Future Seas Econon Report

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1 Introduction

This is a weekly report for the Economic group of the Future Seas Project. I downloaded landings data publicity available from PacFIN. The data has a panel data structure, where we observe commercial **west coast** species over *years*.

Changes from previous reportand work to do:

- Start developing Bayesian model for landings
- Leraning how to build a model in Stan
- Incorporate comments from monthly meeting
- Analyze logbook data for market squid in CA
- Retrieve info about port constraint.

2 Descriptive statistics

Table 1 shows descriptive statistics for each variable in the dataset:

Table 1: Descriptive statistics.

	Mean	Std.Dev	Min	Max
Landing_year	2001.89	11.65	1981.00	2021.00
Landings	293.31	2172.46	0.00	66890.30
N_dealers	20.38	13.01	0.75	68.00
N_vessels	42.10	31.42	0.75	182.00
Price	1.37	1.79	0.00	28.53
PSDN_SDM_mean	0.30	0.11	0.10	0.65
Revenue	347993.43	1835052.50	0.00	49987499.00

3 Graphical analysis

3.1 Revenue and landings: Historical averages.

Mean revenues by species are shown in Figure 1, while mean landings by species are shown in Figure 2.

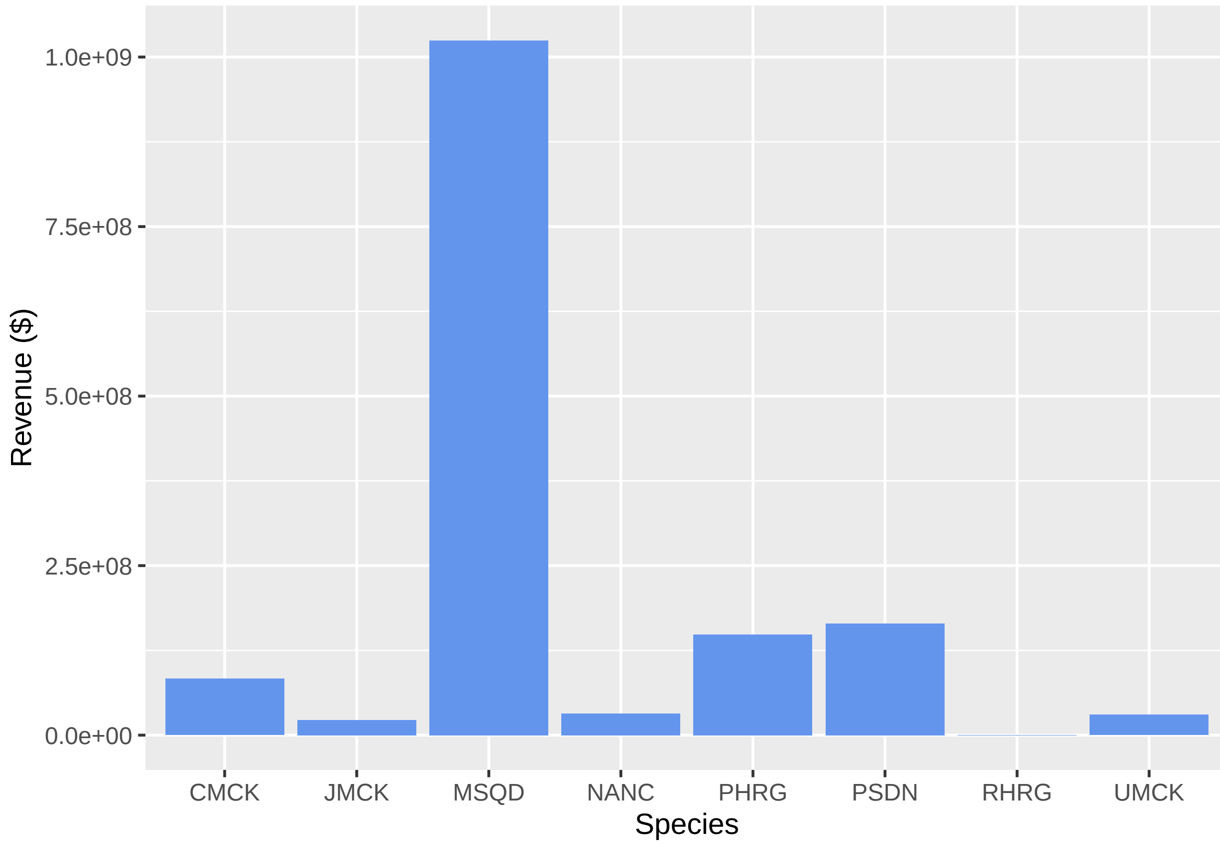

Figure 1: Annual mean revenue by CPS species. 1981-2021.

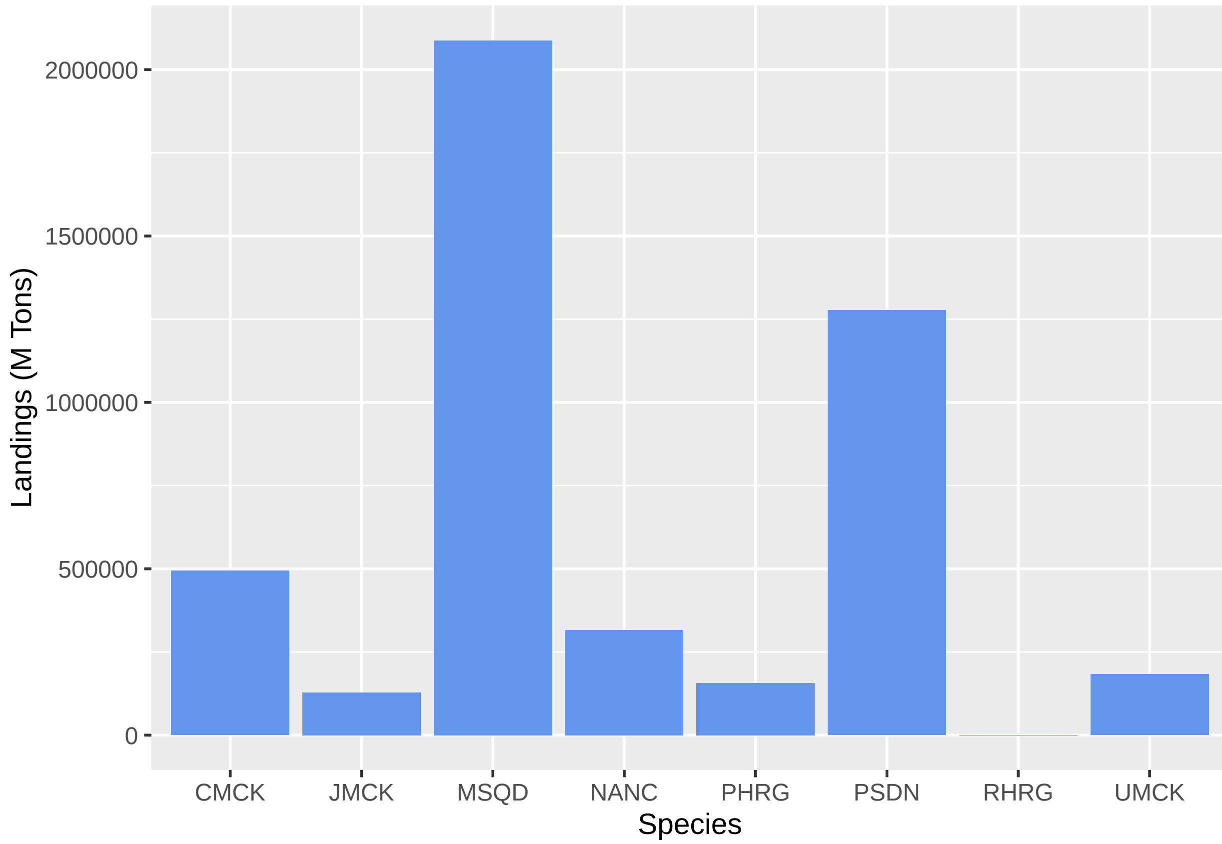

Figure 2: Annual mean landing by CPS species. 1981-2021.

