Displacement effects and implications of Large-Scale Marine Protected Areas

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Abstract

Large-scale Marine Protected Areas (LSMPAs) have seen a significant increase over the last years. Literature shows that fishing effort is effectively eliminated in this protected areas upon implementation. The benefits of reducing effort have been largely studied, and include increases in abundance, biomass, and diversity within the bounded regions. In terms of the fishing implication, no-take zones may produce spillover that provide fish for outside areas. The implications of displacement of fishing effort are not yet fully understood. Evidence suggests that fishing effort re-distributes along the borders of the MPA, following an ideal free distribution. Novel data products allow us to track fishing effort at the vessel-level, allowing us to identify changes in behavior at both the fleet and vessel level. This papers evaluates the implications of implementing a LMPA, the Phoenix Islands Protected Area (PIPA). We evaluate changes in fishing effort, and track vessels to see where they go after the implementation of PIPA. Our results show that vessels in the effected region increase fishing effort after the implementation of PIPA. THey are redistributed to X. These findings have major implications for MPA implementation, especially as countries rush to meet the goals of 10% ocean protection as mandated by the SDG.

Contents

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Introduction

The rest of the paper is outlined as follows: Section provides further information about PIPA and Palau, section describes our data and empirical strategy, section presents our results, in section **??** we discuss our findings and provide management recommendations.

Table 1: Number of fishing vessels (identified by mmsi) for each gear before and after PIPA implementation.

Gear	Treated	Before	After	Change (A / B)
drifting_longlines	FALSE	105	218	2.0761905
drifting_longlines	TRUE	139	118	0.8489209
purse_seines	FALSE	49	89	1.8163265
purse_seines	TRUE	78	81	1.0384615

Table 2: Mean fishing hours for each gear before and after

Gear	Treated	Before	After	Change (A / B)
drifting_longlines	FALSE	481.42502	473.5823	0.9837094
drifting_longlines	TRUE	548.22580	524.8121	0.9572919
purse_seines	FALSE	66.50483	172.3775	2.5919548
purse_seines	TRUE	56.87322	146.2015	2.5706563

Background

Methods

Data

Number of vessels

Explain BACI strict

Analyses being run

Correct number of vessels in tables

Add figure legends

The Global Fishing Watch (GFW) data contain 235 vessels that have fished within PIPA waters [1]. From these, 206 did so at least once before 2015.

Then, I look at the entire fishing effort of vessels that fished at least once in PIPA before 2015. In other words, I use GFW data to track vessel-level activities inside and outside PIPA before and after 2015. However, all boats included in this case fished at least once in PIPA before 2015 (*i.e.* no control group). First I look at vessels whose `mmsi` code starts with `529`, indicating that they come from Kiribati [2]. The overall pattern for fishing time (total and mean) show a downward trend that initiated well before 2015 (Fig. **??**). The number of vessels as given by unique mmsi numbers shows a maximum near the end of 2014, and then decreases after 2015.

Analysis

To do

- [x] Divide pipa vessels by type of boat (longline vs. purse seine)

[1]Perhaps some of these vessels only fished there for a couple hours one year. Therefore, I would need to further identify which ones were transient vs constant fishing events using some cutoff. For now, I run regressions for all vessels and for vessels that fly the Kiribati flag (n = 12). The true number of impacted vessels must lie between these two groups, but it provides a starting point.

[2]link: http://www.vtexplorer.com/mmsi-mid-codes-en/

- [x] Identify two counterfactuals:
  - [x] A: PNA, similar vessel, never fished inside PIPA
  - [ ] B: Taiwan, Never in PNA, Similar region
- [x] Change in fishing hours before vs after
- [ ] ~~Change in total hours before vs after~~
- [ ] Change in distance before vs after
- [ ] Where do PIPA vessels go?

The current approach is to estimate what percentage of fishing effort from the PNA was displaced by PIPA and use this to infer something about Palau. While this provides a measure of the displacement, it does not fully address the possibility of costs increasing. I believ we can use individual tracks (as opposed to just the gridded effort) and obtain show how their behavior changed (*i.e.* are they fishing further away, are they fishing more, where are they now?).

