

Fishing Bans in Chinese Waters: Effectiveness and Spillovers

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February 11, 2025

ADEA-QUT Conference

Fisheries & Aquaculture

Approximately
1 in 10
PEOPLE
rely on fisheries
and aquaculture for
their livelihoods.



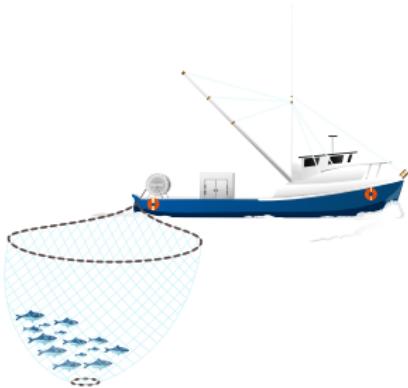
FISH STOCKS

71% of the commercially important marine fish stocks monitored by FAO
are fished within biologically sustainable levels (2011)

10%
Under-fished

61%
Fully fished

29%
Over-fished





Regulating Fishery:

- ▶ Large number of small-scale fishing vessels
- ▶ Vast ocean, hard to patrol
- ▶ Inter-jurisdictional spillover

In This Paper

- ▶ China's Seasonal Fishing Bans:
 - China is by far the largest country in fisheries
 - Implemented the first large-scale seasonal fishing ban
- ▶ Questions:
 - Does the fishing ban work?
 - Scope for international policy coordination?
- ▶ Empirical Challenges:
 - Measurement
 - Causal Identification

How?

- ▶ Main Data: Remote Sensing Imageries
 - Boat detections at night
 - Near global coverage
 - High frequency: nightly
- ▶ Empirical Approaches:
 - RD in Time
 - Spatial RD in Density
- ▶ Other Data:
 - Global Fishing Watch: Data derived from AIS signals
 - NASA Ocean color: oceanographic conditions

Related Literature

► Remote sensing data

- Chen & Nordhaus (2011); Henderson, Storeygard, and Weil (2012); Hodler & Raschky (2014); Donaldson & Soreygard (2013); Axbard (2016); Marx, Stoker, and Suri (2017); Burgess, Costa, and Olken (2017); etc.

► Fisheries & Piracy

- Besley, Fetzer, and Mueller (2015); Flückiger & Ludwig (2015); Axbard (2016); Kroodsma et al. (2018)

► My contributions:

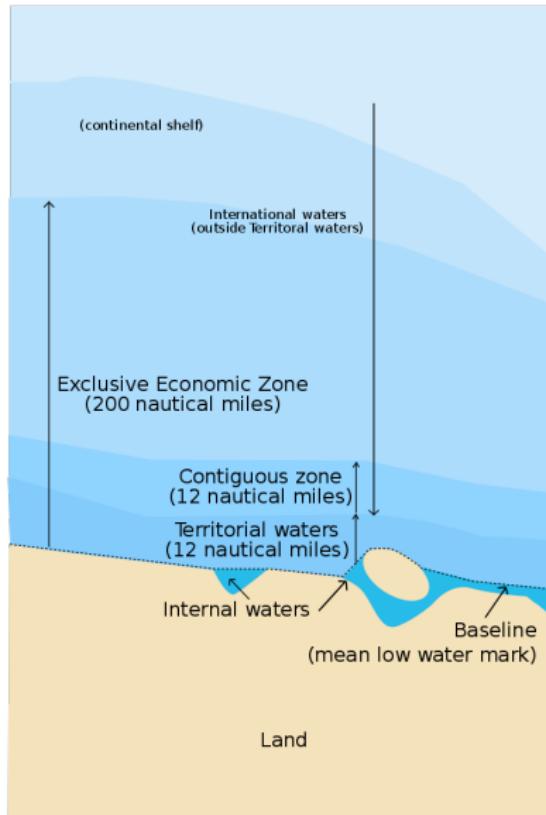
- Use novel data from the new generation weather satellite program to look at China's seasonal fishing ban: effectiveness & spillovers

Main Results

- ▶ Effectiveness:
 - 72% reduction in boat detections within China's EEZ during bans
 - Sharp increase post-ban
 - Compliance weakens over time
 - Areas with favorable fishing conditions show higher non-compliance
- ▶ Spillovers:
 - Decline in boat detections in neighboring EEZs during China's bans
 - Evidence of Chinese boats operating abroad and foreign boats in China's EEZ

Exclusive Economic Zone (EEZ)

- ▶ 200 nautical mile (\approx 370 km) from baseline
- ▶ A coastal state has sovereign rights below the surface of the sea, including marine resources.
- ▶ GIS Data of EEZ boundaries:
 - MarineRegions.org
 - World EEZ v8
- ▶ Disputed areas are excluded in this study.



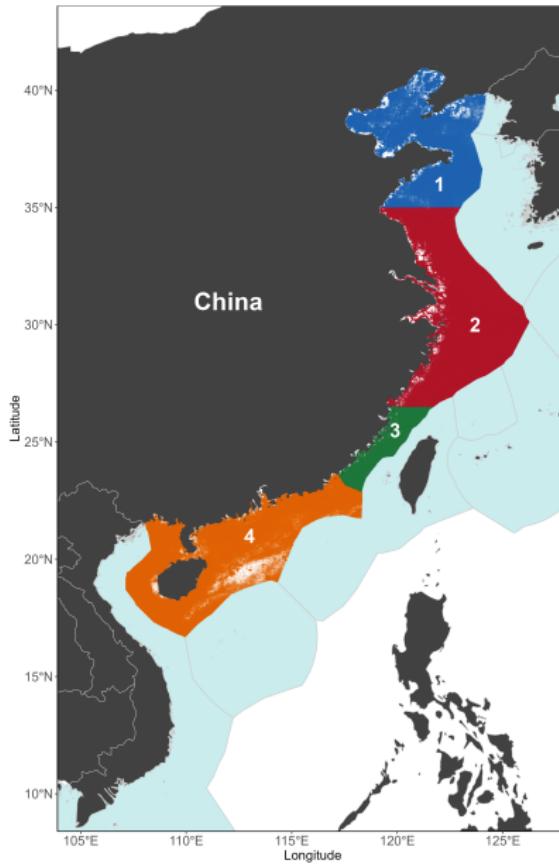


Google Earth

Imagery © 2015 DigitalGlobe,
DODSS, NOAA, USGS, NAVFAC, GIBCO

Imagery Date: 12/14/2015 22°16'13.55" N, 50°42'11.86" E elev -5139 m eye alt 7239.72 km

Zones of Fishing Ban



Duration of Fishing Bans

#	Zone Description	2009 – 2016		2017 – 2018	
		Start	End	Start	End
1	Northern Yellow Sea	June 1	Sep. 1	May 1	Sep. 1
2	Southern Yellow Sea & Northern East China Sea	June 1	Sep. 16	May 1	Sep. 16
3	Southern East China Sea	May 16	Aug. 1	May 1	Aug. 16
4	Taiwan Strait & South China Sea	May 16	Aug. 1	May 1	Aug. 16
		May 16	Aug. 1	May 1	Aug. 16

Number of Seafaring Fishing Vessels by Size

	Number		Tonnage	
Less than 12 meter	186,781	68.6%	882,361	10.0%
12 meter to 24 meter	49,697	18.2%	1,919,347	21.8%
24 meter or longer	35,844	13.2%	5,989,801	68.1%
Total	272,322	100%	13,838,949	100%

Defense Meteorological Satellite Program (DMSP)

Operational Linescan System (OLS)

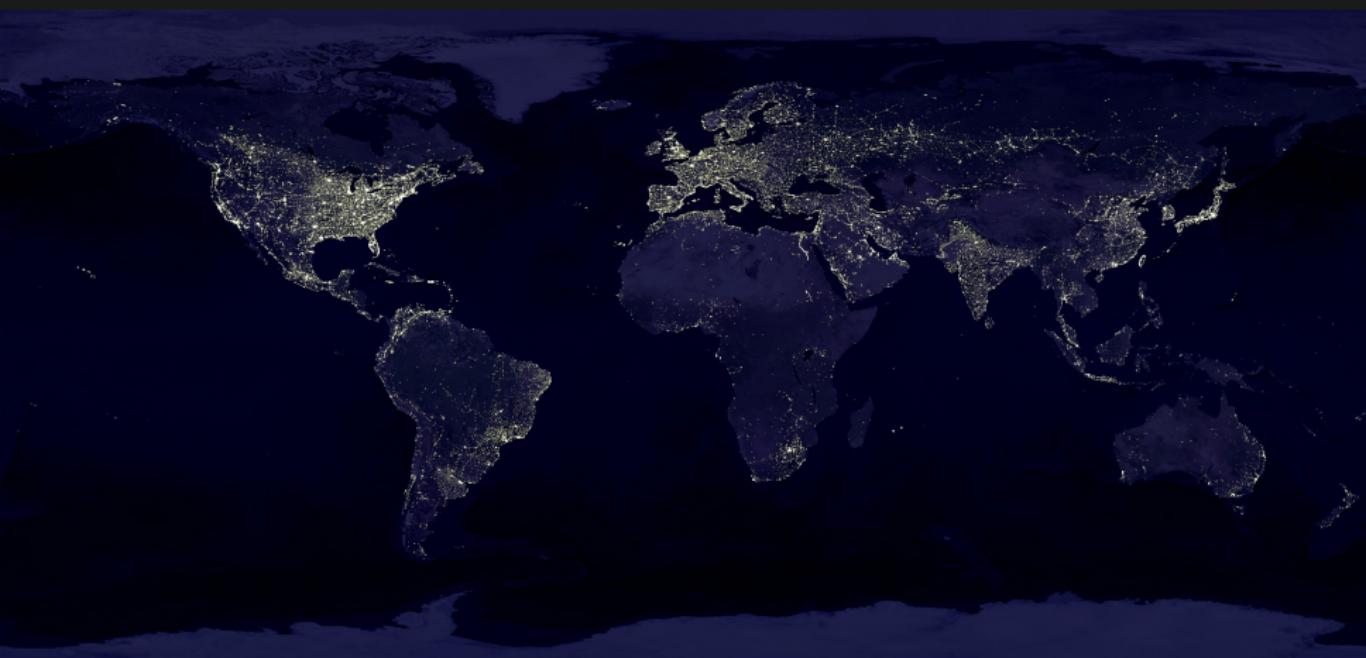


Photo Source: NASA

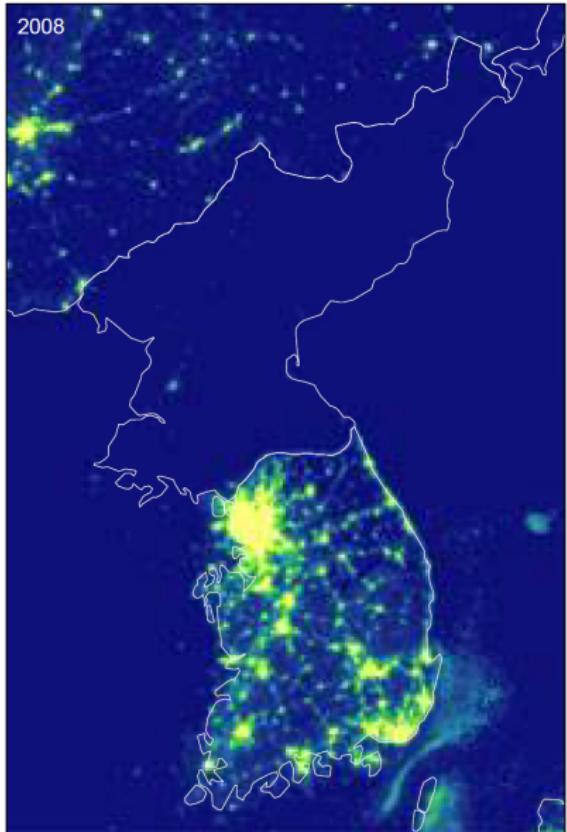
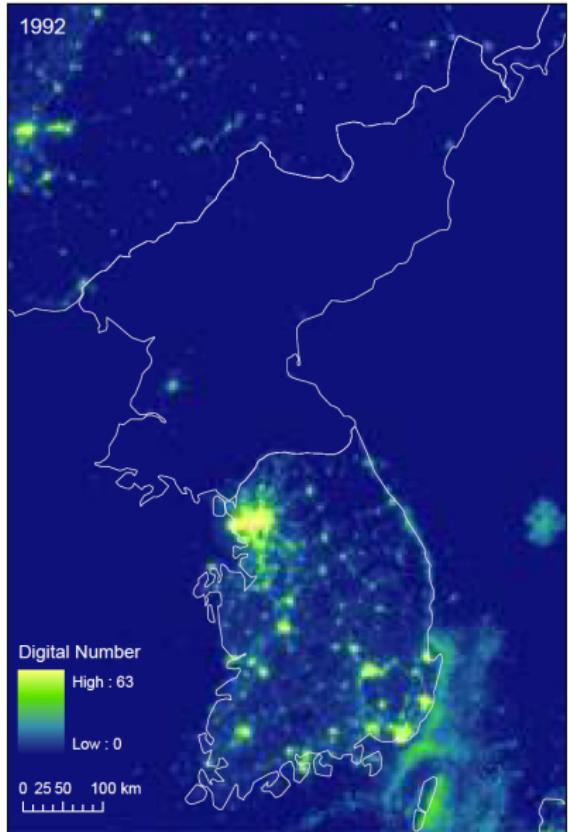
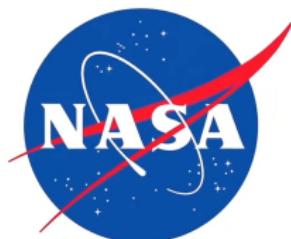