3.2 Price and landings: Time series

Figure 3 shows landing over time by species, while Figure 4 shows landing and prices over time for selected CPS species.

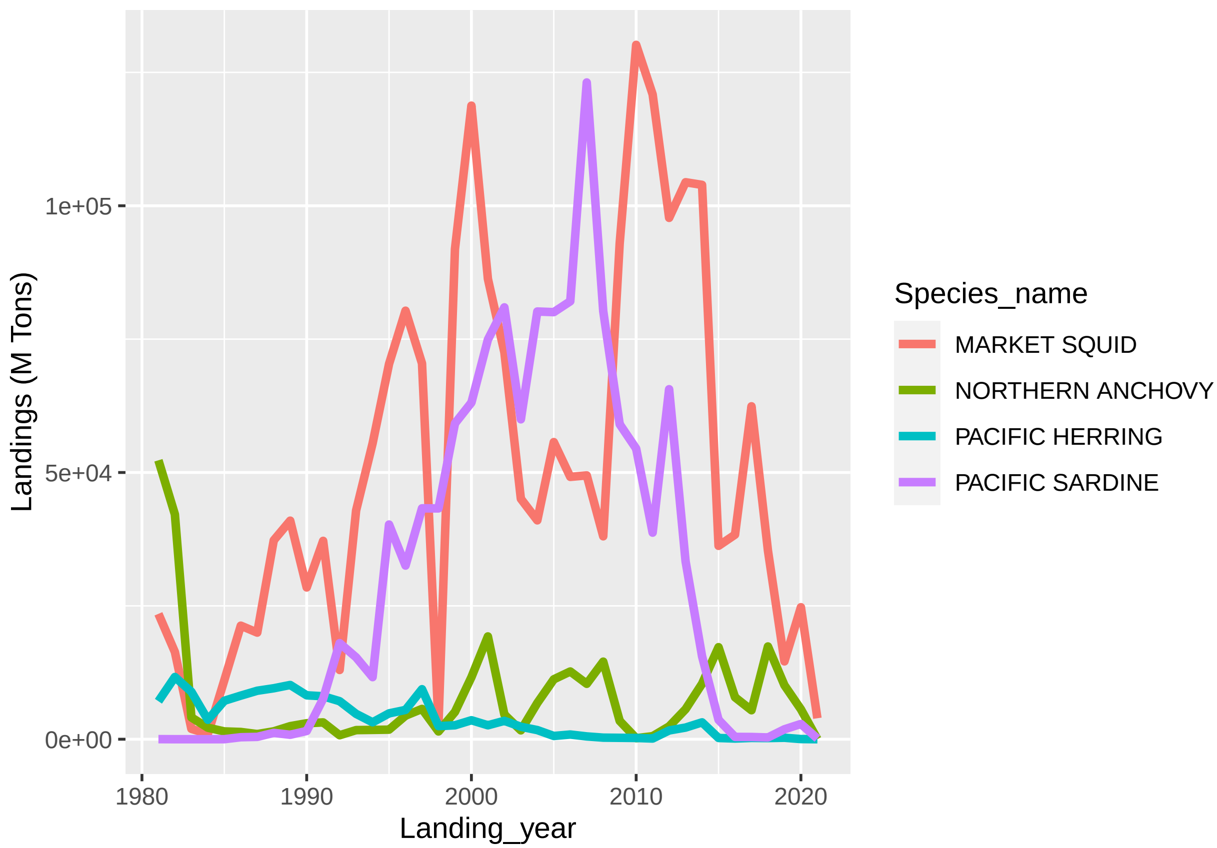

Figure 3: Total annual landing by CPS species.

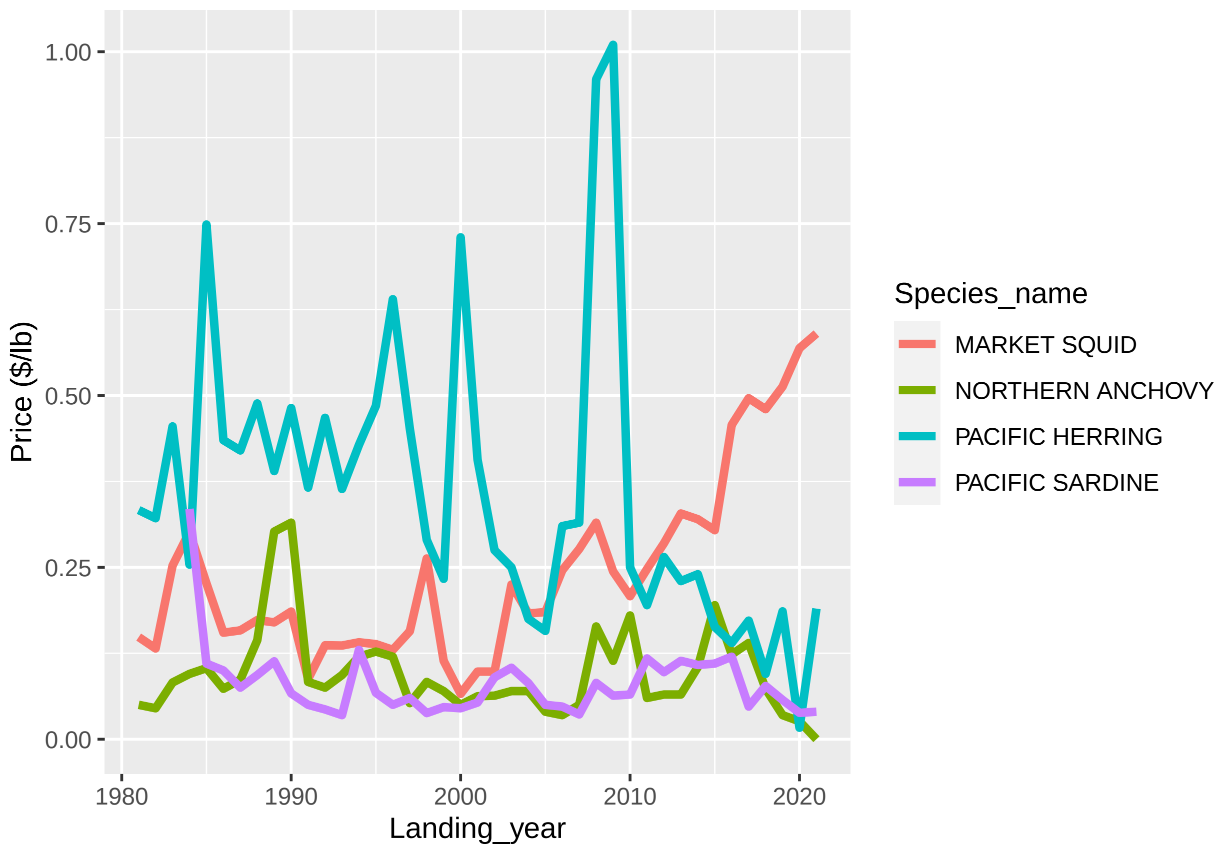

Figure 4: Annual averages of prices by CPS species.

