The Effect of Climate Change and Regulations on Fishers Portfolios:

Substitution between Coastal Pelagic Species

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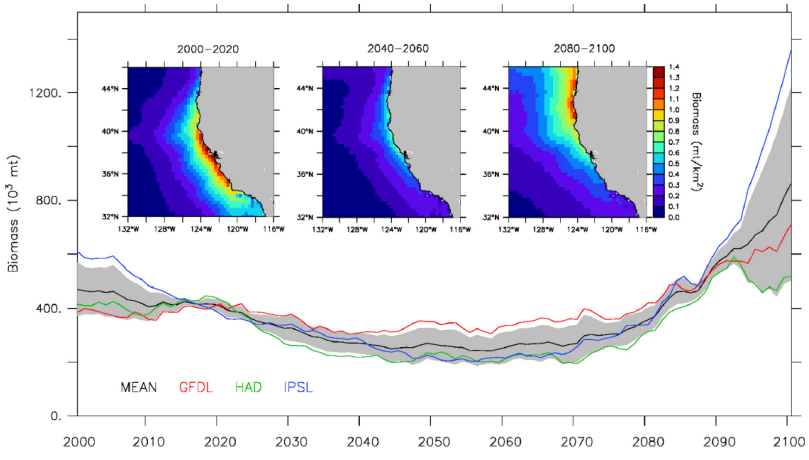
California Current System

1. Unique ecosystem
    - Provide many ecosystem services,
    - Sustains commercial and recreational fisheries,
    - Protected species,
    - **Forage species (e.g. Coastal Pelagics).**
2. Climate is changing:



3. Changes in species distribution and regulations

Research Question

- **Big picture:**
  - How will climate change impact fishing communities?
- **Specific question:**
  - How does changes in species distribution and regulations (i.e. closures) will affect catch composition and landings in the *Coastal Pelagic Species (CPS)* fishery?

Methodology

- **Two approaches:**
  - Landing model (result for the public aggregate data).
  - Participation model (no results yet).
- **Data:**
  - Fish tickets from The Pacific Fisheries Information Network (PacFIN)
  - Current and projected species distribution (Muhling et al, 2020).
  - Fishing locations from logbooks (maybe Global Fishing Watch)

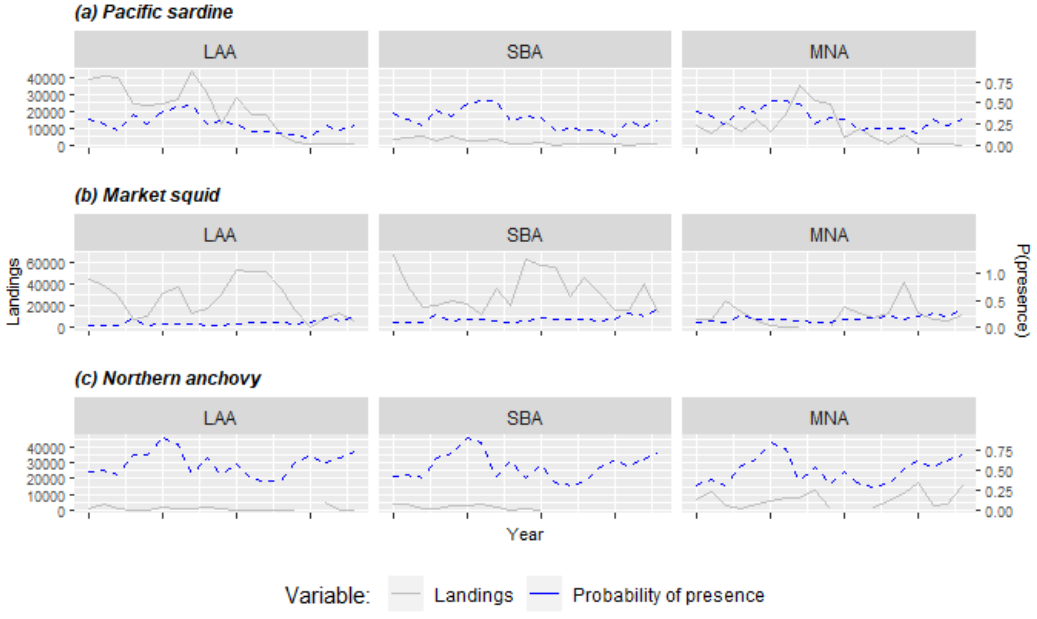
Landing model

Landing model

- Hierarchical Bayesian Hurdle model
  - Uncertainty from modeling and observation. All parameters are random variables
  - **Multilevel effects (i.e. hierarchical effects by ports/vessel)**.
  - Incorporate previous knowledge as a prior (Smith et al, 2020).
  - Hurdle allows to model the zeros.

