


Unravelling the Multiple Margins of Rent Generation from Individual Transferable Quotas

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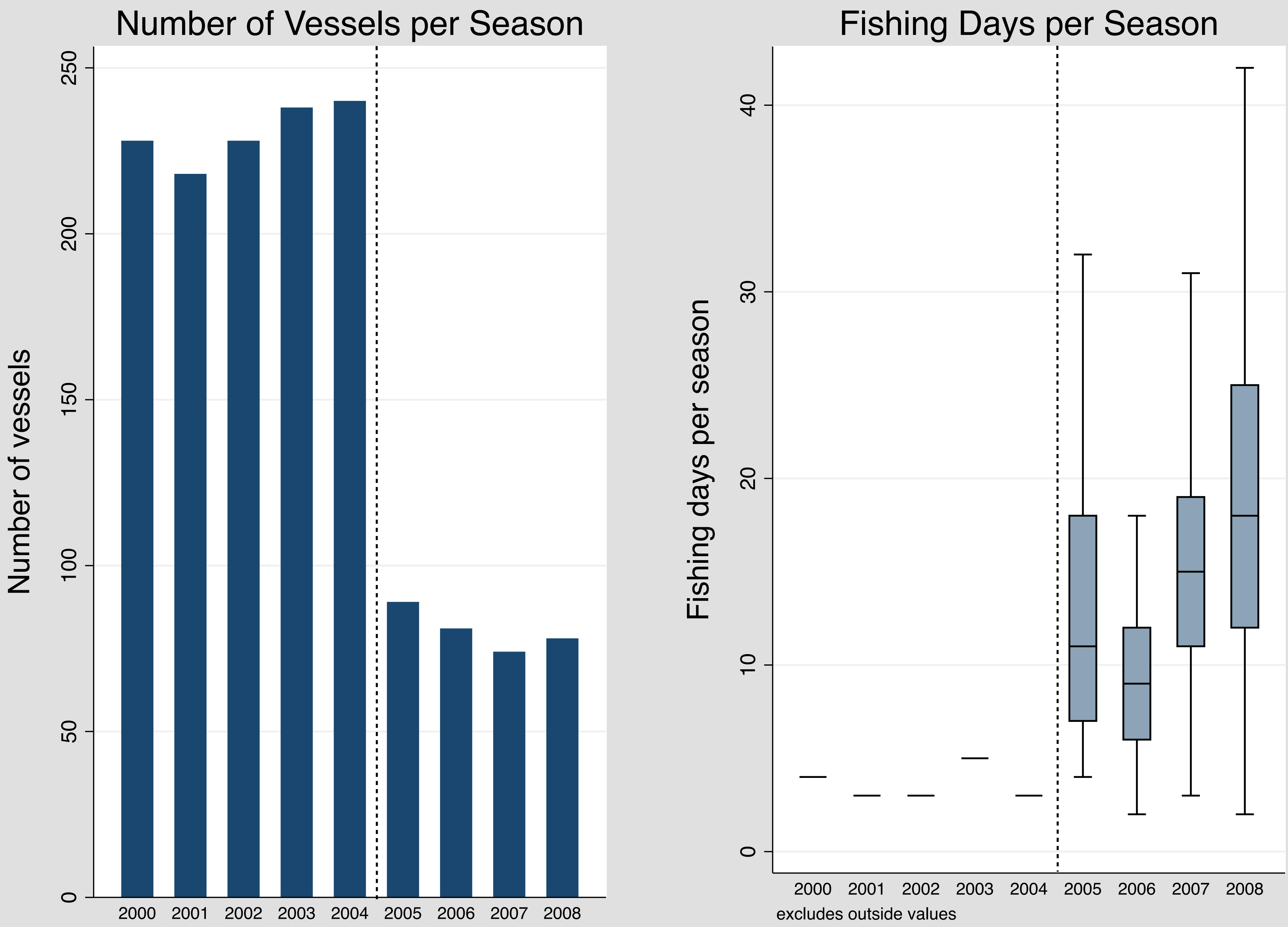
Limited Entry Programs

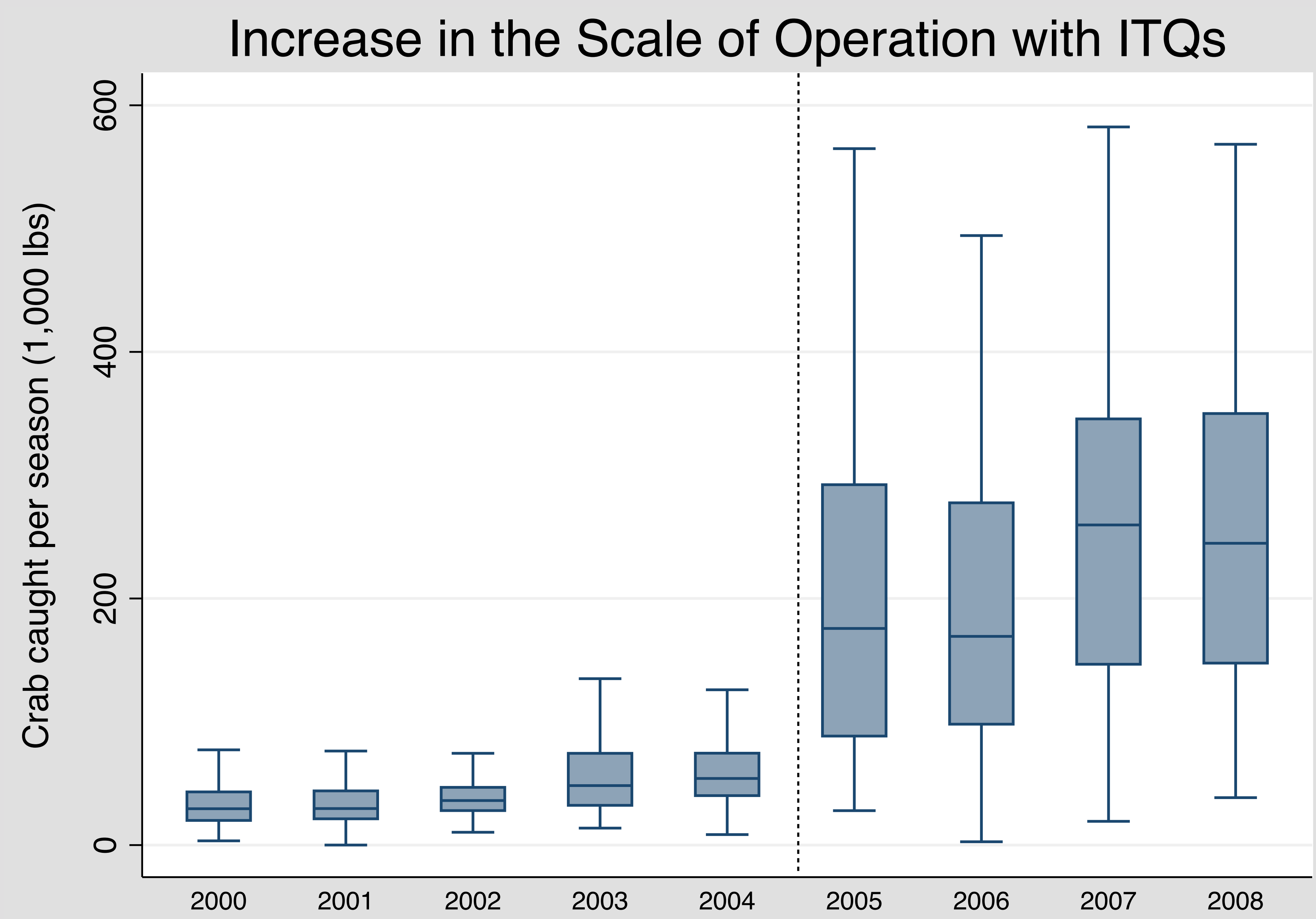
- Limit the number of vessels that can participate
- Set a total allowable catch (TAC) for the fishery
- “Rule of capture” can induce a “race to fish”
- Common results:
  - Unsafe fishing conditions
  - short seasons
  - risk of over-harvesting
  - dissipation of rents

Introducing ITQs

- ITQs allocate quotas or shares of the TAC to fishery participants
- Shares can be traded between participants
- Predictions about ITQs have been borne out in practice:
    - Reduction in fleet size
    - Increase in the scale of operation for remaining vessels
    - Extended season length



Number of Vessels per Season
Number of vessels
0
50
100
150
200
250
2000
2001
2002
2003
2004
2005
2006
2007
2008
Fishing Days per Season
Fishing days per season
0
10
20
30
40
2000
2001
2002
2003
2004
2005
2006
2007
2008
excludes outside values


Increase in the Scale of Operation with ITQs
Crab caught per season (1,000 lbs)
0
200
400
600
2000
2001
2002
2003
2004
2005
2006
2007
2008

How Do ITQs Generate Rents?

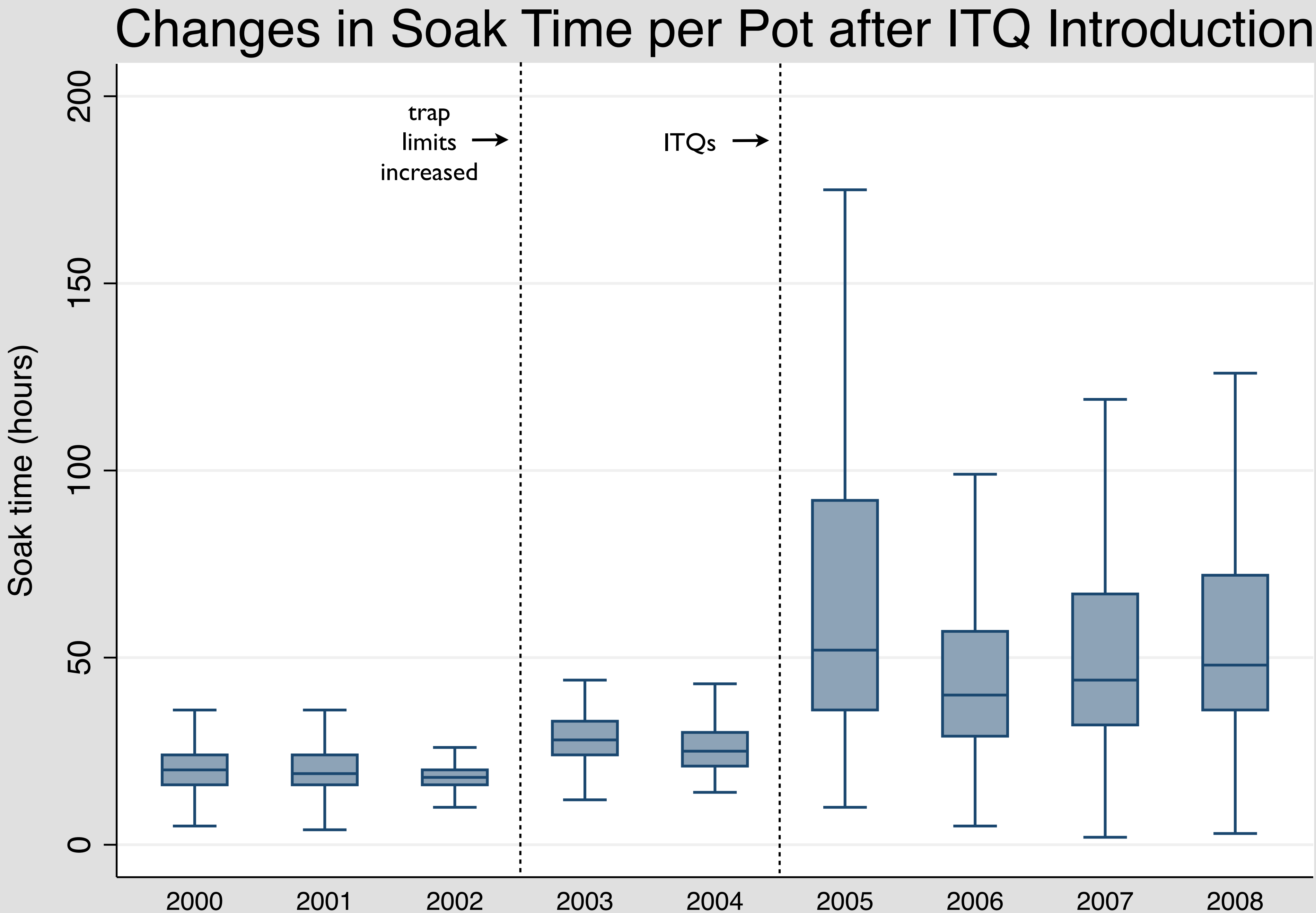
Two simultaneous sources:

1) *"Consolidation effect"*: cost savings from a reduction in fleet size and increased scale of operation for remaining vessels.