Model specifications

Our model specification uses a difference-in-differences approach. In this case, we interact the before-after dummy with a treatment dummy. The treatment-control groups follow our definition in the data description. The model takes the form of:

$$H_{ijk} = \alpha + \beta Post_i \times Treat + \mu_j + \phi_k + \epsilon_{ijk}$$

Results

In this section I present some of the preliminary results of regressions similar to what you have conducted for US MNMs using hours as an estimate of fishing effort. First, I explore patterns of fishing effort only inside PIPA (Fig. 1). Consistent with the blue paradox[1], we see an increase in the number of vessels, total hours, mean hours, and number of data points between 2014 and 2015. Shortly after that, all measures decrease in 2015.

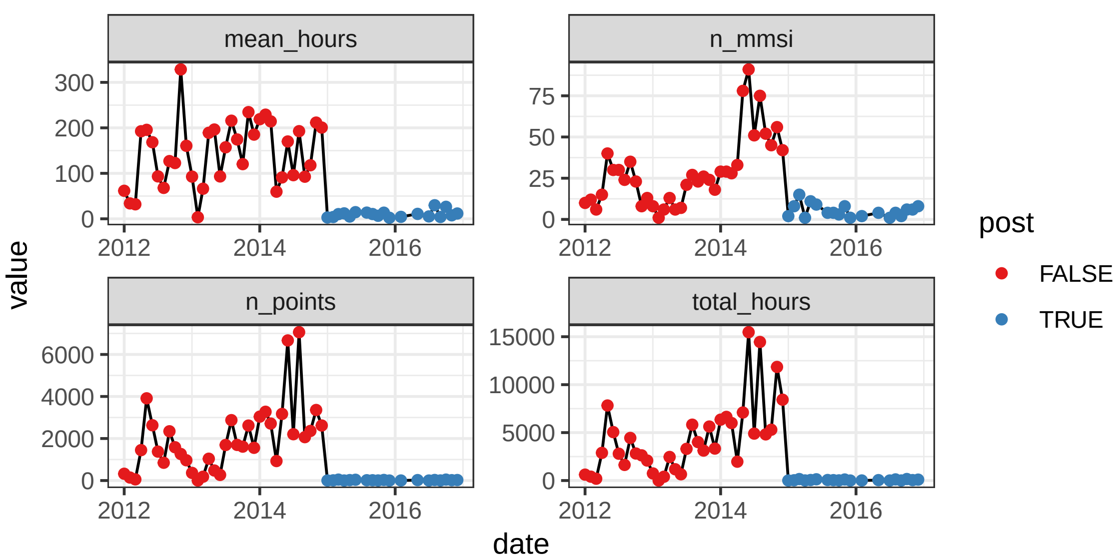


Figure 1: Monthly hours, number of vessels, and data points observed inside PIPA. These clearly show the blue-paradox effect.

Given the similar trends observed in total fishing hours and mean fishing hours, I calculate total fishing hours at the year-month-vessel level and regress that on a `post` dummy that indicates years before or after 2015, which is interacted with a `treated` dummy that indicates if vessels fished at least once within PIPA or only in PNA waters. Results of this regression are presented in Table ??. In this table, column (1) presents the regression only against the policy dummy, column (2) includes month fixed effects, column (3) includes month and year fixed effects, and column (4) includes month, year, and vessel fixed effects. All three specifications show negative coefficients. The full model explains 71% of the variance in monthly fishing hours by vessel. This specification has the lowest policy coefficient (labeled `post`), and it is not different from zero at the $\alpha = 0.05$ level.

I then repeat a similar analysis but for all fishing vessels that fished at least once inside PIPA before 2015. In this case this likely represents an underestimate of the effect, as it could include vessels who once fished inside PIPA, but are not even in the region any more. The number of unique mmsi codes (Fig. 2) follows a similar pattern as in the previous case. However, mean hours and total hours show stable trends before and after. As opposed to only Kiribati vessels who seemed to reduce the number of fishing hours, a similar analysis of all vessels shows positive coefficients that are not statistically significant ($alpha < 0.05$). Results of the regressions are shown in Table 4. Like before, column (1) presents the regression only against the policy dummy, column (2) includes month fixed effects, column (3) includes month and year fixed effects, and column (4) includes month, year, and vessel fixed effects.

