A Real Options Approach to Fishery Participation

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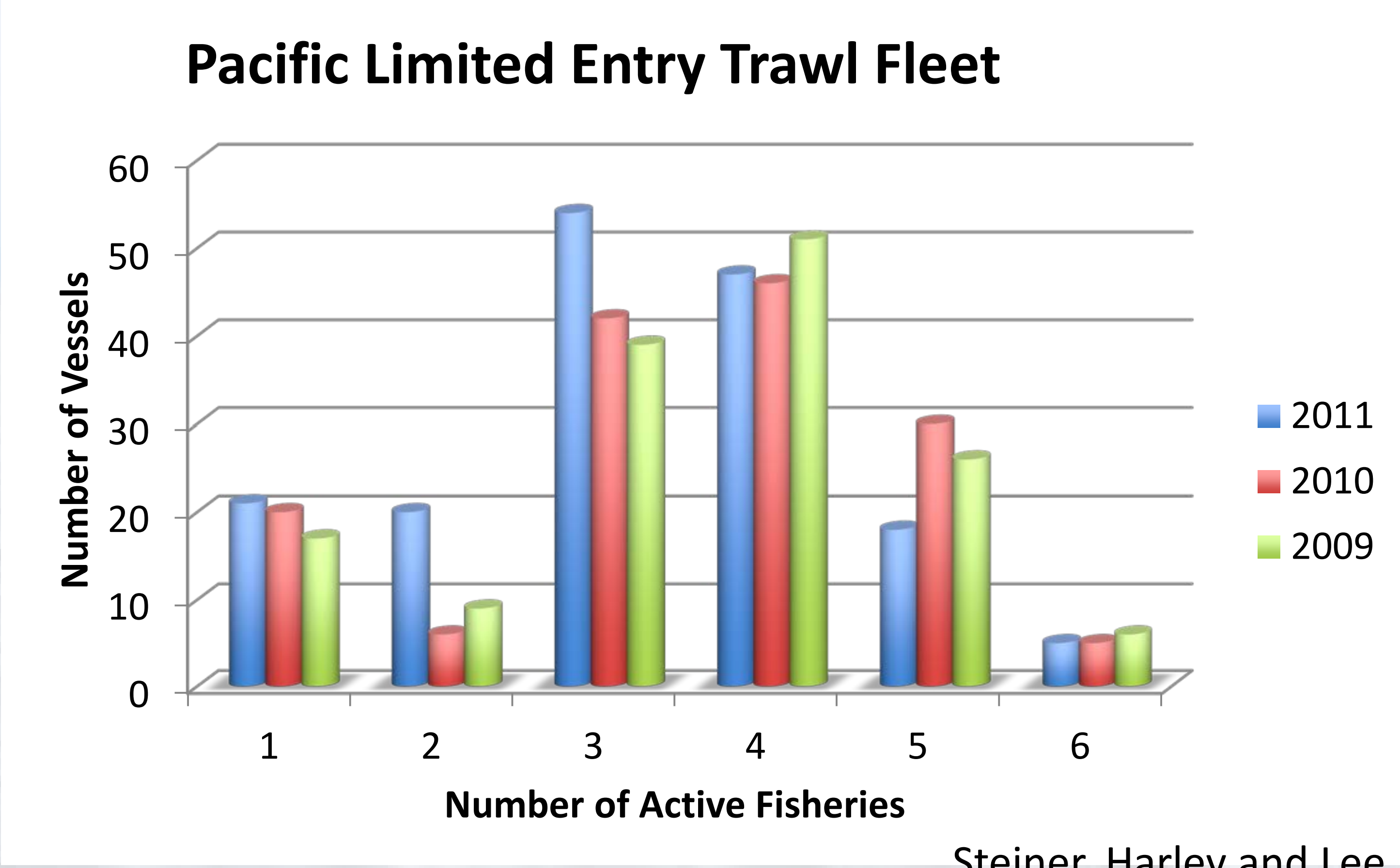
Mutifishery Participation