Focus of most previous studies.

2) "Incentive effect": cost savings from changes in fishing practices in response to altered incentives provided by the security of harvesting rights.

Relatively neglected. Requires a deeper understanding of how fishermen catch crab.



Changes in Soak Time per Pot after ITQ Introduction
Soak time (hours)
0
50
100
150
200
trap
limits
increased
ITQs
2000
2001
2002
2003
2004
2005
2006
2007
2008

Why do we care?

ITQs are not without controversy.

➔ Sources of rent generation can be captured through different policies.

Example 1:

Vessel buyback programs may generate rents through consolidation effects.

Question: Can we achieve similar benefits as ITQs if we simply reduce the fleet size in a limited entry program?

Why do we care?

ITQs are not without controversy.

➔ Sources of rent generation can be captured through different policies.

Example 2:

ITQ introduction with a prohibition on quota trading (IQs) may generate rents through incentive effects without consolidation.

Question: Can ITQs with no quota trading achieve similar benefits as ITQs with unrestricted trading?

Research Questions

1. How are rents generated under ITQs?

   → What portion of rents can be attributed to:

      a) consolidation effects

      b) incentive effects

2. How do ITQs compare to other forms of fishery management (e.g. limited entry, vessel buybacks, or IQs)?

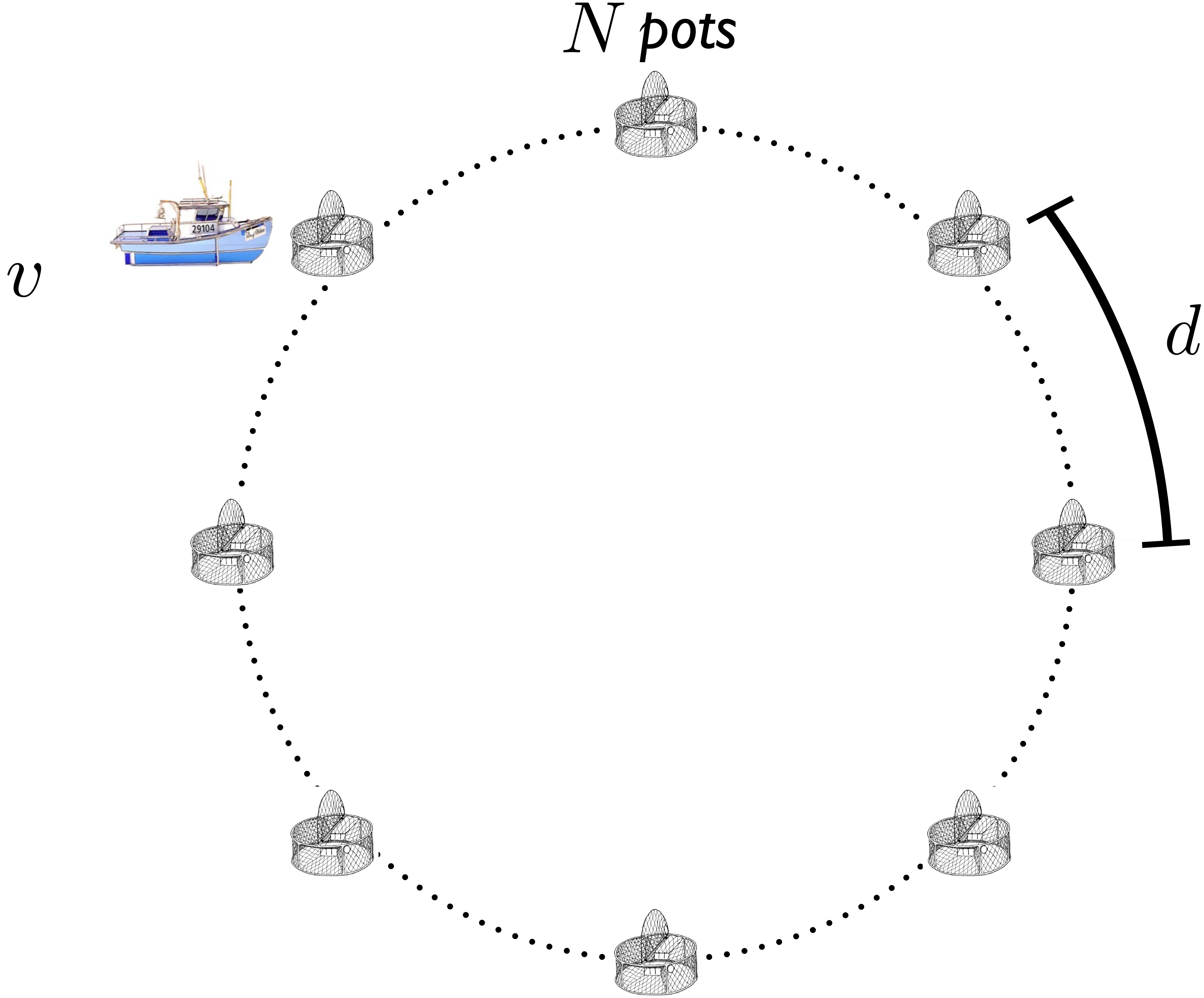
Methods

1. Develop a crab harvesting production model
2. Embed production model in a behavioral model that captures the regulatory environment of ITQs and limited entry
3. Solve the model numerically and calibrate it to 2004 fishery conditions
4. Conduct model simulations to ask “what if” questions:
    a. What if fleet size was simply reduced without ITQs?
    b. What if ITQs were introduced but trading was prohibited (IQs)?

Crab Harvesting Model

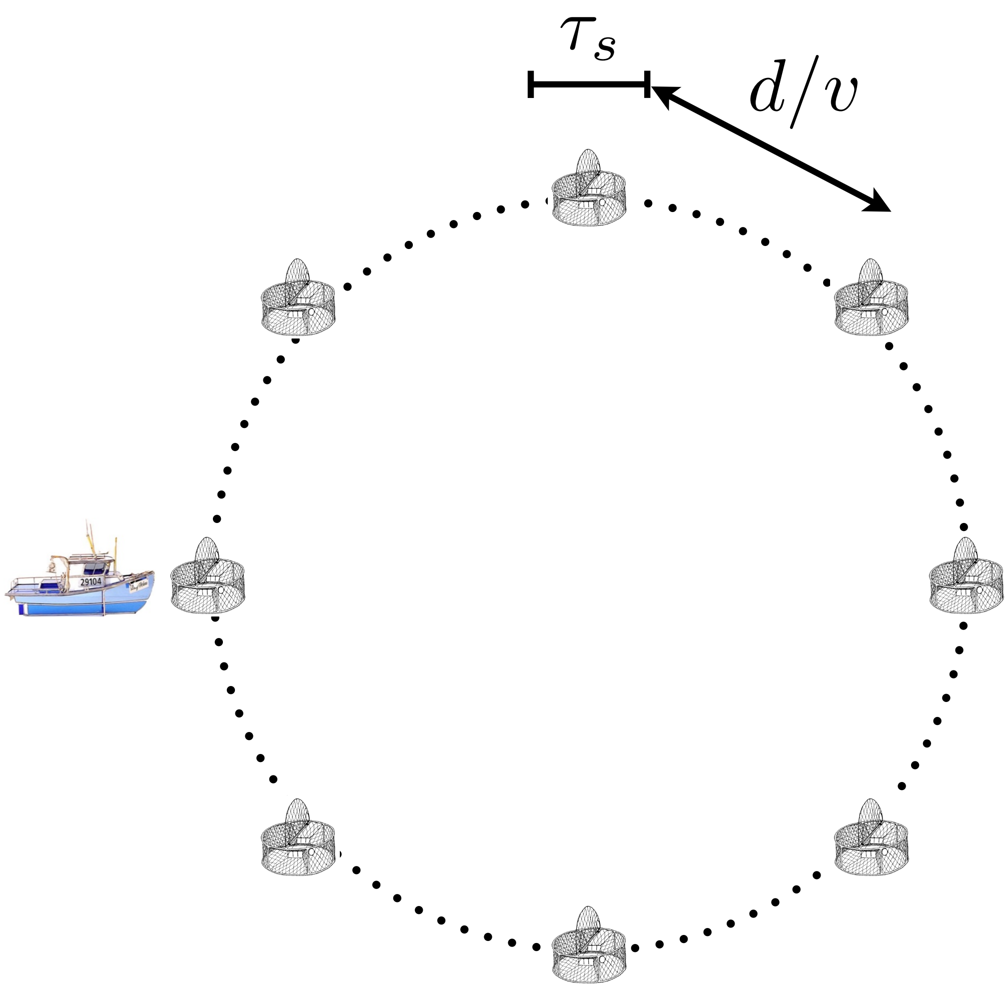
Capture the fundamental decisions made by the skipper:

- Soak time
- Number of pots
- Distance between pots
- Velocity of travel
- Pot lifts per day
- Fishing days
- Number of trips



N pots
v
29104
d

Timing



N *pots*

Handling time / pot:

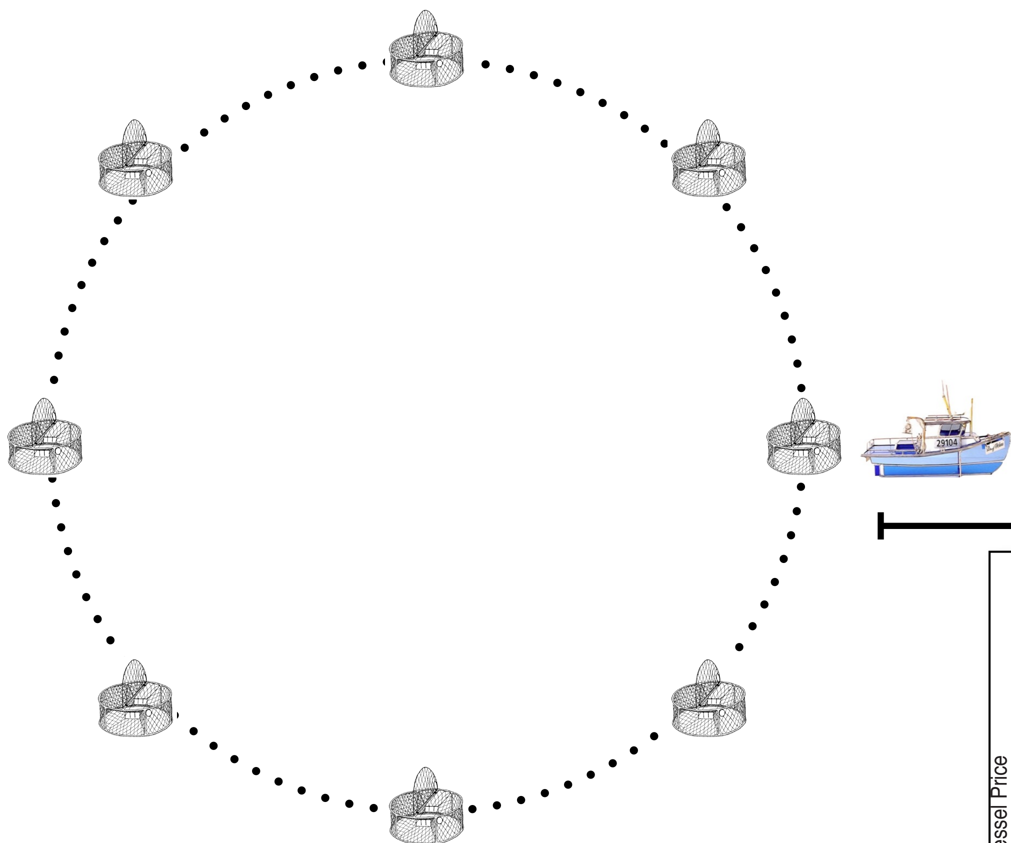
$$\tau_h = \tau_s + d/v$$

Soak time / pot:

$$S = N\tau_h$$

Timing

$$T^f$$



t trips

Handling time / pot:

$$\tau_h = \tau_s + d/v$$

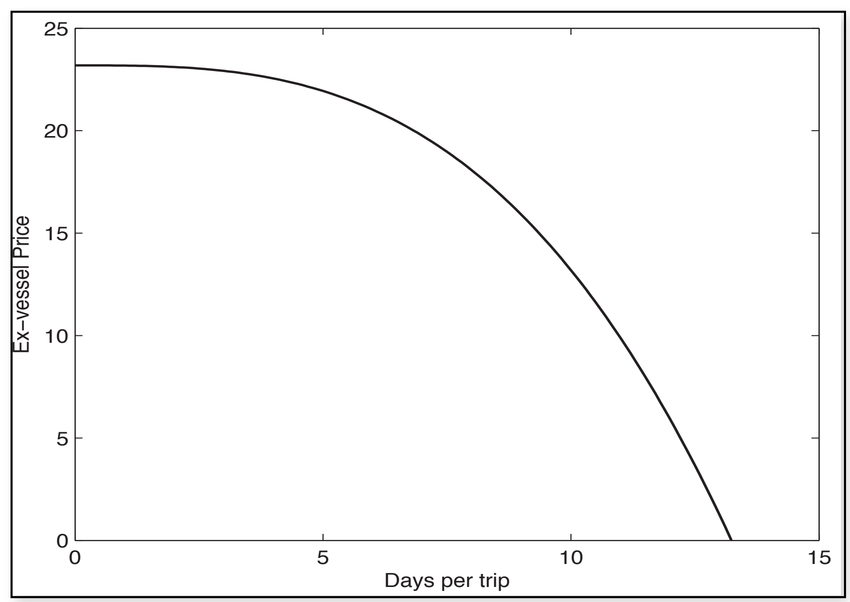
Soak time / pot:

$$S = N\tau_h$$

Fishing days / trip:

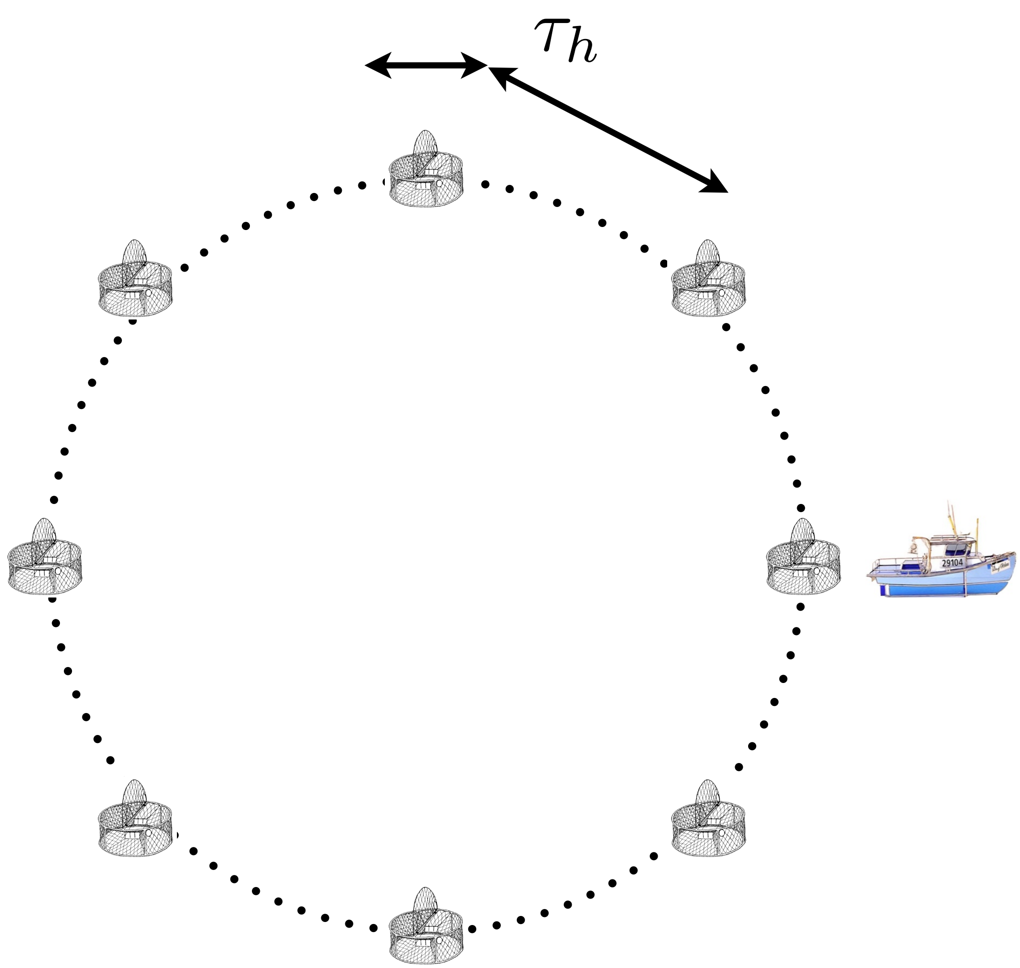
$$T^f = T/t - T^t$$

$$T^t$$



Crab deterioration function

Timing



Handling time / pot:

$$\tau_h = \tau_s + d/v$$

Soak time / pot:

$$S = N\tau_h$$

Fishing days / trip:

$$T^f = T/t - T^t$$

Pot sets / season:

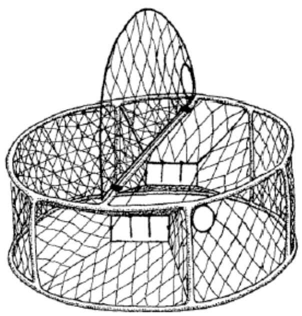
$$P^S = T^f t/\tau_h$$

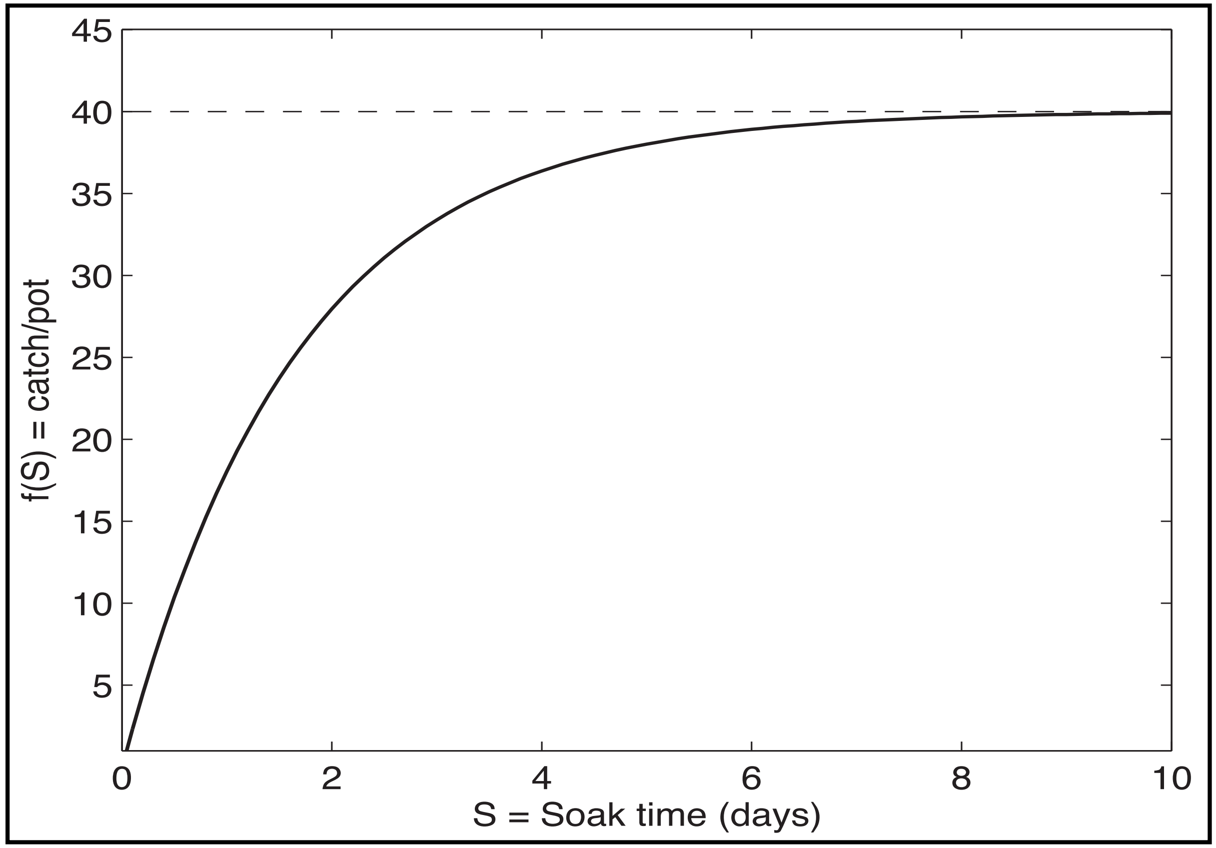
Pot lifts / season:

$$P^L = P^S - N$$

$$\frac{catch}{pot} = \delta D\left(1 - e^{-\gamma S}\right), \quad D > 0\,;\gamma > 0$$

