Examining the Effectiveness of NGOs' Expenditures on Species Recovery: the Case of Pacific Northwest Salmonids

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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 (Chinook, Coho, chum, sockeye, pink and steelhead) dropped dramatically in the last decades.
- NGOs advocate for Pacific salmon and steelhead

Contribution

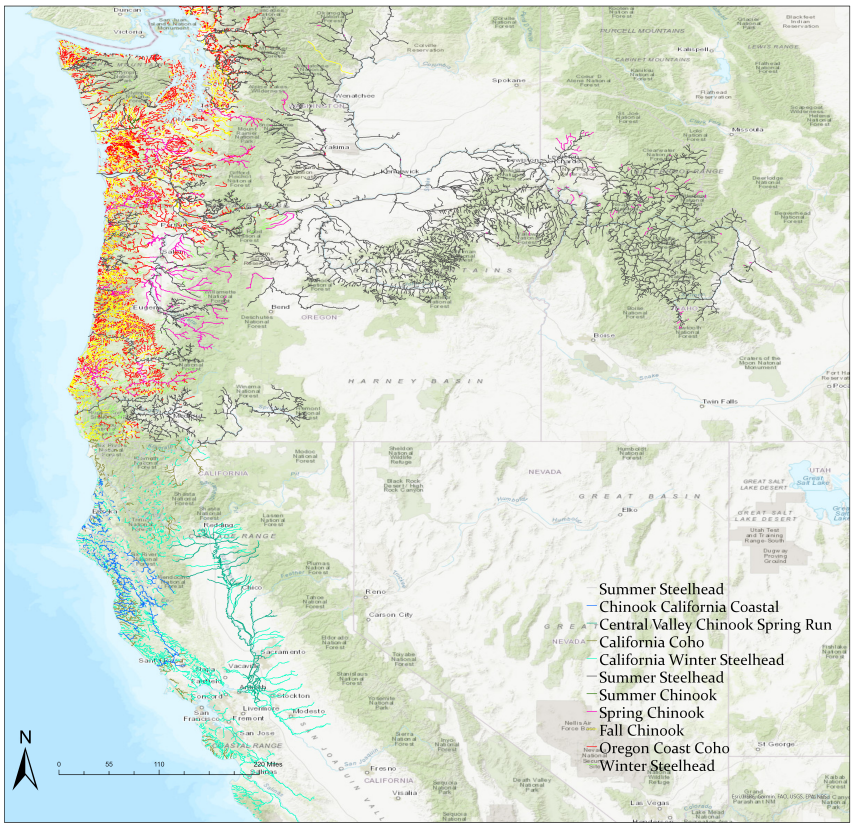
This paper

- Will be the first to examine the NGOs' expenditure on species recovery
  - Ferraro et al. (2007), Kerkvliet and Langpap (2007), Langpap and Kerkvliet (2010) study the impact of government spending on species recovery
- Uses species population data to examine the effect of conservation efforts on species population change
  - The research of the effectiveness of NGO and government expenditures on improving species population is rare, because of the lack of detailed population data and identification challenge (Langpap et al., 2018)
  - The temporal and spatial scales of many ecosystems are too broad to be experimentally controlled (Butsic et al., 2017)

The Distribution of Pacific Northwest Salmonids

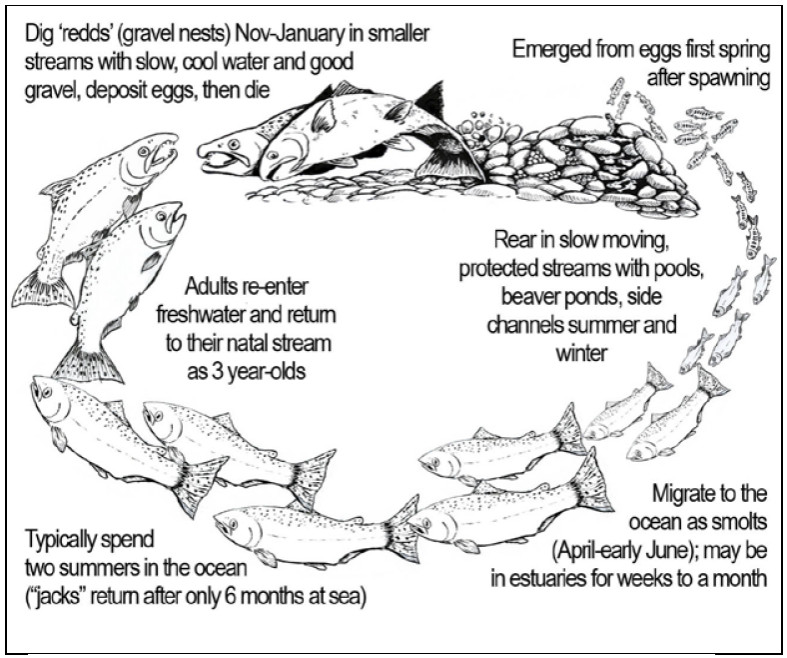
We look at Chinook, Coho and steelhead in Washington, Idaho, Oregon, and California

