

ENSO increases foreign fishing

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Abstract

Illegal, unreported and unregulated (IUU) fishing contributes to x% of the global fishing economy. Foreign fishing in a nation's Exclusive Economic Zone (EEZ) contributes to a y% of IUU fishing [Cabral et al., 2018]. Drivers of foreign fishing include a, b and c, but it is unclear how this may change under climate change. We show ENSO events increase foreign fishing by z%. This effect is larger for vessels with less fishing experience and lower for vessels with higher fishing experience. We also find the effect is lower for more adaptive gears such as longliners. This quantitative evidence linking climate and fishing behavior have important implications for climate projections and adaptation of this sector

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²⁷ Updated on: 2018-11-14

²⁸ To do list

- ²⁹ • Revise methods and explain how SST - nino 3 teleconnection was calculated
- ³⁰ • Describe each dataset
- ³¹ • Build a brief introduction
- ³² • Update the specifications

³³ **Introduction**

³⁴ **Methods**

³⁵ **Data**

³⁶ **GFW data**

FF and non-FF by gear

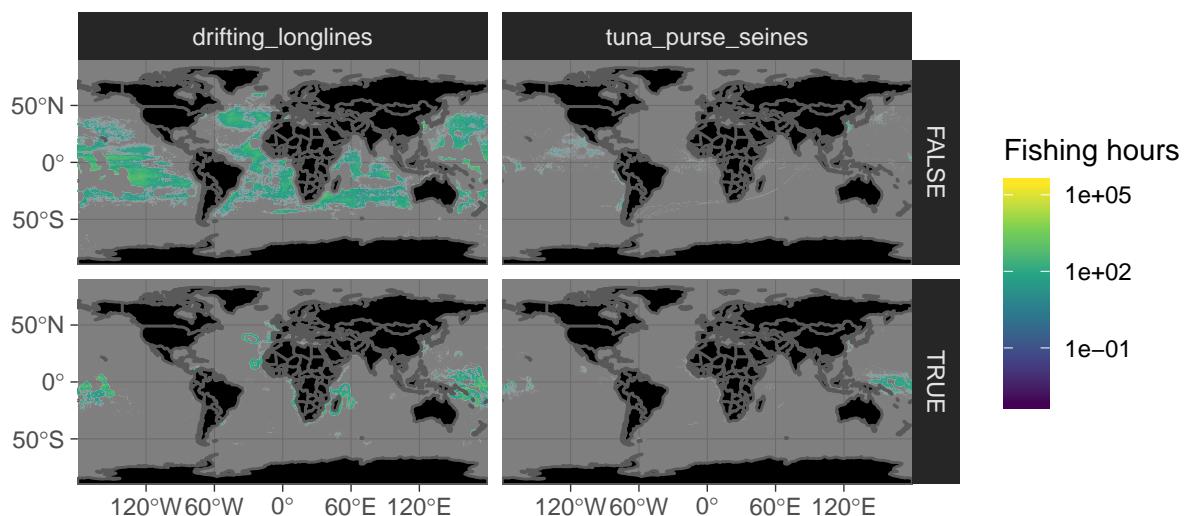


Figure 1: Fishing effort (hours) by gear and foreign fishing

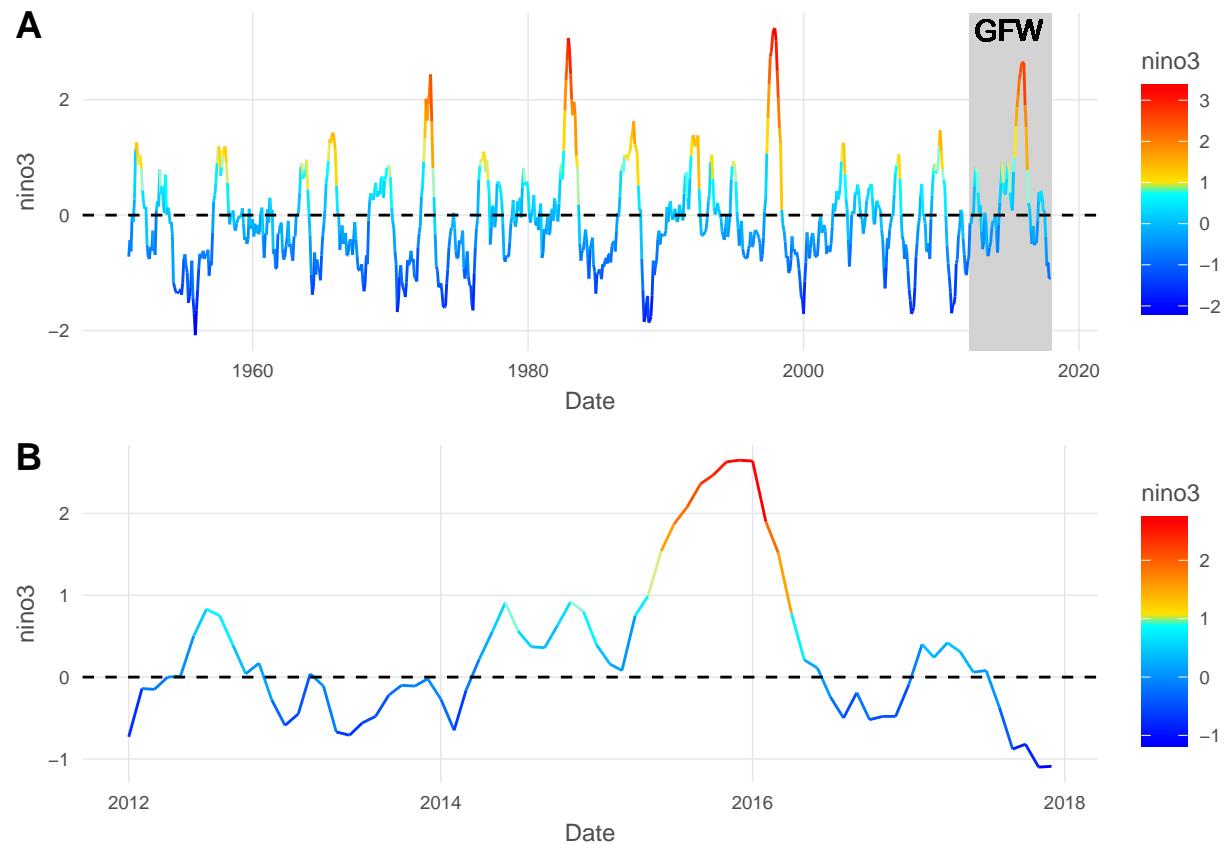


Figure 2: Timeseries of nino3 index (detrended) for A) The entire length and B) timespan matching GFW data