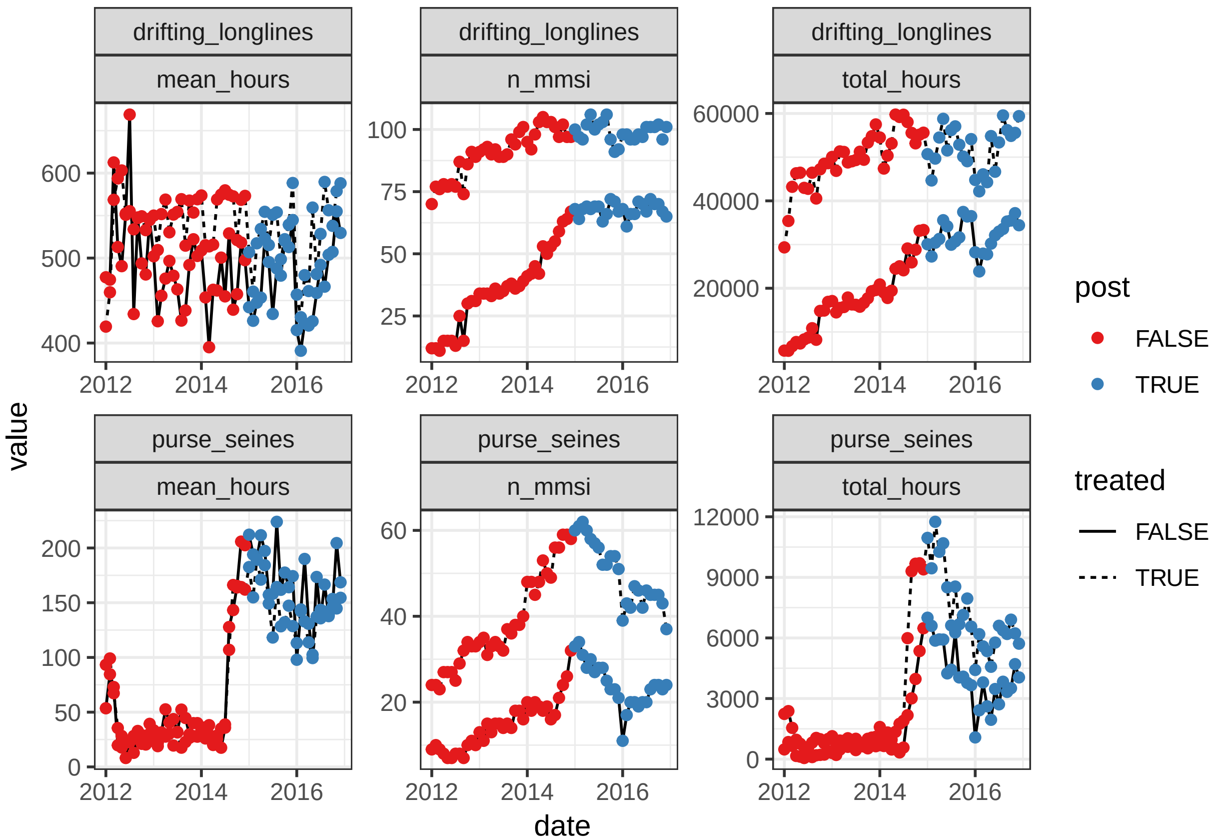