Landing model

- Separate model for:
  - Pacific sardine, Northern anchovy and Market squid.
- Ports were chosen using historical landings.
- Interaction between species
  - Through the probability of presence (SDMs outputs)



Landing model: Bayesian framework.

- In general, our Bayesian models have the following structure:

$$[\theta_i|q_{i,t}] \propto f\left(q_{i,t}|\theta_i\right) \times [\theta_i]$$

  - where $q_{i,t}$ is the observed landings of the corresponding species in port $i \in (1, \ldots, L)$ at year t, L is the total number of port, and θ_i are the parameters (i.e. random-coefficients) to be estimated at the port level.

- The distribution $f\left(q_{it}|\theta_j\right)$ can be rewritten as:

$$f\left(q_{it}|\theta_i\right) = \begin{cases} p_{it} & \text{if} \quad q_{it} = 0 \\ [1 - p_{it}] \, \text{gamma}\left(q_{it}|\frac{\mu_{it}^2}{\sigma^2}, \frac{\mu_{it}}{\sigma^2}\right) & \text{if} \quad q_{it} > 0. \end{cases}$$

  - where $\text{logit}(p_{it}) = \mathbf{X}\boldsymbol{\gamma_i}$ and $\mu_{it} = \mathbf{X}\boldsymbol{\beta_i}$.

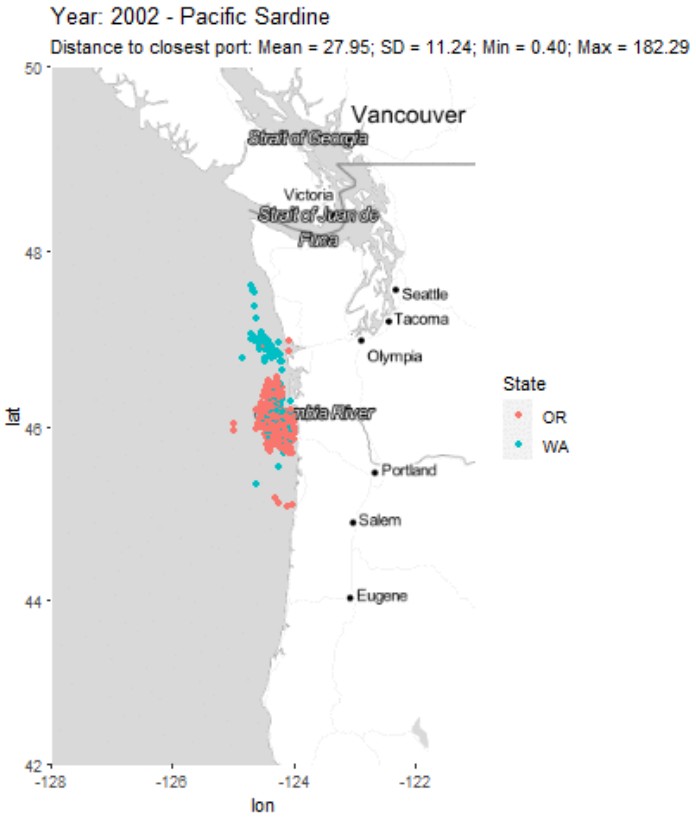
Landing model: Bayesian framework.

- Specifically μ_{it} is defined as the following:

$$\begin{aligned}\mu_{it} =& \beta_i^0 + \beta_i^1 Pr(Prec.PSDN)_{it} \\ &+ \beta_i^2 Pr(Prec.MSQD)_{it} \\ &+ \beta_i^3 Pr(Prec.NANC)_{it}\end{aligned}$$

- where $Pr(Prec)$ is the probability of presence. $\text{logit}(p_{it})$ follows the same structure.

