Examining the Effectiveness of Nonprofit Groups' Expenditures on Species Recovery: the Case of Pacific Salmon and Steelhead

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Motivation

- Environmental groups actively devote resources to species recovery
  - Over 1954-2004, the Natural Conservancy spent $5.3 billion on land acquisition to promote biodiversity
- Population of Pacific salmon and steelhead dropped dramatically in the last decades
- NGOs advocate for Pacific salmon and steelhead
  - File petitions and lawsuits for listing (e.g. WildEarth Guardians v. Jeffries, 2018)
  - Habitat restoration, monitoring

Research Questions

- Do NGOs' expenditures have a positive impact on Pacific salmon population?
- If so, are NGOs' expenditures efficient in recovering Pacific salmon population?
- What are the mechanisms through which the NGOs' expenditures take effect?

Contribution

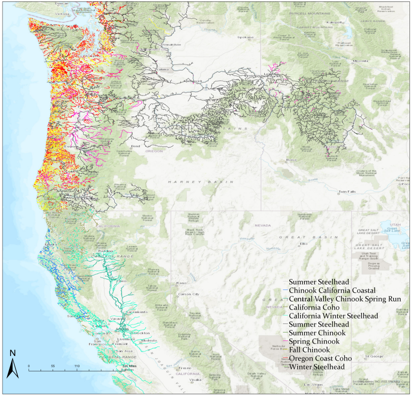
This paper

- Will be the first to examine the NGOs' expenditure on species recovery
  - Past literature focus on government spending (Ferraro et al. 2007; Kerkvliet and Langpap 2007; Langpap and Kerkvliet 2010)
- Uses detailed species population data to construct a quasi-experimental setting
  - The temporal and spatial scales of many ecosystems are too broad to be experimentally controlled (Butsic et al., 2017)

The Distribution of Pacific Salmon and Steelhead

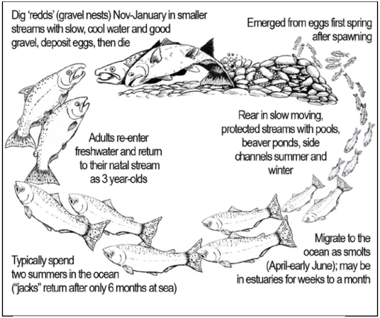
This paper studies Chinook, Coho and steelhead in Washington, Idaho, Oregon, and California

Salmonids Distribution in Pacific Northwest Region



Salmon Life Cycle

- Salmon has unique life cycle
  - Chinook will be in ocean for 1.5-4.5 years
  - Coho will be in ocean for 0.5-1.5 years
  - Steelhead will be in ocean for 2-3 years
- We look at spawners' population
- Expenditures will only impact young fish on land
- Expenditure will have a *lagged* effect on salmon spawner population

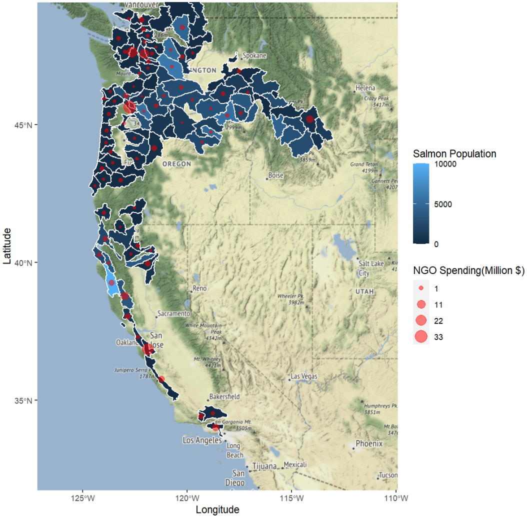


Source: Final ESA Recovery Plan for Oregon Coast Coho Salmon

Features of NGO Spending

- NGOs tend to invest locally (Grant & Langpap, 2019)
  - We use watershed to control for the factors impacting salmon populations
  - HUC8 is the smallest unit that one single NGO could have an impact
- Activities like habitat restoration improve salmon populations in a long-term and cumulative way

Quasi-Experimental Setting



Data: 2000-2018

- Different levels of HUC shapefile: US Geological Survey (USGS)
- Shapefile of the distribution of salmonids: NOAA
- Natural origin spawner population: StreamNet; CalFish; State of Salmon in California
- NGO expenditure: National Center for Chartable Statistics Data Archive (NCCS)
- Government expenditure: U.S. Fish & Wildlife Service Annual Expenditure Report
- Annual water temperature: National Water Information System Water Quality Portal
- Dams Removal: National Dam Removal Database by USGS

Summary Statistics

106 watersheds through 2000-2018

	Observation	Mean	SD	Min	Max
Fish per Mile	2000	2.176469	(5.346655)	0	71.96194
Cumulative NGO (Mill. $)	2000	8.373767	(37.47544)	0	648.228
Cumulative GVNT (Mill. $)	2000	20.31117	(29.57467)	0	161.8155
Water Temperature ($^{\circ}C$)	1421	12.2988	(3.640045)	1.407518	25.2
No. Dams removed	2000	.0035	(.0590719)	0	1

Main Model

$$Salmon_{it} = \alpha NGO_{i,t-m} + \beta GVMT_{i,t-m} + \gamma Water_{i,t-m} + \rho Dam_{i,t-m} + \lambda_t + \mu_i + \epsilon_{it}$$

