The Economic Impact of Spatial Closures

Evidence from the Stellar Sea Lion Protective Measures in the North Pacific

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Motivation

• Spatial closures are a prominent tool for ecosystem-based management
  – Potential benefits have been discussed thoroughly in the literature

• Ex-post estimates of the short-run costs incurred by fishing industry are relatively scarce.
Why Are Closures Costly?

• Forgone harvests and revenues:
  – Can fishers catch target species in other areas?
    • Do other areas yield lower-valued products?
  – Can fishers target other species?
    • Are other target species less valuable?

• Increased operating costs:
  – Do other areas have lower CPUE?
  – Do fishers incur higher costs fishing other areas/species (e.g. fuel and/or processing)?

• Impacts of closures will be context-specific
Challenges for Estimating the Costs of Closures

• No plausible estimate of the counterfactual:
  – *What would revenues/costs have been in the absence of the closures?*
  – Closures not designed with *ex-post* evaluation in mind

• Lack of economic data:
  – Revenue and catch data often exist
  – Cost data are relatively rare
Estimating the Cost of Closures

• We estimate the short-run costs of a large spatial closure to protect Stellar Sea Lions.
  – Multi-species fishery with harvester cooperatives

• We have a plausible estimate of the counterfactual:
  – Not all vessels were directly affected by closure
  – Comparative case study: Diff-in-diff, synthetic control

• We have annual revenue and cost data:
  – Vessels required to complete Economic Data Reports (EDR) on an annual basis.
Stellar Sea Lion Protection Measures

- Listed as “threatened” under ESA in 1990 and “endangered” in 1992
- Rely for food on commercial species: walleye pollock, Atka mackerel, and Pacific cod
- Protective measures:
  - Closures near SSL critical habitat
  - Seasonal and spatial TAC
Stellar Sea Lion Protection Measures

• ESA consultation finds previous measures “ineffective” (2010)

• Additional measures implemented in 2010:
  – More (and larger) spatial closures to Atka mackerel and Pacific cod fisheries
Aleutian Islands Commercial Fisheries

• Atka mackerel
  – One fleet of catcher processors (7 vessels)
  – 2008-2010: Average 61,000mt ($61.6 million wholesale), 25% in area 543

• Pacific cod
  – Multiple fleets, variety of vessels/gear
  – 2008-2010: Average 24,000mt ($24.1 million wholesale)

• Regulatory Impact Review
  – $24-47 million wholesale “at risk” for Atka mackerel CPs
Aleutian Islands Commercial Fisheries

- Focus on just the Atka mackerel CPs. Why?
  - We have a plausible control group for estimating the counterfactual
  - We have annual revenue and cost data:
    - Revenues from selling product and leasing quota
    - Operating expenditures (e.g. fuel, labor, food, fish taxes, etc.)
    - 3 years before, 4 years after, 17 vessels, a total of 119 observations
SSL Protective Measures: Pre-2011
SSL Protective Measures: Post-2011

Alt 1: Atka Mackerel Management
- 3nm No Transit
- Closed to Atka Mackerel Fishing
- Atka Mackerel Open Area with 10% Harvest Limit
- Open to Non-Pelagic Trawl Gear when no other restrictions in effect

Source: Steve Lewis, NMFS Alaska Region Analytical Team
SSL Protective Measures

[Graph showing trends in metric tons (thousands) from 2008 to 2014 for different years and categories: 541, 542, 543, and Total. The graph compares Allowable Biological Catch (ABC) and Total Allowable Catch (TAC).]
Estimating the Impact: Identification

• Counterfactual: annual net revenues (revenue – variable costs) that would have been earned in the absence of the closure.