3.2.1 Sardine

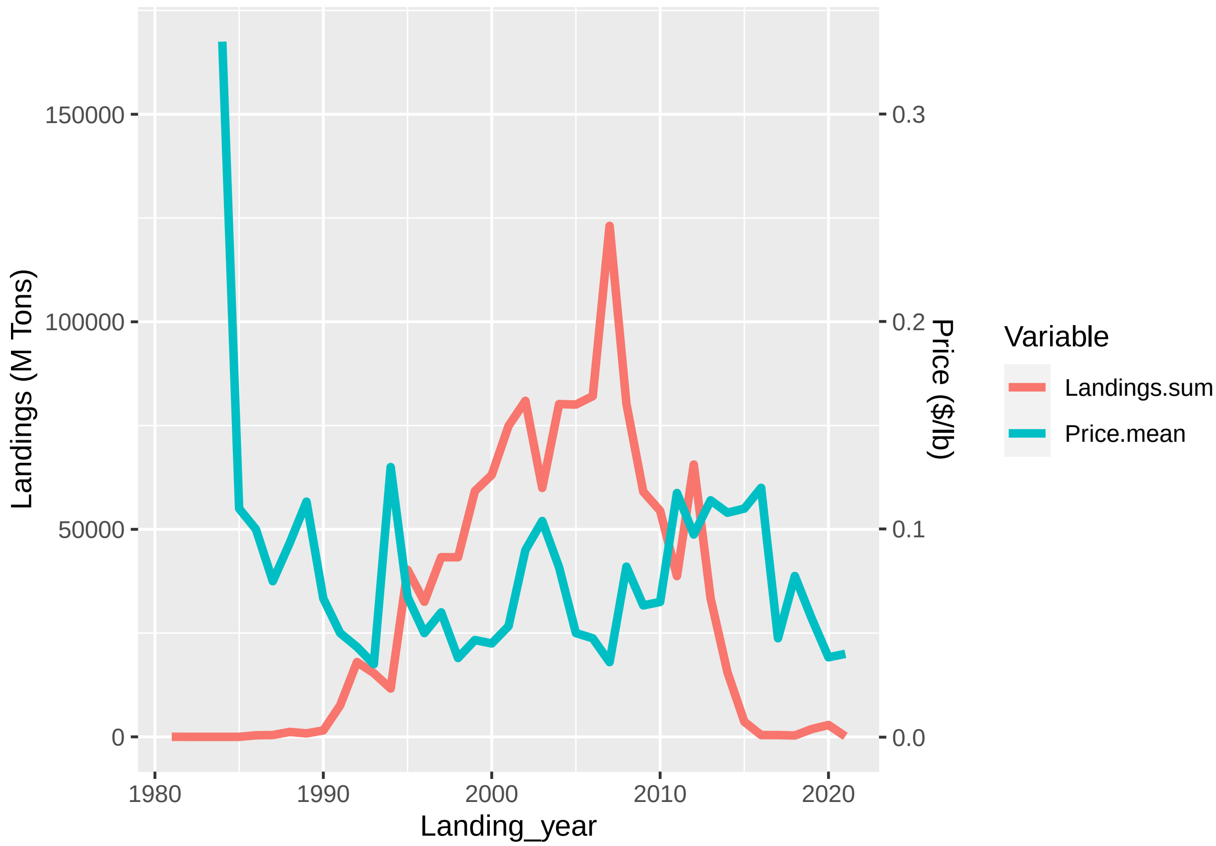

Figure 5: Landing v/s Prices. Pacific Sardine.

3.2.2 Anchovy

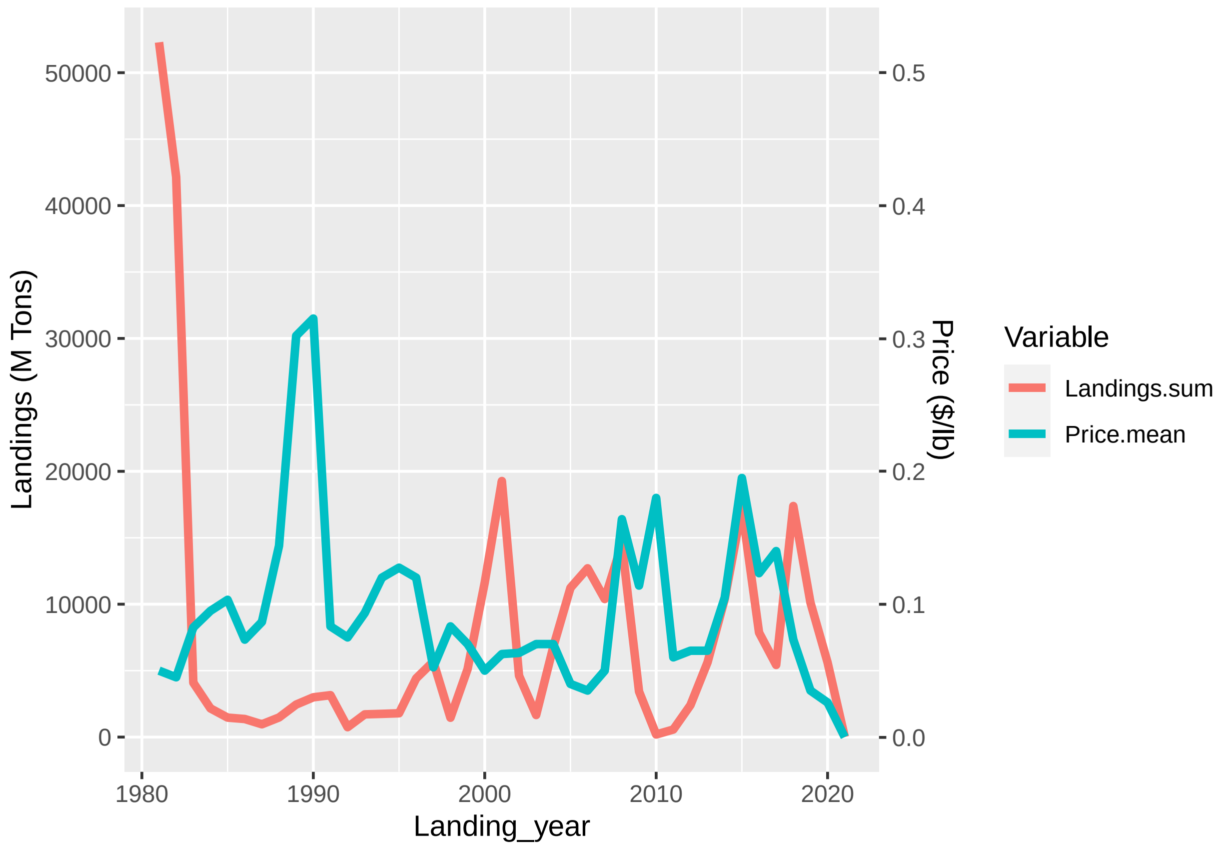

Figure 6: Landing v/s Prices. Northern Anchovy.