- Other variables:
  - Annual Catch Limits (ACL)
  - Closure
  - Prices by port
  - Average distances traveled (To be included)
  - Fuel cost (To be included)



Participation model

Participation model

<< No results yet! >>

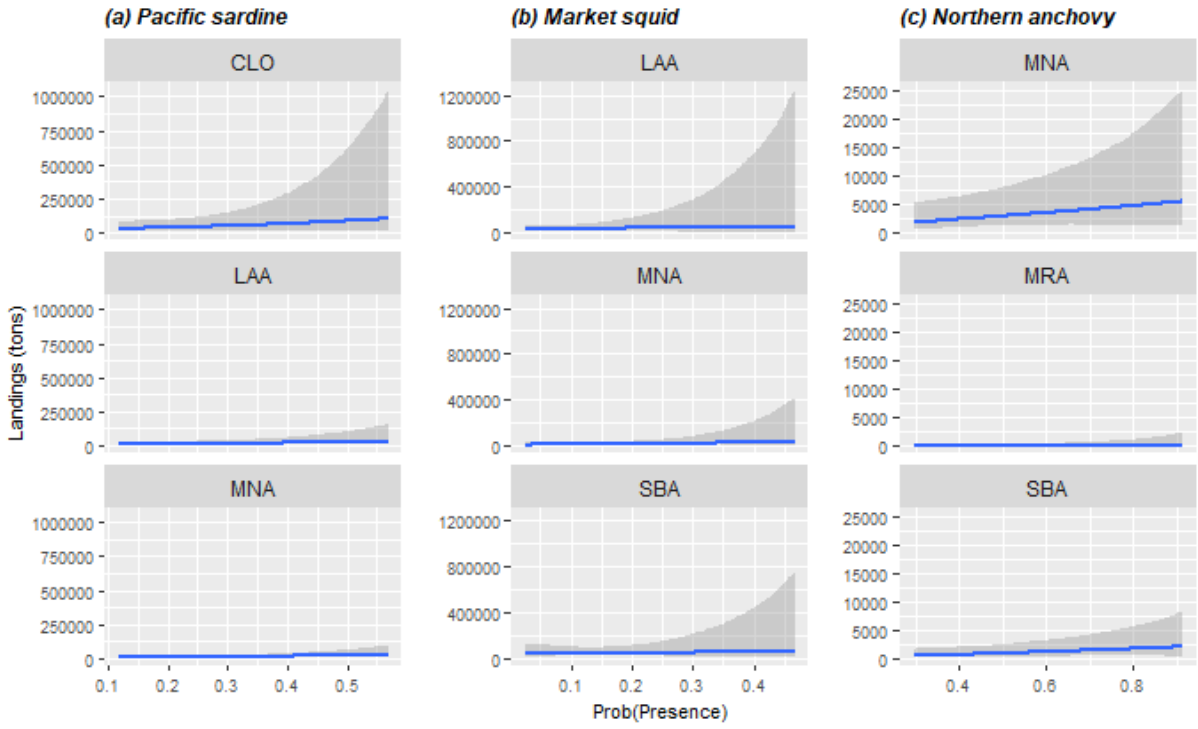
- Effect of abundance/closure in seasonal participation.
- We model the probability p_{ijm} that vessel i fishes species j in month m as:

$$\begin{aligned}\text{logit}(p_{ijy}) =& \beta_1 + \beta_2 Closure + \beta_3 Mean.revenue_j + \beta_4 ExpectedCatch_j \\ &+ \beta_5 HHI_i + \beta_6 Percent.revenue_j + \beta_7 LCG_i + \beta_8 LI_i \\ &+ \beta_9 Year.fished.\end{aligned}$$