FIGURE 2. LONG-TERM GROWTH: KOREAN PENINSULA

Henderson, Storeygard, and Weil (2012)

Suomi National Polar-Orbiting Partnership Satellite

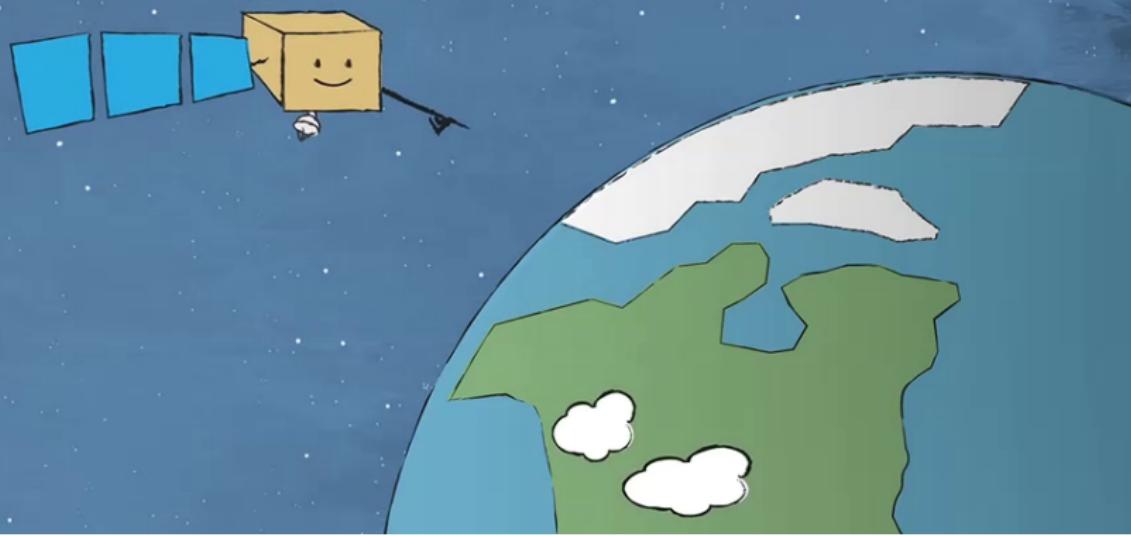
- ▶ New generation weather satellite launched on October 28, 2011
- ▶ Polar-Orbiting
- ▶ Better sensors: VIIRS



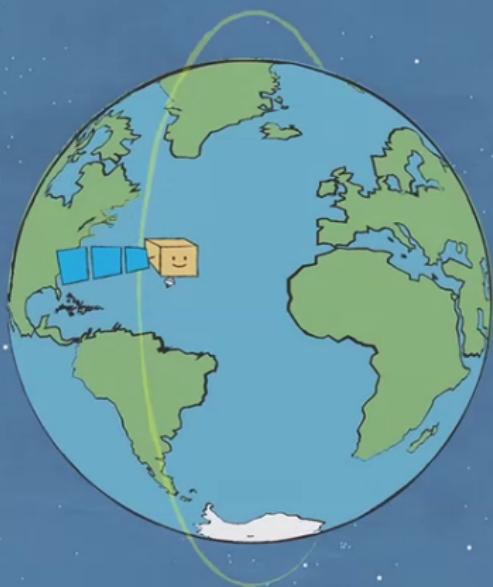
National Oceanic and Atmospheric Administration

U.S. Department of Commerce

Suomi National Polar-Orbiting Partnership Satellite



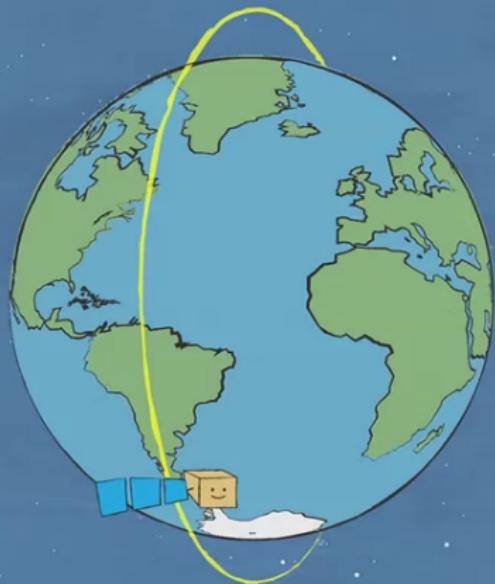
Suomi National Polar-Orbiting Partnership Satellite



Suomi National Polar-Orbiting Partnership Satellite



Suomi National Polar-Orbiting Partnership Satellite



Polar
Orbit

Suomi National Polar-Orbiting Partnership Satellite



Polar
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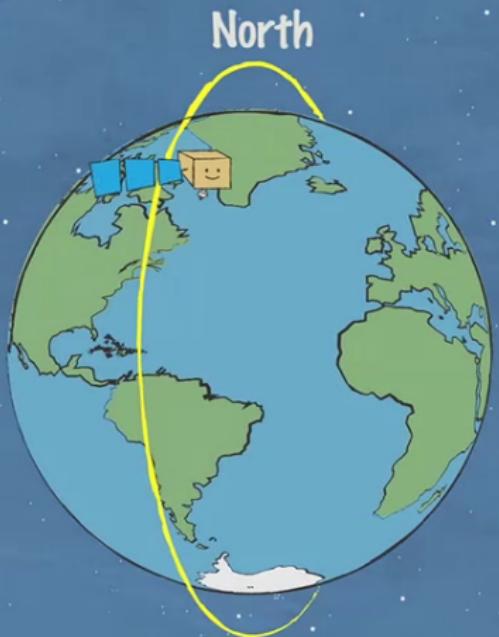
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Suomi National Polar-Orbiting Partnership Satellite



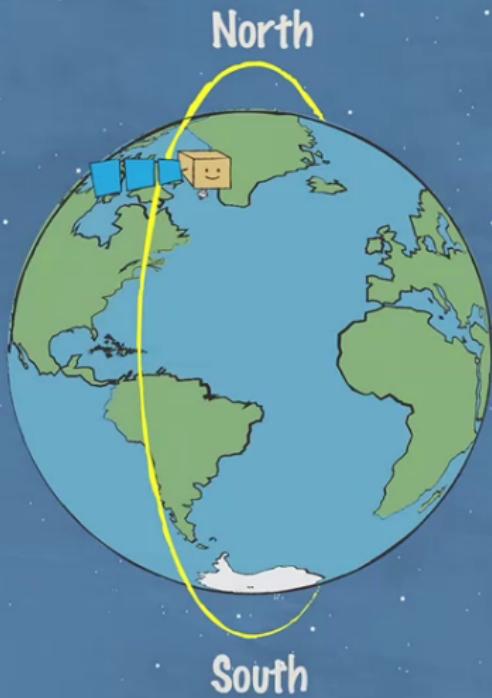
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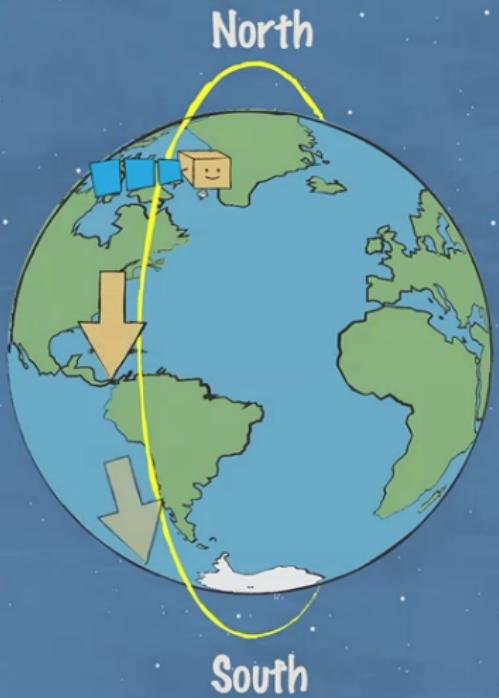
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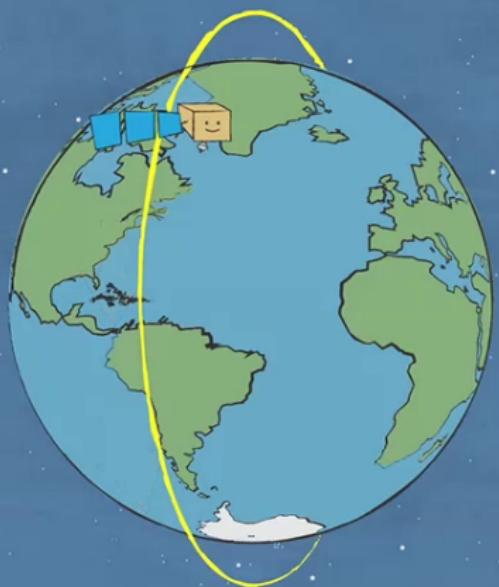
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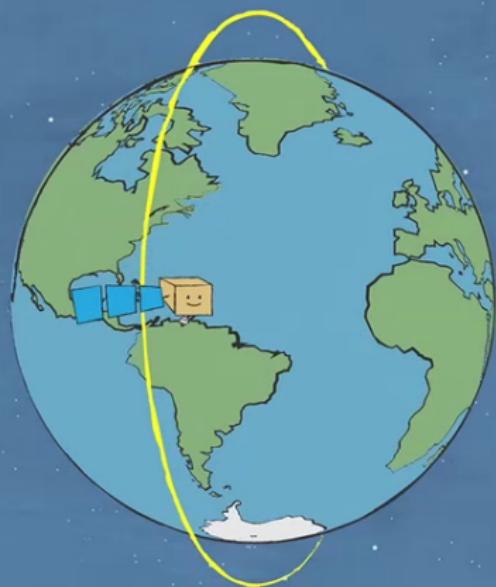