3.2.3 Market squid

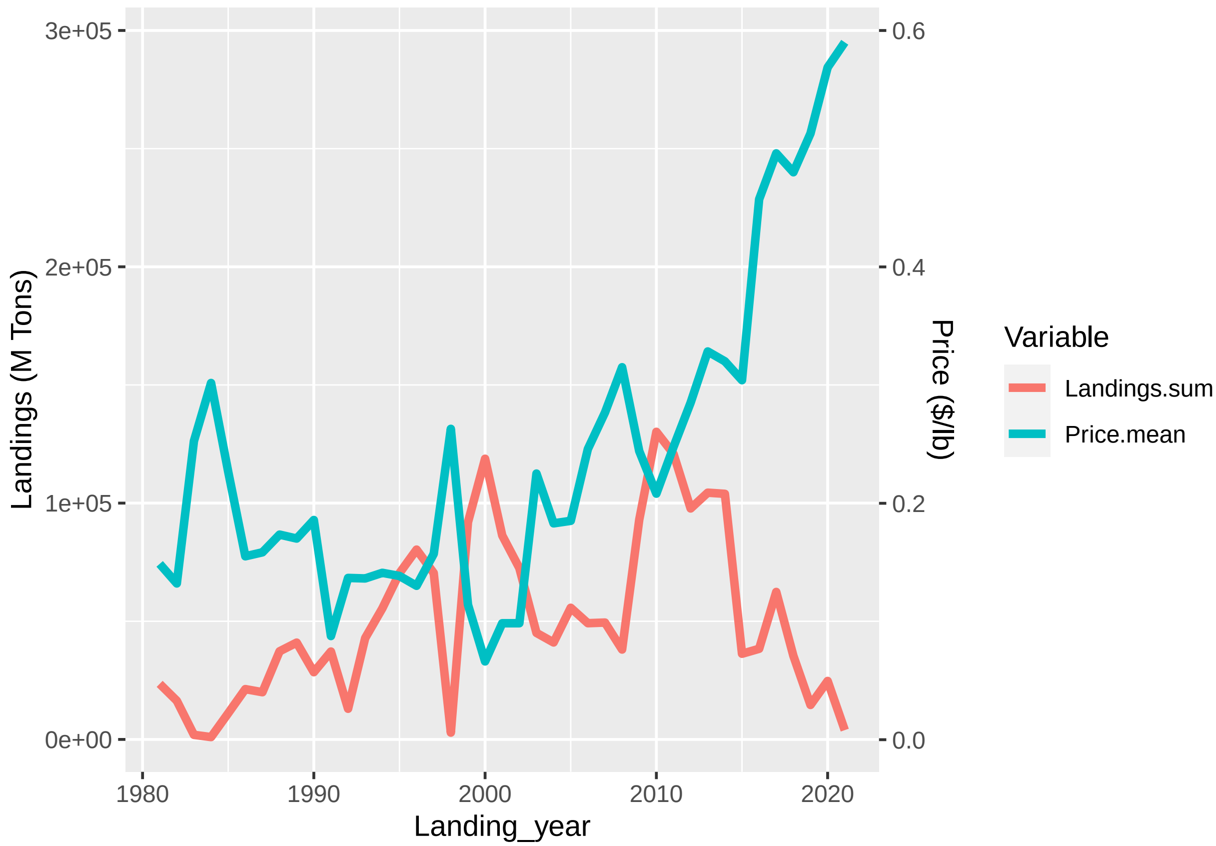

Figure 7: Landing v/s Prices. Market Squid.

3.2.4 Pacific Herring

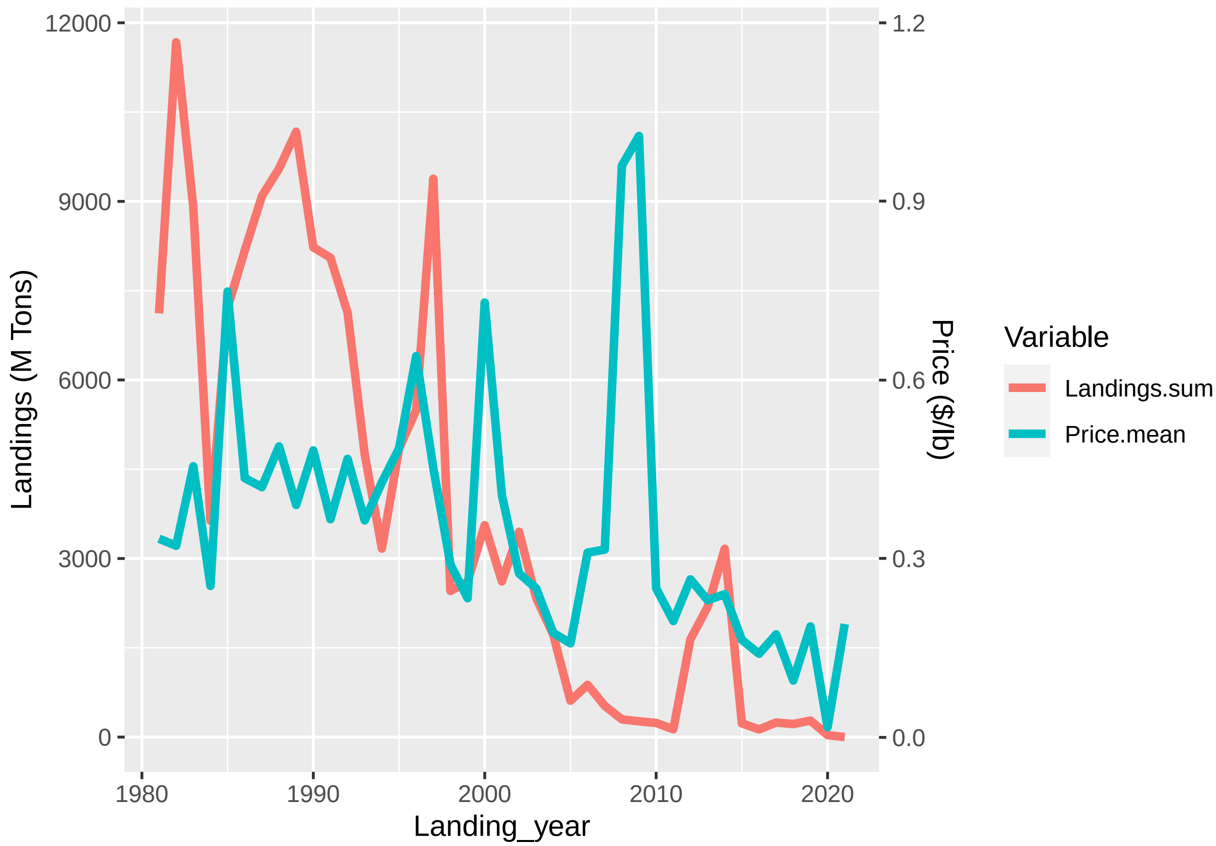

Figure 8: Landing v/s Prices. Market Squid.