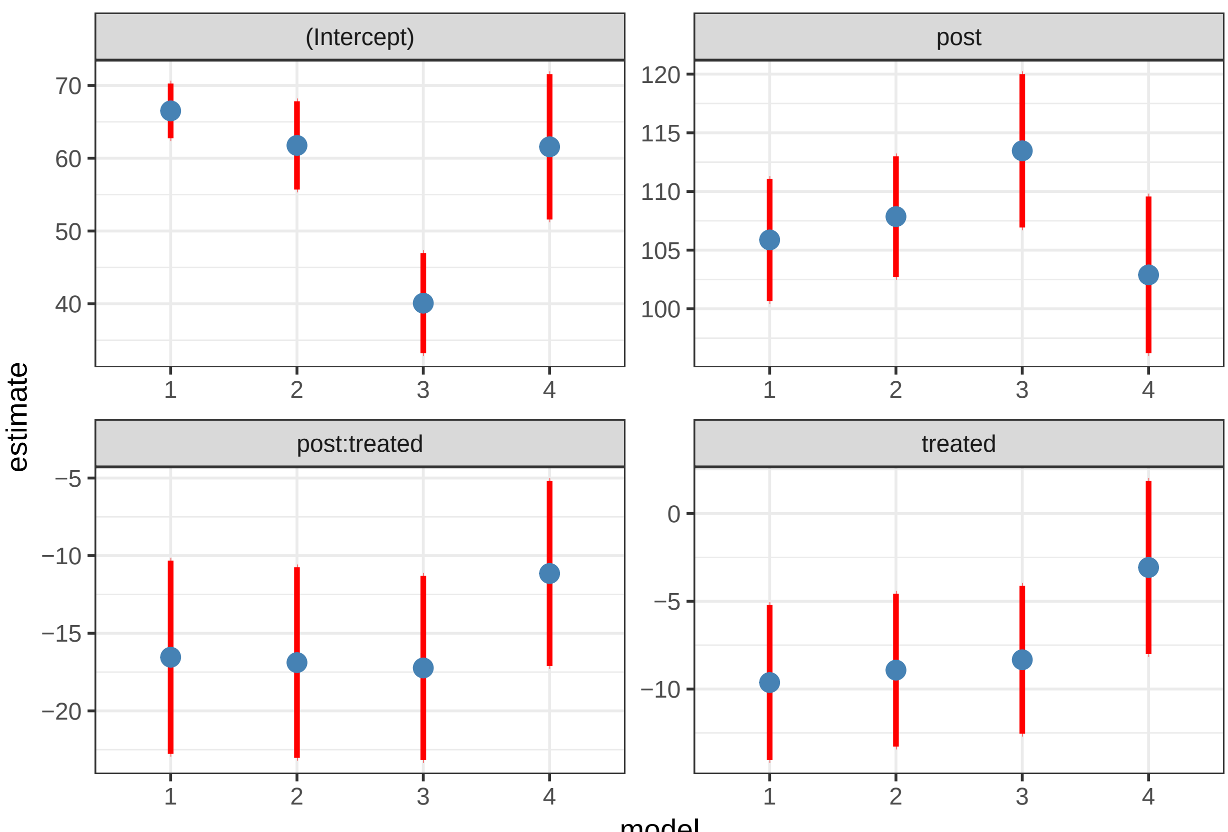