Polar
Orbit

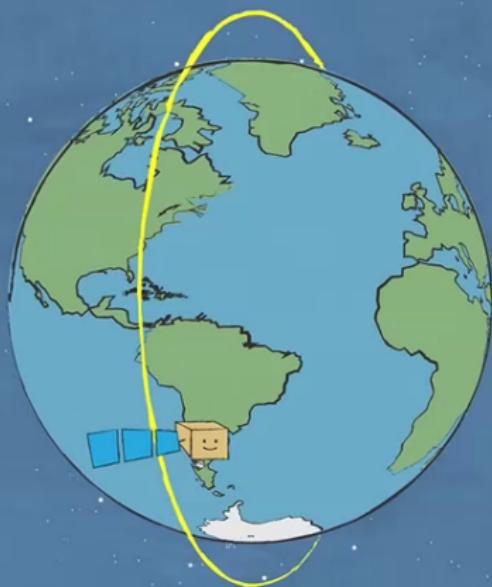
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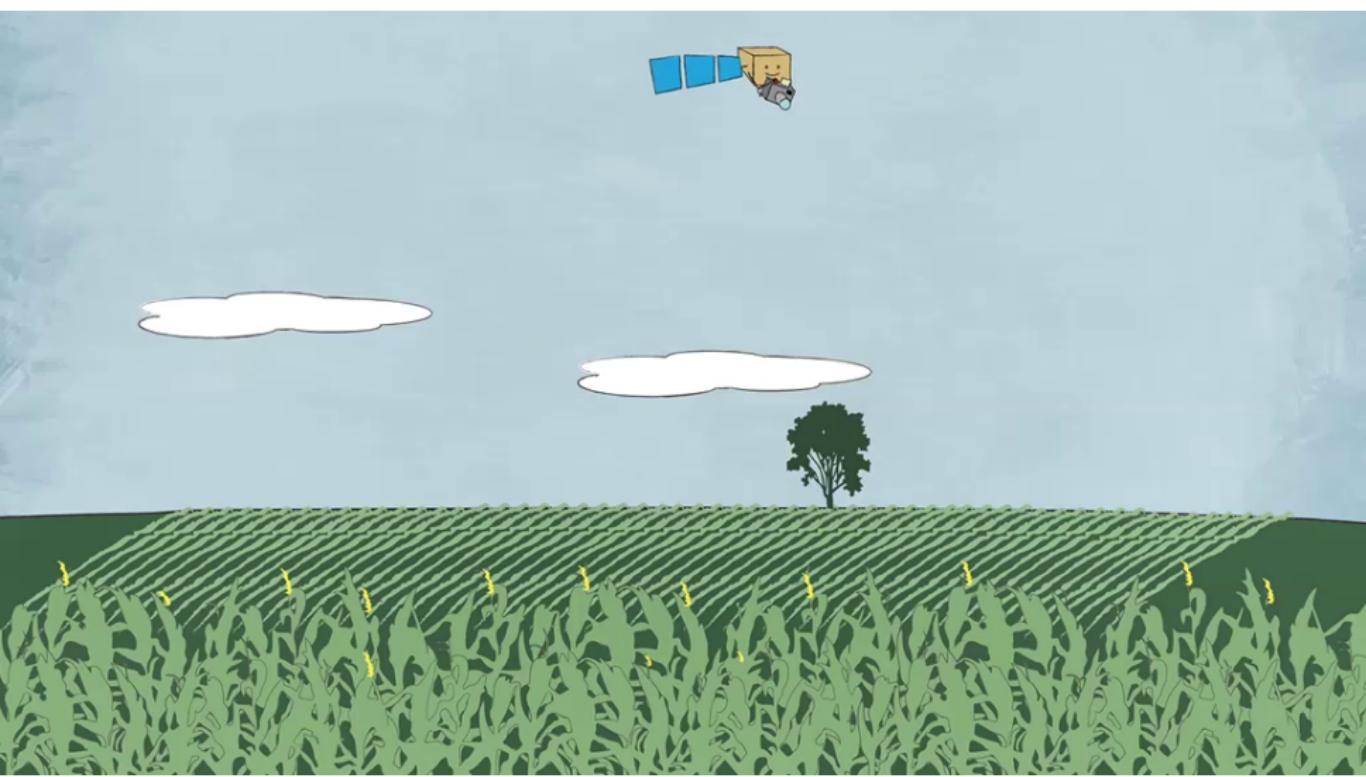
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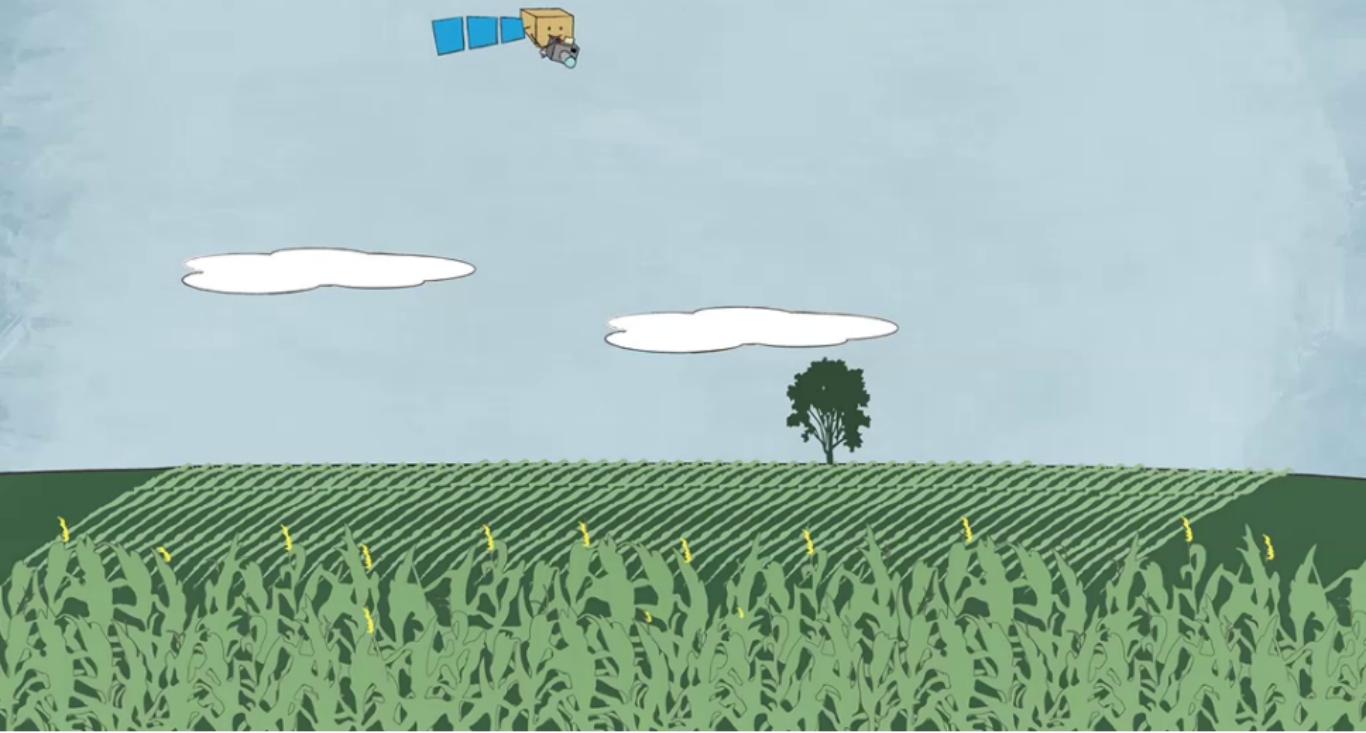
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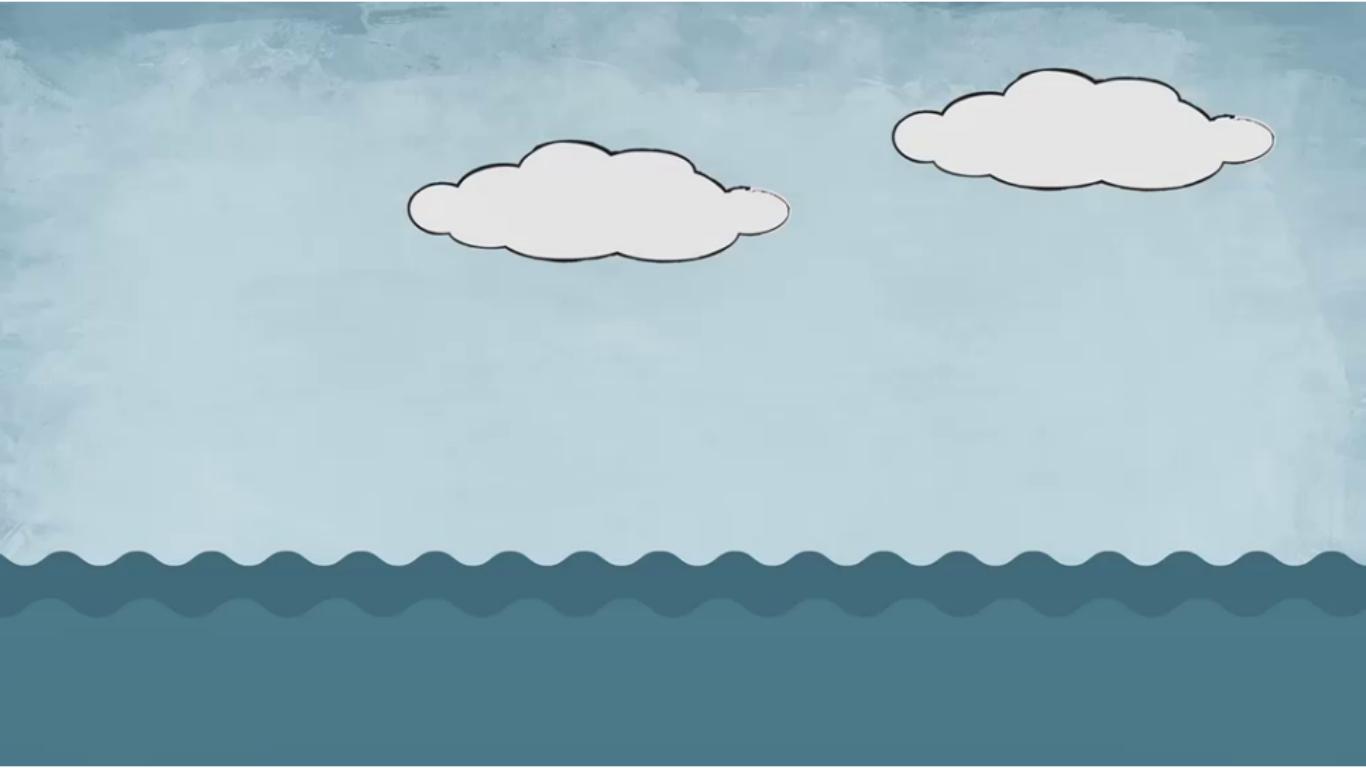
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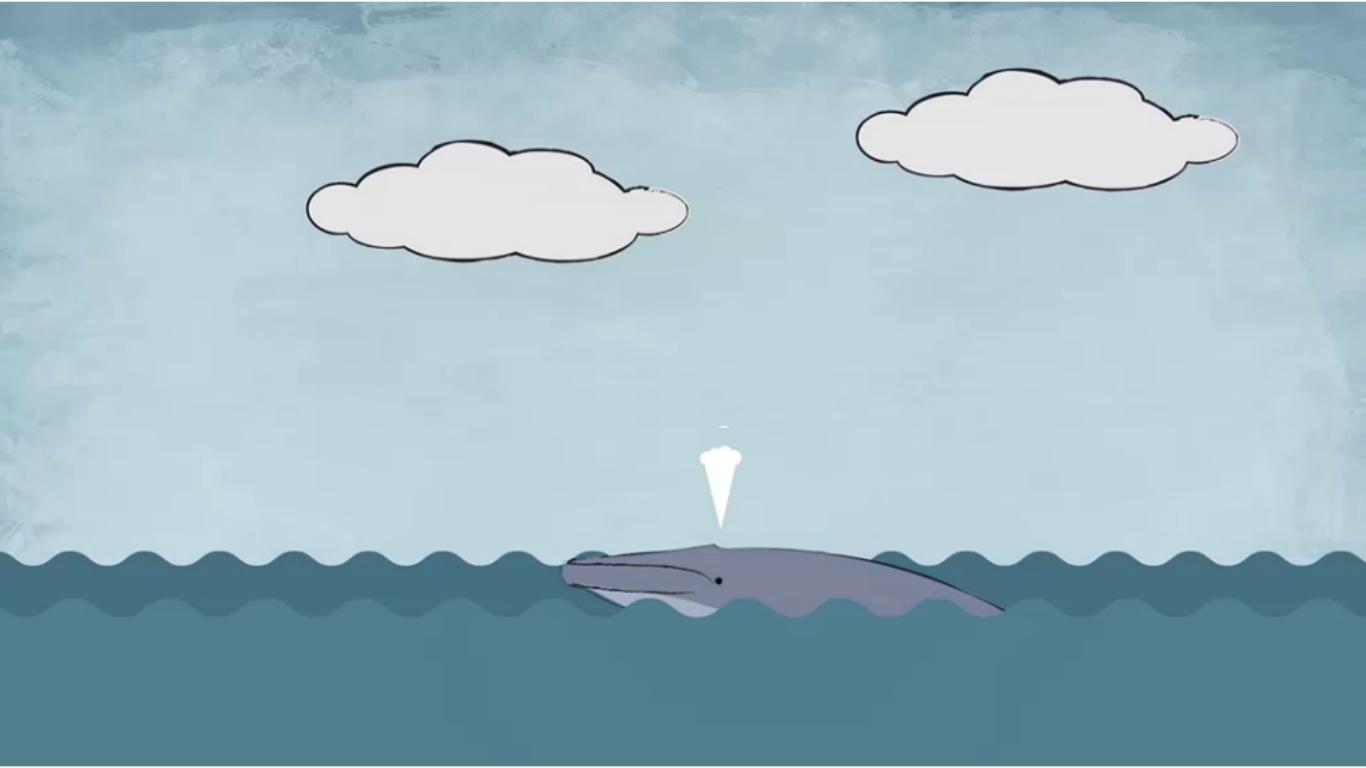
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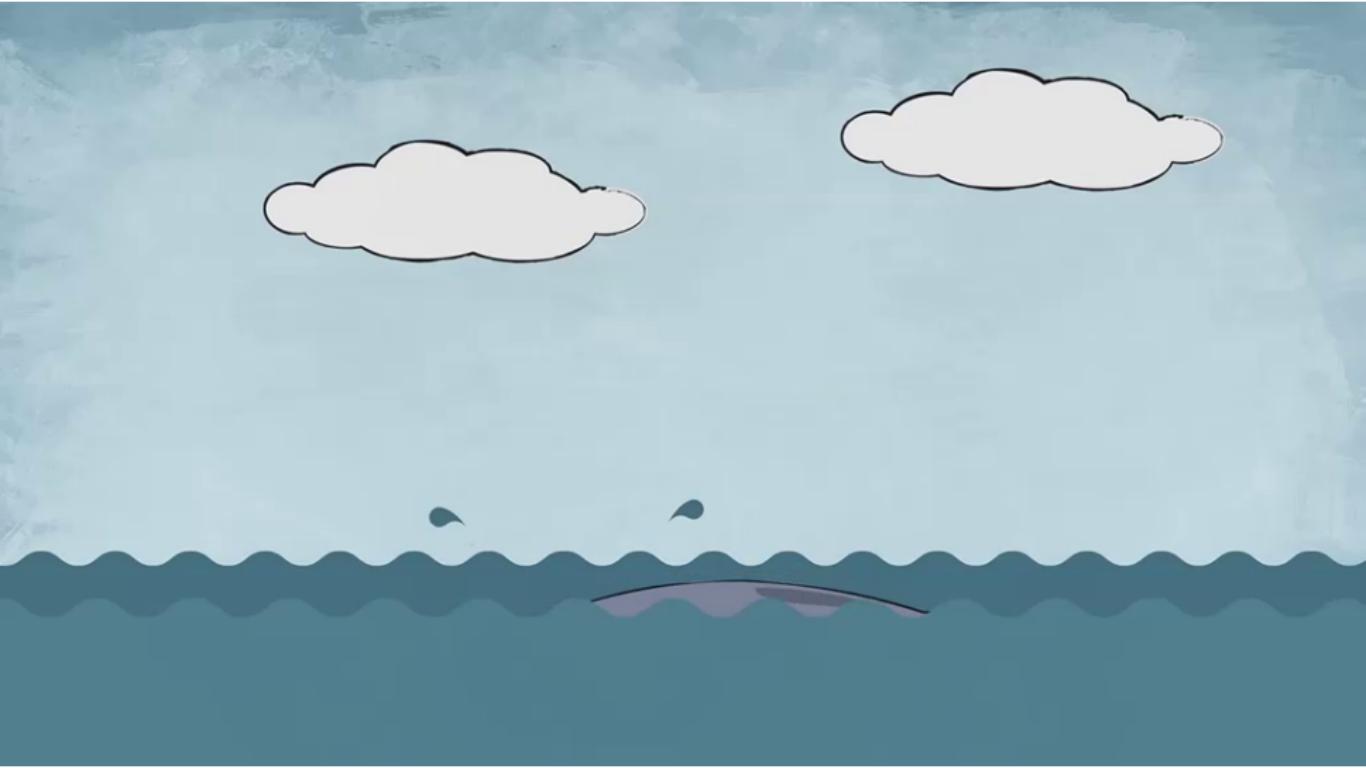
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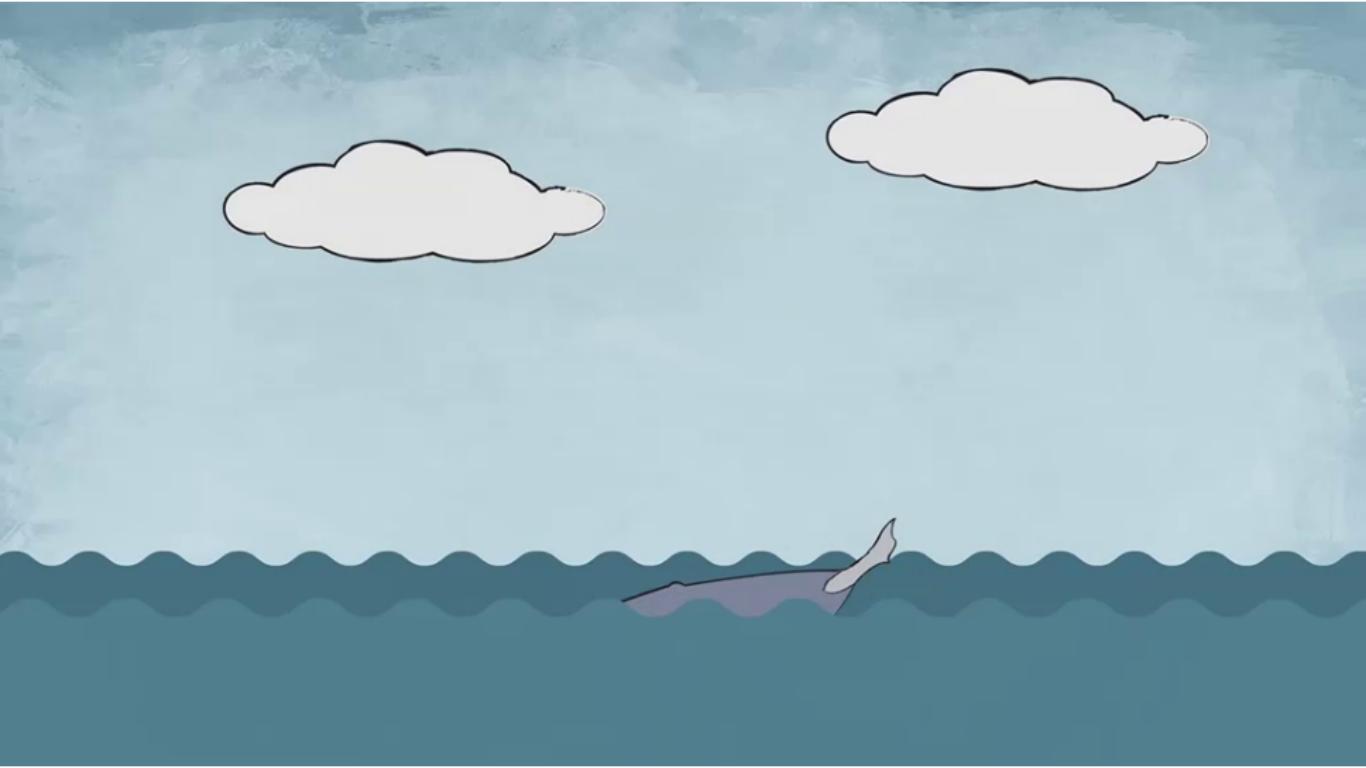
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Suomi National Polar-Orbiting Partnership Satellite