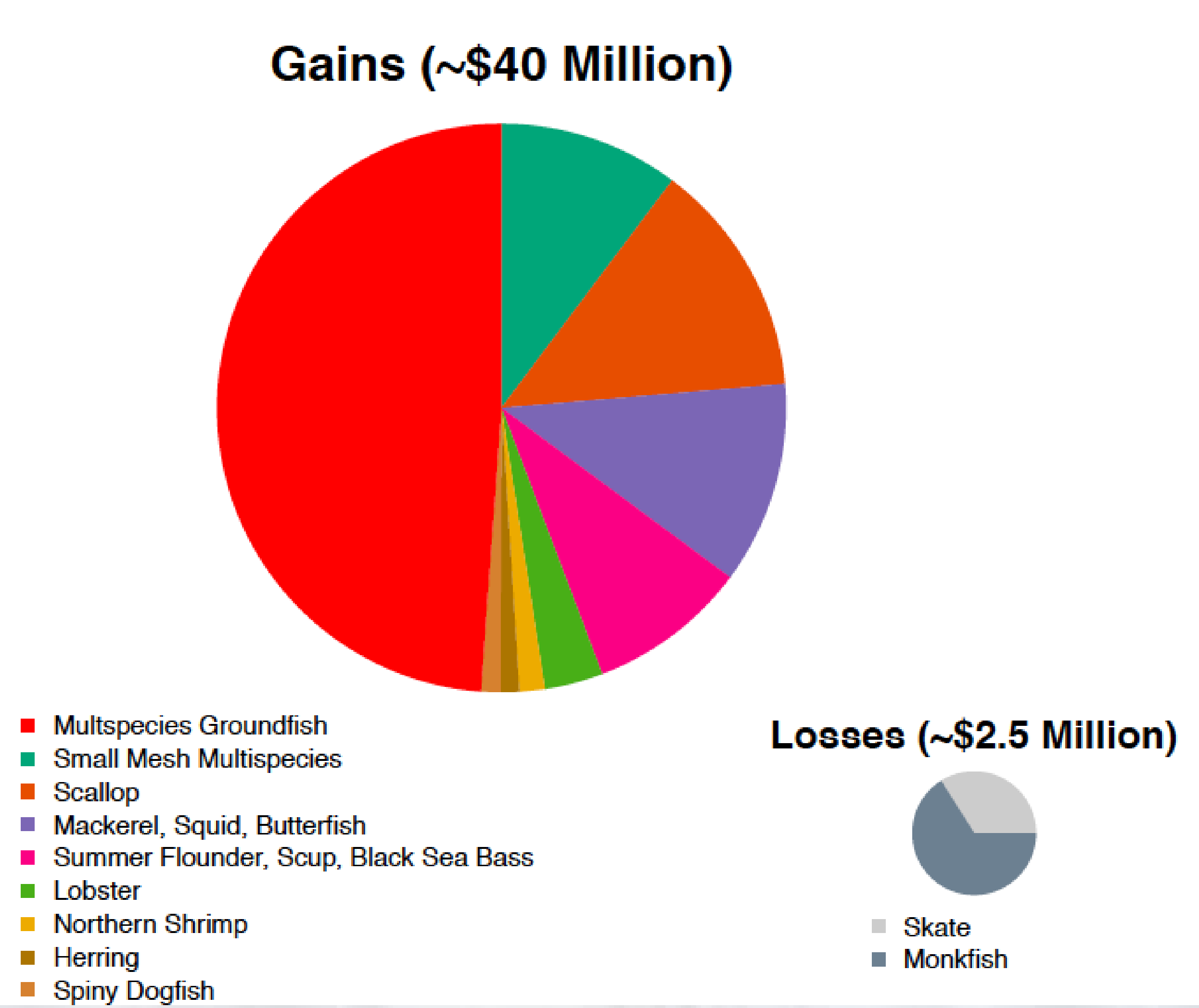
- Most vessels participate in several fisheries during a fishing year
  - These fisheries are often separately managed



Steiner, Harley and Lee NWFSC 2014

Effects of Management Changes

- 2010 revenue effects of NE Multispecies Catch Share, by fishery
  - Half of net gains came from changing timing and participation in separately managed fisheries