3.3 Historical averages by state and port

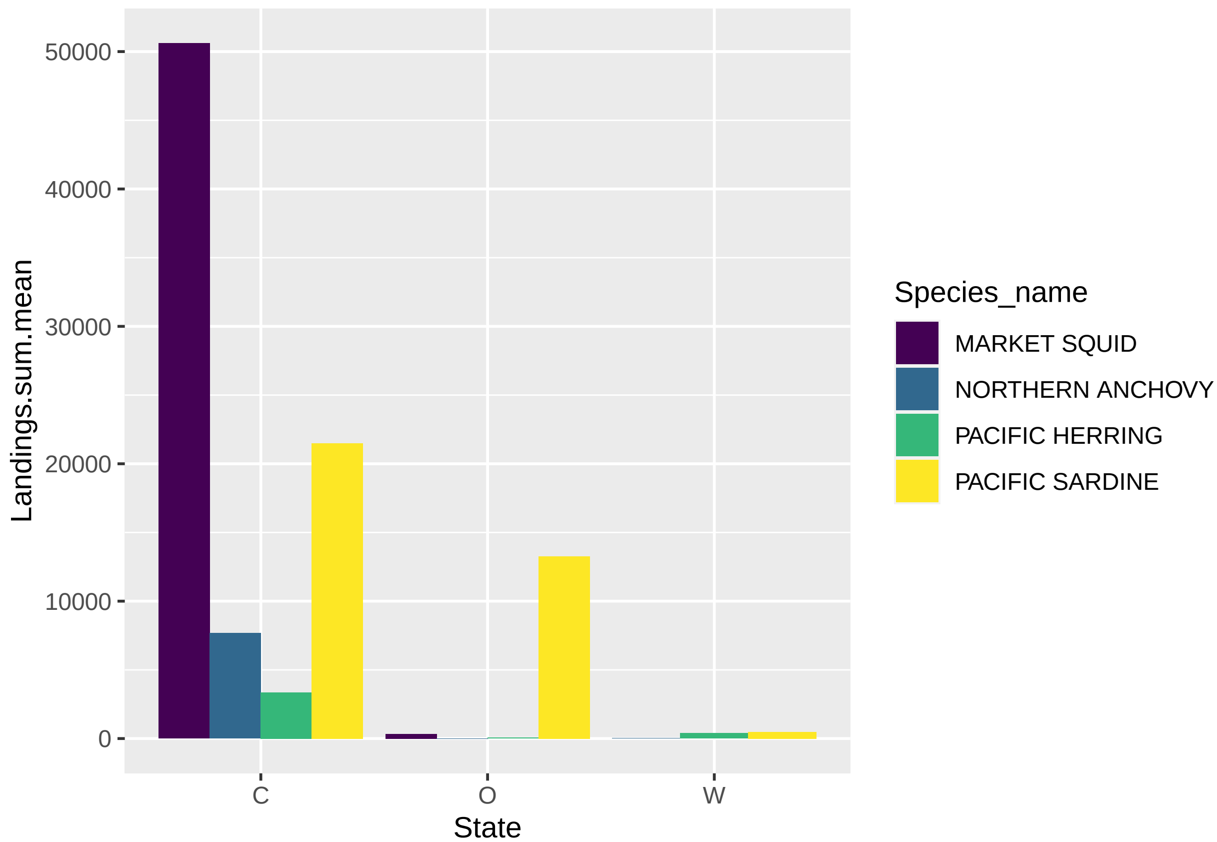

Figure 9: Landing by state.

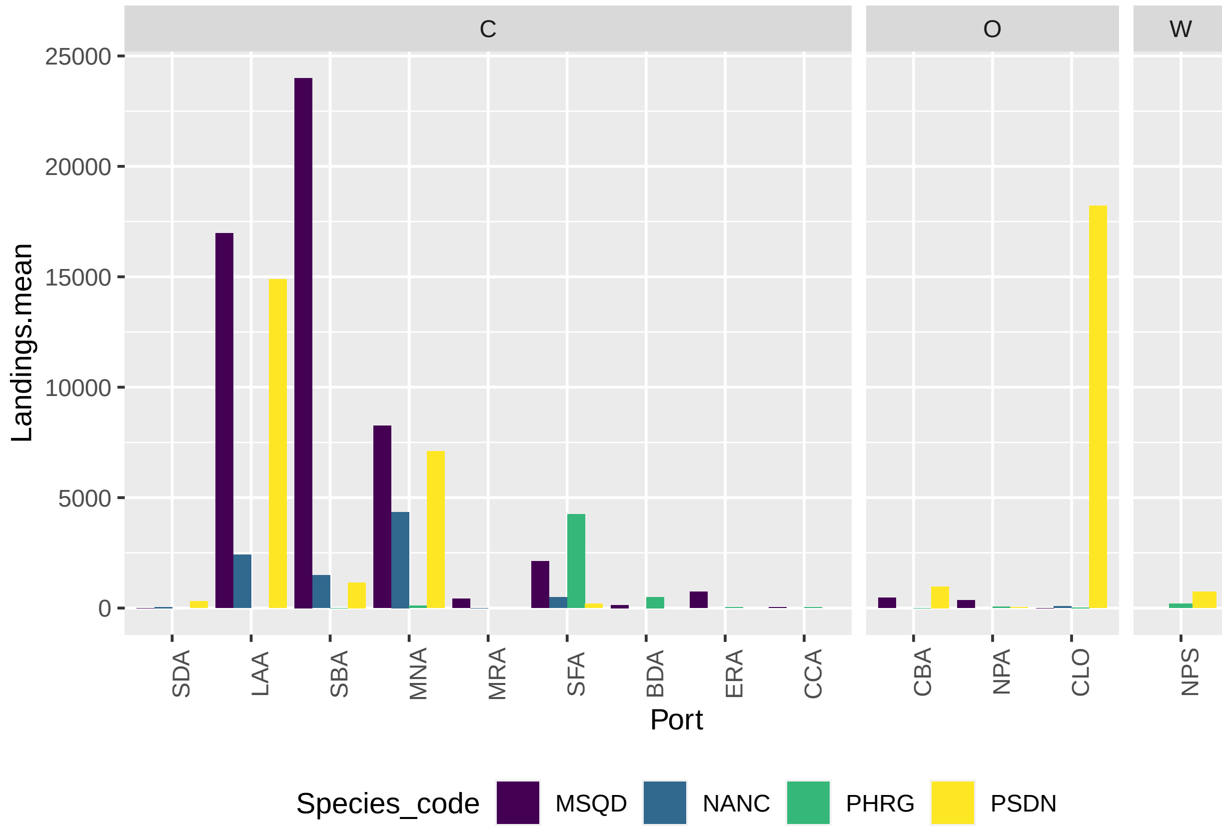

Figure 10: Landing by Port.

