Voluntary Approaches to Conserving Endangered Species - The Case of Stochastic Bycatch

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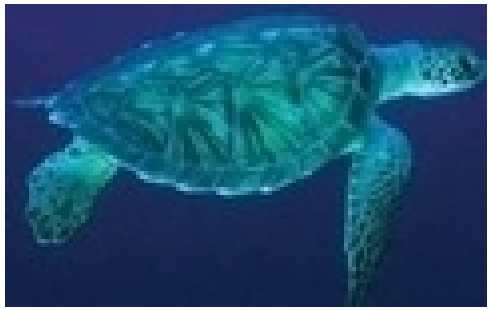
Voluntary approaches to reduce bycatch



(a) Sea Turtles - longline fishing, trawl fishing.

(b) Seals - trawl fishing.

(c) Porpoises - gill net fishing.

(d) Albatross - longline fishing.

(e) Sea Lions - squid fishing.

(f) Dolphins - tuna fishing.

Motivation

- Most of the literature on voluntary approaches has been in the context of pollution.
- Previous literature (Segerson and Wu, 2006) has proposed using voluntary-threat policies in the context of nonpoint pollution.
- Some recent experimental evidence (Suter et al., 2008) indicate that these approaches can be effective in inducing efficient behavior.

Motivation

Problem: Bycatch/Nonpoint pollution is stochastic.

Basic Question:

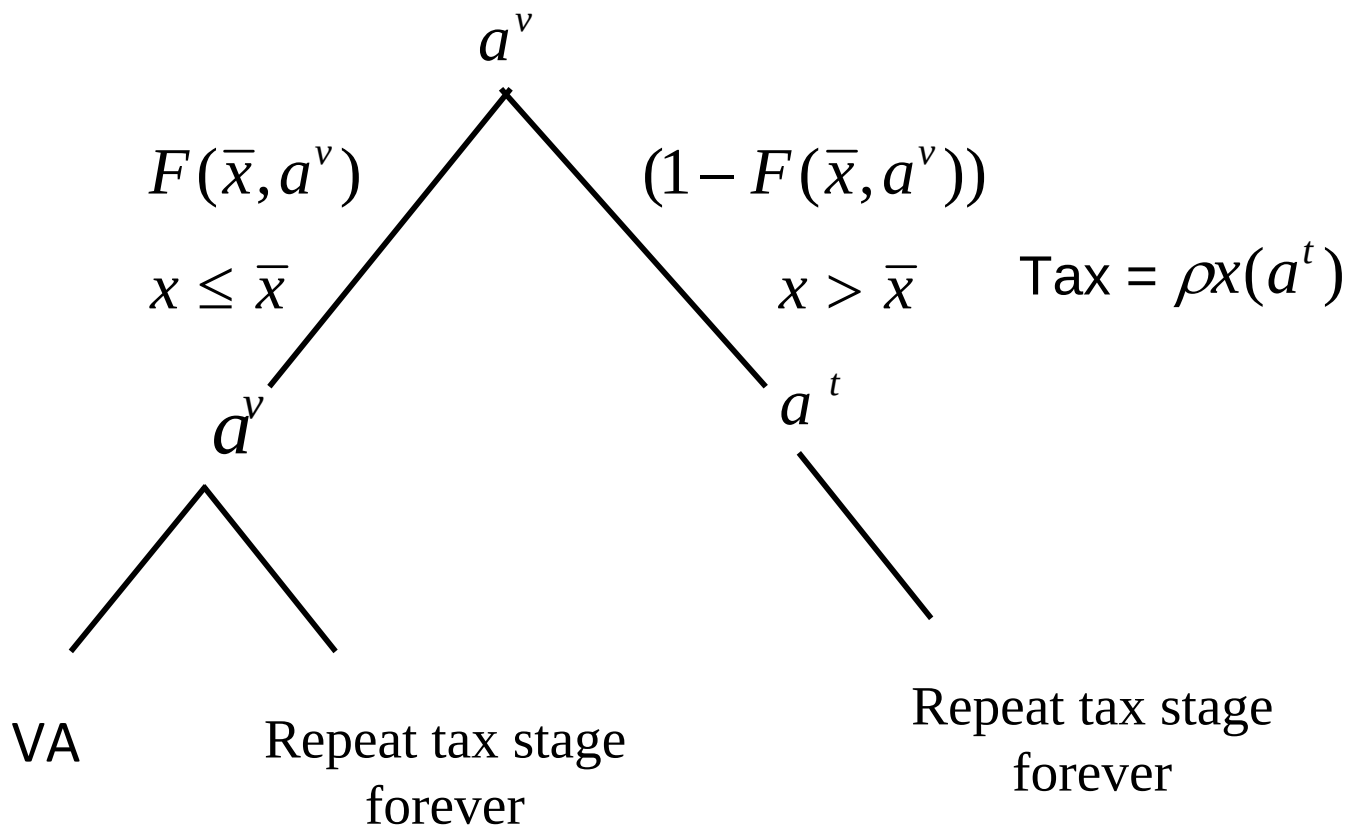
- *Can these V-T policies work in the presence of environmental uncertainty/stochasticity?*