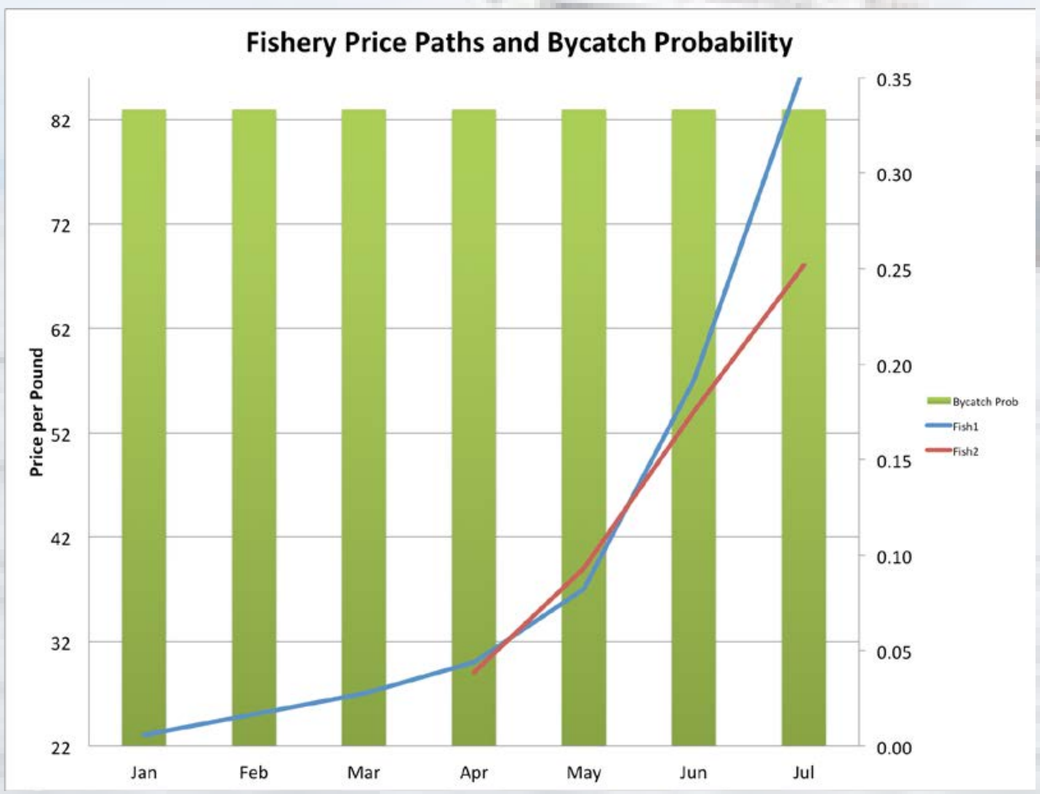
Based on Scheld & Anderson ICES JMS (2014)

Policy Analysis is Single Fishery

- When evaluating a new management action, analysis only examines behavior within the altered management plan
- Location choice models (usually) focus only on spatially reallocating same amount of effort
- Need for tools to understand how management actions, or changes in conditions, affect harvesters annual plans for fishery participation

Fishery Participation Choice

- Vessel participates in two 7-period fisheries
  - Fishery 1: 7 periods, limited by bycatch quota=5
    - Bycatch quantities are random
  - Fishery 2: Opens period 4, ample TAC



(Known) prices increase over season, with Fishery 1 price high enough that want to ensure enough bycatch quota to fish in final period

Real Options Framework

- Model as American barrier option

$$V_t = \max_{\Omega} \mathrm{E}\left[\sum_i \sum_j \sum_\tau \delta^\tau \{\omega_{j\tau} = i\}\{\mathrm{BCA}_{i\tau} < \mathrm{TAC}_i\}\, \pi_i(P_{i\tau}, C_{i\tau})\right]$$