Suomi National Polar-Orbiting Partnership Satellite

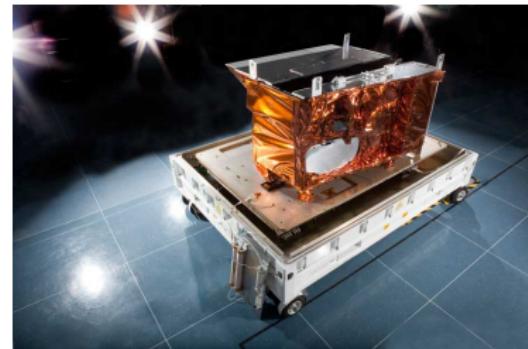


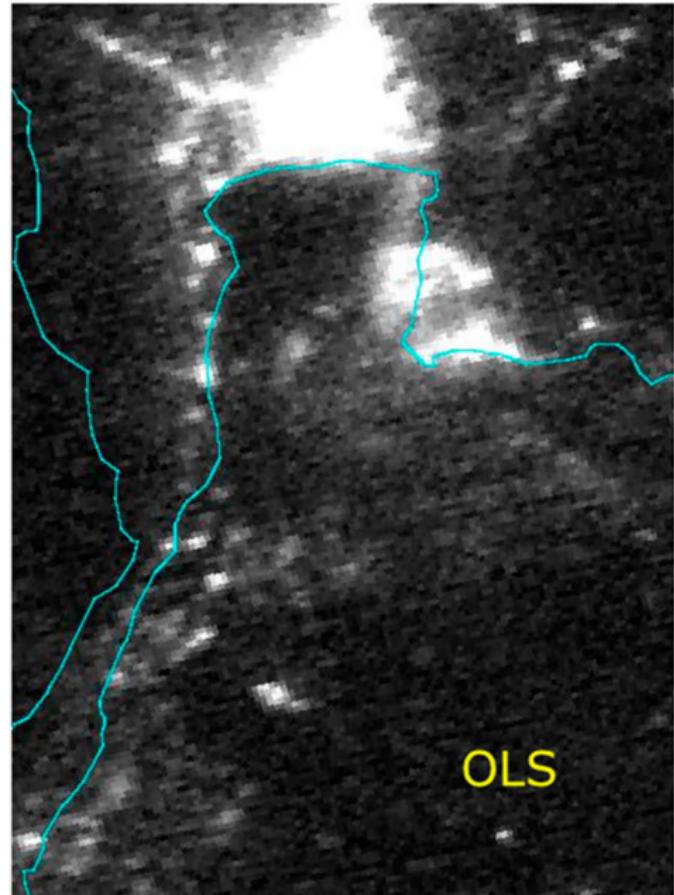
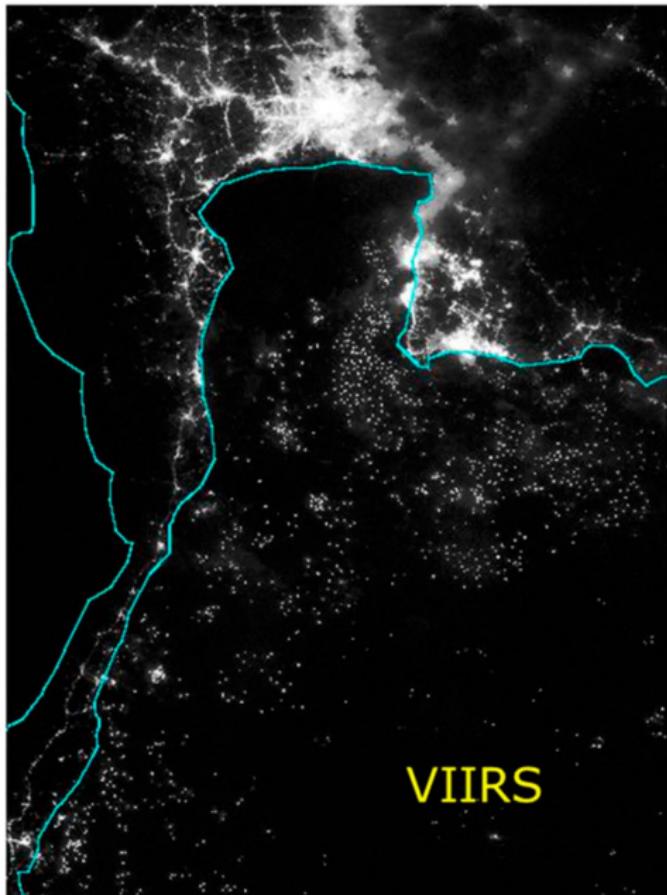
Suomi NPP Satellite - VIIRS

VIIRS Day/Night Band

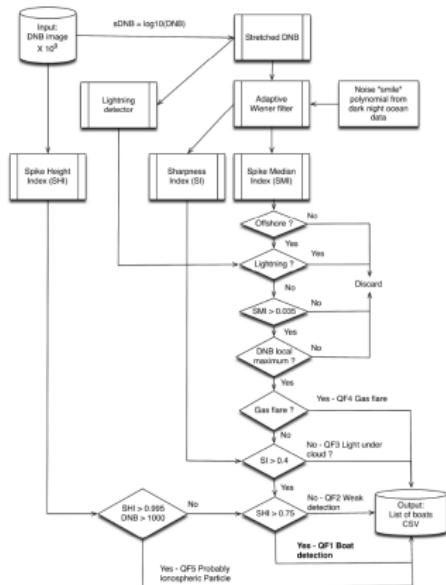
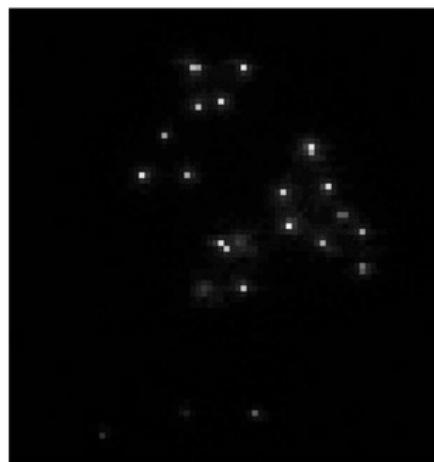
- ▶ 742m footprint: 45 times smaller than DMSP-OLS
- ▶ Lower detection limits: dimmer lighting detectable
- ▶ Multispectral, dynamic range, in-flight calibration, better quantization, etc.

Visible Infrared Imaging Radiometer Suite (**VIIRS**)





Automatic Boat Identification System



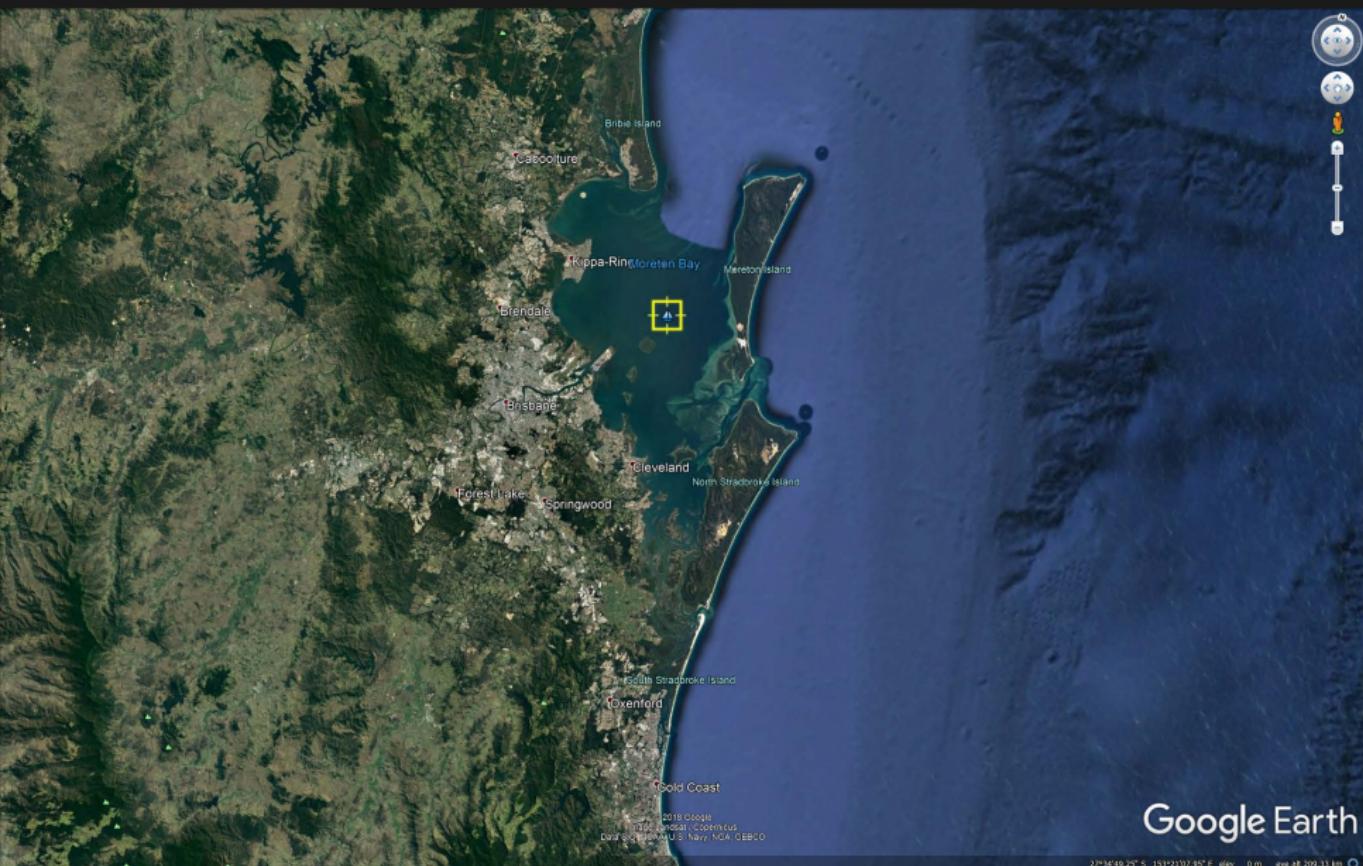
Elvidge et al., (2015) at *Remote Sensing*



