Technology or Incentives? Bycatch Avoidance in the BSAI Groundfish Fishery

Matthew Reimer
University of Alaska Anchorage

Joshua Abbott
Arizona State University

Jim Wilen
University of California Davis

UAA Institute of Social and Economic Research
UNIVERSITY of ALASKA ANCHORAGE

Rights-based Management in Multi-species Fisheries

Additional complexity: catch-quota balancing

Ex ante examinations: weak targeting potential

$\Longrightarrow$ challenges for rights-based management

Squires (1987), Pascoe (2007, 2010)

Ex post examinations: stronger targeting potential than previously thought

Sanchiricho (2006), Branch (2008)

Rights-based Management in Multi-species Fisheries

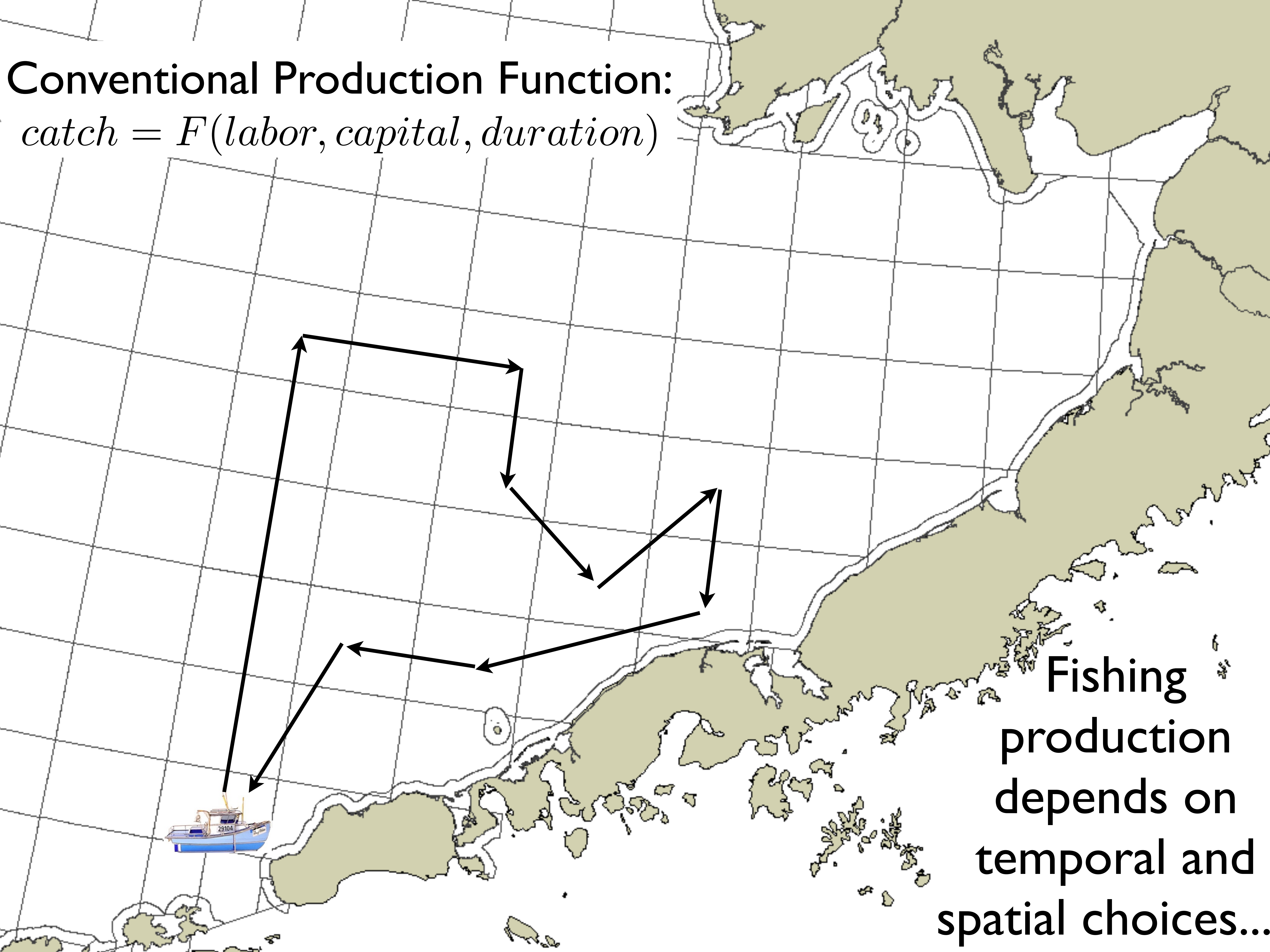
Hypothesis:

Conventional models of fishery production reflect more about the *incentives* for substitutability than the *technological* possibilities of cross-species substitution.

Ability to target confounded with *incentive* to target.

Conventional Production Function:

$$catch = F(labor, capital, duration)$$



Fishing production depends on temporal and spatial choices...

BSAI Non-Pollock Groundfish Fishery

Did rights-based management induce bycatch avoidance?

The Bering Sea Groundfish Fishery

Pre-Amendment 80 (prior to 2008):

- Target species TACs allocated as common property over multiple “sub-seasons”

- TAC for PSC (e.g. halibut) allocated to target species fisheries

- Target fisheries typically closed due to binding PSC TAC

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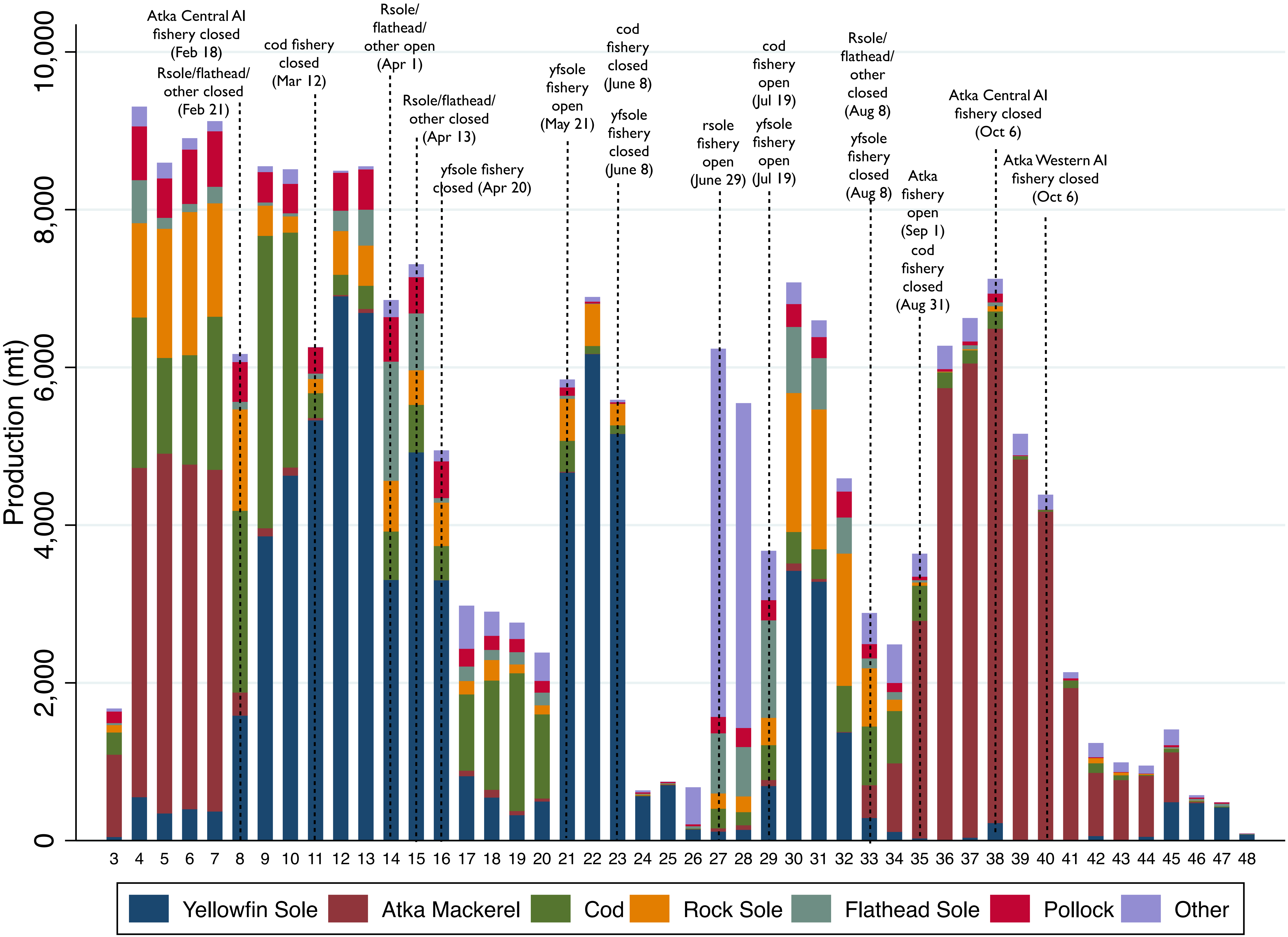
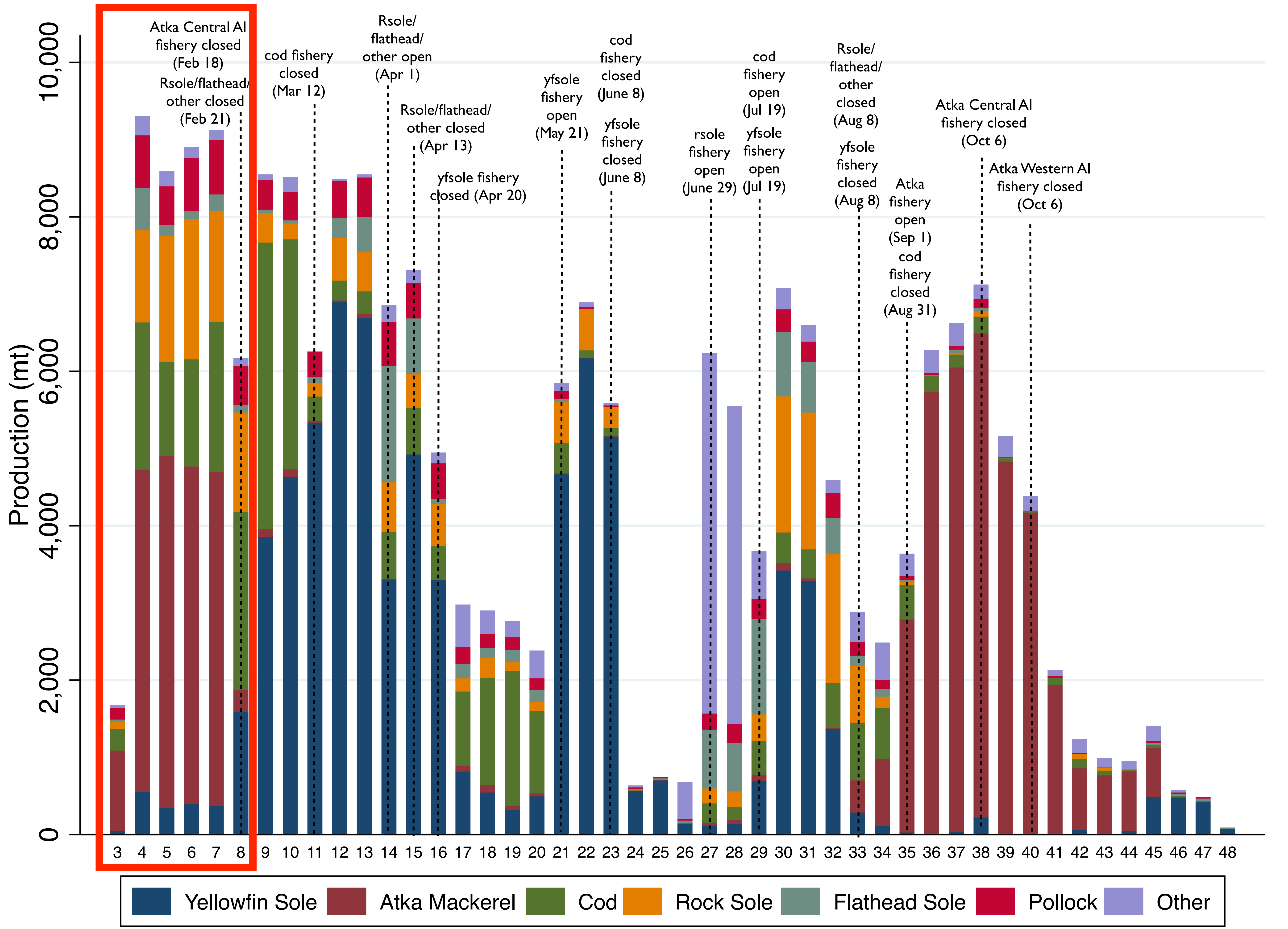
Post-Amendment 80 (2008 and after):