Context: Consider a farmer/fisher who makes an abatement/avoidance decision that determines a level of ambient pollution/bycatch, given by $x(a, \epsilon)$, which in turn generates some environmental damage, $D(x)$.

Issues that arise with uncertainty

- With stochasticity, performance standards cannot be met with certainty.
- It calls for the use of marginal incentives.
- In the context of policies that involve group performance standard on bycatch or ambient pollution, it raises the question of smoothing of outcomes across firms.

Figure: Fisher's sequence of decisions with the policy in place



Research Question

Question: Can we design the tax rate (ρ) and the voluntary performance standard ($\overline{x}$) to induce an efficient choice in the voluntary stage if,

- $\overline{x}$ is set at the firm level,
- $\overline{x}$ is set at the industry level?

If yes, then how are the optimal policy parameters affected by the degree of uncertainty?

Summary of Initial Results

- When the policy is set both at the firm level and the industry level, a background threat of a permanent tax on bycatch mortalities can be designed to induce fishers to undertake efficient behavior voluntarily.
- In the context of group performance standard, equilibrium solution is not unique.
- In either case, the optimal policy parameter for the performance standard ($\overline{x}$) is sensitive to the degree of uncertainty, discount factor and the underlying distribution for bycatch mortalities.

Model

Assumptions

- Bycatch level is observable.
- Firms are identical
- Perfectly competitive market environment. Only source of market failure is the bycatch issue.
- Output is assumed to be non-stochastic.
- Fishers are risk neutral.
- Marginal damage from a single turtle mortality is constant d.

Social Planner's Problem

Let a fisher's profit in any season be defined as $\pi(a)$:

Expected net social benefit:

$$\sum_{i=1}^{n} \pi(a_i) - E[D(X)]].$$

First order condition implicitly defines a^*:

$$\frac{\partial \pi}{\partial a_i} = -dE[\frac{\partial x}{\partial a_i}].$$

LHS term = Marginal cost of reduced profit
RHS term = Marginal social benefit of reduced environmental damage

Solution Procedure

Backward induction

Tax Stage Solution: If $\rho^* = d$, then $a_t^* = a^*$, where a_t^* is the fisher's optimal choice in any tax period.

Given $\rho^* = d$, we next solve the fisher's optimization problem in the initial voluntary period, where he chooses a^v to maximize the present value of the stream of current and future income, $V(a^v)$.