Salmonids Distribution in Pacific Northwest Region



Salmonids 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
- Expenditure will have a *lagged* effect on salmon spawner population

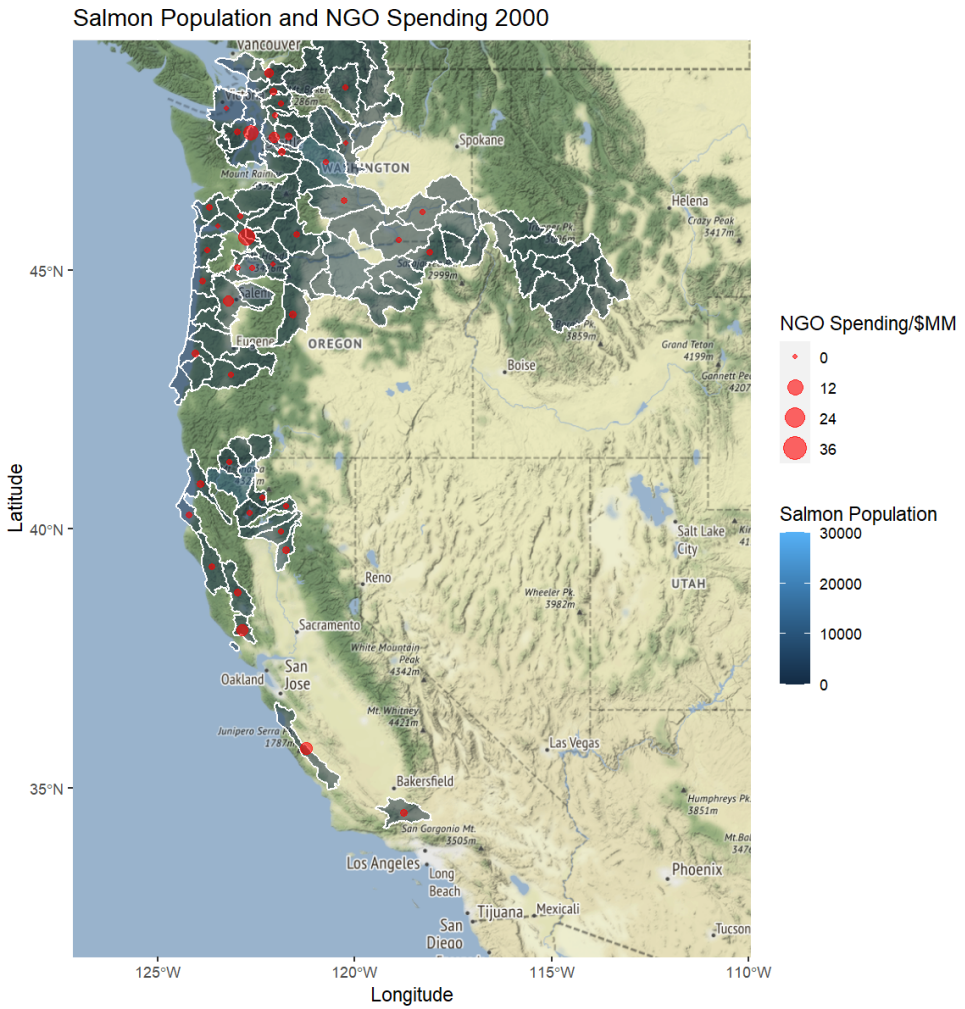


Source: Final ESA Recovery Plan for Oregon Coast Coho Salmon

Features of NGO Spending

- We look at environmental (C groups) and animal-related groups (D groups) that have an impact on salmon populations and their habitat;
- 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
- NGO improve salmon populations in a long-term and cumulative way

