Displacement of fishing effort by Large Scale Marine Protected Areas

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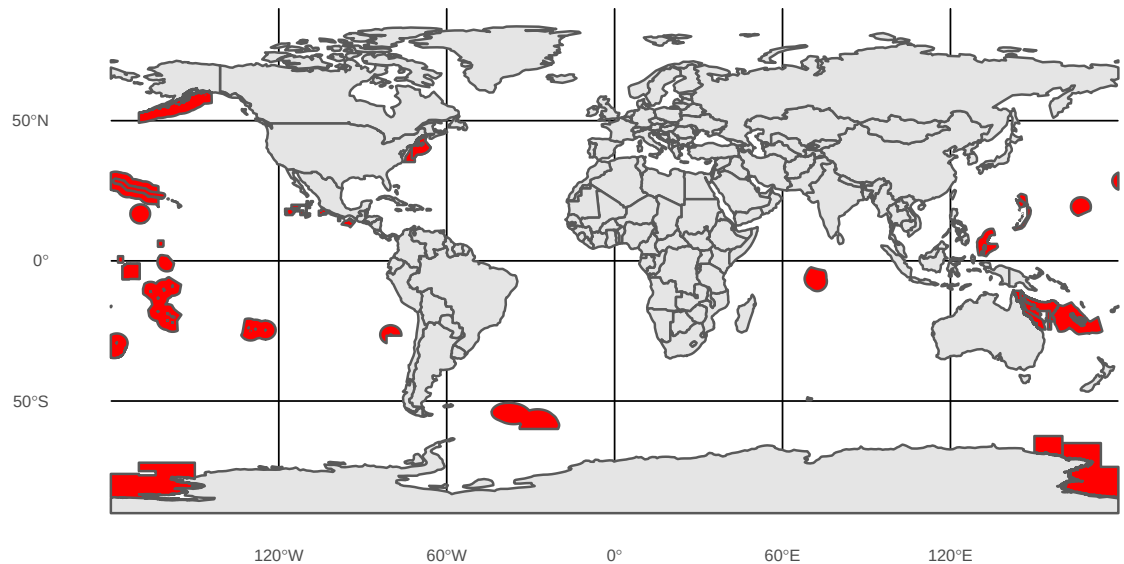
Background

MPAs

- Marine Protected Areas (MPAs): Spatial management of fishing effort
- Areas $>$ 250,000 Km^2 are Large Scale (LSMPAs)[1]
  - Industrial fishing largest human activity in pelagic environment[2]
  - Recent widespread implementation, unknown implication for fisheries



[1] Toonen et al. 2013.

[2] Gray et al. 2017.

LSMPAs

- Erroneously assumed to have little social implications due to their remoteness[3]
- *Blue paradox* shows preemptive fishing[4]:

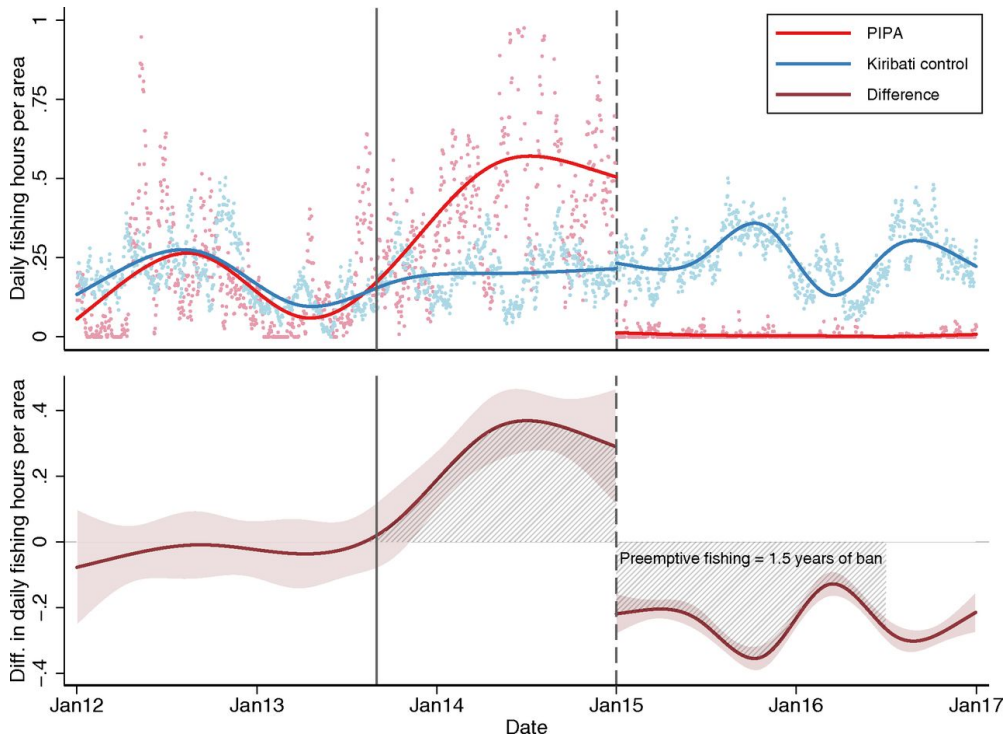


Figure 1: Preemtive fishing due to MPA implementation (Modified from McDermott et al (2018))

[3] Agardy, Sciara, and Christie 2011.

[4] McDermott et al. 2018.

MPAs and fishing effort

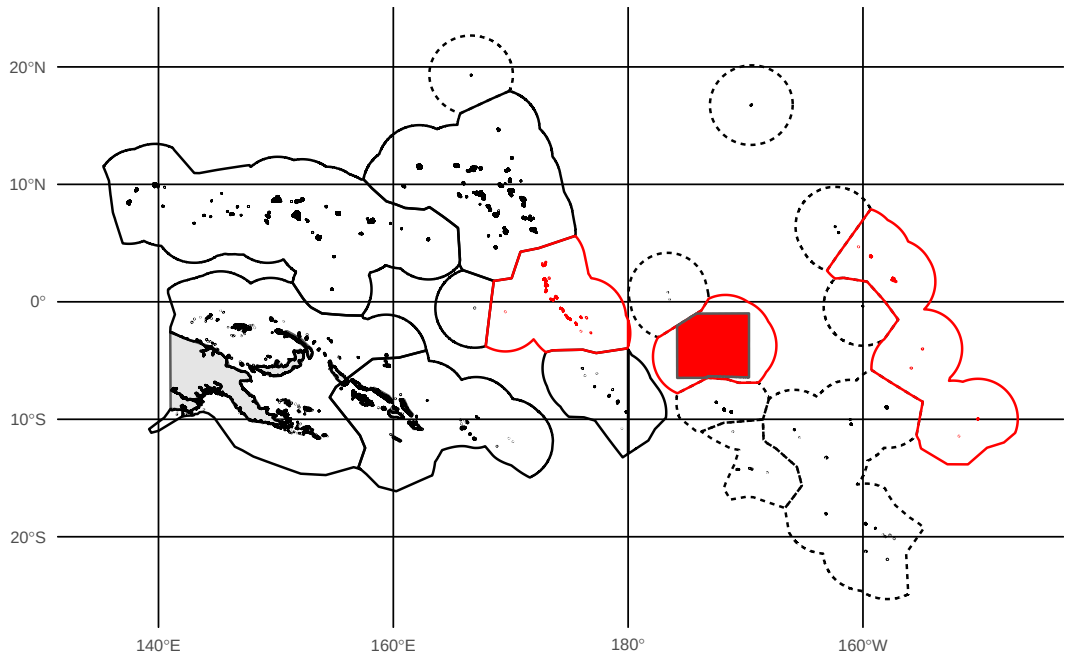
Models range from *cookie-cutter* approach to spatially explicit reallocation of fishing effort based on habitat characteristics:

- All these focus on the long term equilibrium[5]
- Resource users may show idiosyncratic responses[6]
- Redistribution of fishing effort may not be optimal, especially over the first years[7]
- Not accounting for fisher's behavior may lead to unexpected outcomes[8]

[5] White et al. 2013.
[6] Cabral et al. 2017.
[7] Stevenson, Tissot, and Walsh 2013.
[8] Smith and Wilen 2003.