Voluntary Stage

Fisher's Optimization Problem in the initial VA period, given ρ^*:

Maximize

$$V(a^v) = \pi_v(a^v) + \beta F(\overline{x}, a^v)\overline{V} + [1 - F(\overline{x}, a^v)][\sum_{T=1}^{\infty} \beta^T E\{\pi_t(a^*)\}]$$

First Order Condition:

$$\frac{\partial \pi_v}{\partial a^v} + \beta \frac{\partial F}{\partial a^v}[\overline{V} - \frac{E[\pi_t(a^*)]}{(1-\beta)}] = 0,$$

or, after solving for $\overline{V}$,

$$\frac{\partial \pi_v}{\partial a^v} + \frac{\beta \frac{\partial F}{\partial a^v}}{1 - \beta F(\overline{x}, a^v)} dE[x(a^*)] = 0,$$

Comparing the Social and the Private problems:

Regulator wants to set $\overline{x}$ such that at $a^v = a^*$,

$$d\frac{\partial E(x)}{\partial a} = \frac{-\beta}{[1-\beta F(\overline{x}, a^v)]}\frac{\partial F}{\partial a}dE[x(a^*)]$$

The above equation implicitly defines optimal standard $\overline{x}^*$.

Some Initial Results

Question: What can we say about $\overline{x}^*$?

Result: In general, it depends on the discount factor, and the distribution parameters, mean and variance.

Comparative Static results for general distribution with constant mean:

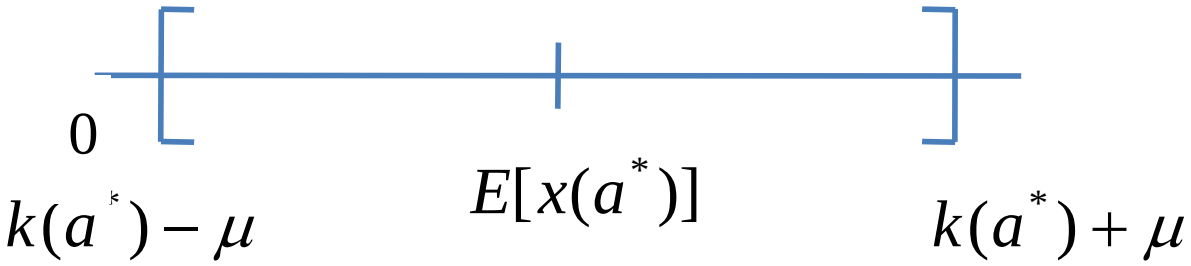
$$\frac{\partial \overline{x}^*}{\partial \sigma}, \frac{\partial \overline{x}^*}{\partial \beta}$$

where σ denotes the variance.

Results driven by whether $\overline{x}^*$ lies below or above the mean, given a^*.

Special Case: Uniform Distribution for x

Figure: Uniform distribution of bycatch mortalities at a^*



$$\bar{x}^* = \frac{(2-\beta)}{\beta}\mu$$

$$\frac{\partial \bar{x}^*}{\partial \mu} > 0 \qquad \frac{\partial \bar{x}^*}{\partial \beta} < 0$$

Group Performance Standard

Assumptions:

- While choosing a, an individual fisher takes the other fisher's choices as given.
- Individual bycatch level of the two fishers are independent of each other.
- If $x_i \in [k(a) - \mu, k(a) + \mu]$ where $i = 1, 2$, then $X = x_1 + x_2$ follows a symmetric unimodal triangular distribution over the interval $[2k(a) - 2\mu, 2k(a) + 2\mu]$.

Initial Results

- First-best exists for the voluntary period under certain conditions on μ.
- Two solutions, not perfectly symmetric around the mean.
- Solutions depend on the degree of uncertainty (μ), discount factor (β), and $k(a^*)$.

Remaining Questions

Investigate the role of this policy in facilitating smoothing of outcomes across firms.

How does the optimal group performance standard compare to the optimal individual standard, e.g., $\overline{X}^* \geq \overline{2}x^*$, or $\overline{X}^* \leq 2\overline{x}^*$?

Questions/Comments?

Thank You!