Image: Landsat Copernicus
Data: SIO, NOAA, U.S. Navy, NGA (GEBCO)

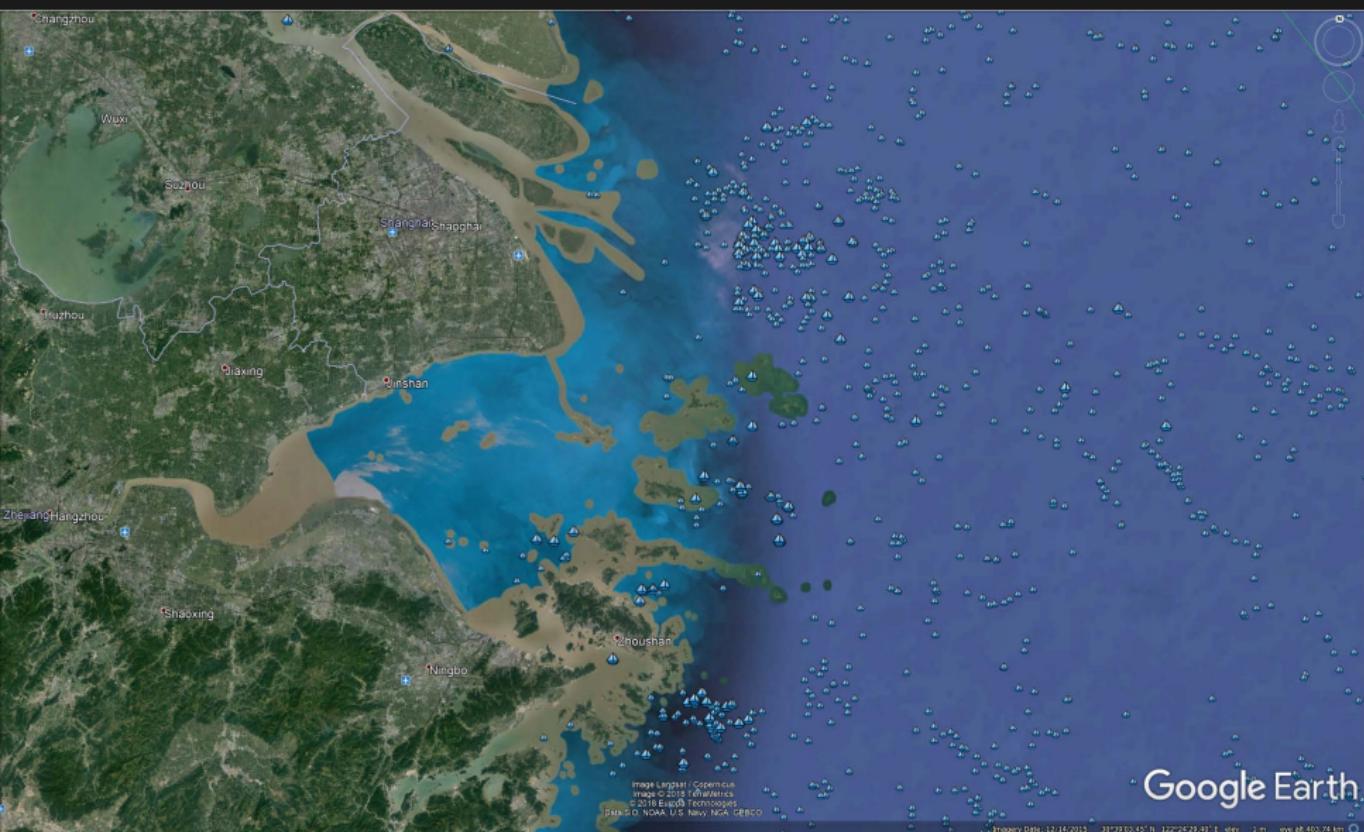
Google Earth

93°35'48.91"S 70°36'53.97"E elev -23 m eye alt 7259.72 km



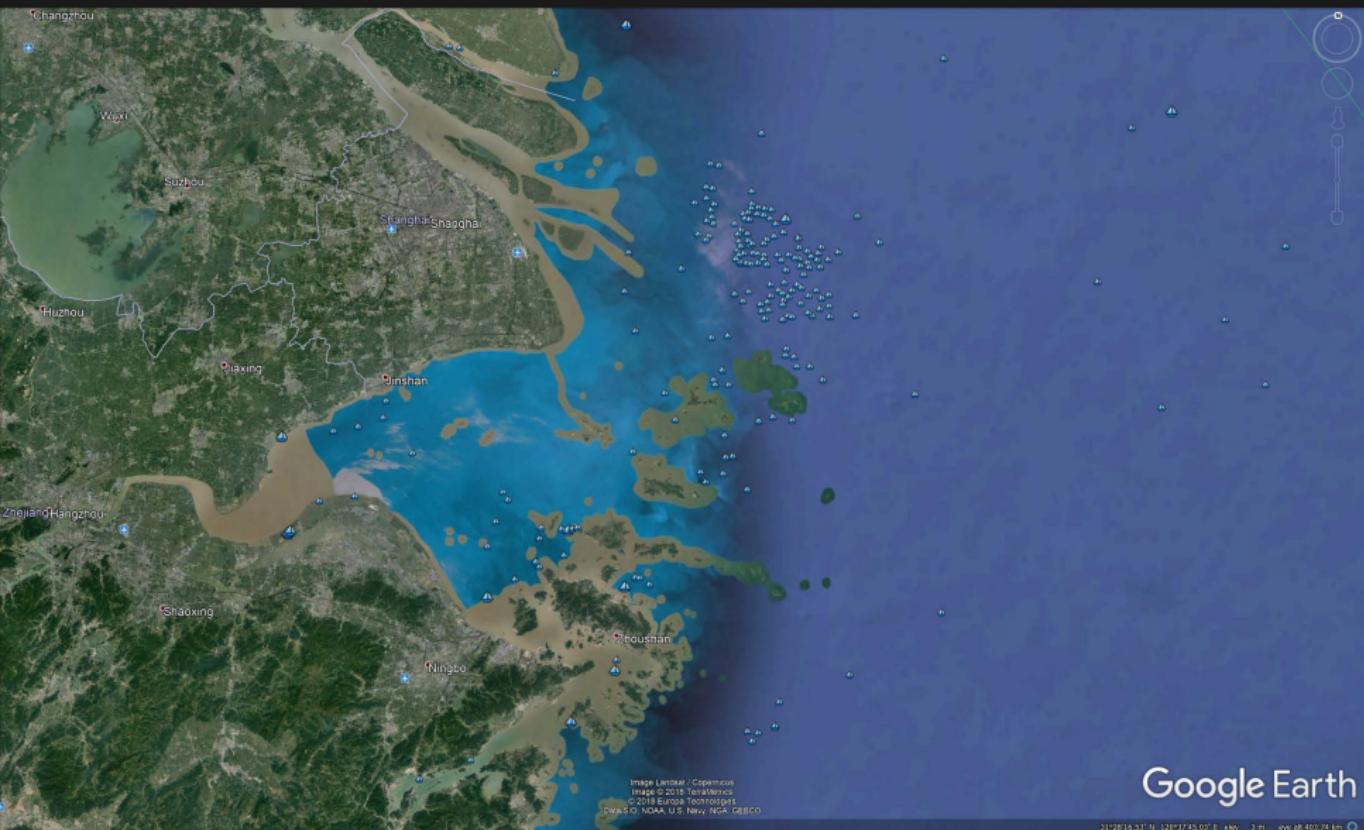
Brisbane on May 31, 2018

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Shanghai on April 15, 2018

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Google Earth

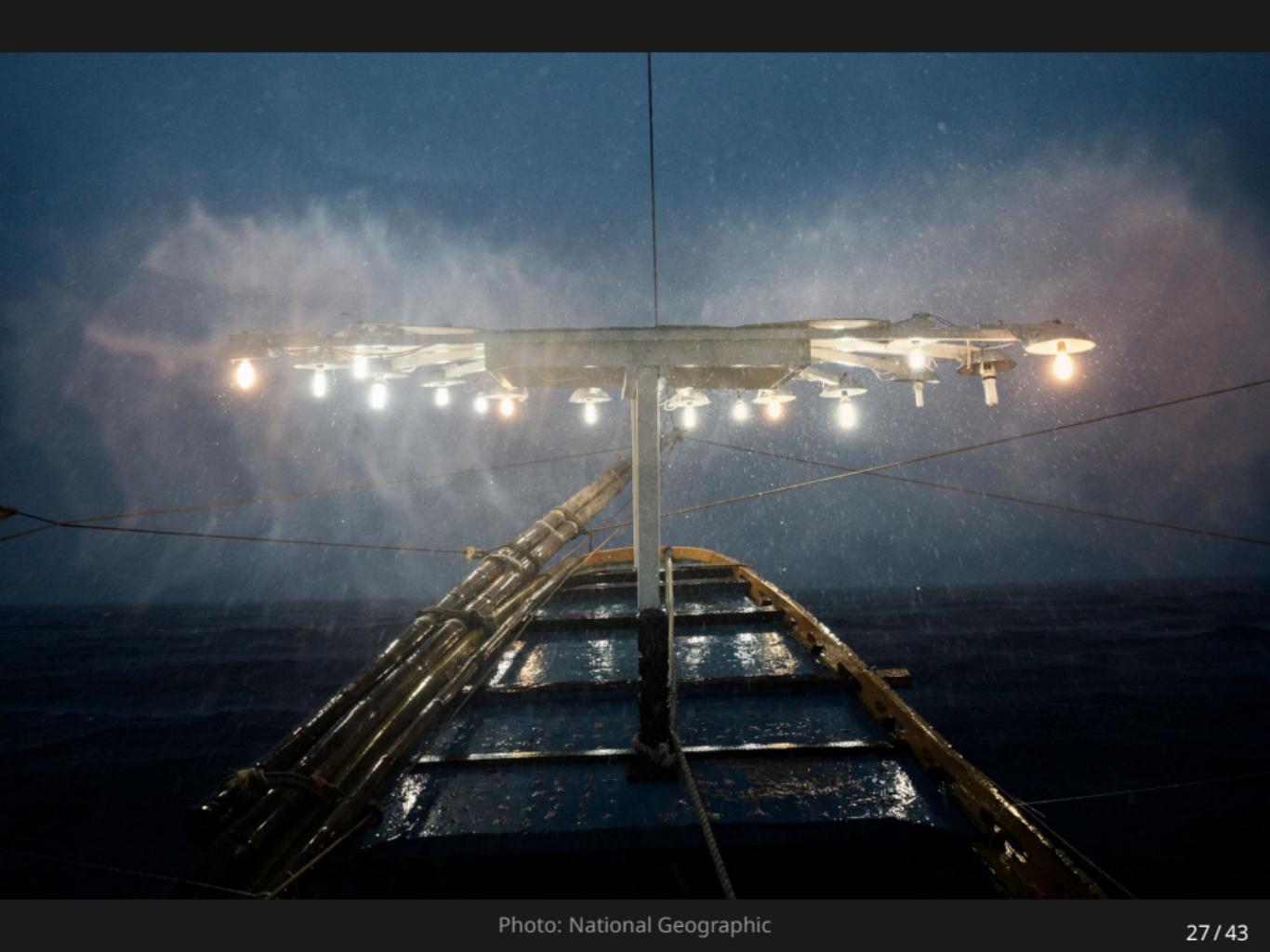
Shanghai on May 15, 2018

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Fishing Vessels at Sanya Harbor during Ban Period in 2016