Production



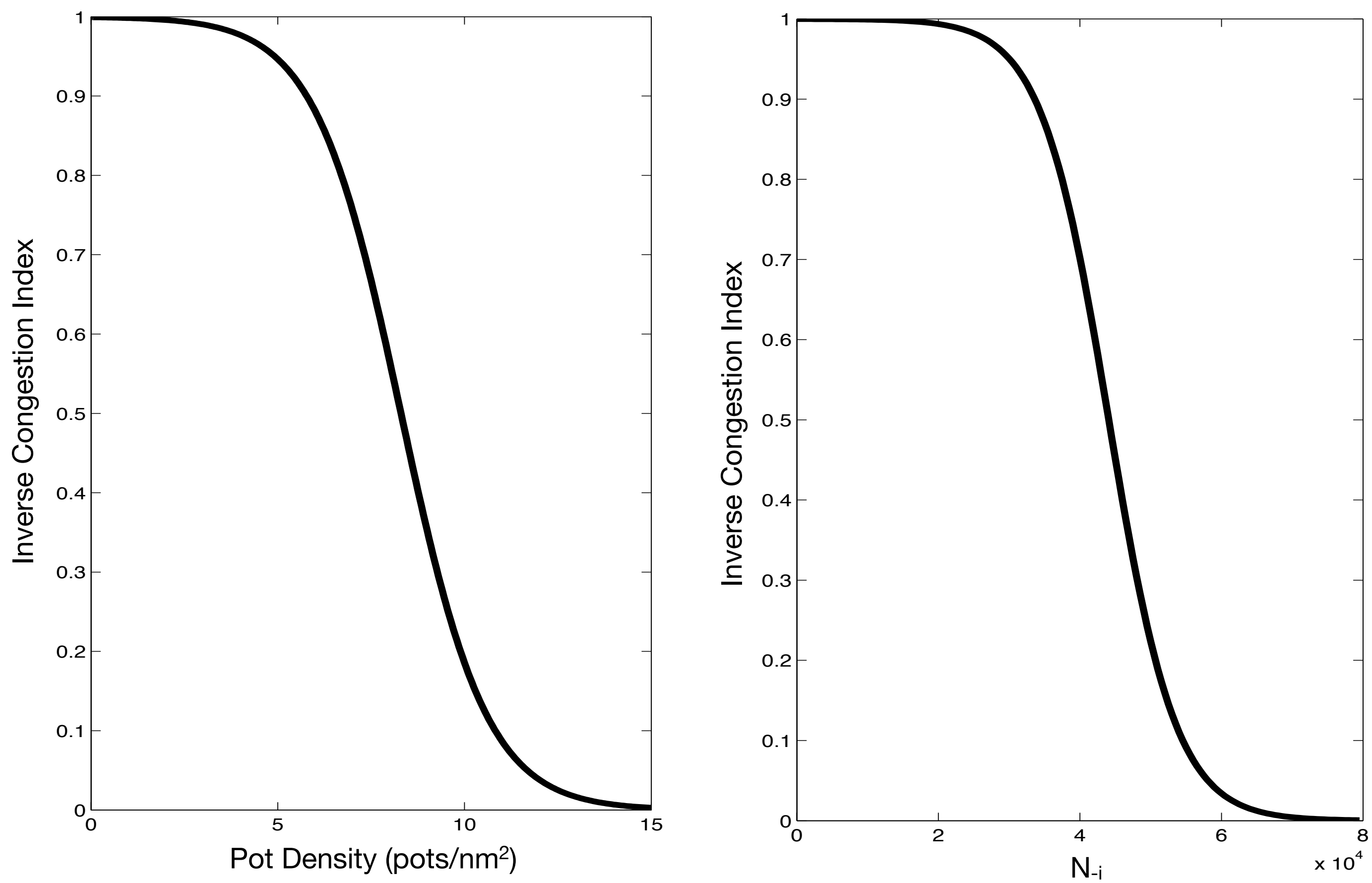


Per pot Production: $f(S) = D\left(1 - e^{-\gamma S}\right)$; $D = 40$, $\gamma = 0.6$

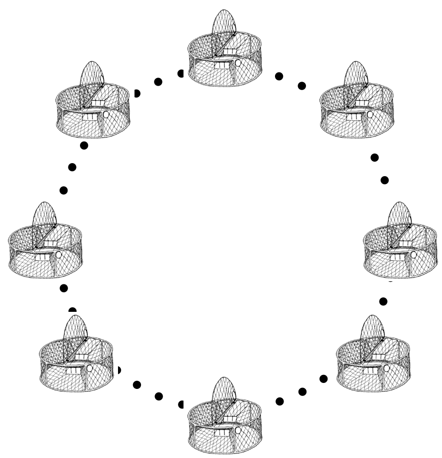
$$\frac{catch}{season} = P^L \times \frac{catch}{pot}$$

Inverse Congestion Function

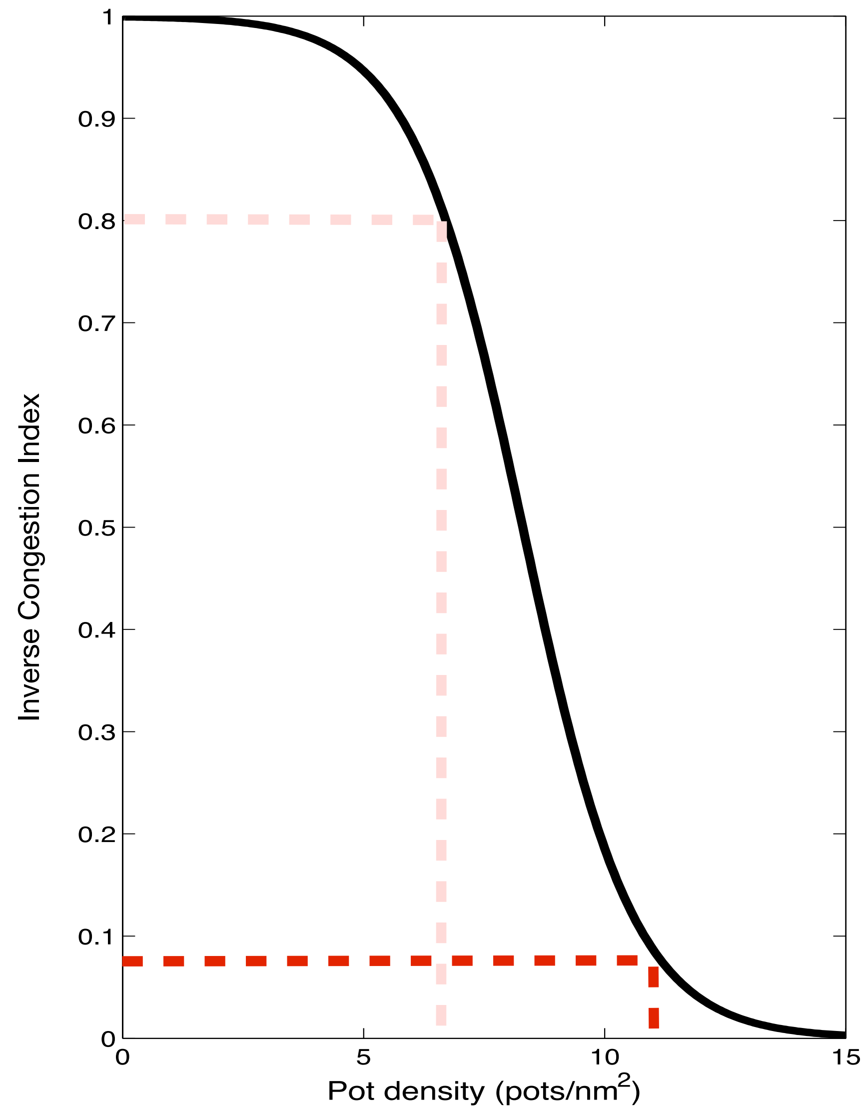
$$\delta(d, N, N_{-i}) = \underbrace{\left[\frac{1}{(1 + exp\{\lambda_d(density - m_d)\})}\right]}_{\text{Own pot congestion}} \underbrace{\left[\frac{1}{(1 + exp\{\lambda_N(N_{-i} - m_N)\})}\right]}_{\text{Cross pot congestion}}$$



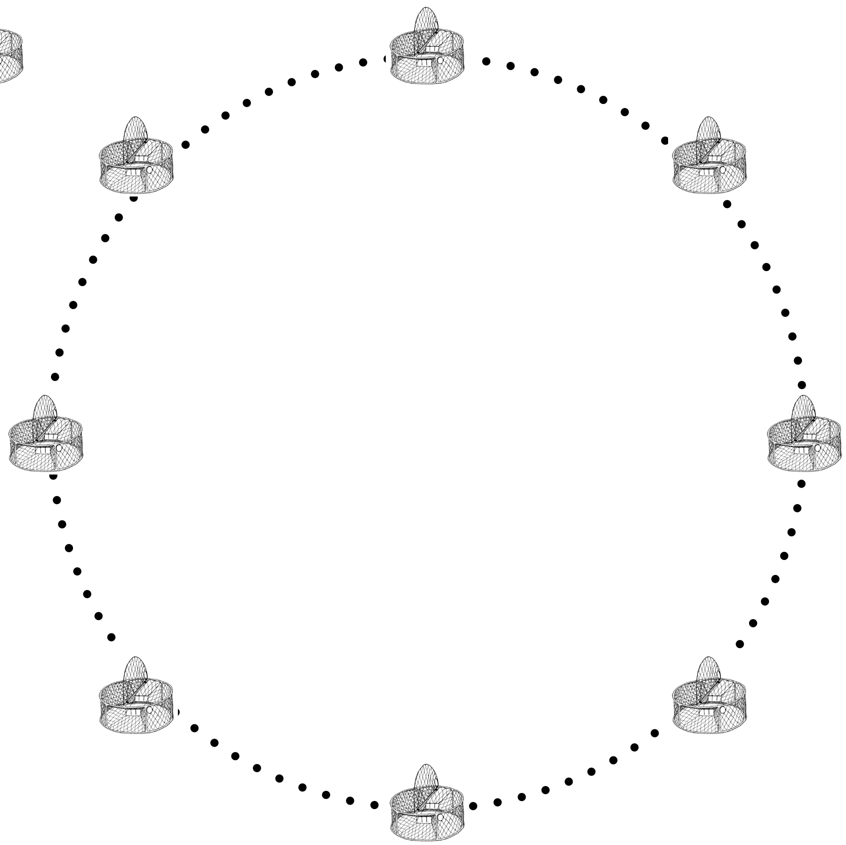
Own Pot Congestion

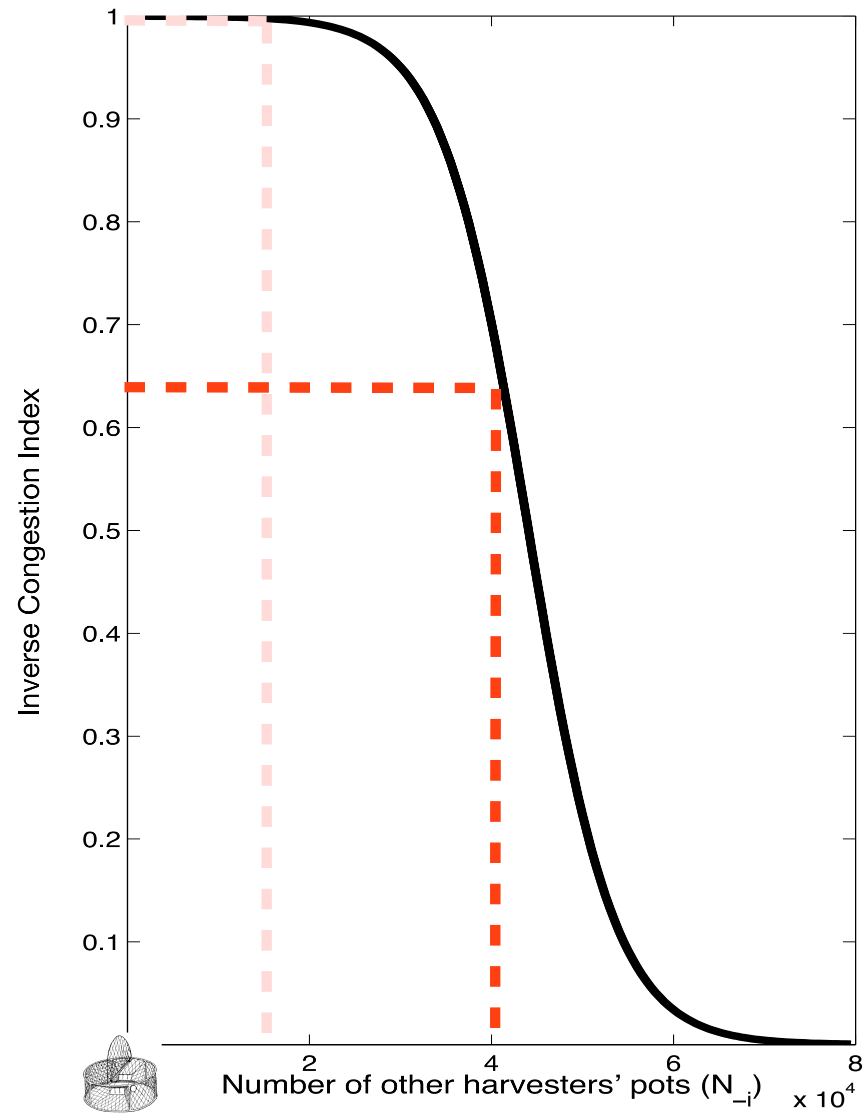


$$density = \frac{4\pi}{Nd^2}$$



Cross-pot Congestion





Seasonal Costs

$$C(d, v, N, t, T) = \underbrace{c_u}_{\text{usage costs}} + \underbrace{c_o}_{\text{operating costs}} + \underbrace{c_t t}_{\text{travel costs}}$$

$$c_u = \underbrace{r}_{\text{Vessel rental cost}} + \underbrace{c_N N}_{\text{Pots rental cost}}$$

$$c_o = \left[\frac{pots\ set}{season}\right]\left(\left[\frac{set\ cost}{pot}\right] + \left[\frac{steam\ cost}{pot}\right]\right) + \underbrace{c_l T}_{\text{Seasonal cost of labor provisions}}$$

$$\frac{steam\ cost}{pot} = \alpha v^{\beta} d \qquad \beta > 1$$

Behavioral Model

Behavioral Model

- Each fishery is static game of complete information between η homogeneous vessels with an endogenous season length T