PIPA

- Phoenix Island Protected Area
  - Belongs to Kiribati
  - Implemented in 2015
  - Kiribati is part of the PNA, along with other 8 countries



Questions

Questions

- How does vessel-level behavior change due to PIPA implementation?
- What happens to the displaced fishing effort?

Methods

Data

- On-board Automatic Identification Systems (AIS)
- Global georeferenced vessel positions (3.1 billion and growing):
  - Activity (fishing / not fishing)
  - Time (hours)
  - Vessel characteristics (flag, gear, length, width)

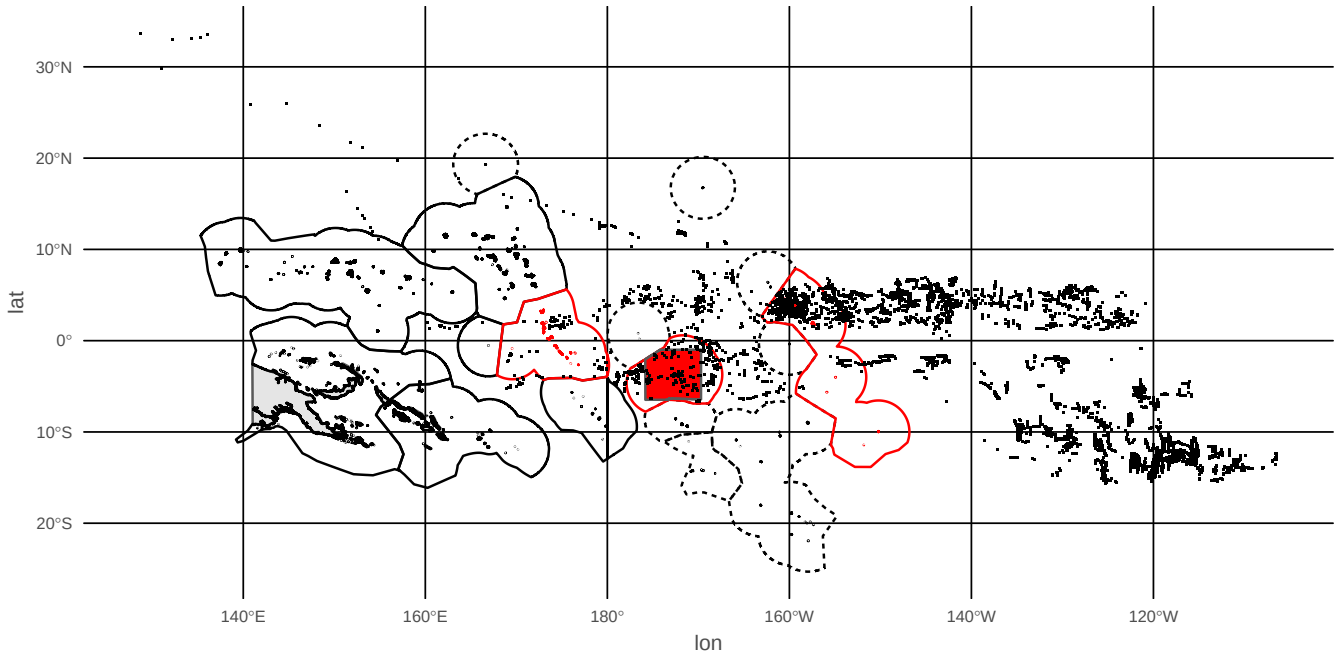


Figure 2: Sample track of Chinese longliner (10K fishing points of ~400K total)

Data

Two groups:

- Treated
  - Vessels who fished inside PIPA at least once before closure
  - Continued to fish elsewhere after implementation of PIPA
- Control:
  - Vessels never fished within PIPA waters
  - Vessels belong to other PNA countries
  - Vessels have fished in surrounding areas (*i.e.* PNA-countries' EEZ) before and after PIPA closure
- Over 45 million individual AIS messages (positions)

Data

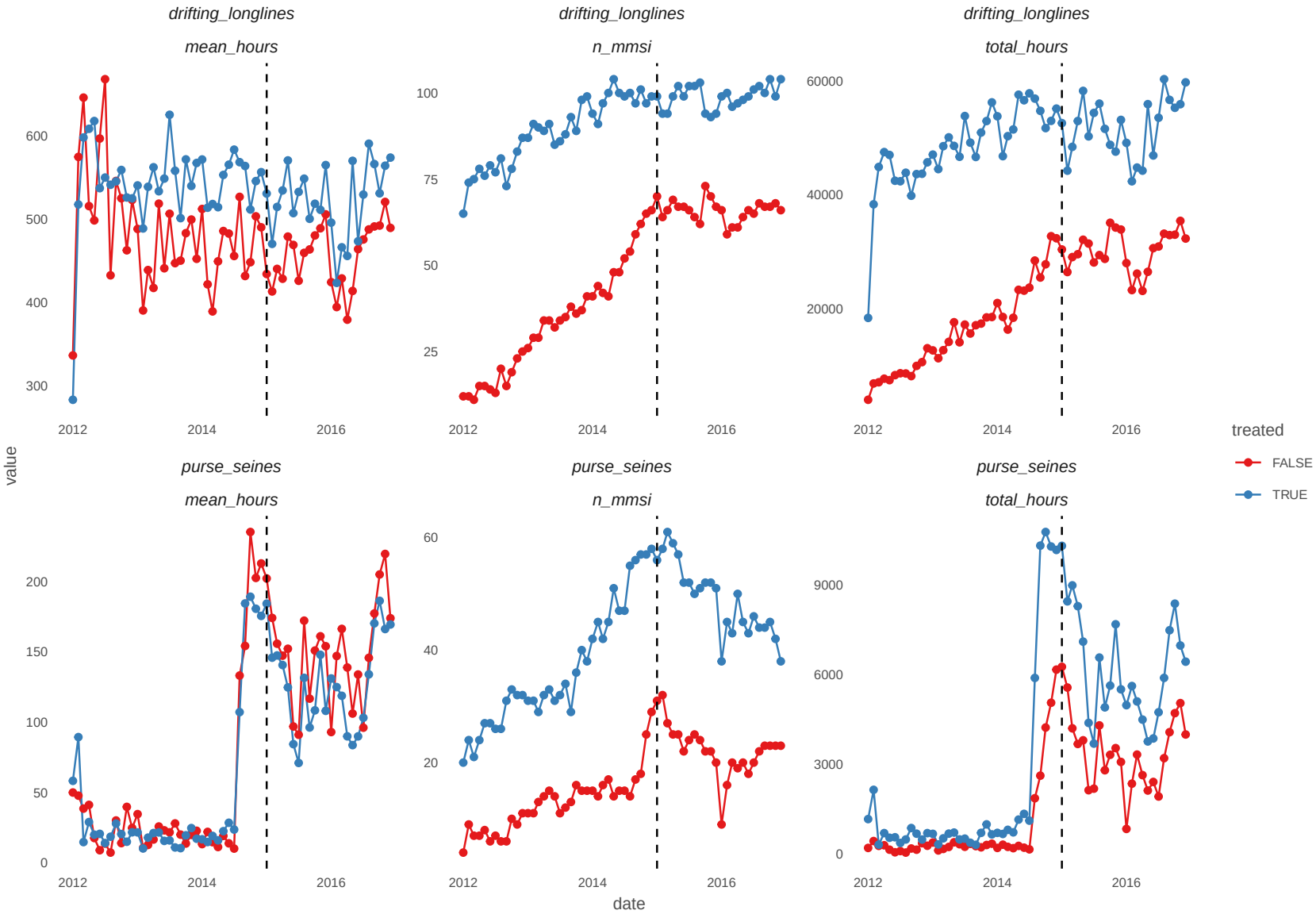


Figure 3: Fishing hours and number of vessels by month for all vessels.