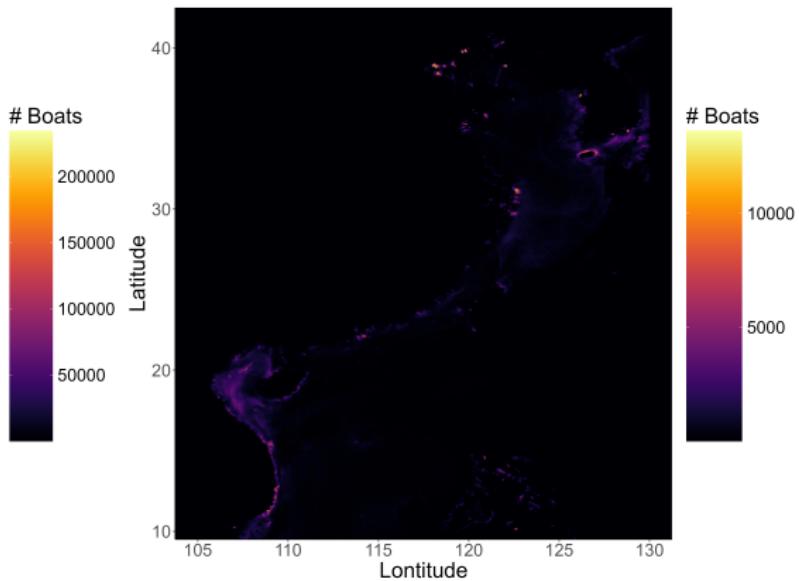
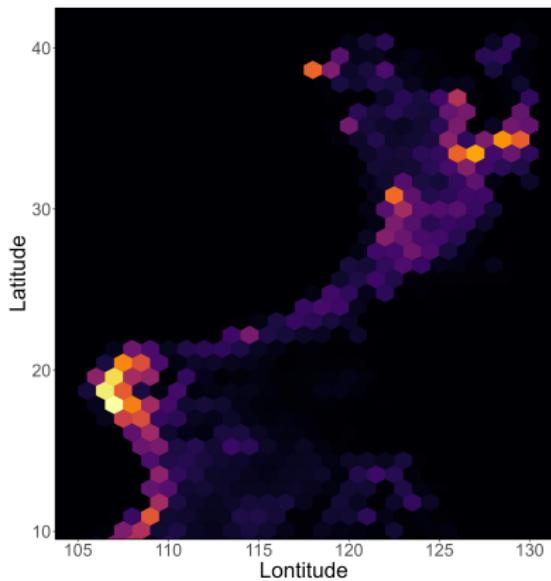
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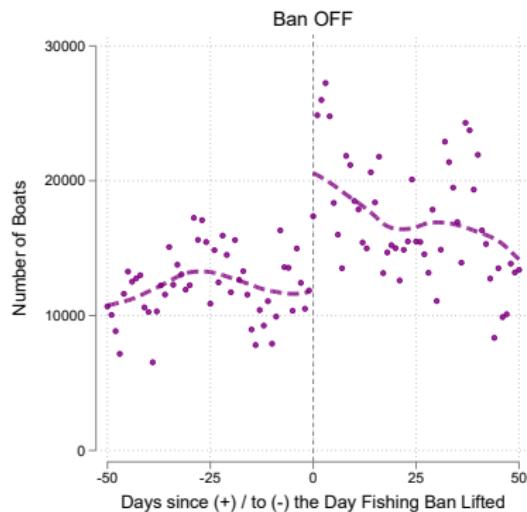
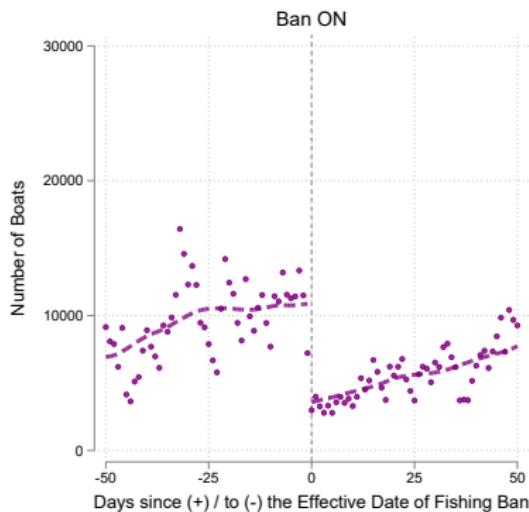
Boat Detection

- ▶ Sample Period
 - April 2012 to May 2018
- ▶ Spatial Coverage
 - Coast of East Asia & Southeast Asia
 - $105^\circ \leq \text{Longitude} \leq 130^\circ$
 - $4^\circ \leq \text{Latitude} \leq 41^\circ$

Spatial Distribution of Boat Detections



Boats Detected at Night around the Imposition and Lifting of Fishing Bans



Fishing Ban and Boat Detections (RDiT)

	Ban ON		Ban OFF	
	(1)	(2)	(3)	(4)
Fishing Ban Effective	-0.911*** (0.162)	-0.644*** (0.113)	-0.687*** (0.133)	-0.451*** (0.111)
Observations	4791	4791	5053	5053
Sample	Days before lifting ban		Days after effective ban	
Day of Year	Quadratic	Quadratic	Quadratic	Quadratic
Day of Week F.E.	-	X	-	X
Day of Lunar Month F.E.	-	X	-	X
Cloud Cover	-	X	-	X

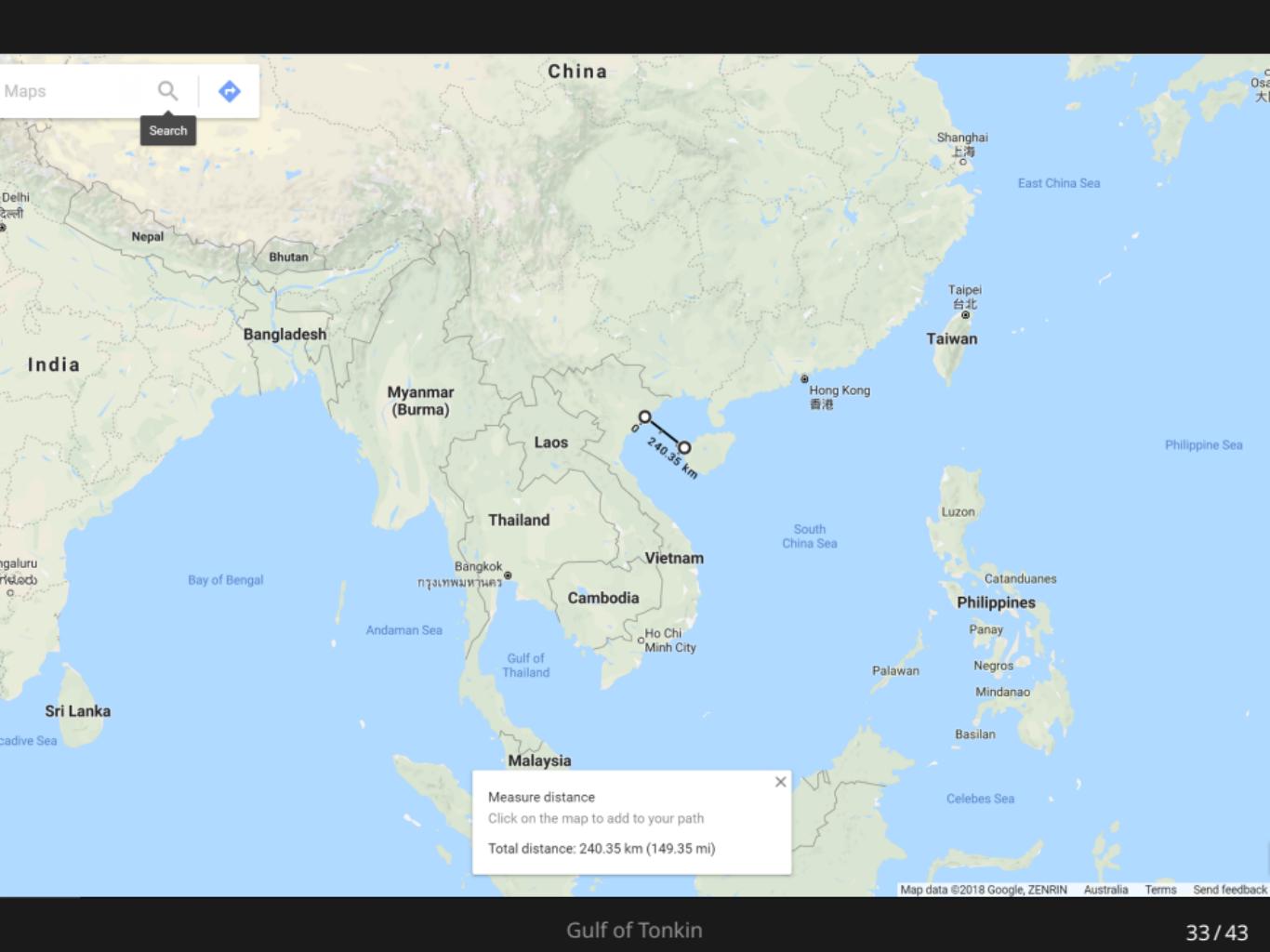
Notes: All specifications include regulatory zone fixed effects.

Newey-West standard errors (max lag = 35) are in parentheses.

*** p<0.01; ** p<0.05; * p<0.10.

Robustness & Validity

- ▶ Randomization inference
- ▶ Nonparametric RD
- ▶ Donut hold RD
- ▶ Continuity tests with oceanographic variables
 - sea surface temperature
 - chlorophyll-a concentration
- ▶ Difference-in-differences



Maps



Search

India

Nepal

Bhutan

Bangladesh

Myanmar (Burma)

Laos

Thailand

Cambodia

Vietnam

Sri Lanka

Malaysia

Philippines

Luzon

Catanduanes

Panay

Negros

Mindanao

Palawan

Basilan

Celebes Sea

Gulf of Tonkin

East China Sea

Philippine Sea

South China Sea

Hong Kong 香港

Taiwan

Taipei 台北

Shanghai 上海

Delhi दिल्ली

Ho Chi Minh City 胡志明市

Bangkok กรุงเทพมหานคร

Andaman Sea

Gulf of Thailand

Malacca Sea

Philippines Sea

Osaka 大阪

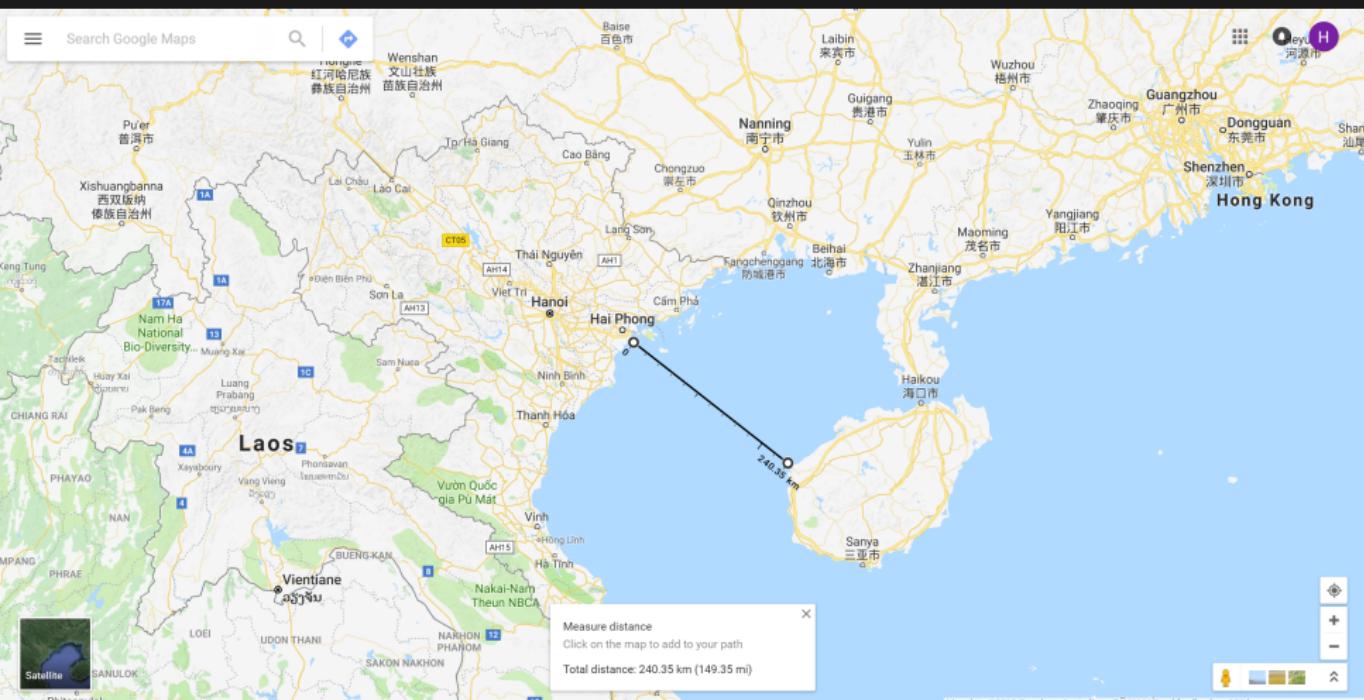
Measure distance

Click on the map to add to your path

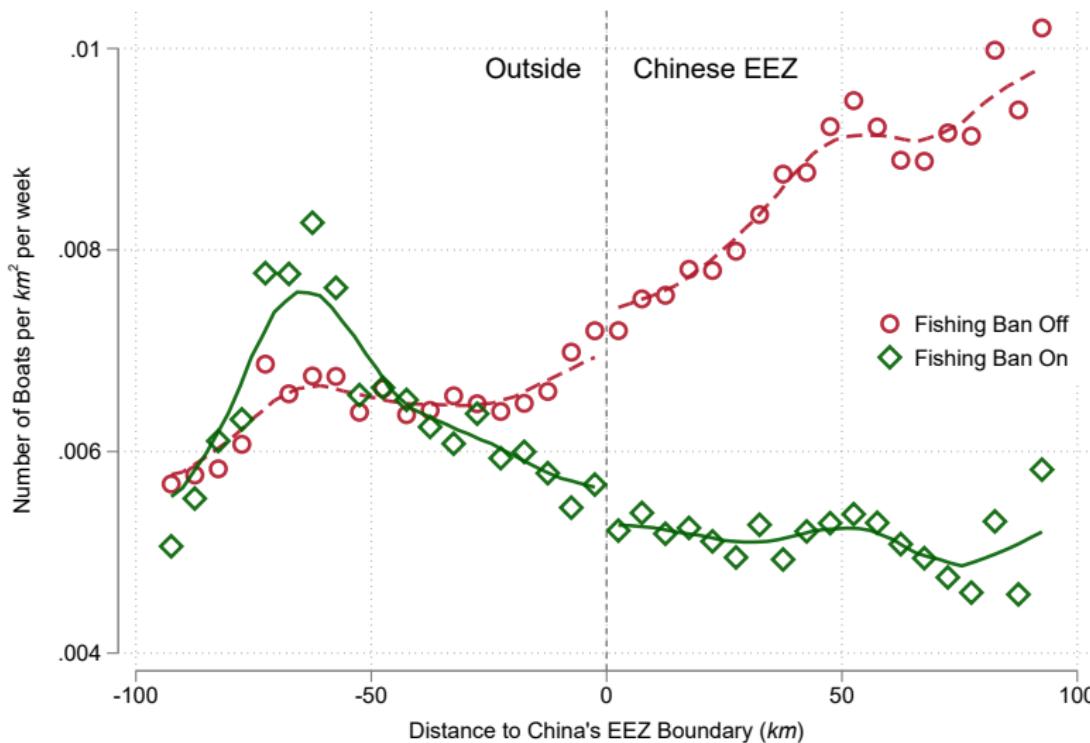
Total distance: 240.35 km (149.35 mi)