- Each vessel chooses an action and commits to this action for the entire season

$$d > 0 \qquad \bar{v} > v > 0 \qquad N > 0 \qquad t \in \{1, 2, 3, \dots\}$$

- Actions chosen to maximize seasonal profits given the actions of all other vessels:

$$\max_{d,v,N,t} \qquad \Pi = \underbrace{\rho(t,T)}_{\text{ex-vessel price}} \underbrace{P^L(d,v,N,t,T)}_{\text{pot lifts per season}} \underbrace{g(d,v,N,N_{-i})}_{\text{catch per pot}} - \underbrace{C(d,v,N,t,T)}_{\text{costs per season}}$$

$$\text{subject to: } \left[\frac{catch}{trip}\right] \leq H$$

Regulatory Environment

ITQ Season Length T^{ITQ}*:*

$$Q = \frac{catch}{season}$$

$$\Longrightarrow T^{ITQ} = \left[\frac{Q}{g(d,v,N,N_{-i})} + N\right]\tau_h(d,v) + T^t t.$$

where $Q = TAC/\eta$

Limited Entry Season Length T^{LE}*:*

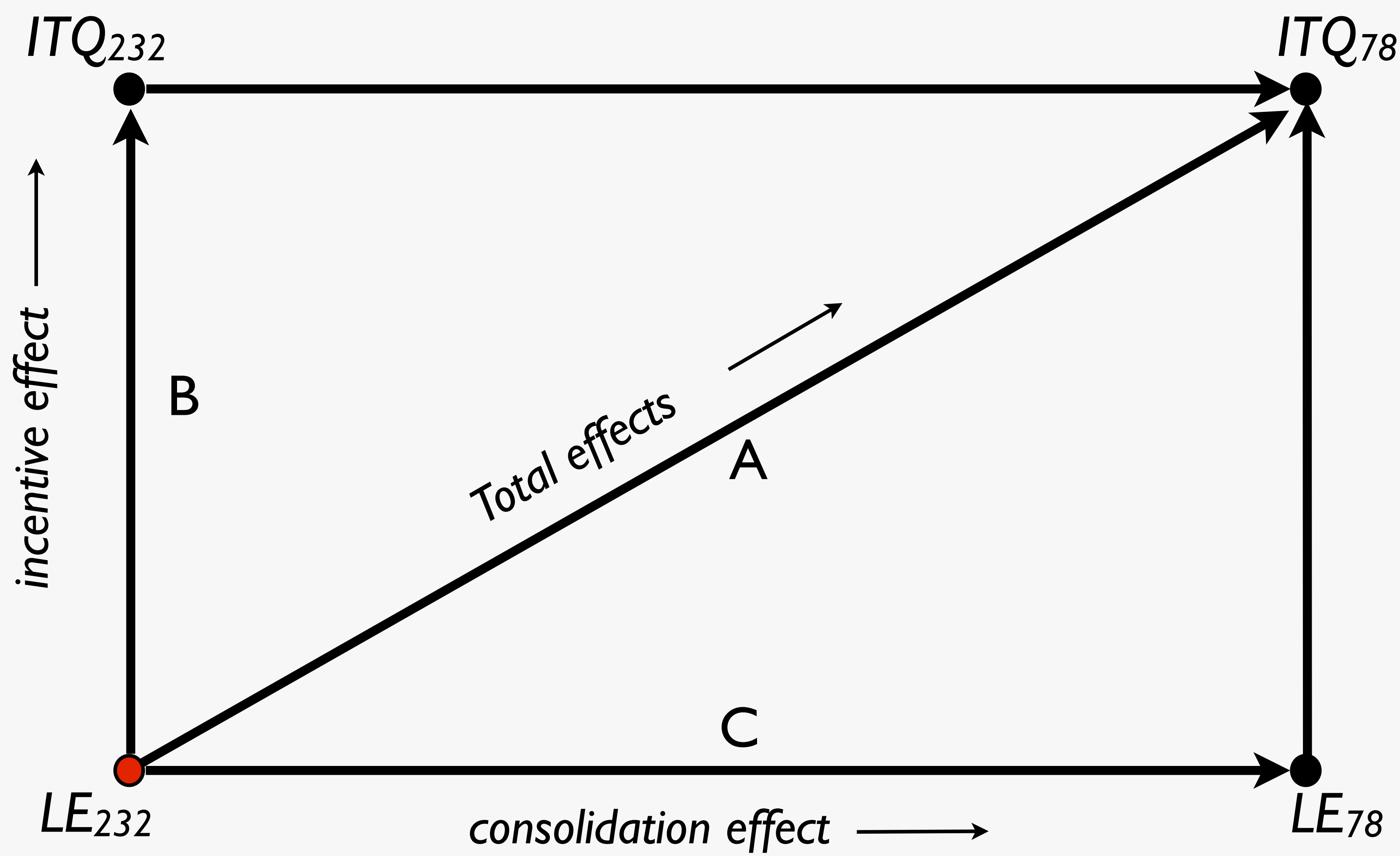
$$TAC = \frac{catch}{season} + (\eta - 1)\frac{catch}{season_{-i}}$$

$$\Longrightarrow T^{LE} = \frac{TAC + \left(\frac{T^t}{\tau_h(\cdot)}t + N\right)g(\cdot) + (\eta - 1)\left(\frac{T^t}{\tau_{h_{-i}}}t_{-i} + N_{-i}\right)g_{-i}}{\frac{g(\cdot)}{\tau_h(\cdot)} + (\eta - 1)\frac{g_{-i}}{\tau_{h_{-i}}}}.$$

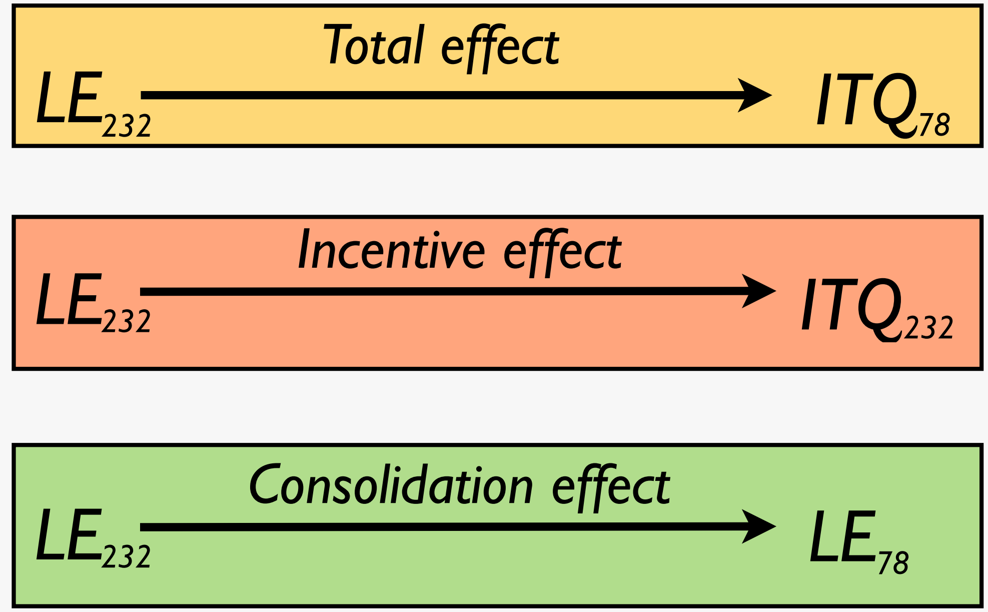
Calibration and Model Performance

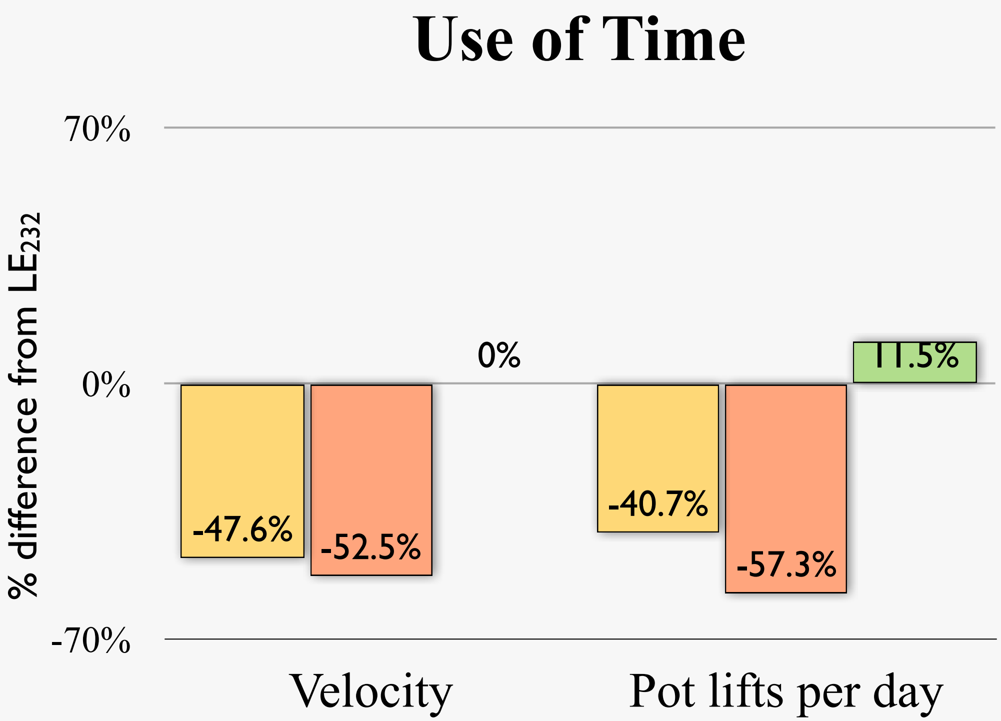
Calibration Point	Actual Median			Model Prediction		
	(1) 2004	(2) 2006	(3) Difference (%)	(4) 2004	(5) 2006	(6) Difference (%)
Soak time (days)	1.02	1.54	+50.94	1.24	1.59	+28.23
Pot lifts/day	111.67	83.17	-25.52	143.58	80.03	-44.26
Fishing days	3.00	9.00	+200.00	3.71	10.92	+194.34
Registered pots	200.00	150.00	-25.00	178.62	127.38	-28.69
Crabs/pot	21.00	30.00	+42.86	27.06	38.14	+40.95
Fuel/crab (gal)	0.842	0.413	-50.95	0.556	0.148	-73.38