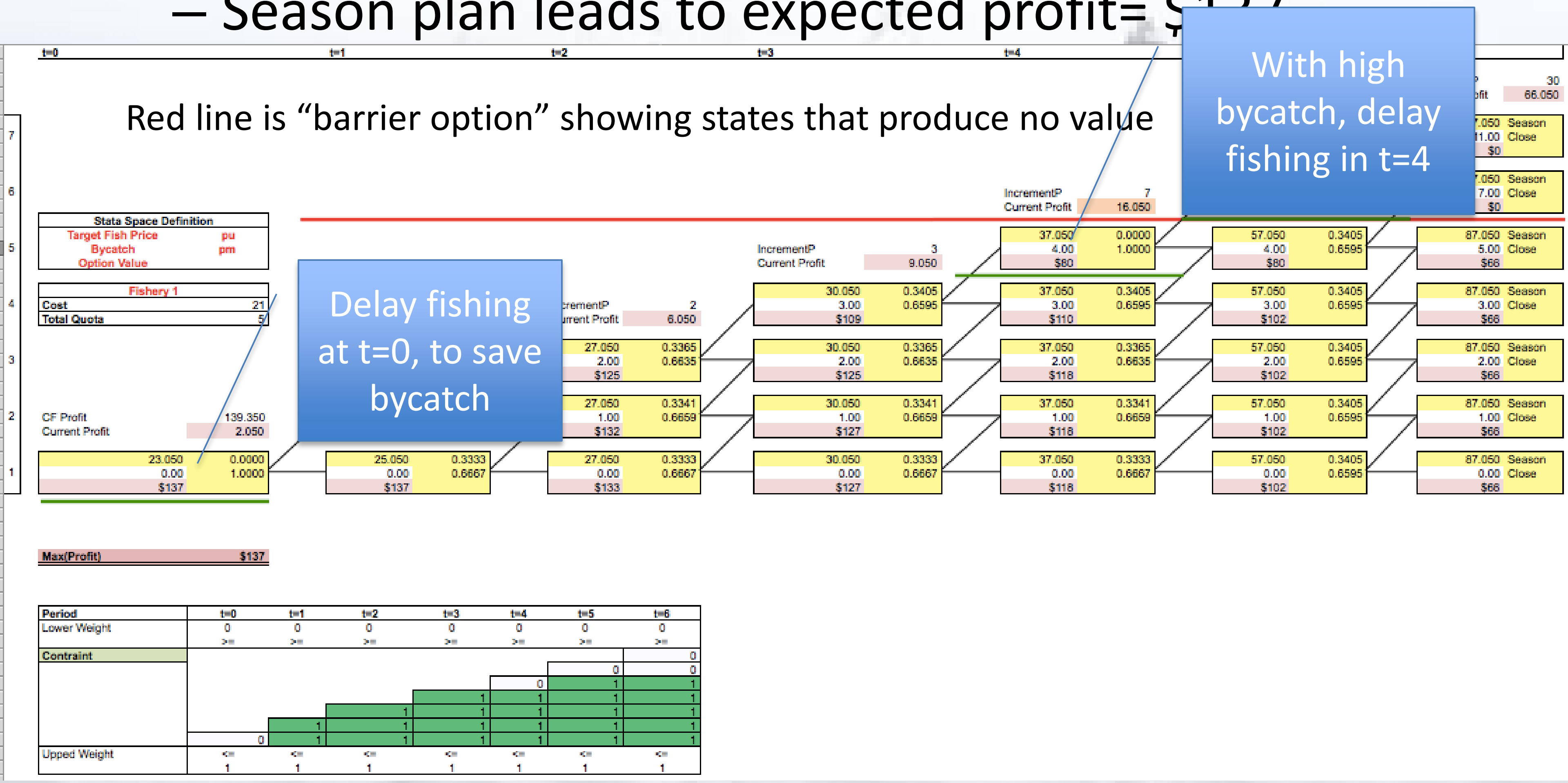
  - Where Ω is participation plan for fishery i in period τ with accumulated bycatch j, BCA_t is the bycatch quota accumulation, and $\pi_i(P_{it}, C_{it})$ profit from i at t
- Tools based on dynamic programming
  - Numerical techniques developed for complex, large state-space decisions where stochasticity plays key role
  - Emphasis on value of (option to) wait to catch fish, either by not fishing, or fishing something else

Real Options Implementation

- Key simplifications
  - Discretize state space onto “lattice”
    - Key state variable is bycatch accumulation
    - Test on single set of beliefs about target catch, price
  - Functionalize transition probability matrix
    - Bycatch accumulation is Markov process
    - $\ln(b_{t+1}) = \ln b_t + \mu(b_t, \sigma^2) - \sigma^2/2 + \sigma\varepsilon_{t+1}$
    - σ is “volatility” of bycatch
    - Use state space to value participation plans; optimization with integer programming for participating in each fishery