Analyses

Change in vessel-level behavior with a DiD

$$y_{i,t} = \alpha + \beta_1 Post_t + \beta_2 Treat_i + \beta_3 Post_t \times Treat_i + \epsilon_{i,t}$$

- $y_{i,t}$ monthly fishing hours by vessel i in time period t
- $Post_t$ before-after PIPA dummy
- $Treat_i$ treatment dummy
- β_3 is our DiD estimate
- month, flag, year controls

Analyses

Spatial redistribution

- Treated vessels only

$$y_{i,t} = \alpha + \beta_1 Post_t + \beta_{2,i} Country_i + \beta_{3,i} Post_t \times Country_i + \epsilon_{i,t}$$

- $y_{i,t}$ proportion of fishing hours that country i receives at time t
- $Post_t$ before-after PIPA dummy
- $Country_i$ country dummy

Preliminary results
(Focusing on purse seiners for now)

Change in fishing

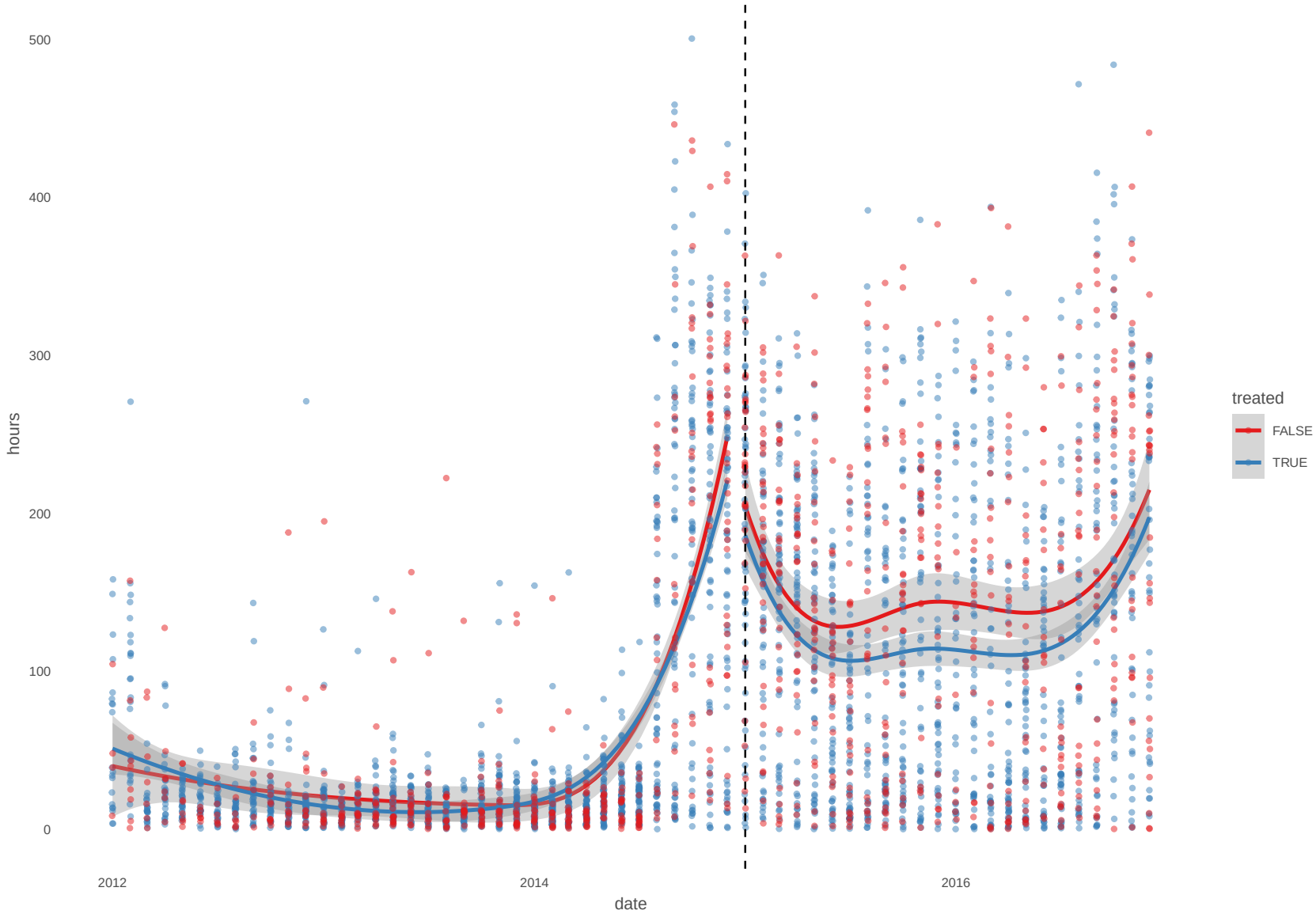


Figure 4: Fishing hours and number of vessels by month for all vessels.

Change in fishing

Table 1: Fishing hours from GFW for purse seiners (n = 106; 38 control, 68 treatment).

	Dependent variable:			
	hours			
	(1)	(2)	(3)	(4)
post	92.958***	95.733***	45.614***	41.920***
	(6.229)	(5.860)	(8.239)	(8.214)
treated	−6.575	−5.558	−3.680	6.541
	(4.985)	(4.570)	(4.270)	(5.195)
post:treated	−18.646***	−18.564***	−20.502***	−18.709***
	(7.230)	(6.878)	(6.685)	(6.787)
Constant	59.490***	61.032***	−18,348,700.000***	−16,807,078.000***
	(4.422)	(6.289)	(4,041,387.000)	(3,759,572.000)
Months	No	Yes	Yes	Yes
Year	No	No	Yes	Yes
Country	No	No	No	Yes
Observations	3,489	3,489	3,489	3,481
R^2	0.164	0.233	0.272	0.299
Note:				*p<0.1; **p<0.05; ***p<0.01