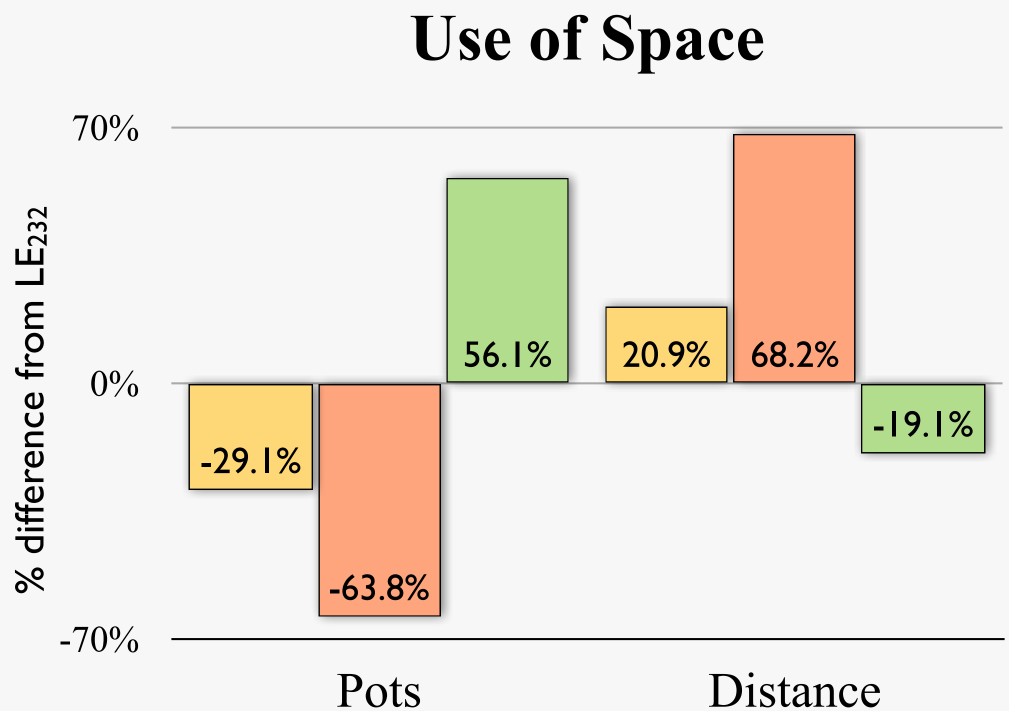
Experimental Design



Changes in Fishing Practices





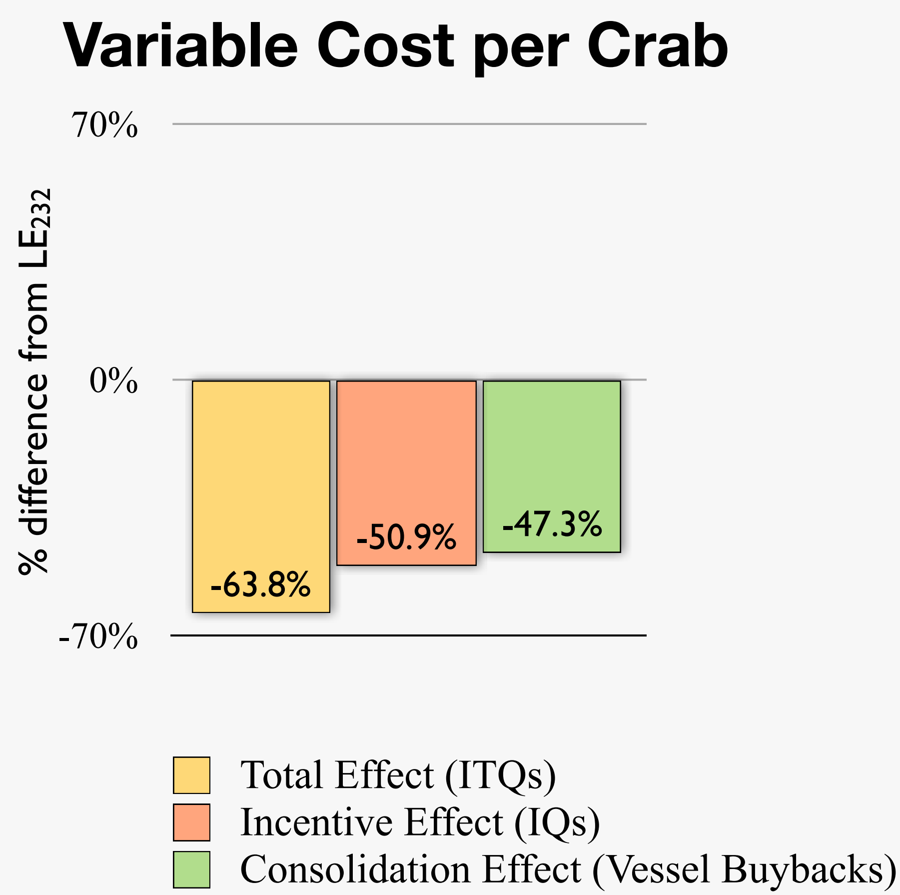


Policy Implications: Variable Costs

ITQs, IQs, and vessel buybacks have the potential for tremendous cost savings in the RKC fishery⋆

1. Incentive effect induces harvesters to "slow down"

2. Consolidation allows harvesters to spread increased variable costs over more crab



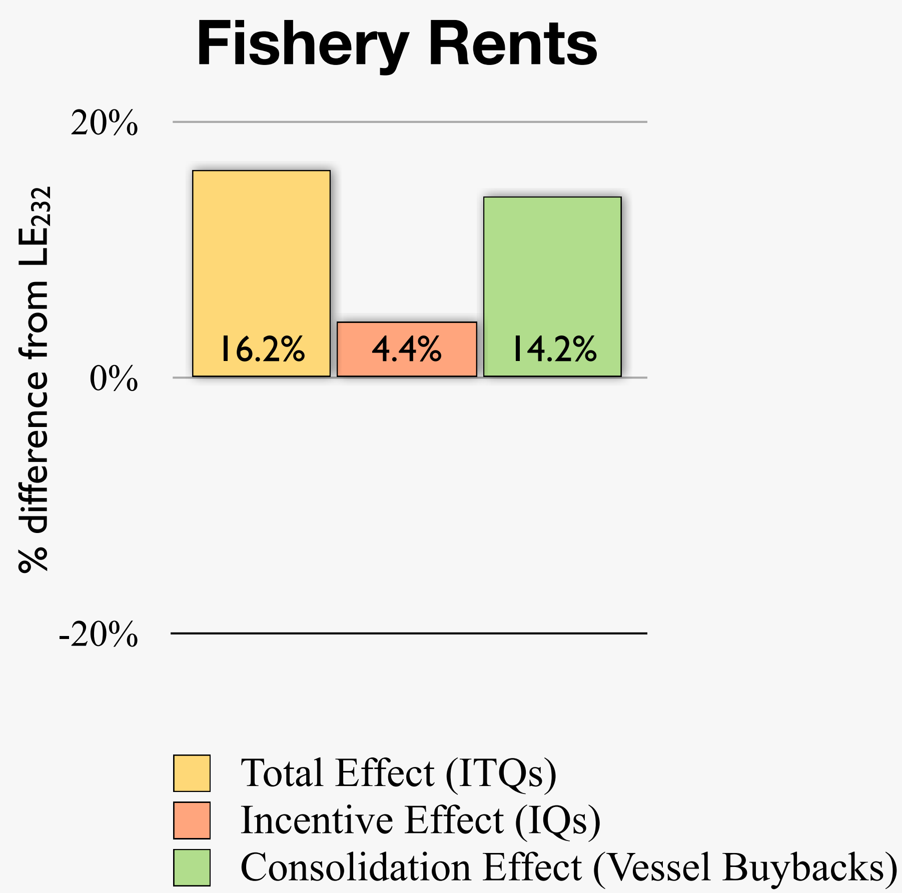
⇒ ITQs capture cost savings from both incentives and consolidation.

Policy Implications: Fishery Rents

ITQs, IQs, and vessel buybacks have the potential to generate moderate rents in the RKC fishery.⋆

1. Majority of rent generation comes from elimination of redundant capital

2. IQs generate only marginal gains in rent for the RKC fishery.



Policy Implications: Fishery Rents

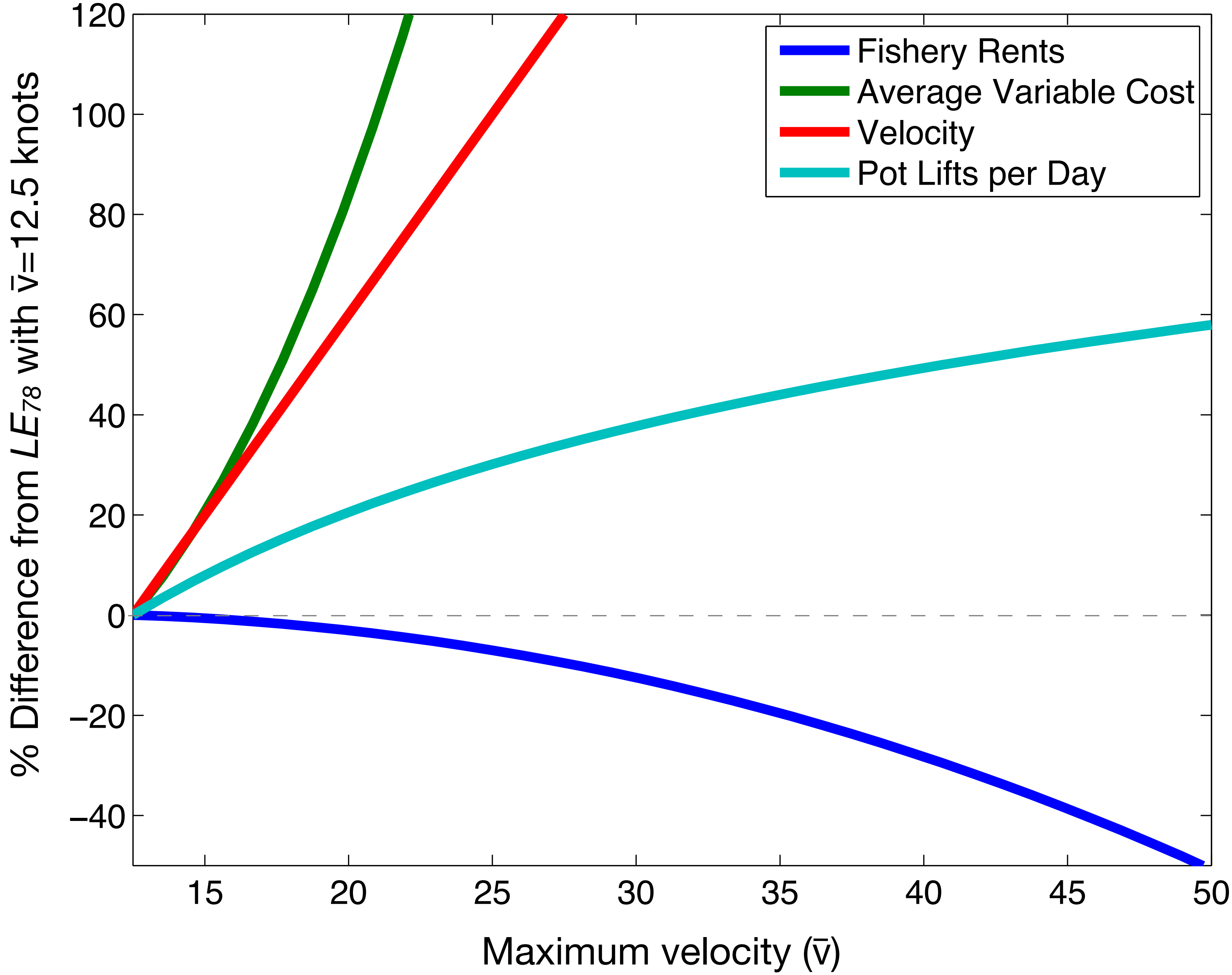
Limited entry RKC fishery was already generating rents! How?