38 SST Data

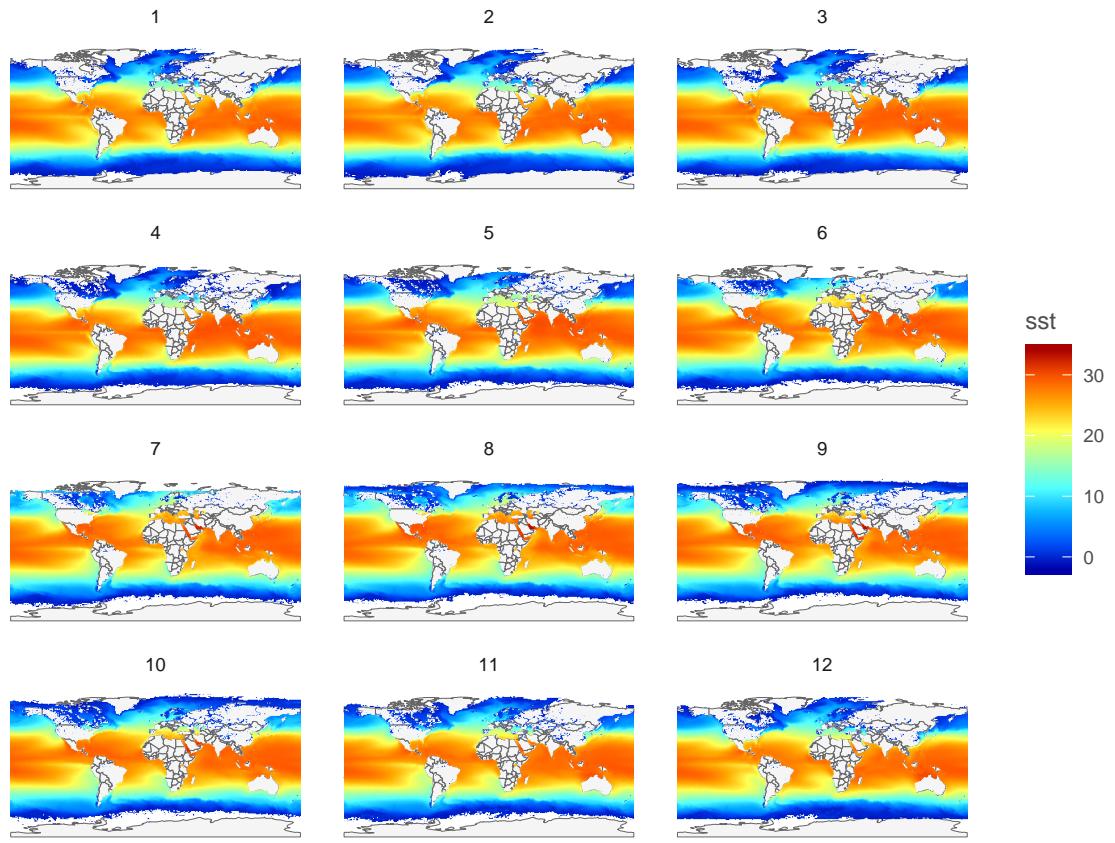


Figure 3: Mean monthly SST

³⁹ **Empirical specifications**

⁴⁰ **ENSO and Foreign Fishing**

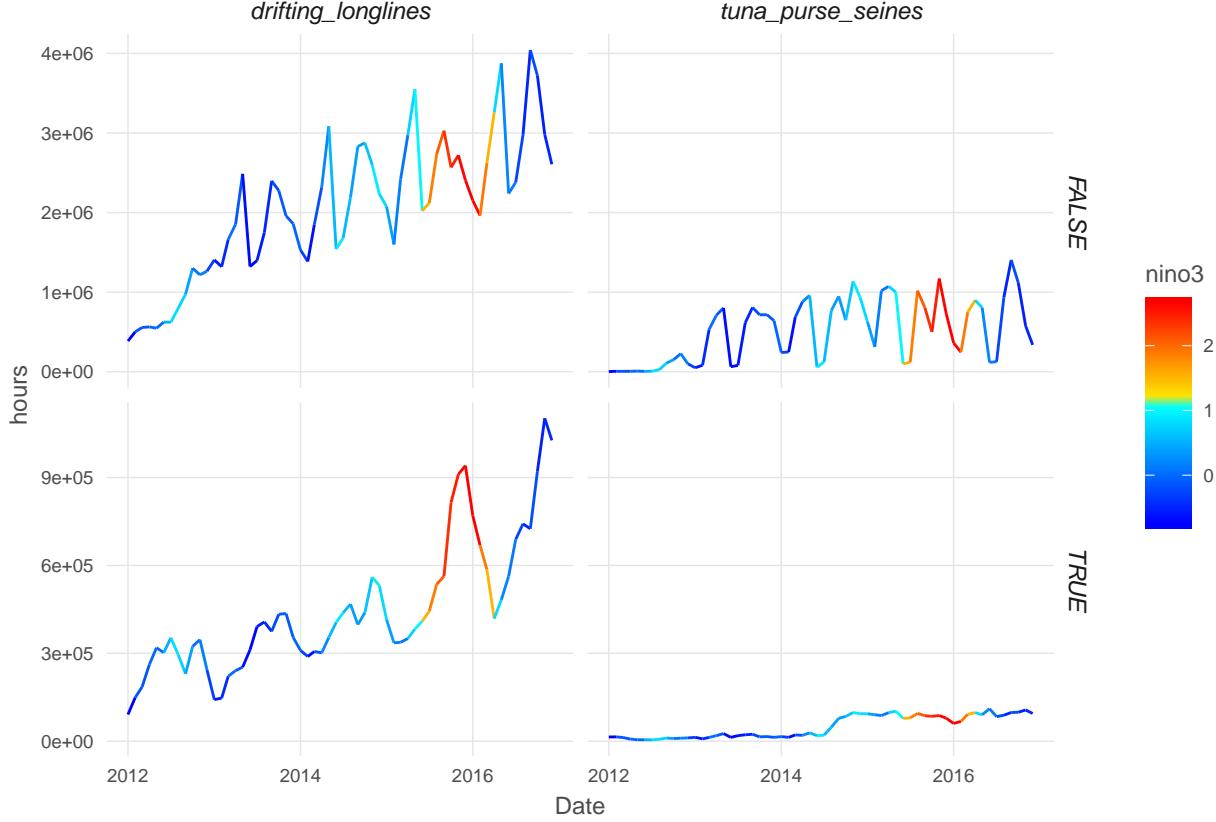


Figure 4: Trends in fishing hours by gear and foreign

⁴¹ We estimate the effects of ENSO on Foreign Fishing using a difference-in-difference strategy to compare the
⁴² effects of ENSO on foreign fishing in regions impacted by ENSO to its effects on foreign fishing in regions not
⁴³ impacted by ENSO.

$$\log(FF_{ct}) = \alpha + \beta ENSO_t \times \Pi_{ct} + \phi_t + \lambda_c + \epsilon_{ct}$$

⁴⁴ FF_{ct} represents the foreign fishing variable of interest by country and year. We use an inverse hyperbolic
⁴⁵ sine¹ of our foreign fishing variable in my main specification to transform zeroes in the data [Burbidge et al.,

¹ $\ln(FF + \sqrt{1 + FF^2} \rightarrow \ln(2L)$

46 1988, Card and DellaVigna, 2017]. α is a constant and β captures the linear effect of ENSO on countries in
 47 effected regions compared to counties in regions unaffected by ENSO. The treatment is ENSO interacted with
 48 a dummy, Π_{ct} , that equals 1 for countries in ENSO-effected regions and 0 for countries in unaffected-ENSO
 49 regions. ϕ_t are monthly fixed effects and λ_c are country fixed effects. Standard errors are clustered at the
 50 country level

51 **Identify treatment regions**

52 First we established a relationship between ENSO and two local environmental variables that drive the
 53 geographical presence of fish stocks, sea-surface temperature (SST) and windspeed. We use composite images
 54 of average monthly SST value, SST_t , from the NASA Dataset². We run the following regression model:

$$SST_t = \omega + \phi ENSO_t + \sum_{p=1}^N \mu_p t^p + \epsilon_t$$

²<ftp://podaac-ftp.jpl.nasa.gov/>

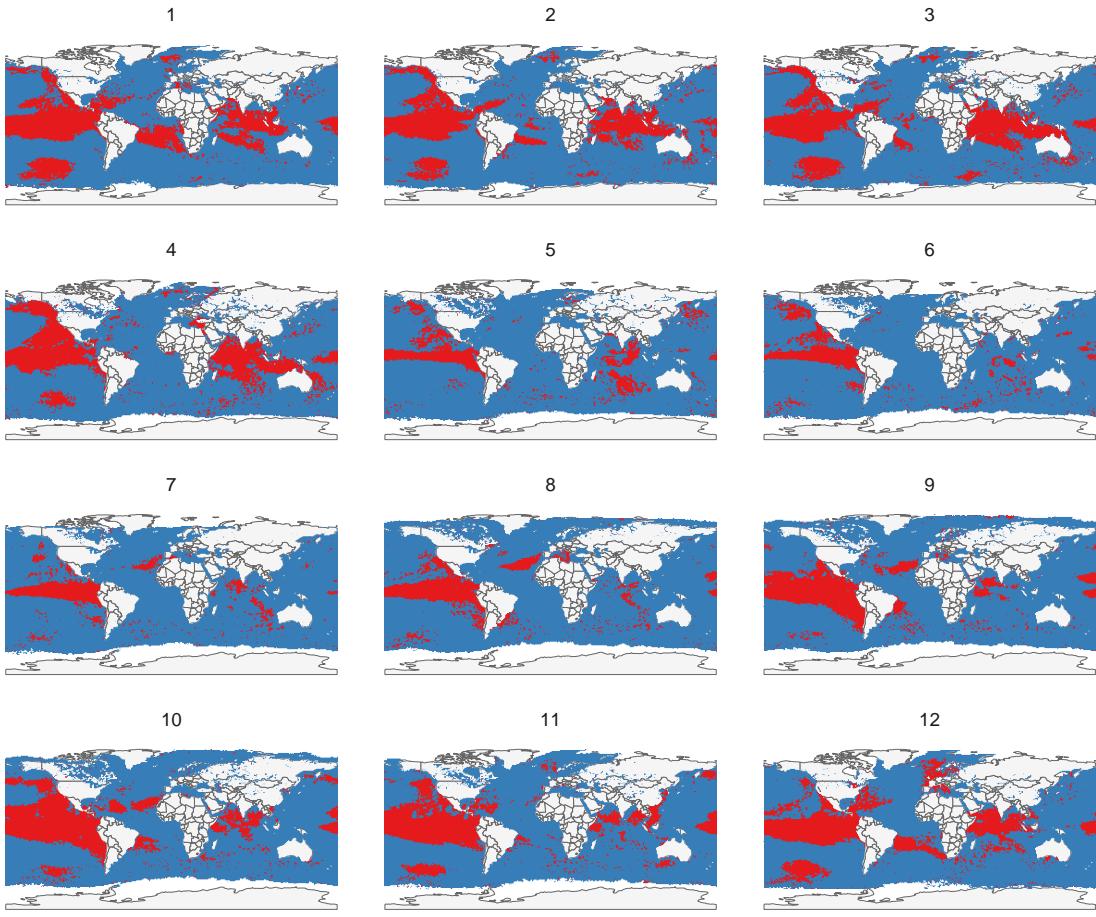


Figure 5: Monthly correlations between SST and nino3 index. Numbers above each pannel indicate the month (1 = Jan, 12 = Dec). Red zones indicate the pearson's correlation coefficient was > 0 and $p < 0.1$.