Figure 2: Fishing hours and number of vessels by month for all vessels that fished inside PIPA at least once.

Table 3: Fishing hours from GFW for all vessels (n = 206) that at some point fished in PIPA. Asterisks indicate significance levels. Numbers in parenthesis represent heteroskedastic-robuste standard errors.

	Dependent variable:			
	hours			
	(1)	(2)	(3)	(4)
post	105.873***	107.859***	113.466***	102.890***
	(5.532)	(5.364)	(5.887)	(6.076)
treated	−9.632**	−8.924**	−8.334**	−3.076
	(4.257)	(4.023)	(3.725)	(4.540)
post:treated	−16.544**	−16.889***	−17.235***	−11.150*
	(6.481)	(6.358)	(6.126)	(6.162)
Constant	66.505***	61.758***	40.085***	61.569***
	(3.780)	(5.352)	(5.699)	(9.753)
Month FE	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Flag FE	No	No	No	Yes
Observations	3,692	3,692	3,692	3,692
R^2	0.238	0.262	0.312	0.339
Note:				*p<0.1; **p<0.05; ***p<0.01

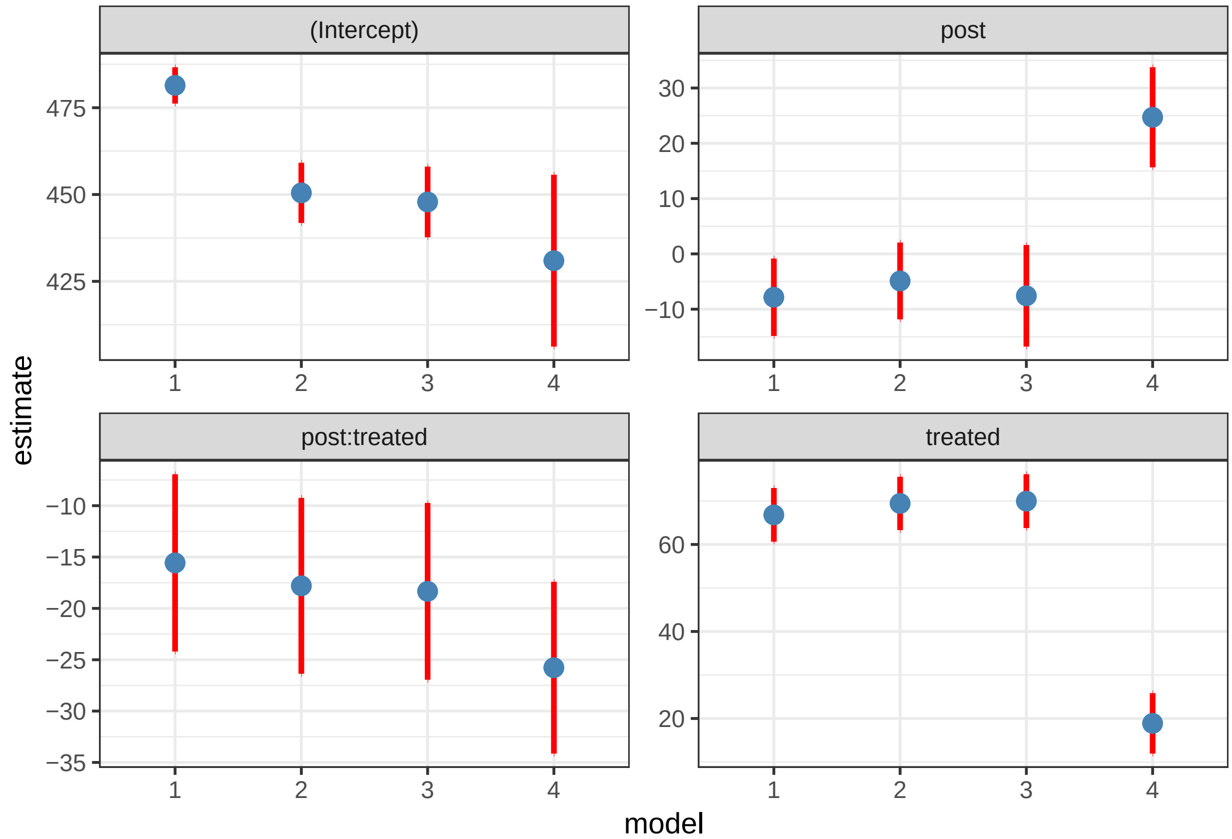
Purse seiners



Longliners

Table 4: Fishing hours from GFW for all vessels (n = 206) that at some point fished in PIPA. Asterisks indicate significance levels. Numbers in parenthesis represent heteroskedastic-robuste standard errors.

	Dependent variable:			
	hours			
	(1)	(2)	(3)	(4)
post	-7.843	-4.894	-7.580	24.708^{***}
	(7.514)	(7.480)	(9.336)	(9.315)
treated	66.801^{***}	69.434^{***}	69.959^{***}	18.878^{***}
	(6.541)	(6.549)	(6.603)	(7.257)
post:treated	-15.571^{*}	-17.806^{**}	-18.340^{**}	-25.775^{***}
	(8.958)	(8.899)	(8.936)	(8.743)
Constant	481.425^{***}	450.475^{***}	447.866^{***}	430.947^{***}
	(5.733)	(9.239)	(10.280)	(24.476)
Month FE	No	Yes	Yes	Yes
Year FE	No	No	Yes	Yes
Flag FE	No	No	No	Yes
Observations	8,558	8,558	8,558	8,558
R^2	0.026	0.044	0.044	0.107
Note:				*p<0.1; **p<0.05; ***p<0.01



(Intercept)
post
post:treated
treated
estimate
model
475
450
425
30
20
10
0
−10
−15
−20
−25
−30
−35
60
40
1
2
3
4

Discussion

Further work

References

1. McDermott, G. R., Meng, K. C., McDonald, G. G., and Costello, C. J. *Proc Natl Acad Sci USA* aug (2018).