3.4 Time series by state and area ports

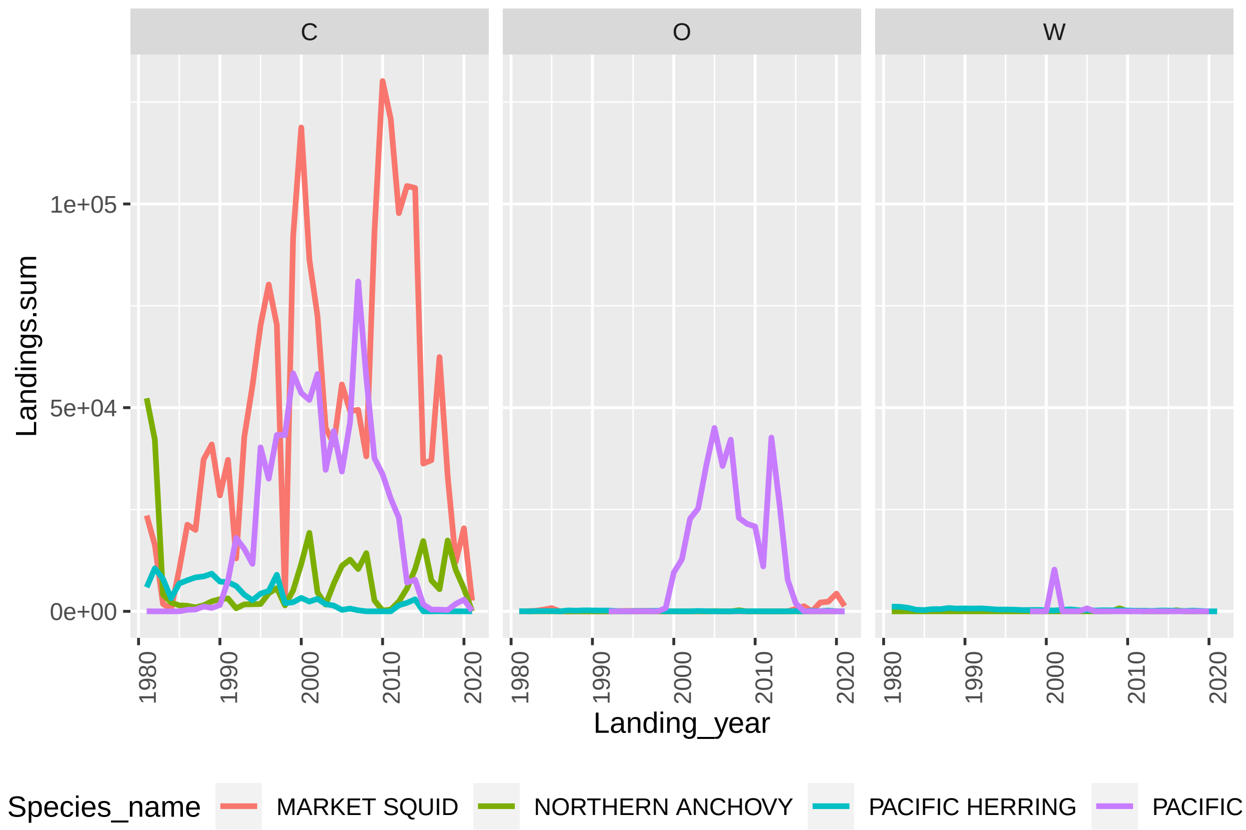

Figure 11: Annual average landing by state.

3.4.1 California ports

Figure 12: Annual average landing by area ports in California. *Notes:* BDA = Bodega Bay; CCA = Crescent City; ERA = Eureka; LAA = Los Angeles; MNA = Monterey; MRA = Morro Bay; SBA = Santa Barbara; SDA = San Diego; SFA = San Francisco.

3.4.2 Oregon ports

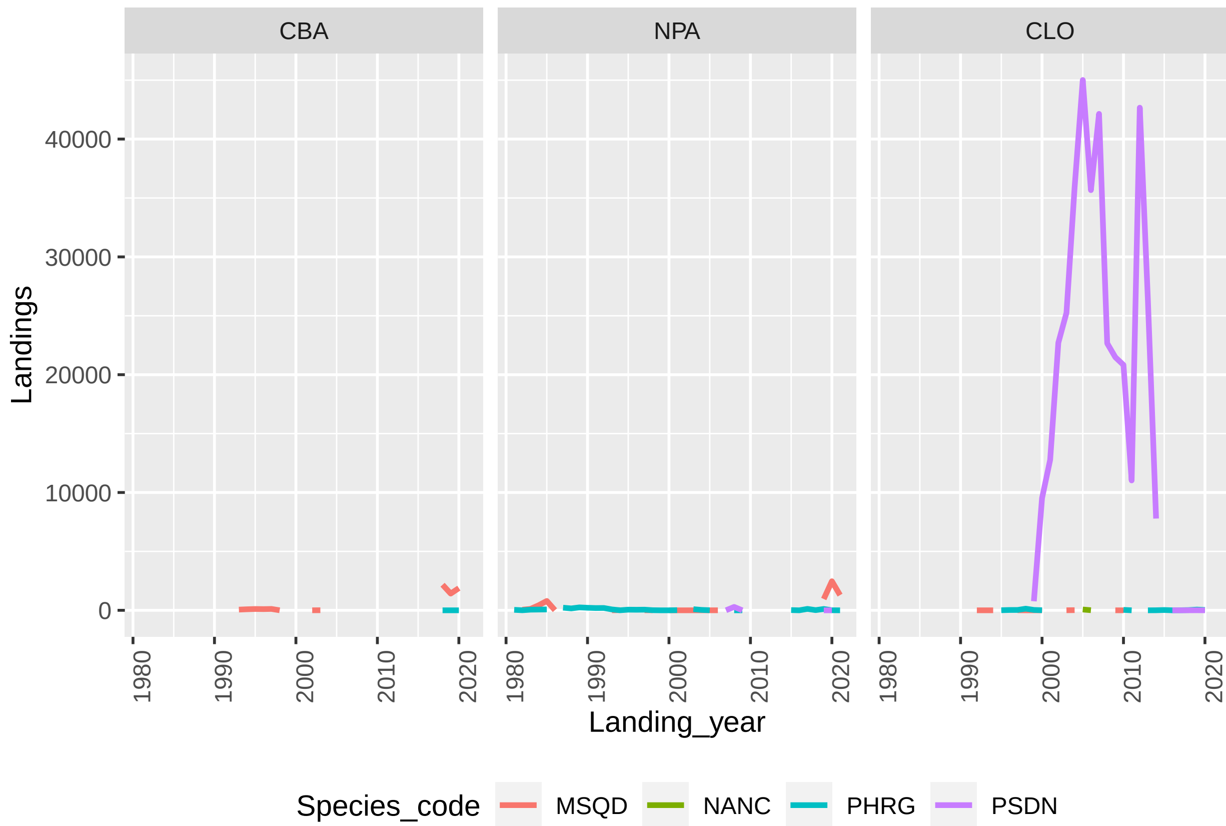

Figure 13: Annual average landing by area ports in Oregon. *Notes:* BRA = Brookings; CBA = Coos Bay; CLO = Columbia River (OR); NPA = Newport.