Quasi-Experimental Setting



Data: 2000-2018

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

Model

Salmon Population

- Natural origin salmon(wild salmon) is different from hatchery fish;
- Dataset has longitude and latitude of each population record;
- Fish population is aggregated at HUC8 level
- Use the shapefile of distribution of salmonids to calculate total river miles in each watershed

back

NGO Spending and Government Spending

- NCCS has each NGOs' address;
- Use Google Maps API to get the longitude and latitude of each NGO;
- Both NGOs' and government's expenditures are aggregated at HUC8 level;
- Government spending is species specific

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Main Model: Two-way Fixed Effects Panel Model

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

- i: watershed; t: year; m: year lag;
- $Salmon_{it}$: salmon spawner per river mile in watershed i at year t;
- $NGO_{i,t-m}$: Cumulative NGOs' expenditure in watershed i at year $t-m$;
- $GVMT_{i,t-m}$: Cumulative government's spending in watershed i at year $t-m$;
- $Water_{i,t-m}$: Water temperature in watershed i at year $t-m$; $Water_{it}$: Water temperature in watershed i at year t;
- $Dam_{i,t-m}$: Number of dams removed in watershed i at year $t-m$
- λ_t: year fixed effect; μ_i: watershed fixed effects

Main Results for Different Time Lags

Fish per Mile	(1) $m=1$	(2) $m=2$	(3) $m=3$	(4) $m=4$	(5) $m=5$
Cumulative NGO	0.0076**	0.0091**	0.0102**	0.0087*	0.0069*
$Spending_{i,t-m}(\$MM)$	(0.0032)	(0.00420)	(0.0043)	(0.0044)	(0.00364)
Cumulative GVNT	0.0442***	0.0475***	0.0523***	0.0501***	0.0486***
$Spending_{i,t-m}(\$MM)$	(0.0164)	(0.0172)	(0.0191)	(0.0176)	(0.0166)
Water $Temp_{it}$	-0.0093	-0.0324	-0.0220	-0.0134	0.0274
$(^\circ C)$	(0.0638)	(0.0553)	(0.0552)	(0.0529)	(0.0819)
Water $Temp_{i,t-m}$	-0.149*	-0.107	-0.0753	0.0390	-0.0144
$(^\circ C)$	0.0800	(0.0714)	(0.0569)	(0.0367)	(0.0215)
No. Dams	0.020	-0.0752	0.0255	-0.933***	-0.535
$Removed_{i,t-m}$	(0.626)	(0.650)	(0.511)	(0.298)	(0.390)
Year FE	Y	Y	Y	Y	Y
Watershed FE	Y	Y	Y	Y	Y
Observations	1049	1027	1009	981	952
R^2	0.067	0.061	0.060	0.055	0.052
Adjusted R^2	0.049	0.042	0.040	0.033	0.029

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?

$$RetFish(t) = RetFish(0) + (RetFish(T) - RetFish(0))(1 + [\frac{T-t}{T-\tau}])(\frac{t}{T})^{\frac{T}{T-t}}$$

(Lewis et al., 2019)

- $RetFish(t)$: number of returning adult OC Coho salmon in time t;
- T: terminal time, $T = 50$
- τ: a parameter that tunes the timing of the maximum rate of change. $\tau = 38.7$ is the slow path. $\tau = 13.7$ is the quick path;
- $RetFish(0) = 150000$

Cost vs Benefit

Conservation Goal	Cost($MM)	Benefit, quick path($MM)	Benefit, slow path($MM)
250,000	[6.186,43.574]	[168,796]	[107,508]
325,000	[10.826,76.255]	[234,1110]	[188,908]
375,000	[13.919,98.042]	[278,1320]	[241,1170]

*not adjusted for discount rate.
*Estimated benefit from Lewis et al. (2019).

Conclusion

We examine the effectiveness of NGOs' expenditures on species recovery using the case of Pacific salmon and steelhead.
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

Thank you!