- i: watershed; t: year; m: year lag;
- $Salmon_{it}$: salmon spawner population, fish per mile;
- $NGO_{i,t-m}$: Cumulative NGOs' expenditure;
- $GVMT_{i,t-m}$: Cumulative government's spending;
- $Water_{i,t-m}$: annual average water temperature;
- $Dam_{i,t-m}$: Number of dams removed;
- λ_t: year fixed effect, control for ocean conditions;
- μ_i: watershed fixed effects, control for historical land use

Identification Strategy

- Lagged explanatory variables (Green et al., 2005; Spilimbergo, 2009; Nesta et al., 2013)
- Two-way fixed effects

Main Results

Fish per Mile	(1) $m = 5$	(2) $m = 5$
Cumulative NGO	0.00545**	0.00646**
$Spending_{i,t-m}(\$MM)$	(0.0022)	(0.0027)
Cumulative GVNT	0.0200***	0.0221**
$Spending_{i,t-m}(\$MM)$	(0.0099)	(0.0099)
No. Dams	-0.177	0.282
$Removed_{i,t-m}$	(0.481)	(0.571)
$Water\ Temp_{i,t-m}$	-0.0123	-
$(°C)$	(0.0188)	-
Year FE	Y	Y
Watershed FE	Y	Y
Observations	1421	2000

Standard errors in parentheses. Standard errors are clustered at HUC8 level.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

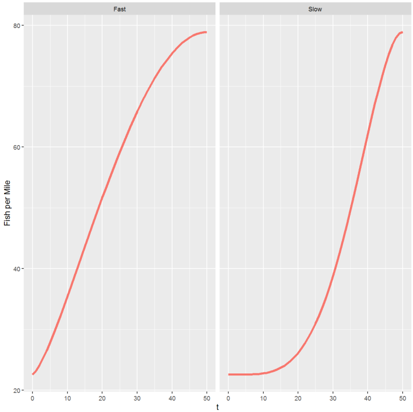
Cost Analysis: Oregon Coast Coho

To improve Oregon Coast Coho population to certain goals in 50 years, how much will it cost?

Annual Returning Fish

$RetFish(t) = RetFish(0) + (RetFish(T) - RetFish(0))(1 + [\frac{T-t}{T-\tau}])(\frac{t}{T})^{\frac{T}{T-t}}$ (Yin et al., 2003)

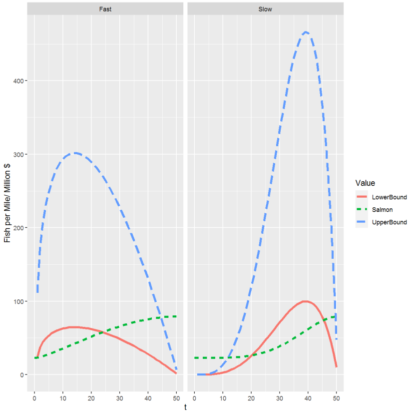
- $RetFish(t)$: number of returning adult salmon;
- $T = 50$
- τ: defines the growth path. $\tau = 38.7$ is the slow path. $\tau = 13.7$ is the quick path;
- $RetFish(0) = 150000$



Annual Expenditures

Lower bound estimation:
$EXP_t = \frac{RetFish(t+1) - RetFish(t)}{\hat{\alpha} + \hat{\beta}}$
Upper bound estimation:
$EXP_t = \frac{RetFish(t+1) - RetFish(t)}{\hat{\alpha}}$

- to be conservative, we use the smallest estimated coefficients
- $\hat{\alpha}$: estimated coefficient for NGO spending;
- $\hat{\beta}$: estimated coefficient for government spending;



Total Cost vs Total Benefit

Conservation Goal	Cost (Billion $)	Benefit-Slow(Billion $)	Benefit-Fast(Billion $)
325,000	[1.03, 4.83]	10.59	12.77
375,000	[1.33, 6.21]	11.13	12.96
525,000	[2.22, 10.34]	12.80	13.32

*All costs and benefits are present value of the total value.
*Estimated benefit from Lewis et al. (2019). Original data are annual benefit over a ten-years period.
*Discount rate to calculate the present value of total benefit is 2.1%, estimated by Lewis et al.(2022) .

Do investments depreciate over time?

- $Salmon_{it} = \alpha_1 NGO^{c=5}_{i,t-m} + \beta GVMT_{i,t-m} + \gamma Water_{i,t-m} + \rho Dam_{i,t-m} + \lambda_t + \mu_i + \epsilon_{it}$
- $Salmon_{it} = \alpha_2 NGO^{c=10}_{i,t-m} + \beta GVMT_{i,t-m} + \gamma Water_{i,t-m} + \rho Dam_{i,t-m} + \lambda_t + \mu_i + \epsilon_{it}$

c: NGO expenditures are accumulated to c years.

$\hat{\alpha_1} = \hat{\alpha_2}$?

Can not reject that $\hat{\alpha_1} = \hat{\alpha_2}$. Investments do not depreciate over time.

Conclusion

Our results show that:

- Both NGO and Government spending positively affect salmon abundance;
- For at least one Pacific salmon population, the estimated costs of achieving recovery goals are well below previously estimated benefits of achieving the same goals;
- Conservation efforts like habitat restoration generate long-term, positive impact on salmon population

Thank you!

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