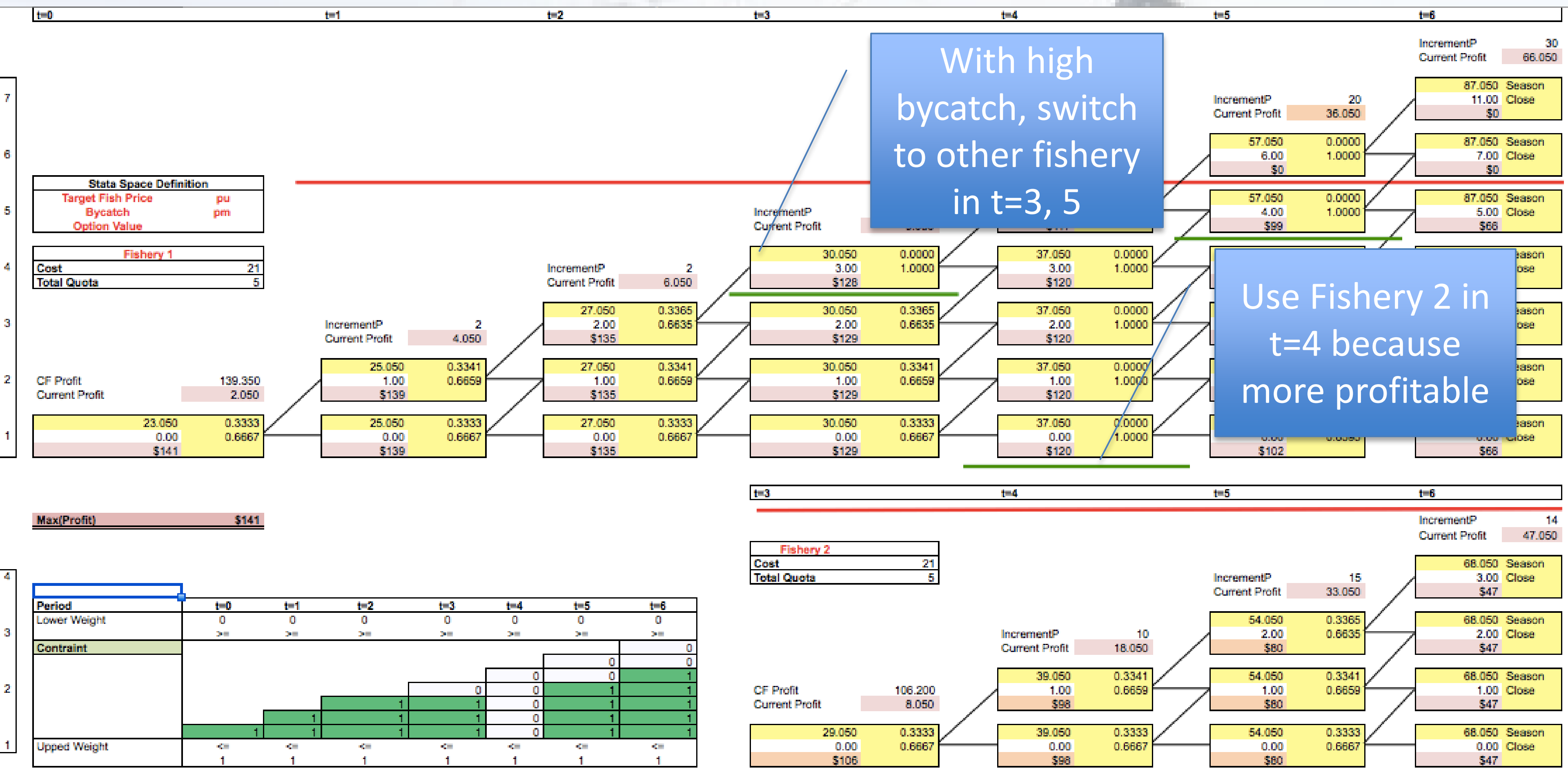
Fishery 1 in Isolation

- Do not fish in first period, or period 5 if accumulated more than 3 bycatch
  - Season plan leads to expected profit= $137



Fishery 1 Interacts with Fishery 2

- With option to switch if have too much bycatch, now fish in Period 1
  - Season plan leads to expected profit=141



Implications

- Expected value of Fishery 1 depends on option to participate in Fishery 2
  - Depending on risk profiles and the value and timing of other opportunities, management changes in one fishery can affect the timing and extent of participation in that fishery, and other fisheries
  - Fishery 2 provides better options (expected value effect) at some times, and an alternative in case of “unlucky” bycatch realizations (variance effect)
  - Failure to account for this will lead to incorrect assessment of management changes
    - Get the value wrong
    - Get the timing wrong
    - Get extent of participation wrong
- Working on
  - Valuing management switch from derby to quota
  - Valuing gear changes that affect bycatch risk
    - Especially with time-varying bycatch
  - Applying to actual fishery data us empirical computational finance tools