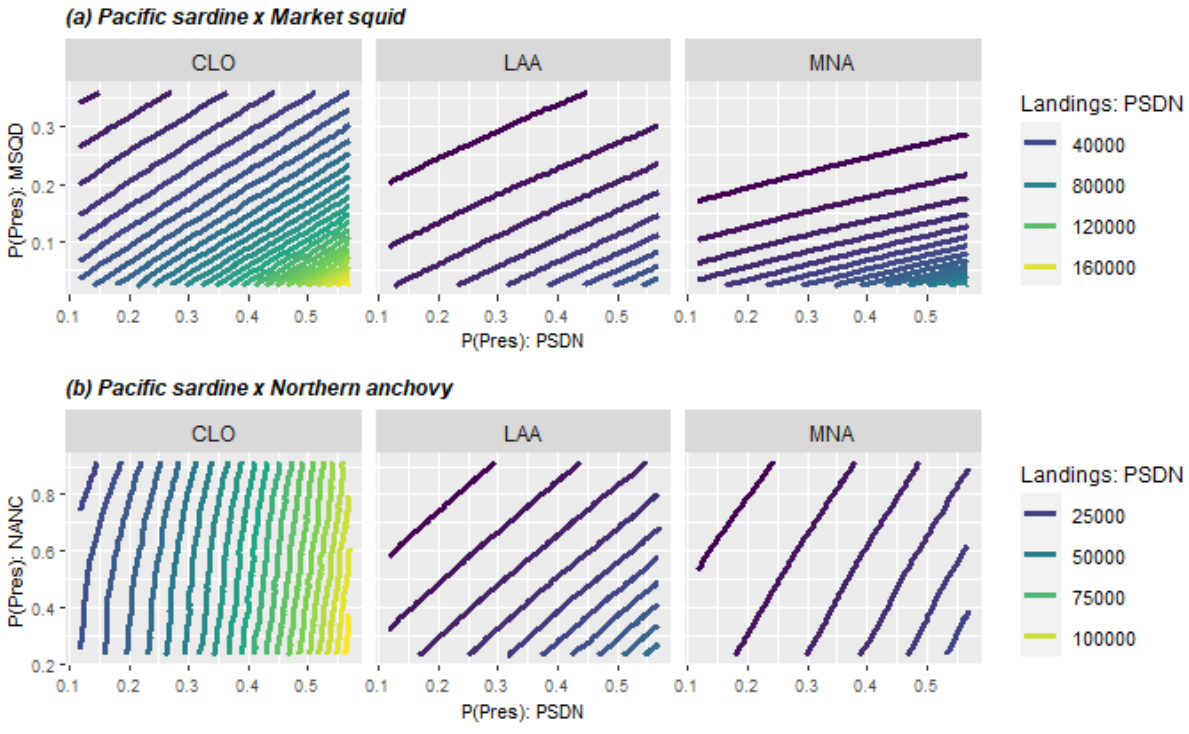
- From Richerson & Holland (2017):
  - HHI = Diversification measurement
  - Percent.revenue = Dependence on the species in consideration
  - Latitudinal center of gravity (LCG) = Typical landings location
  - Latitude inertia (LI) = Dispersion around center of gravity