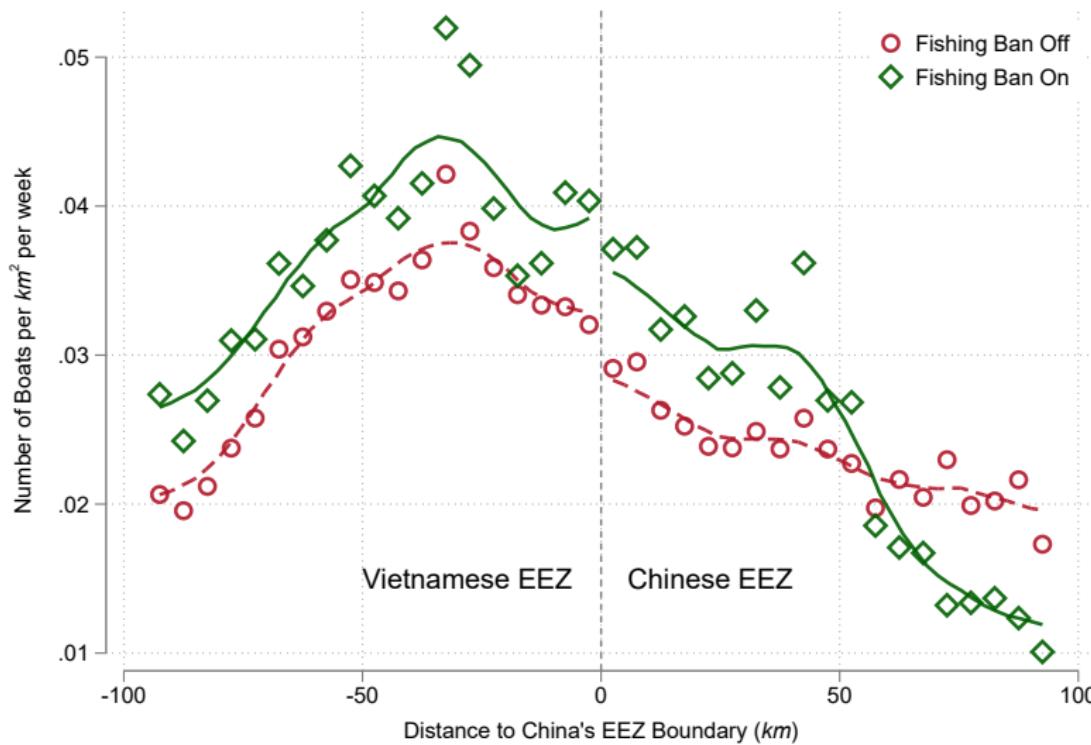
Gulf of Tonkin



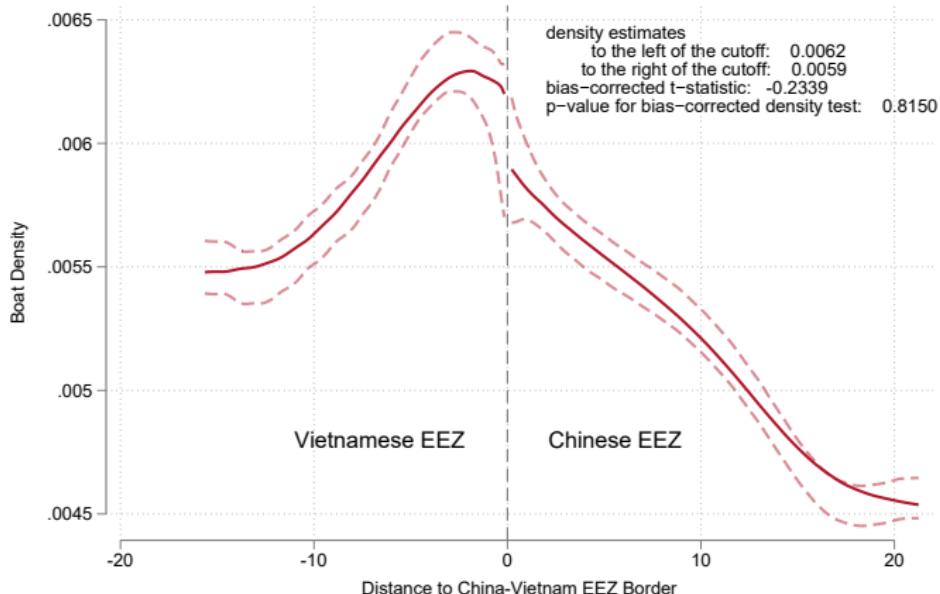
Boat Density at China's EEZ Boundaries (Excluding China-Vietnam Border)



Boat Density around the China-Vietnam EEZ Boundary

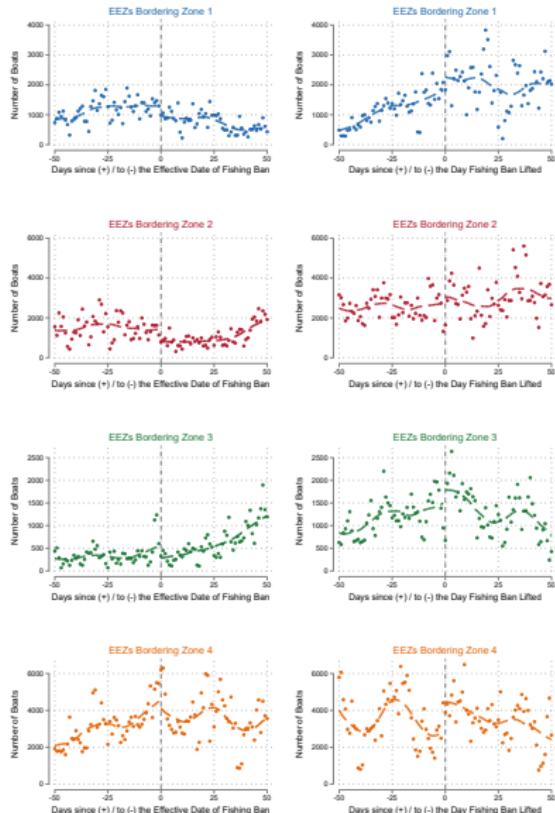


Density Discontinuity Test around the China-Vietnam EEZ Boundary



Cattaneo et al. (2020) simple local polynomial density estimator.

Boat Detections in Neighboring EEZs



Limitations of Boat Detections

Nature of spillovers?

- ▶ Reduced profitability affecting Vietnamese waters as enforcement preventing Chinese vessels from operating in Vietnamese waters? or
- ▶ Vietnamese vessels opportunistically entering Chinese EEZ?

Limitations of Boat Detections:

- ▶ Vessel's flag state?
- ▶ Fishing intensity?

Automatic Identification System (AIS)

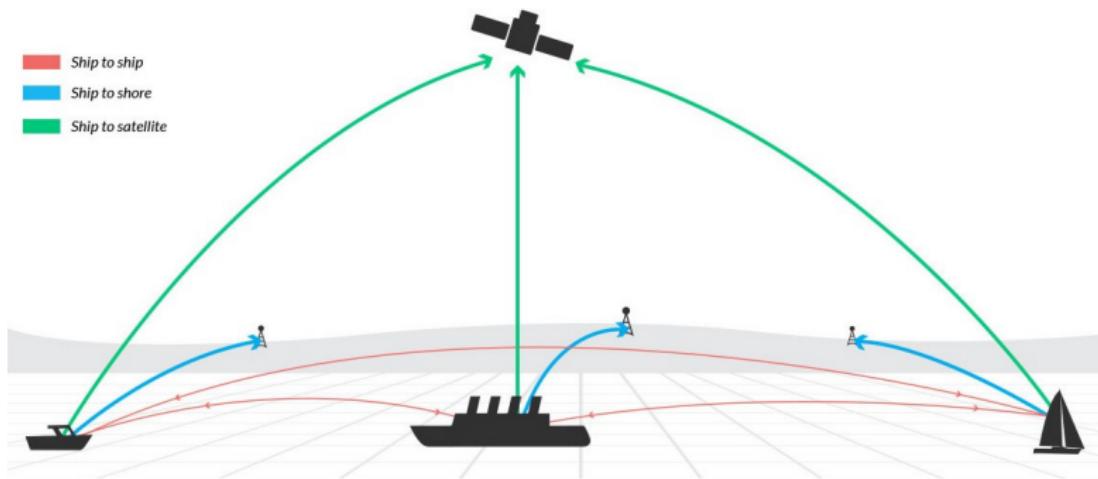


Figure: NATO Shipping

Automatic Identification System (AIS)

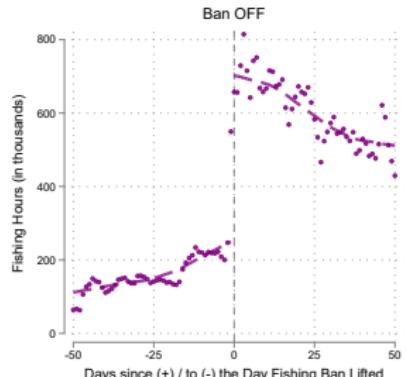
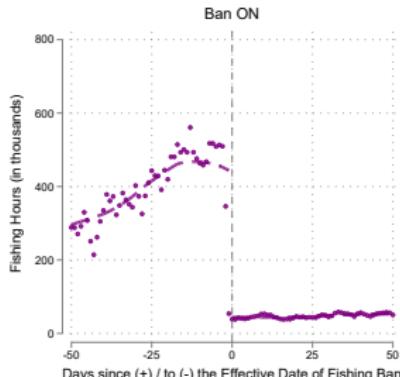
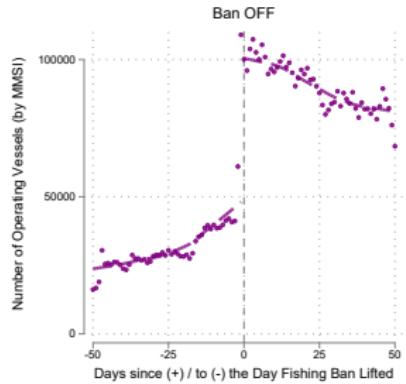
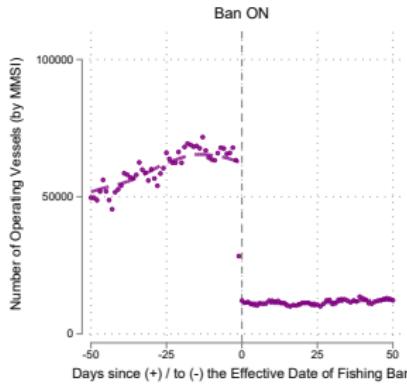
Automatic Identification System (AIS):

- ▶ Enhances maritime navigation safety.
- ▶ Provides vessel identification and tracking.
- ▶ Supports collision avoidance and traffic management.

Fishing activities from AIS signals:

- ▶ ML algorithms (2 CNNs) by Kroodsma et al. (2018)
- ▶ from Global Fishing Watch

Fishing Effort based on AIS Signals



Conclusion

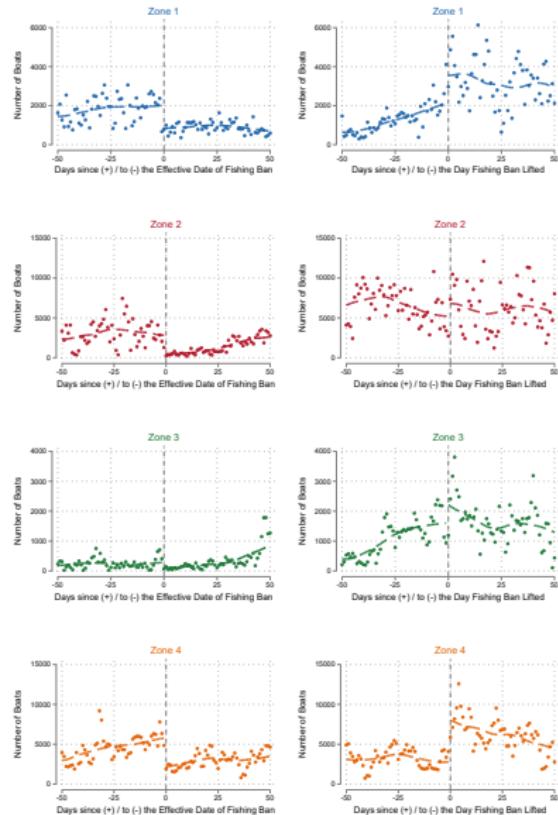
- ▶ Fishing bans significantly reduce activity, but compliance weakens over time.
- ▶ Spillovers affect neighboring countries
- ▶ Remote sensing data valuable for enforcement

Thanks!