Effort redistribution

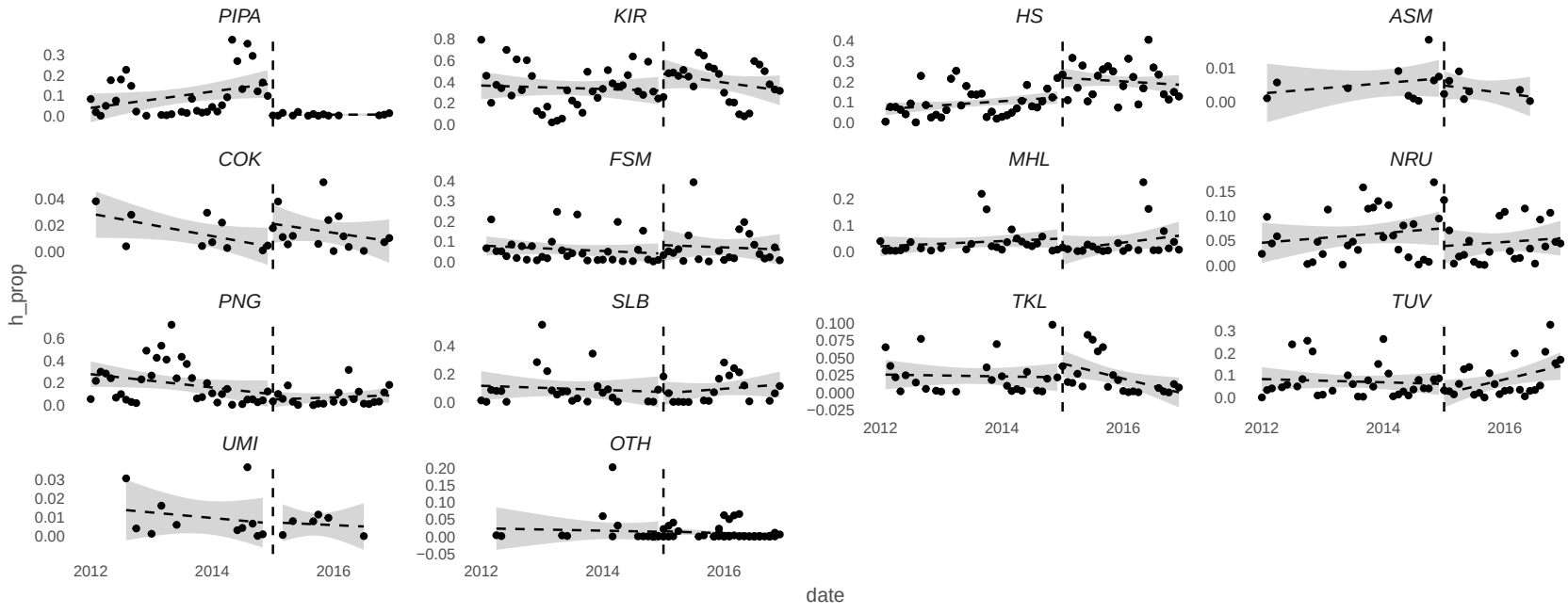


Figure 5: Monthly relative allocation of fishing effort by PIPA-vessels.

Displacement

Table 2: Change in the relative allocation of fishing hours by purse seiners

term	h_prop
(Intercept)	0.100***
post	-0.094***
post:countryKIR	0.149***
post:countryHS	0.202***
post:countryASM	0.092***
post:countryCOK	0.095***
post:countryFSM	0.105***
post:countryMHL	0.093***
post:countryNRU	0.079***
post:countryPNG	-0.028
post:countrySLB	0.091**
post:countryTKL	0.093***
post:countryTUV	0.101***
post:countryUMI	0.091***
post:countryOTH	0.087***