1. Maximum velocity is binding, preventing vessels from competing away rents.

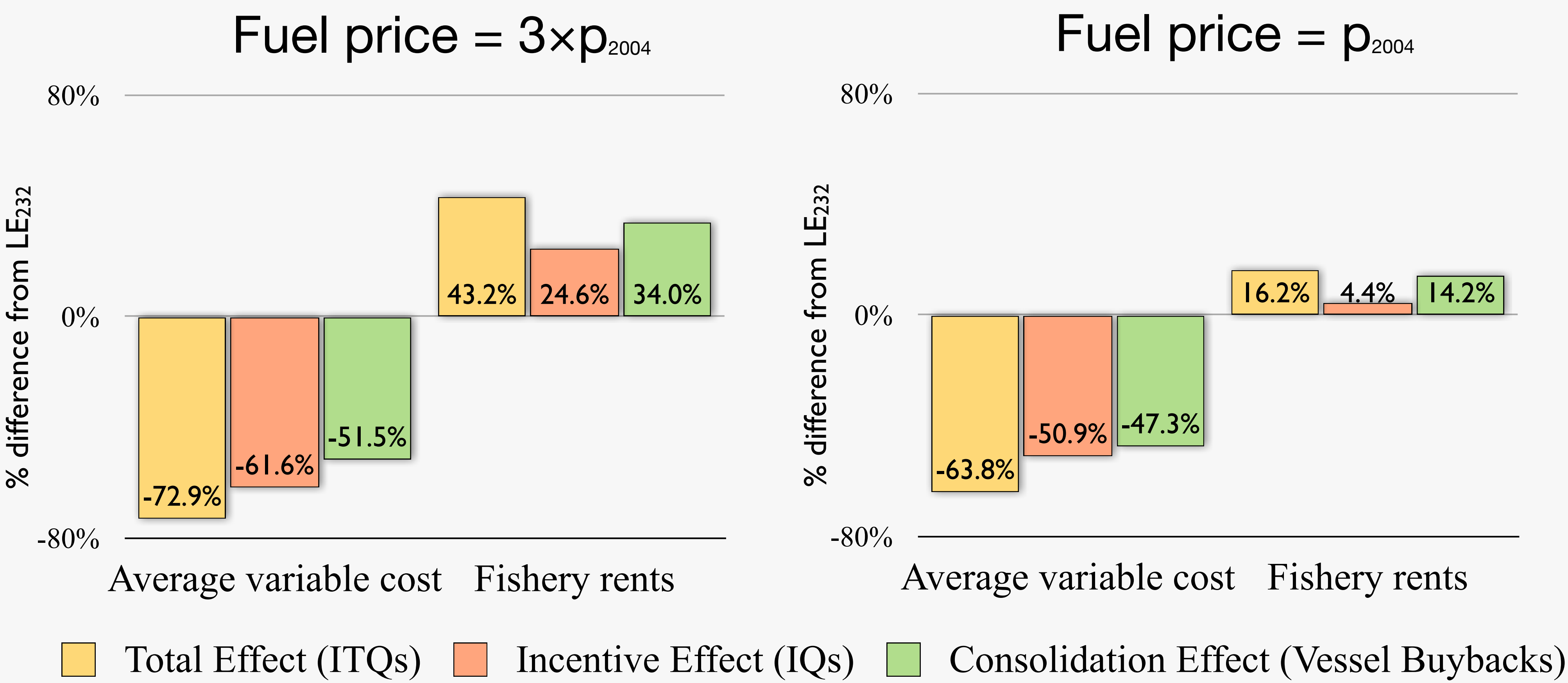
2. Cost of fuel low relative to the price of crab.

Institution	Total Rents ($)
(a) LE_{232}	54,373,840
(b) LE_{78}	62,076,300
(c) ITQ_{232}	56,744,880
(d) ITQ_{78}	63,197,160

Technological Constraint on Rent Dissipation



Rents and Costs with Higher Fuel Prices



⇒ Rent generation from ITQ incentives has the potential to be large if fuel prices continue to rise relative to crab prices.

Conclusion

Rent generation from ITQs arises from two sources:

1. *Consolidation*:
   a. eliminates redundant capital
   b. vessels can take advantage of scale economies
   c. “intensifies” harvesting behavior

2. *Incentives*:
   a. “slows down” harvesting behavior
   b. reduces variable costs per crab

Conclusion

Each source can be captured by alternative policies:

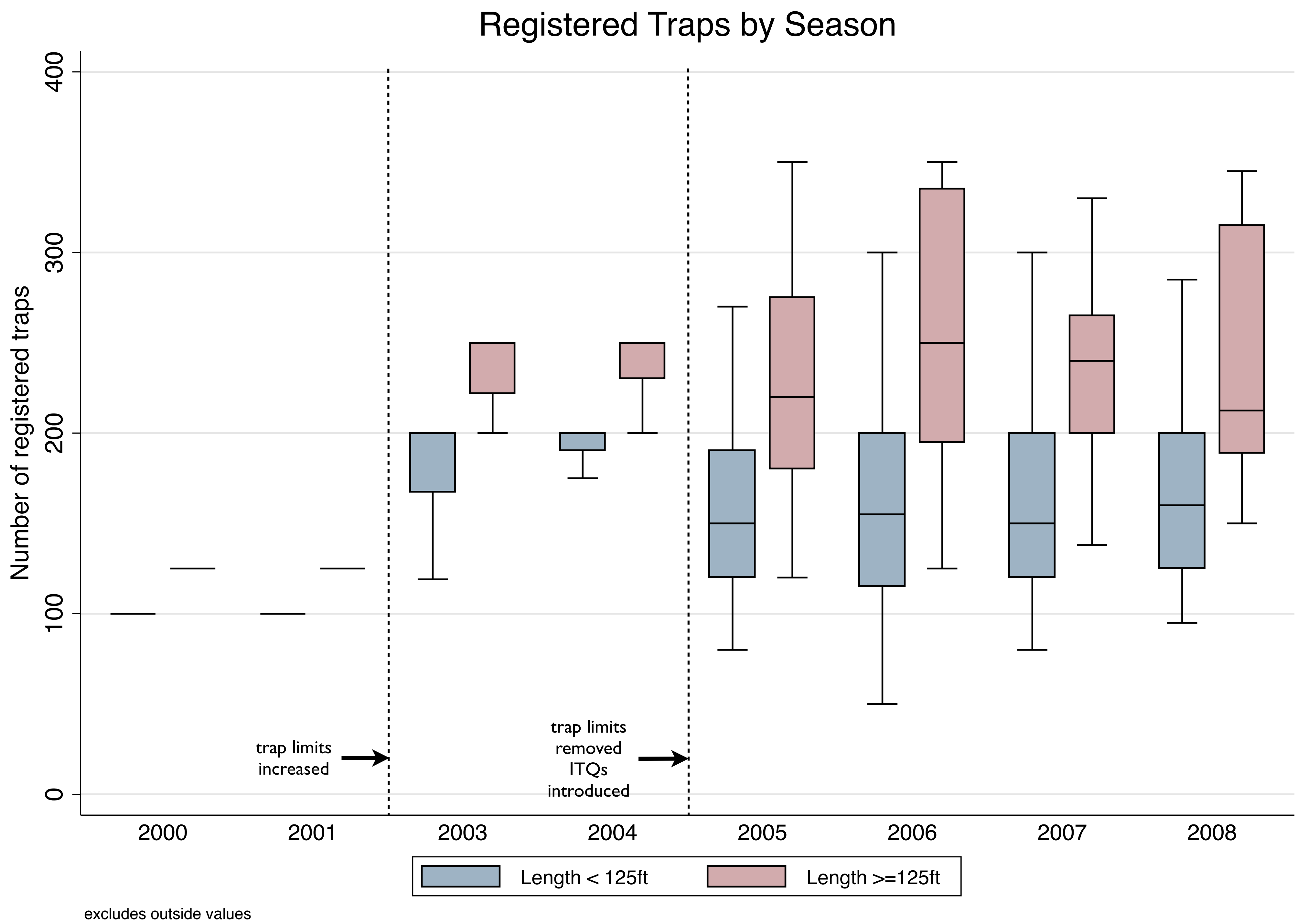
1. *Vessel buybacks under limited entry*:
   a. rent generation from consolidation effects
   b. particularly beneficial if lots of excess capital
   c. relies on a technological constraint
   d. may not be sustainable in the long run
   e. must consider the cost of buying back vessels

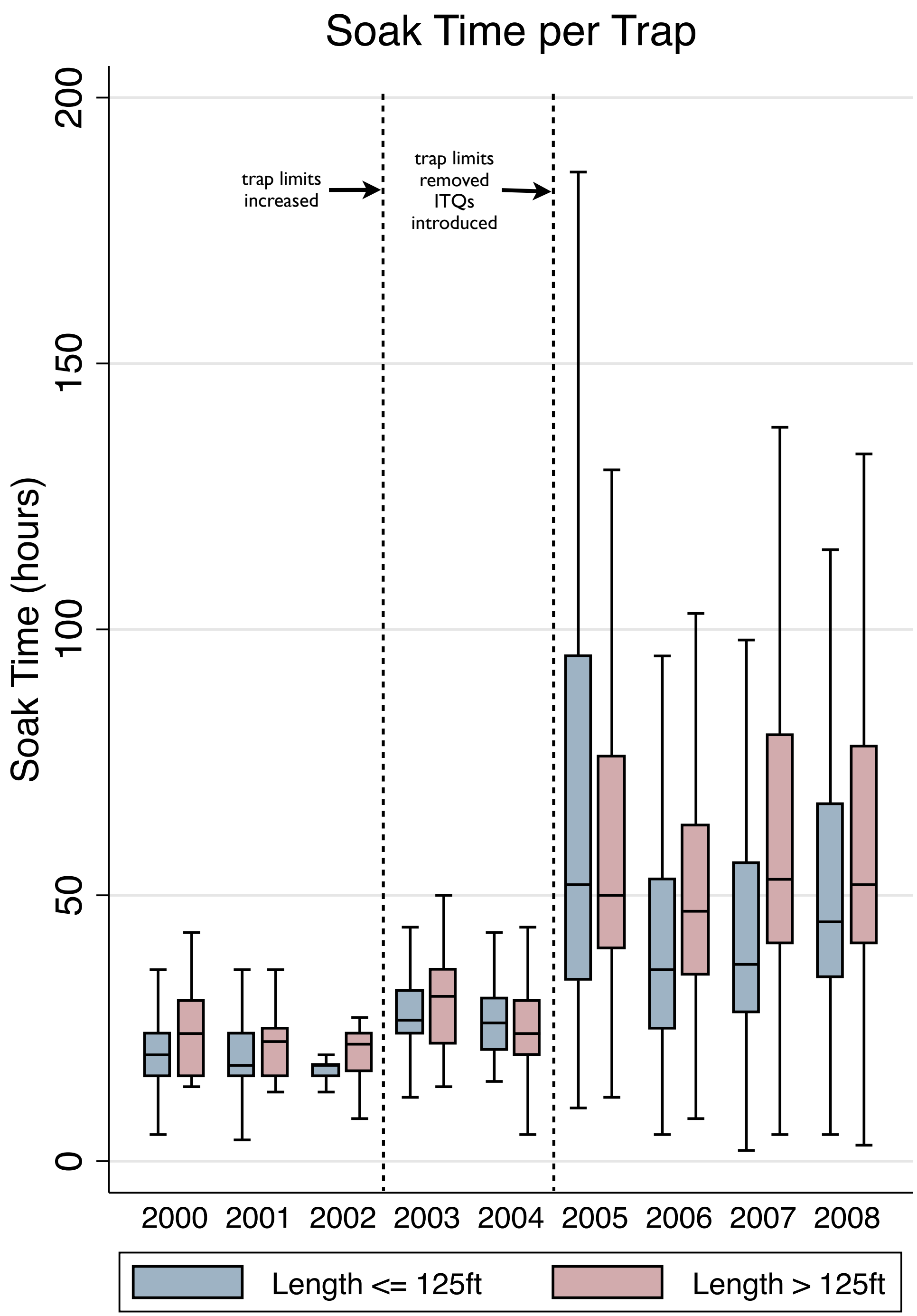
Conclusion

Each source can be captured by alternative policies:

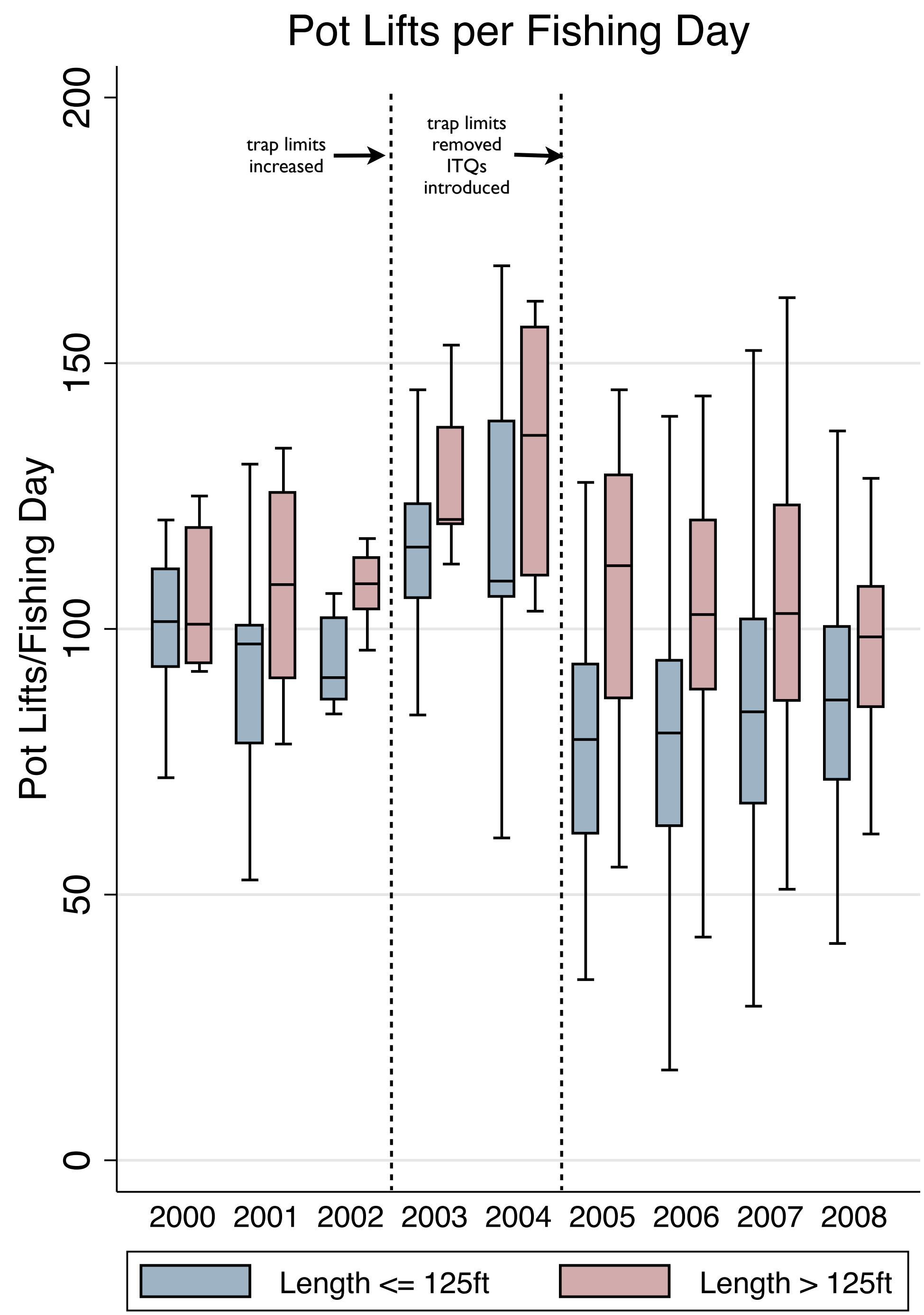
2. *ITQs with prohibition on quota trading (IQs)*:
   a. rent generation from incentive effects
   b. particularly beneficial if rents are dissipated under limited entry
   c. does not take advantage of cost savings from redundant capital elimination and scale economies

ITQs take advantage of both sources of rent generation and thus have the potential for the greatest amount of rents.


Registered Traps by Season
Number of registered traps
0
100
200
300
400
trap limits increased
trap limits removed ITQs introduced
2000
2001
2003
2004
2005
2006
2007
2008
Length < 125ft
Length >=125ft
excludes outside values



Notes: First year of rationalization is 2005.



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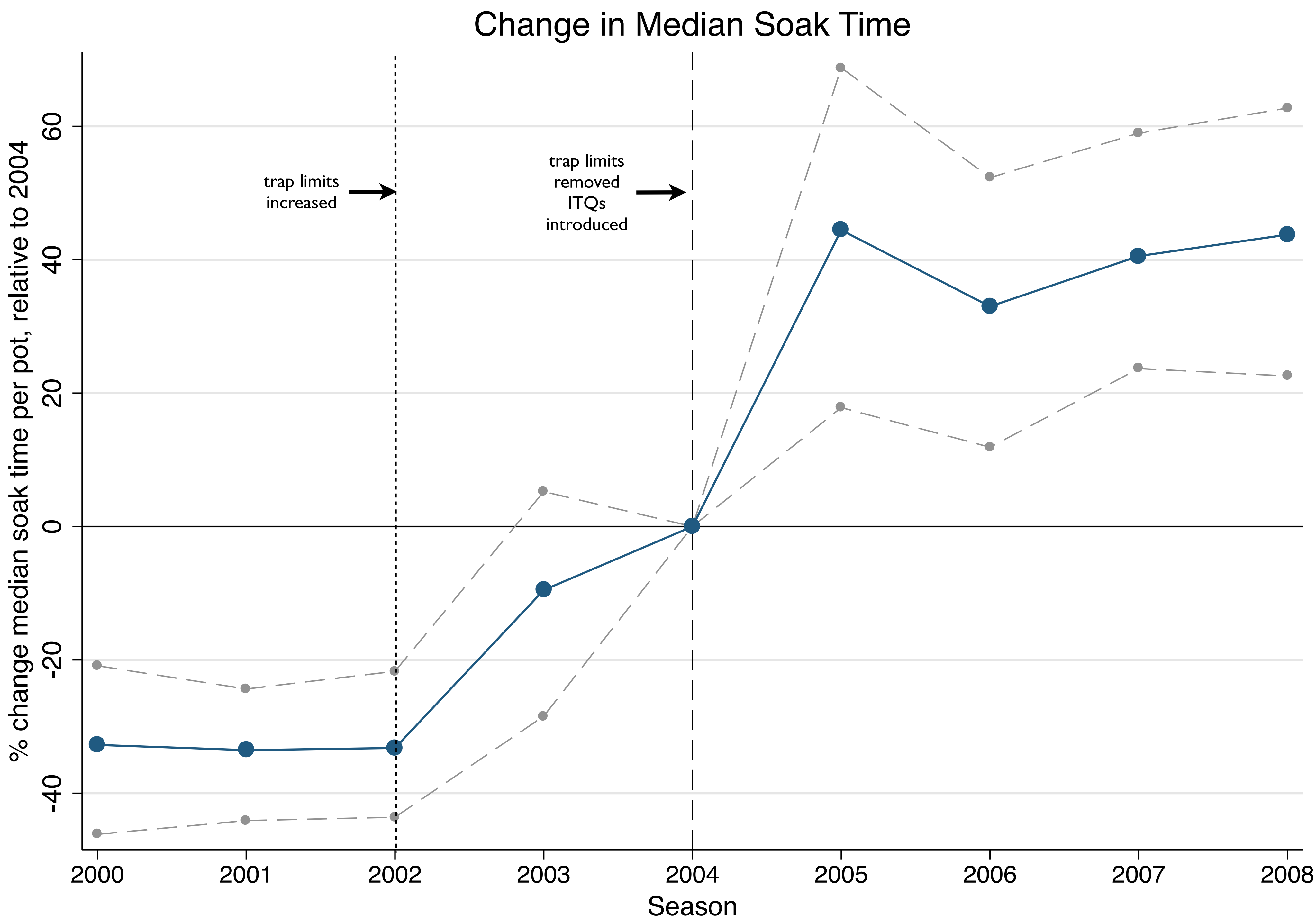
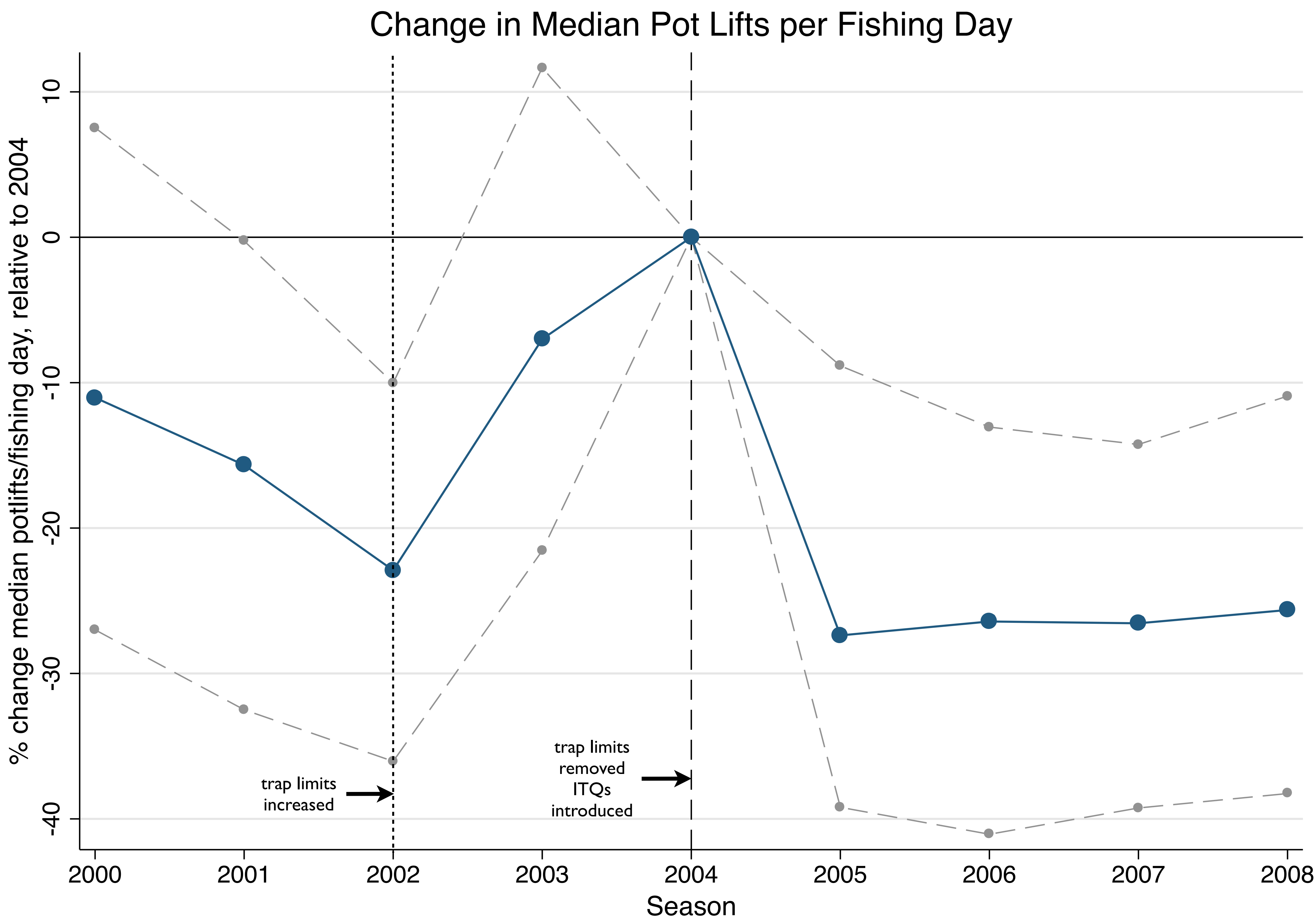

Change in Median Soak Time
% change median soak time per pot, relative to 2004
60
40
20
0
-20
-40
trap limits increased
trap limits removed ITQs introduced
2000
2001
2002
2003
2004
2005
2006
2007
2008
Season



Change in Median Pot Lifts per Fishing Day
% change median potlifts/fishing day, relative to 2004
10
0
-10
-20
-30
-40
trap limits
increased
trap limits
removed
ITQs
introduced
2000
2001
2002
2003
2004
2005
2006
2007
2008
Season