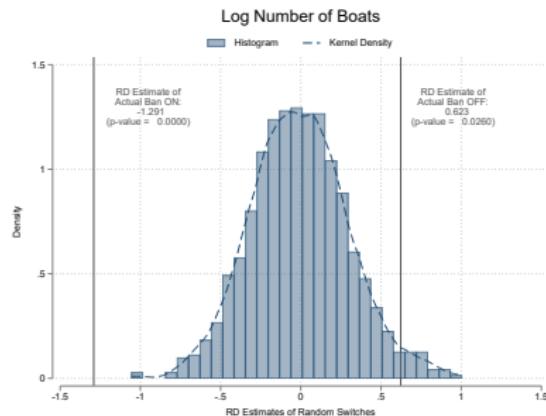
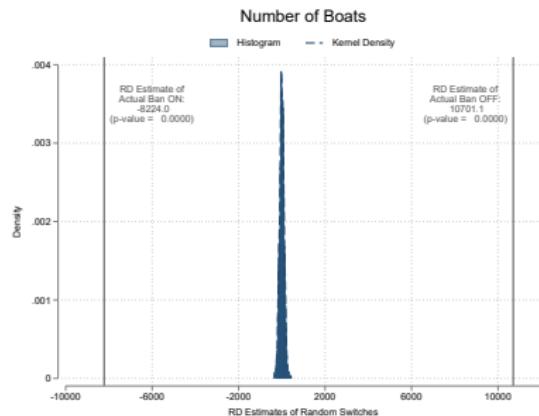
Working Paper
available at:

<https://haishan-yuan.weebly.com/>

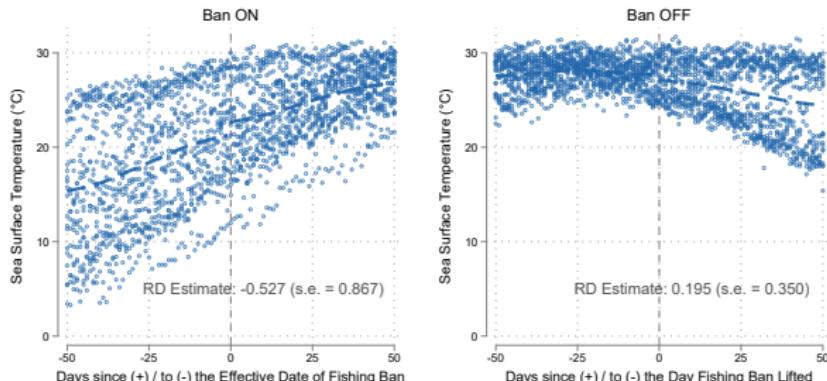
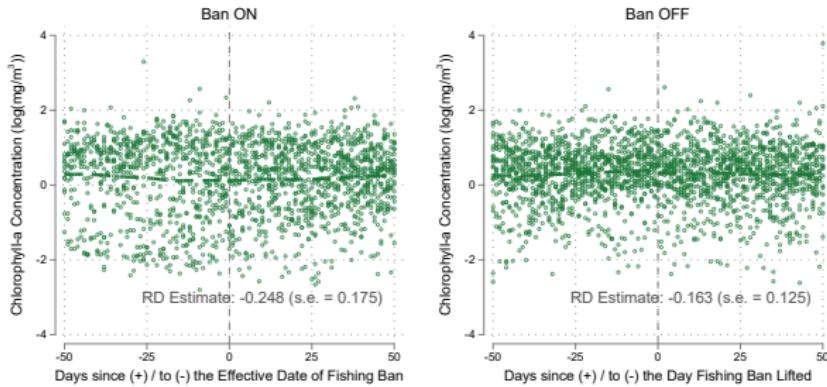
RD in Time by Zone



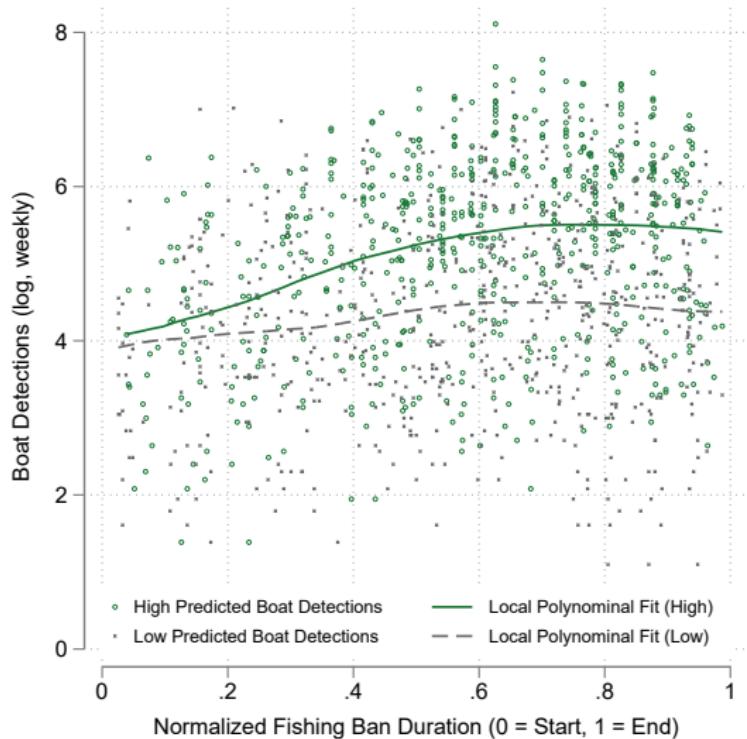
Randomization Inference



Continuity of Oceanographic Variables



Boat Detections during Fishing Ban by Oceanographic Conditions



Difference-in-Differences Estimates

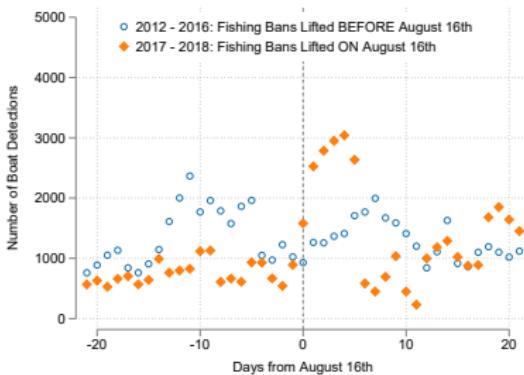
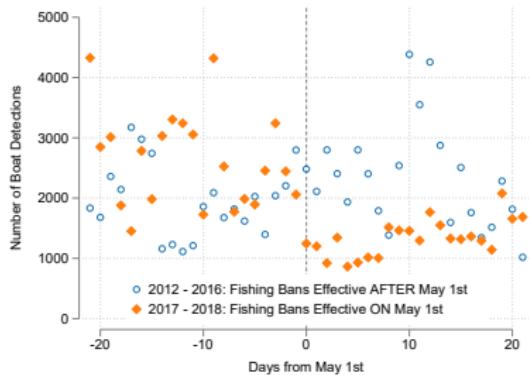
	(1)	(2)	(3)
Fishing Ban Effective	-0.272 (0.139)* [0.111]**	-0.311 (0.139)** [0.122]**	-0.420 (0.125)*** [0.114]***
Fixed Effects			
Year	X		
EEZ × Year		X	X
EEZ × Month	X	X	
EEZ × Month × Day			X
# EEZ Clusters	147	147	147
# Day Clusters	2,644	2,644	2,644
# Obs.	111,977	111,977	111,977

Two-way cluster by EEZs & dates S.E. in parentheses

Conley (1999) S.E. in brackets (1,000 km & 35 nights)

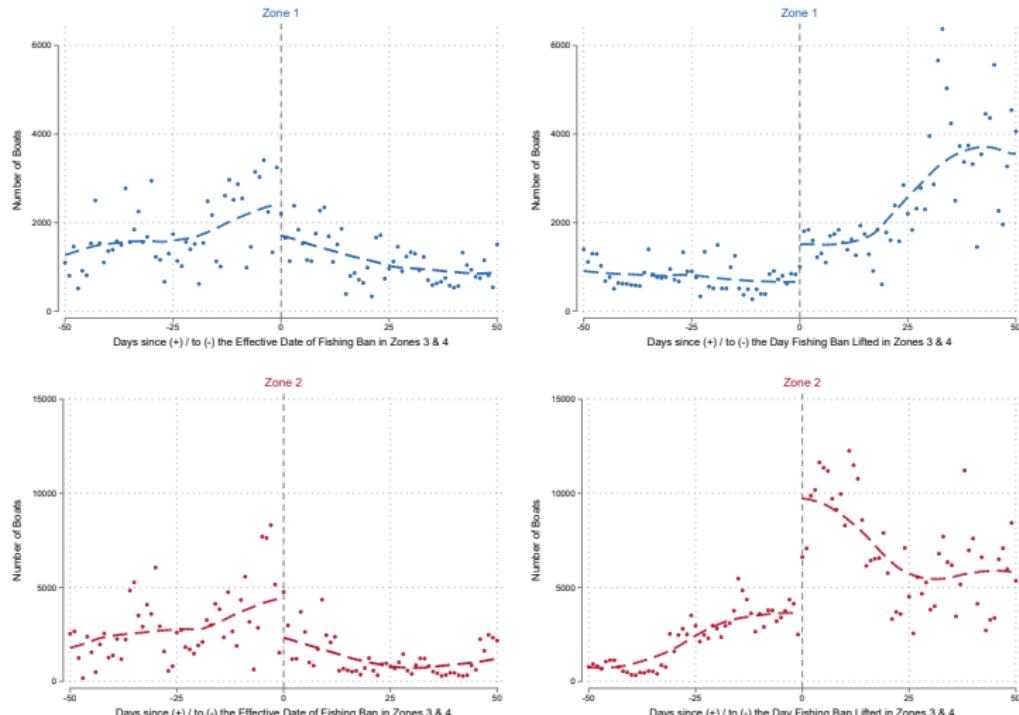
* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$.

Placebo RDiT due to Shifting Start and End Dates of Fishing Ban



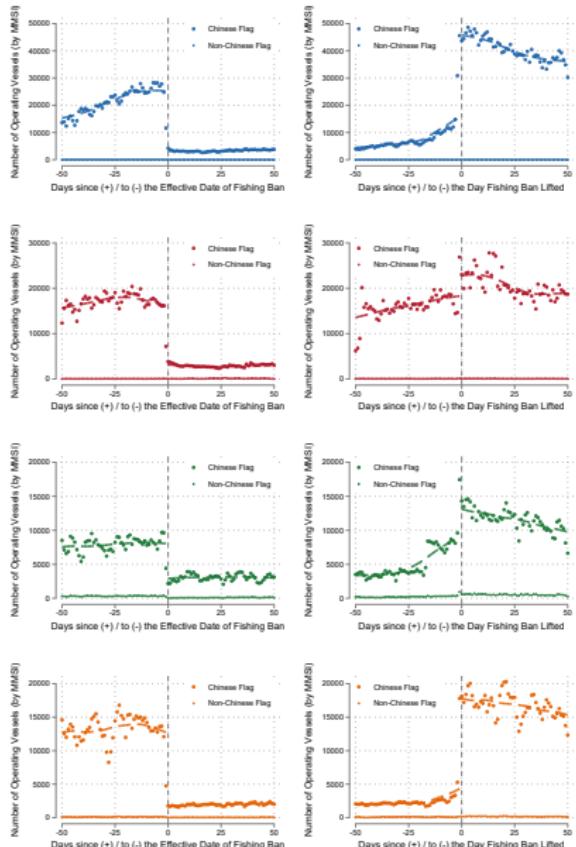
Left panel: May 1st in 2017 (previously June 1st for Zones 1-2 and May 16th for Zones 3-4). Right panel: extension of ban end dates to August 16th in 2017 for Zones 3-4 (previously August 1st).

Spillover from Zones 3 & 4 to Zones 1 & 2

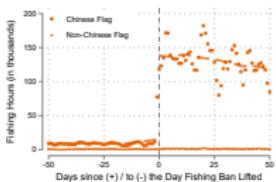
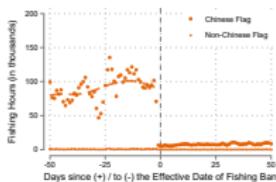
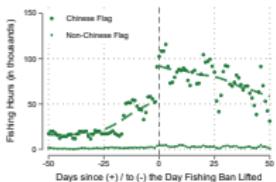
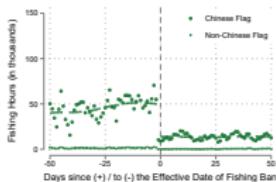
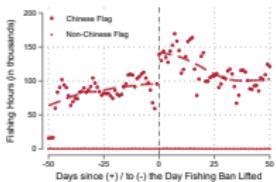
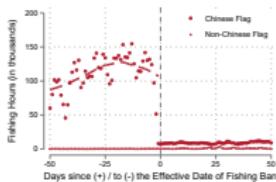
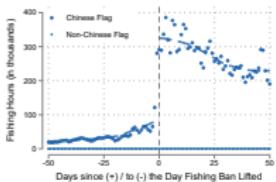
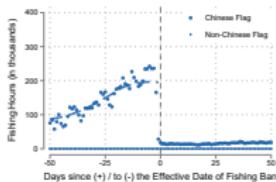


RD plots apply the start and ending dates in Zones 3 & 4 to Zones 1 & 2. Left subplots: starts; Right: ends. Rows 1 = Zone 1.

Vessel Counts based on AIS Signals



Fishing Hours based on AIS Signals



10-12% of the world's population depends on fisheries and aquaculture for their livelihoods

Regional breakdown of employment in the sector



Just 2% of people are employed in fisheries in other parts of the world

The total number of fishing vessels in the world was estimated to be about 4.7 million in 2012

