of monthly Arctic Oscillation index (AO) from 1951-2021.

B.2 EU Data

B.2.1 Time Series and Reference Point Data

EU time series and reference point data is primarily sourced from the Common Fisheries Policy monitoring report from 2020. This report compiled the time series and reference point data for Northeast Atlantic stocks reported by The International Council for the Exploration of the Sea (ICES) Stock Assessment Database, and for Mediterranean stocks reported by the EU's Scientific, Technical and Economic Committee for Fisheries database, and FAO's validated stock assessment forms.

B.3 Defining Pseudo MSST Values

Some stocks in our EU dataset did not have MSST-equivalents. (The EU MSST equivalent was the Safe Biological Limit, SBL.) Reasons for this absence are typically due to a lack of sufficient data to calculate values on which MSST is based, namely B_{MSY} and MSY. For stocks missing their MSST or MSST-equivalents, we calculated a pseudo MSST value. First, a B_{MSY} proxy equal to 50% of the stock's maximum historical biomass (in cases where the B_{MSY} is also absent) was created. Then, The pseudo MSST was defined as half of this proxy value. If a stock had a B_{MSY} value already, we simply took half of this value and set it as our pseudo MSST. For the US, we constructed pseudo MSSTs for 66 stocks, of which 28 stocks have their biomass drop below their pseudo MSST. For EU stocks, we created 142 pseudo MSSTs, and 64 of those stocks' biomass dropped below their pseudo MSST.

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