Results

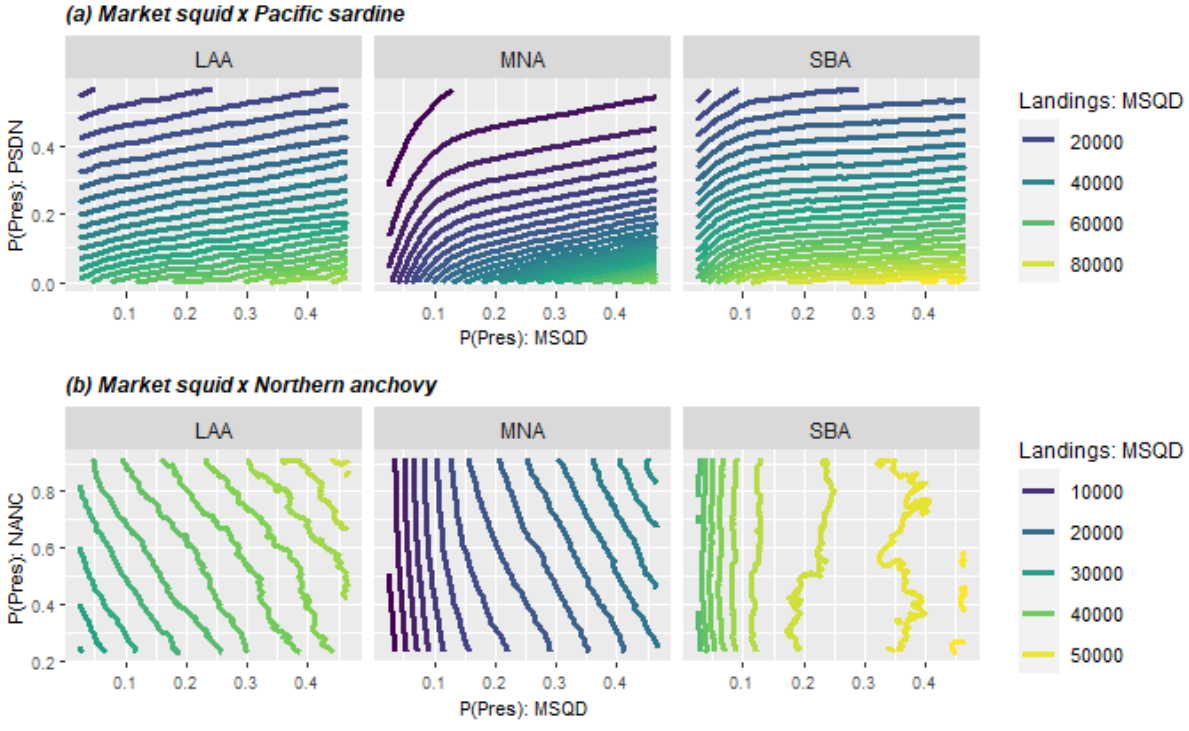
Results: Effect of presence



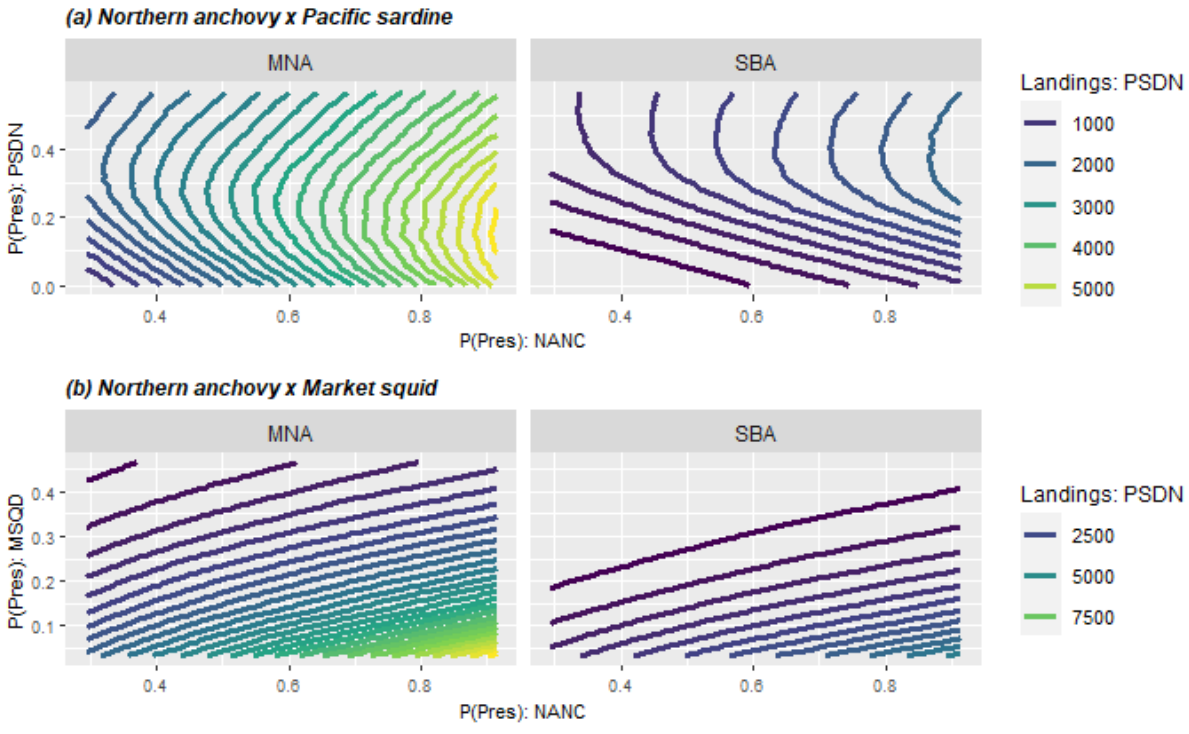
Results: Interaction effects on PSDN



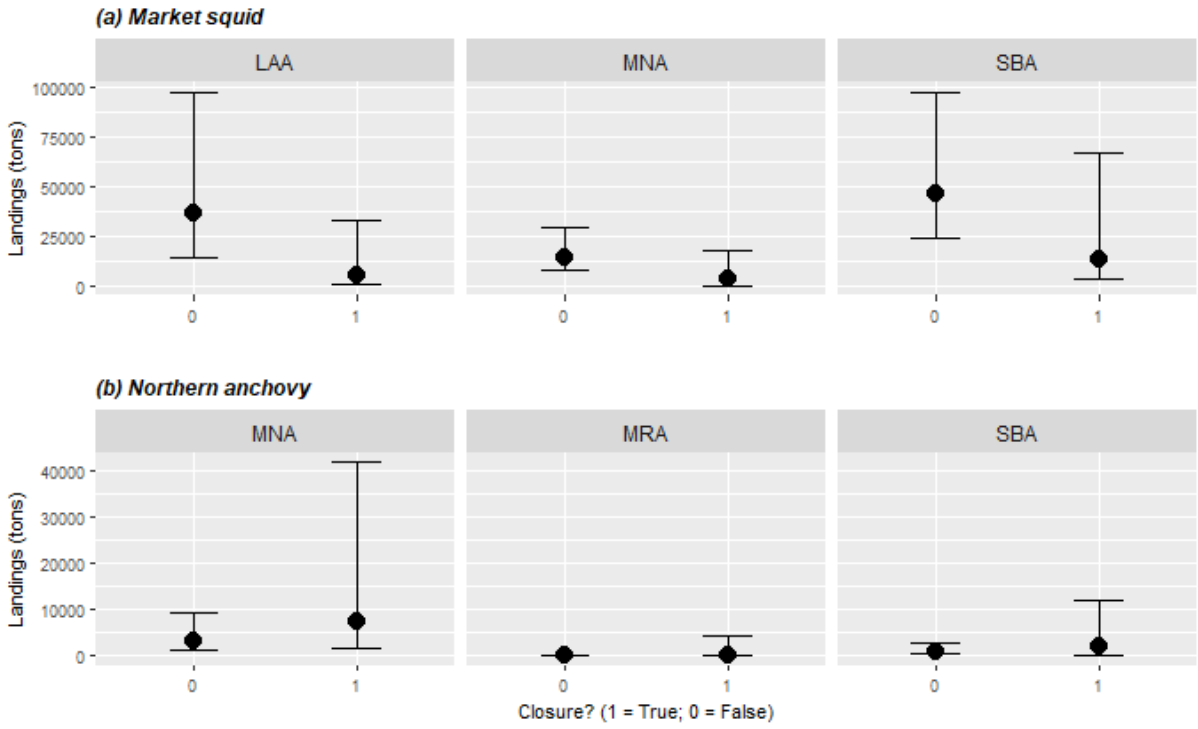
Results: Interaction effects on MSQD



Results: Interaction effects on NANC



Results: Pacific sardine closure



Conclusions

Conclusions

1. Slightly positive effect on presence on landings.
2. Substitution between market squid and Pacific sardine.
    - It seems that Pacific sardine is more preferred than market squid.
3. Northern anchovy is less preferred.
    - Exit when sardine abundance is high or low.
4. Closure reduce market squid landings. Participation decrease?
5. More in details on constraints

Future work

Future work

- Incorporate individual data for landings.
  - Vessels landings? or port landings?
  - Vessel/port heriarchal effects.
- Estimate participation model.
- Forecast using SDM projections.
- Study changes on effort? (number of trips by species)

- Other project:
  - Discrete choice model
    1. Daily information for landings.
    2. Global Fishing Watch.
    3. Decision *where* and *what* to fish.
    4. Forecast future fleet movements.

Thank you for your attention!

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