3.4.3 All ports

Figure 14: Annual average landing by area port. *Notes:* BDA = Bodega Bay; BRA = Brookings; CBA = Coos Bay; CCA = Crescent City; CLO = Columbia River (OR); ERA = Eureka; LAA = Los Angeles; MNA = Monterey; MRA = Morro Bay; NPA = Newport; NPS = North Puget Sound; SBA = Santa Barbara; SDA = San Diego; SFA = San Francisco.

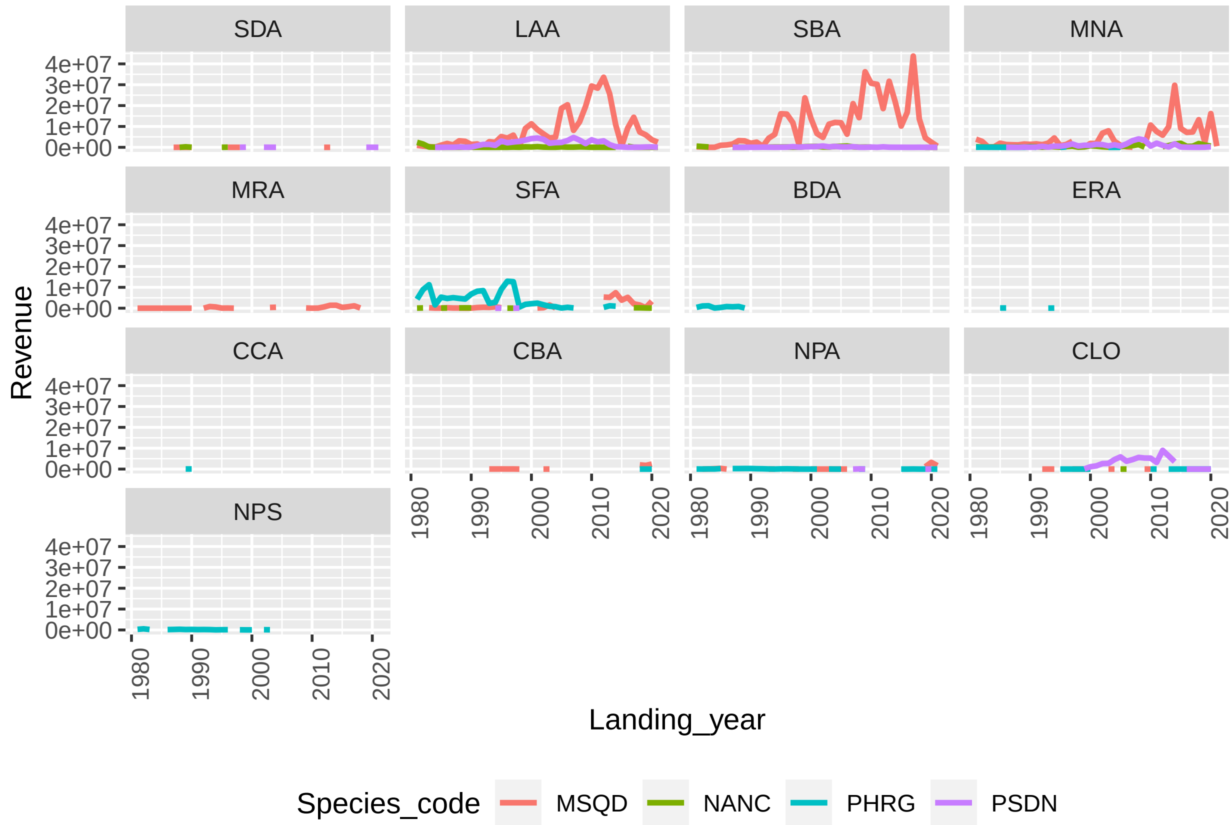

Figure 15: Annual average revenue by area port. *Notes:* BDA = Bodega Bay; BRA = Brookings; CBA = Coos Bay; CCA = Crescent City; CLO = Columbia River (OR); ERA = Eureka; LAA = Los Angeles; MNA = Monterey; MRA = Morro Bay; NPA = Newport; NPS = North Puget Sound; SBA = Santa Barbara; SDA = San Diego; SFA = San Francisco.

3.5 SDM by ports

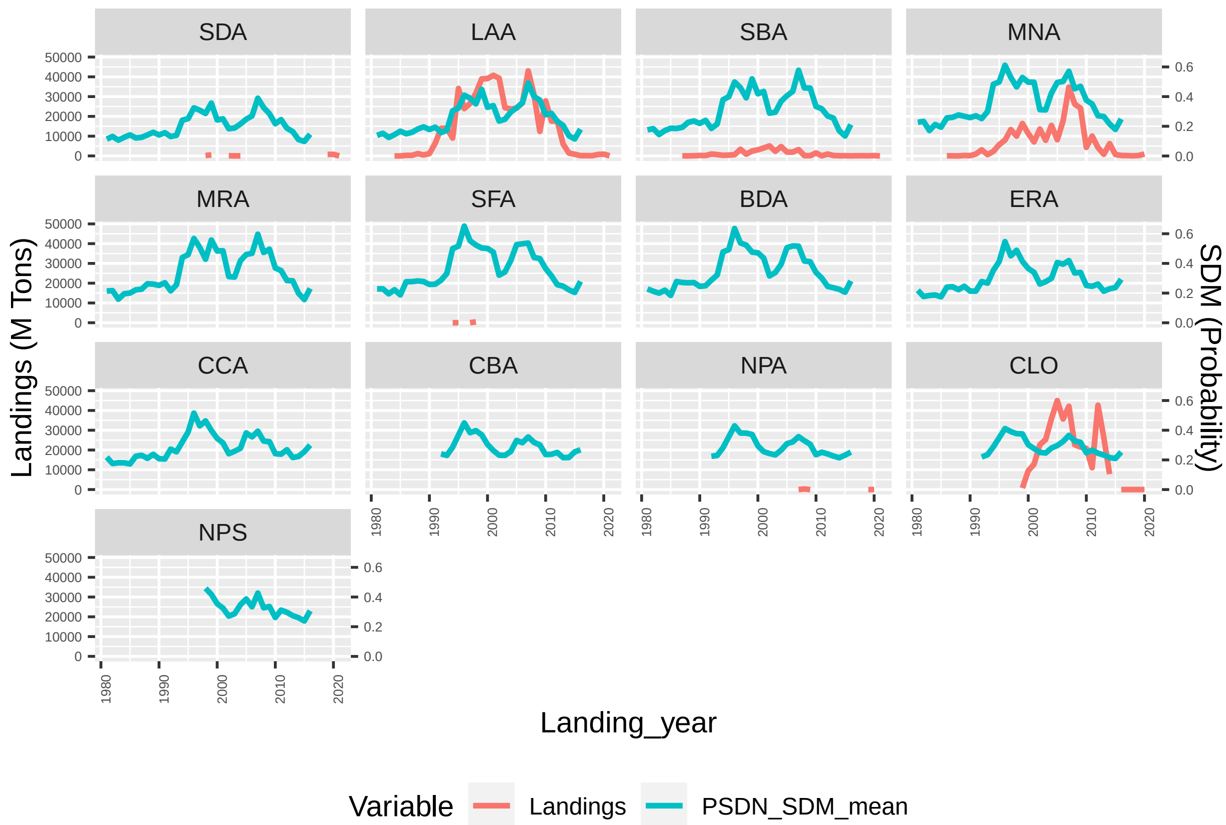

Figure 16: SDM mean for Pacific Sardine by area port. *Notes:* BDA = Bodega Bay; BRA = Brookings; CBA = Coos Bay; CCA = Crescent City; CLO = Columbia River (OR); ERA = Eureka; LAA = Los Angeles; MNA = Monterey; MRA = Morro Bay; NPA = Newport; NPS = North Puget Sound; SBA = Santa Barbara; SDA = San Diego; SFA = San Francisco.