$R^2 = 0.544^{***}$; $n = 707$

Displacement

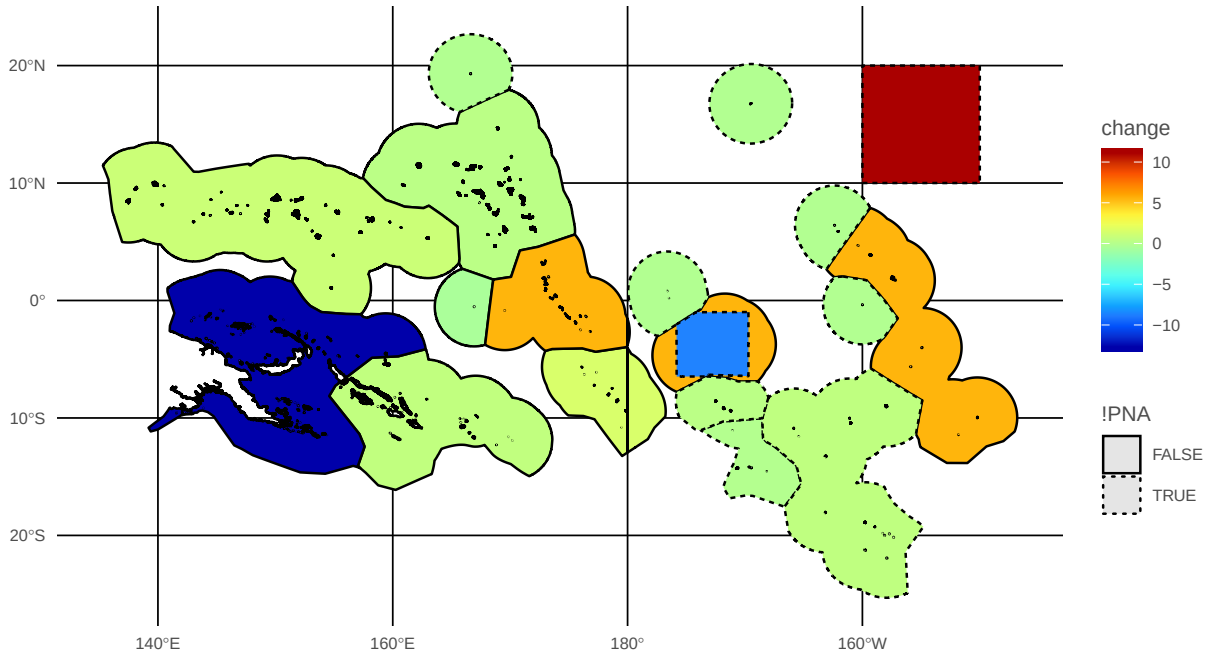


Figure 6: Spatial representation of the mean change in the monthly allocation of fishing effort.

Displacement

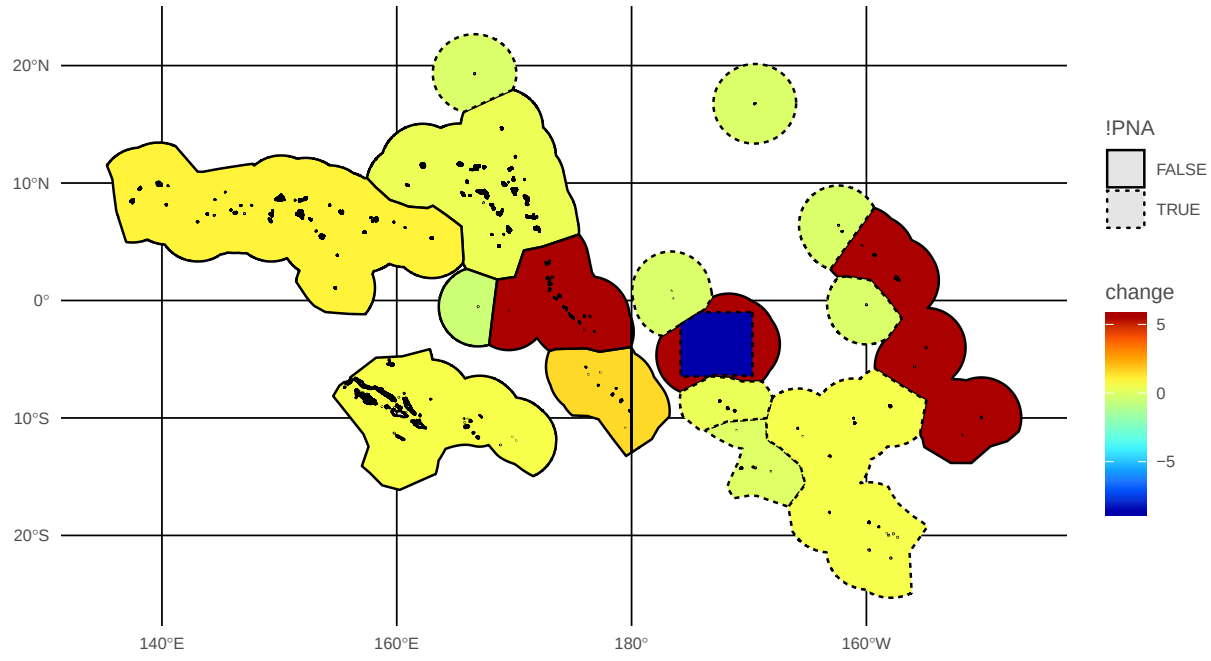


Figure 7: Spatial representation of the mean change in the monthly allocation of fishing effort.

Recap

- Treated vessels fish less post-implementation
  - Only significant for purse seiners
- EEZs receive proportionally more fishing effort than before
  - Proportional change increases with proximity to PIPA

Future work

Change in behavior

- Distance traveled
- non-fishing at-sea hours
- proportion of fishing / searching

Spatial redistribution

- Proportion is bounded, might try a binomial GLM
- Measure of "crowdness"

Concerns

- Spillover effects / treatment affecting control

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