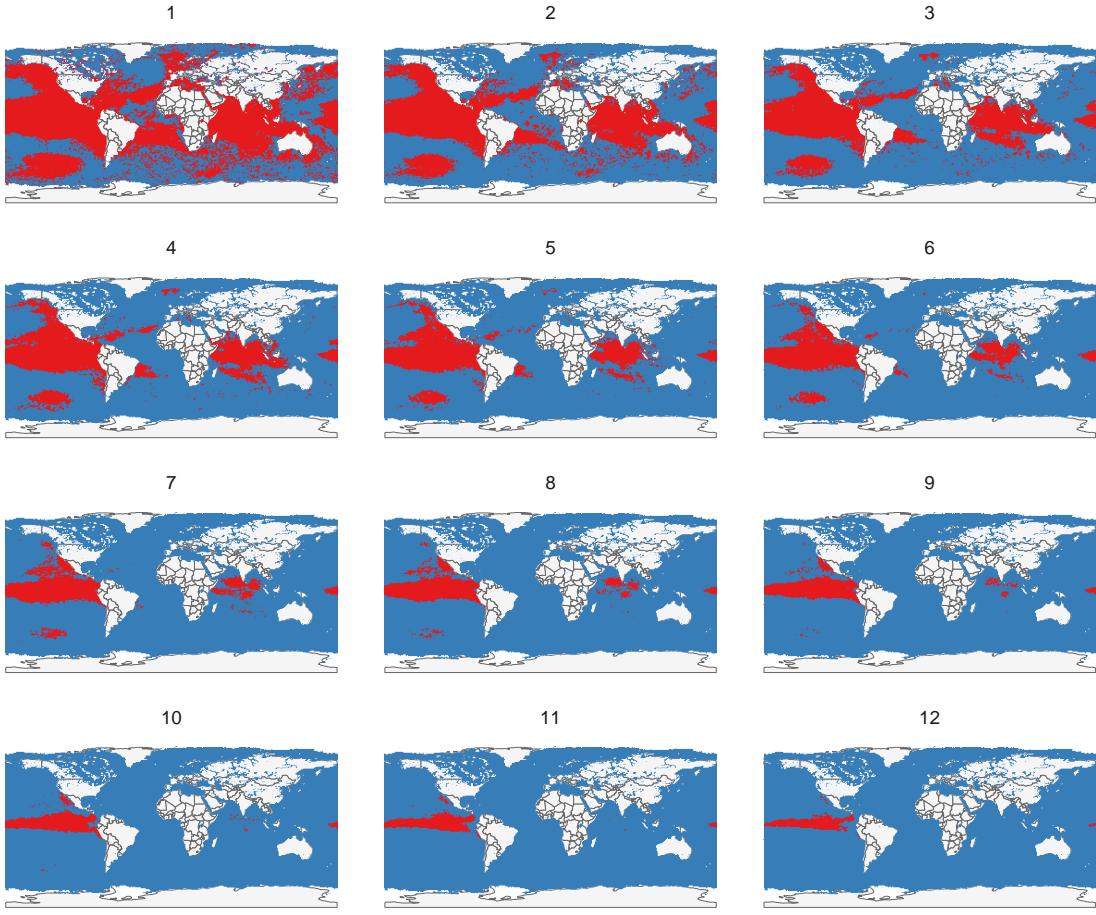


Figure 6: ENSO teleconnection depending on number of months. Number above figures indicate the minimum number of months for which a particular parcel was correlated to nino3 (red). For example, the panel 6 indicates that all red regions where SST showed a positive ($r > 0$) and significant ($p < 0.1$) correlation with nino3 index for at least 6 months.

55 where ω is a constant, ϕ captures the linear effect of monthly ENSO and μ_p captures the effect of a p^{th} -order
 56 polynomial time trend. Standard errors use the Newey-West adjustment which allows for serial correlation
 57 and heteroscedasticity of arbitrary form in the error terms over an optimally chosen window of time [Newey
 58 and West, 1987, 1994].

59 SST during this sample period exhibited trending behavior and thus needed to be detrended. To determine
 60 the polynomial order of the time trend, N , we use the Akaike Information Criteria (AIC) [Akaike, 1974],
 61 which when minimized captures a model's overall goodness of fit while penalizing additional terms with
 62 limited explanatory power. For both fisheries, we observe that the AIC statistic drops when a time trend of

63 second-order or higher is included in Equation 2. Importantly, we detect a positive/negative relationship
 64 between winter ENSO and SST and a positive/negative relationship between winter ENSO and windspeed,
 65 shown in Figure X.

$$\log(FF_t) = \psi + \delta ENSO_t + \sum_{p=1}^N k_p t^p + \mu_t$$

66 ψ is a constant; δ captures the linear effect of ENSO and k_p represents the effect of a p^{th} -order polynomial
 67 time trend. Standard errors use the Newey-West adjustment, allowing for arbitrary forms of serial correlation
 68 and heteroscedasticity in the error term with a bandwidth of 10 months. As a robustness check, we use
 69 different polynomial time trends to remove any long-term trends.

70

71 Results

72 So far these are only for eq 1.

Table 1: Foreign fishing hours and nino3

	Dependent variable:							
	hours				hours2			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
nino3anom	1.202*** (0.088)	1.194*** (0.088)	0.891*** (0.089)	0.412*** (0.089)	0.047*** (0.002)	0.047*** (0.002)	0.036*** (0.002)	0.020*** (0.002)
treated	1.495*** (0.137)	1.448*** (0.137)	1.785*** (0.138)	-2.374*** (0.177)	0.122*** (0.004)	0.122*** (0.004)	0.132*** (0.004)	-0.027*** (0.005)
nino3anom:treated	0.704*** (0.117)	0.798*** (0.117)	0.799*** (0.117)	1.202*** (0.117)	0.014*** (0.003)	0.014*** (0.003)	0.019*** (0.003)	0.048*** (0.003)
Constant	27.895*** (0.109)	28.202*** (0.110)	31.000*** (0.245)	27.247*** (1.189)	3.422*** (0.003)	3.422*** (0.003)	3.555*** (0.007)	3.452*** (0.033)
Gear FE	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Month FE	No	No	Yes	Yes	No	No	Yes	Yes
Country FE	No	No	No	Yes	No	No	No	Yes
Observations	415,884	415,884	415,884	415,884	415,884	415,884	415,884	415,884
R ²	0.002	0.003	0.008	0.023	0.006	0.006	0.016	0.041

Note:

*p<0.1; **p<0.05; ***p<0.01

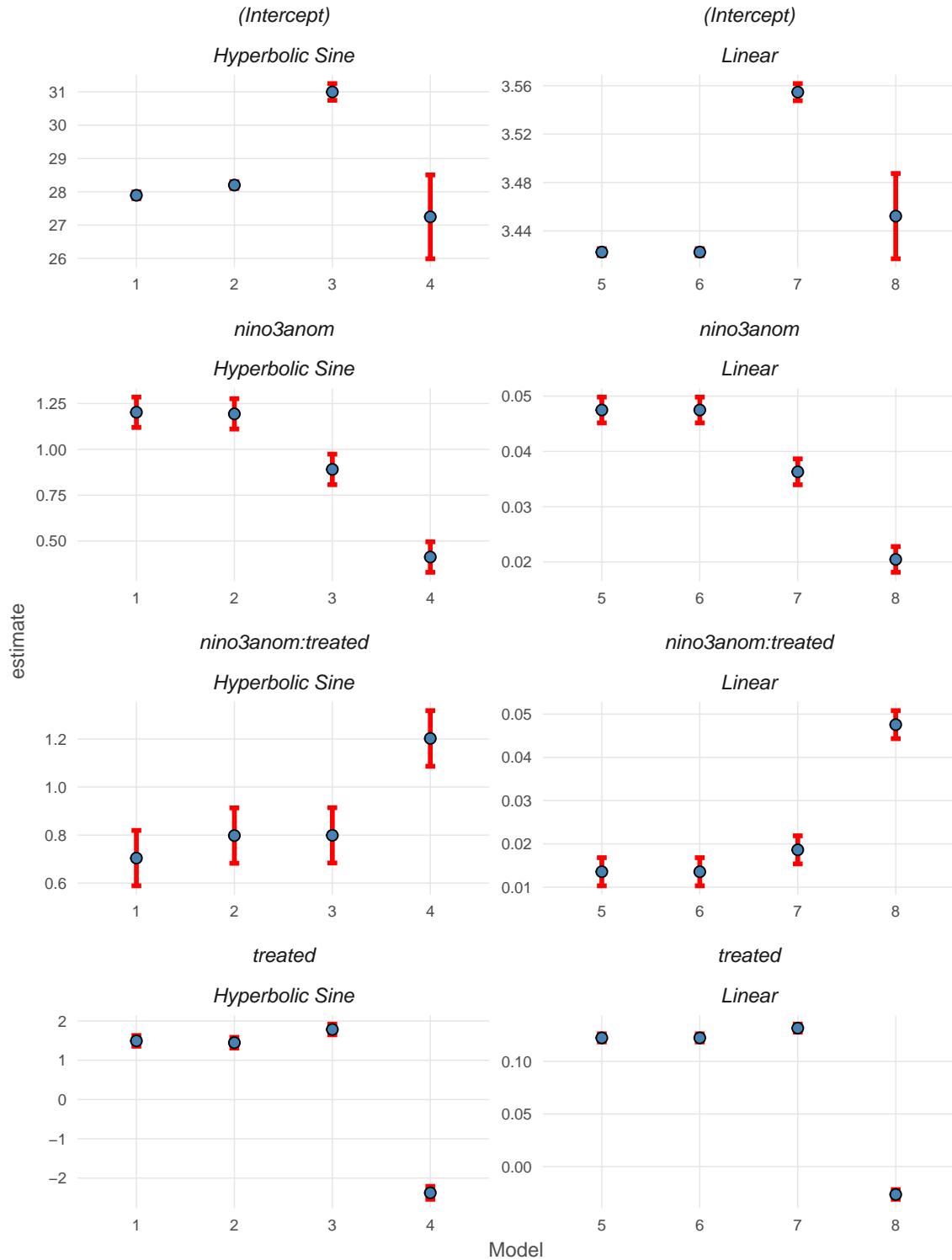


Figure 7: Coefficient estimates for the models ran above. Graphs on the left show estimates after the hyperbolic sine transformation of hours. Right side show no transformation of hours. Model numbers (x - axis) correspond to the columns in table 1 (1 - 4) and table 2 (5 - 8).

⁷³ **References**

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