4 Potential research

4.1 The effect of sardine distribution on landings model

Research question: What is the effect of climate change on ports' landings?

4.1.1 Model fundamentals

In general, landings are conditional to biological stocks (affected by climate change), harvest cost, prices and regulations.

- Outcome variable:
  - Pacific sardine landings by vessel, port and year. In this case we would predict landing by vessel i that land in port j
- Treatment variable:
  - Change spatial distribution of species due to climate.
    - Smith et al. [2021] relate port-level landings to the probaility of presence from a sardine species distribution model (SDM), and then makes projection to quantify future changes in landings.
    - Specifically, Smith et al. [2021] use mean monthly probability of presence of sardine within 60 km of port.
- Explanatory variables
  - Harvest costs (e.g., distances and fuel cost)
  - Own price and substitutes
  - Effort
    - Fishing effort from matching PacFIN data to Global Fishing Watch
    - "VESSEL_NUM" in PacFIN data: "It can be a USCG VID (ex: 1234567 or AK1234nn) or MISSING or UNKNOWN if vessel ID not provided or invalid. It is also "Null" if no vessel was used."
  - Regulations. Incorporate ACL in the model (Smith et al. [2021] obtained this information from CPS Fisheries Management Plan, and Federal Register), maybe with a function that have a ceiling limit, or as **censored data** (Stan code). Same about port capacity...
  - Port fixed-effects (reflect capacity and effort, assuming fixed over time.)
    - Do we need heriarchal random effects for this?
- Random-coefficients?
  - By vessel: Different intercept explained by vessel characteristics?
- Some considerations:
  - Vessels likely to have contract with ports. Less flexibility where they land.
  - Harvest happen near-shore, less probability of longer trips if species move further.
  - Multivariate framework allows us to consider interrelation between species and CPS fleet.
    - Sardine harvest affect squid harvest?
    - If Sardine opens... Sardine more preferred? Sequentially or simultaneous harvest?

4.1.2 Empirical strategy

- Statistical model:
  - Bayesian hierarchical model?
    - Random effects vessels and time.
    - Uncertainty from modeling the process (as well as from the imperfect observation of the process).
    - Model the zeros in data
      - Closures
      - Port restrictions (i.e. no infrastructure)
  - Smith et al. [2021] estimate with GAM framework (allows for non-linear relationships)
  - Some details:
    - Spatial autocorrelation between ports through species abundance? Between areas where vessel harvest?
      - Morris et al. [2019] include spatial errors in a bayesian framework.

4.1.3 Bayesian model

$$[\alpha_i, \beta_i, \gamma, \sigma^2_\alpha, \sigma^2_\beta, \Sigma | \log(q_{i,t})] \propto \text{multivariate normal}(\log(q_{i,t}) | \log(\mu_{i,t}), \Sigma) \times$$
$$[\alpha_i | \mu_\alpha, \sigma^2_\alpha] \times [\beta_i | \mu_\beta, \sigma^2_\beta] \times [\gamma][\mu_\alpha][\mu_\beta][\sigma^2_\alpha][\sigma^2_\beta][\Sigma],$$

where $q_{i,t}$ is the observed landings in port i at year t, $\mu_{i,t} = \alpha_i + \beta_i SDM + \gamma Price + \ldots$, β are parameters to be estimated that describe the process of harvest, σ^2_p is the stochasticity in the harvest process, and $x_{i,t}$ is the vector of variable that explain landing in port i during the landing year t.

4.1.4 Bayesian model: Multivariate normal

A basic Bayesian model for multi-species landings can be described as follow:

$$\ln(landings) \sim \text{multivariate normal}(\ln(\mu), \Sigma)$$
$$\mu = \alpha + \beta_1 SDM + \beta_2 FishingHours + \beta_3 Price$$

4.2 Fishers portfolio model

Research question: Understand the determinant of fisher decision on species harvested.

- Data:
  - PacFin data by vessel?
  - We can identify each vessel and which species they land.
- Model:
  - Conditional logit models?
  - Each species is a category, and probability of being selected is affected by their characteristics. Species distribution might be one of the characteristics.
  - We also can include vessel characteristics in a *random-coefficient model* (e.g. size, gear, etc)
- Problems:

    - Endogeneity in prices? (from non-observable species characteristics that affect prices)
    - Include quota in their decision?
    - Simultanous or sequential harvest?

- Considerations:
    - Easy to change between species (low cost for substitution)

- Network analysis?
    - Understand relationship between fisheries.
    - At the human level? Nodes are fisheries, while they are connected by participating fishing vessels. Edge weight calculated as the number of vessel participating in both fisheries.
    - How is the knowledge in environmental relationships?

4.3 Location choice model

Research question: How fishers decide where to fish?

- ABM model?
    - Grids with different environmental and stock conditions.
    - Random utility models to model fishers' behavior, where expected catch is part of the variables.

4.4 Estimating trade-off of leaving forage species in the ocean

Research question: Do fishers take into account trade-offs in their harvest decision?

- How to quantify this trade off?
    - Atlantis model could give us insight about the trade-off.
    - Require to quantify non-commercial species
        * How is this related to fishers communities?

4.5 Effect of climate change on fishing communities

Research question: How climate change affects fishers communities that depend (directly or indirectly) on forage species?

- Employment?
- Incomes?
- Consumption?

4.6 Price determination model

Research question: Does landing of pacific sardine (or other species) have an effect on prices?

- Some events that can allow us to estimate elasticities.
    - COVID-19 event
        1. From supply as closure / outbreak disrupt production.
        2. Demand affected by market disruptions and restaurant consumption
        3. Market change to other direction (consumption at home).

4. Processor have been affected (cost of closures and implementing sanitary conditions, and reduced demand coastwide)

  - ENSO event

- Using species prices behavior over years we can also analyze substitution pattern and price leadership.
  - Cointegration methods.
  - *Some questions that we can answer:* Are prices following a common trend? Is there any price which is exogeneous from the system? or the leader? Are prices following fishmeal prices, or world market prices? (e.g. from Peru?)

References

Mitzi Morris, Katherine Wheeler-Martin, Dan Simpson, Stephen J Mooney, Andrew Gelman, and Charles DiMaggio. Bayesian hierarchical spatial models: Implementing the besag york mollié model in stan. *Spatial and spatio-temporal epidemiology*, 31:100301, 2019.

James A Smith, Barbara Muhling, Jonathan Sweeney, Desiree Tommasi, Mercedes Pozo Buil, Jerome Fiechter, and Michael G Jacox. The potential impact of a shifting pacific sardine distribution on us west coast landings. *Fisheries Oceanography*, 2021.