• Strategy:
  – Atka mackerel vessels part of a larger fleet of similar vessels not directly affected by closure
  – Use unaffected vessels as a control group for the Atka mackerel vessels (i.e. the treated group)
Difference-in-Differences

\[ Y_{it} = \alpha + \phi_i + \theta_t + \delta \text{treat}_i \times \text{post}_t + X'_{it} \beta + \varepsilon_{it} \]

- \( X_{it} = \text{[weighted price, total quota]} \)
- Key assumptions:
  - “Parallel trends”
    - Unobserved time-varying factors affect all vessels the same
  - Exogeneity
    - Estimate the average treatment on the treated (ATT)
  - No spillover or contamination of control group
Parallel Trends

Wholesale Revenues

Variable Costs

Net Revenues

Net Revenues per Ton

Weighted Price

Total Quota

Nominal US Dollars (millions)

Year

Nominal US Dollars

Year

Nominal US Dollars

Year

Nominal US Dollars

Year

Nominal US Dollars

Year

Metric tons (thousands)

Year

Treated

Control
Difference-in-Differences: with quota
Difference-in-Differences: without quota
Difference-in-Differences: Permutation

### Gross Revenue

- 2011: 0.37
- 2012: 0.36
- 2013: 0.86
- 2014: 0.91
- 2011-2014: 0.22

### Net Revenue

- 2011: 0.55
- 2012: 0.82
- 2013: 0.03
- 2014: 0.19
- 2011-2014: 0.28

### Variable Costs

- 2011: 0.18
- 2012: 0.30
- 2013: 0.19
- 2014: 0.51
- 2011-2014: 0.01

### Net Revenue per Ton

- 2011: 0.81
- 2012: 0.78
- 2013: 0.02
- 2014: 0.46
- 2011-2014: 0.64

### Variable Cost per Ton

- 2011: 0.23
- 2012: 0.50
- 2013: 0.00
- 2014: 0.00
- 2011-2014: 0.03
Synthetic Control Method

\[ \hat{\delta}_{it} = Y_{it} - \sum_{j \neq i} w_j^* Y_{jt}, \quad t \in \{T_0 + 1, ..., T\} \]

• SCM generalizes diff-in-diff, with advantages:
  – Data-driven process to construct comparison group (Abadie et al., 2010)
  – Allows the effects of unobserved vessel-specific factors to vary with time
  – Allows for heterogeneity in treatment effects across vessels
Synthetic Control Results: Net Revenues

Vessel 1

Vessel 2

Vessel 3

Vessel 4

Vessel 5

Vessel 6

Y_{treated} - Y_{synthetic}

2008 2009 2010 2011 2012 2013 2014

2008 2009 2010 2011 2012 2013 2014

2008 2009 2010 2011 2012 2013 2014

2008 2009 2010 2011 2012 2013 2014

2008 2009 2010 2011 2012 2013 2014

2008 2009 2010 2011 2012 2013 2014

Treated Unit

Donor Pool
Synthetic Control Results: DnD effects
Little evidence of an effect: Why?

Substitution possibilities: “slack” in flatfish allocations
Little evidence of an effect: Why?

Substitution possibilities: mackerel and flatfish in other areas
Little evidence of an effect: Why?

Challenges to identification: contamination/congestion
Little evidence of an effect: Why?

Challenges to identification: confounding factors

Note: quota allocations and wholesale prices measured relative to 2008
Little evidence of an effect: Why?
Challenges to identification: confounding factors

• SSL protective measures were not the only thing to happen in/after 2011:
  – Majority of the treated group formed a harvester cooperative in 2011
  – Protective measures closed more areas, but relaxed temporal restrictions in the small area that remained open
  – Years further away from intervention less likely to provide meaningful comparisons
Conclusion

• Little evidence of negative impact associated with SSL protective measures
  – Negative effects occur through higher costs, not forgone revenue
• SCM results indicate heterogeneous effects, but largely consistent with diff-in-diff
• Lack of effect likely due to substitution possibilities of fleet—slack in flatfish quota
• Costs associated with closures will be context specific, and will depend on other management institutions and substitution possibilities
Questions?
SSL Protective Measures: Allocations

The diagram illustrates the metric tons (thousands) allocated annually from 2008 to 2014 for different categories:

- **541**
- **542**
- **543**
- **Total**

The categories are represented by different symbols and line styles:

- **Allowable Biological Catch (ABC)**: Yellow circles and lines.
- **Total Allowable Catch (TAC)**: Diamond shapes and lines.

The graph shows a trend over the years, with fluctuations in allocation amounts.