- Target species and PSC allocations vested directly into cooperatives or limited access fishery

- Initially one cooperative formed: 16 vessels, 7 companies



Production (mt)
0
2,000
4,000
6,000
8,000
10,000
Atka Central AI fishery closed (Feb 18)
Rsole/flathead/ other closed (Feb 21)
cod fishery closed (Mar 12)
Rsole/ flathead/ other open (Apr 1)
Rsole/flathead/ other closed (Apr 13)
yfsole fishery closed (Apr 20)
yfsole fishery open (May 21)
cod fishery closed (June 8)
yfsole fishery closed (June 8)
rsole fishery open (June 29)
cod fishery open (Jul 19)
yfsole fishery open (Jul 19)
Rsole/ flathead/ other closed (Aug 8)
yfsole fishery closed (Aug 8)
Atka fishery open (Sep 1)
cod fishery closed (Aug 31)
Atka Central AI fishery closed (Oct 6)
Atka Western AI fishery closed (Oct 6)
3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Yellowfin Sole
Atka Mackerel
Cod
Rock Sole
Flathead Sole
Pollock
Other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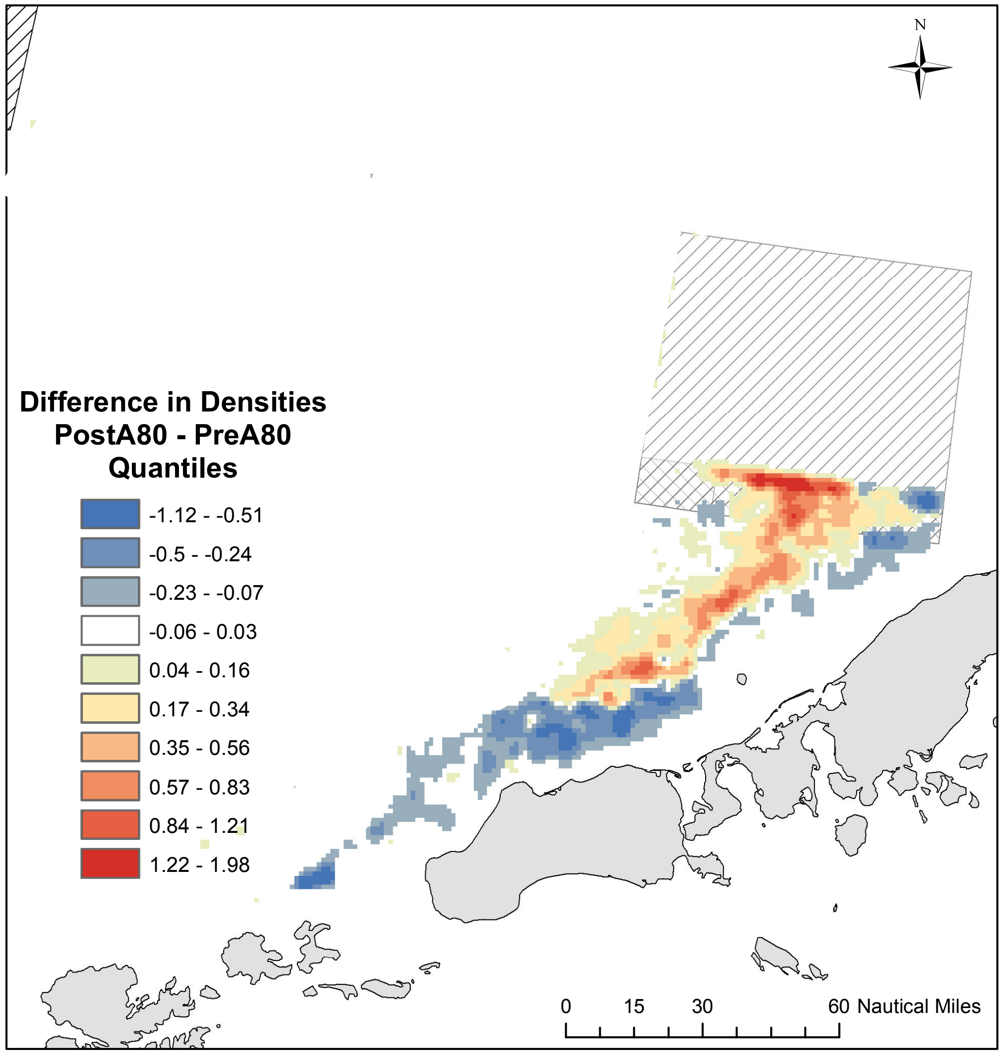
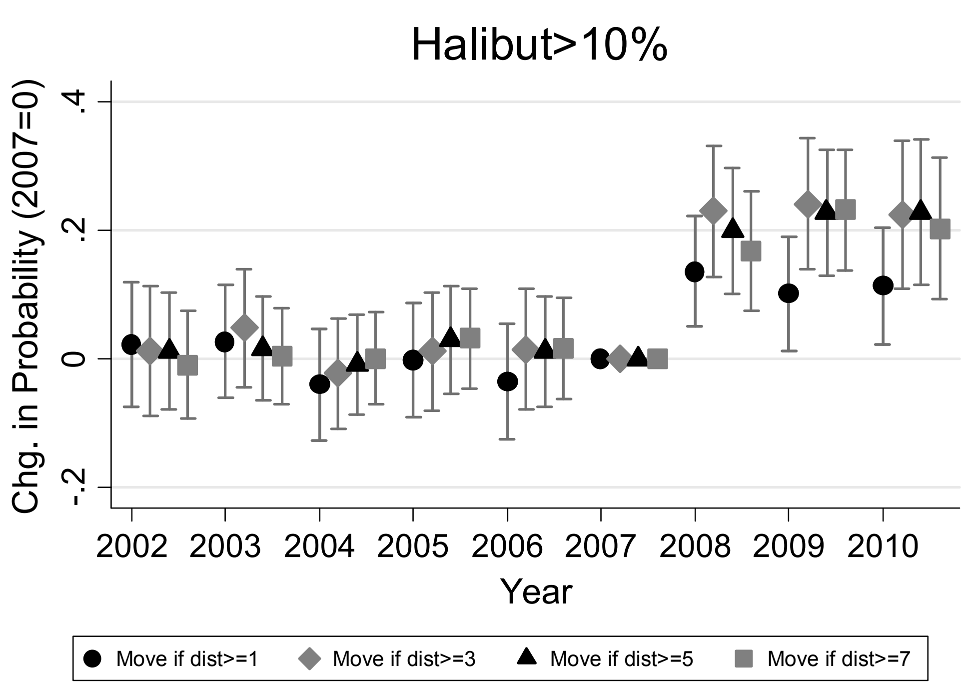
Change in Fishing Practices





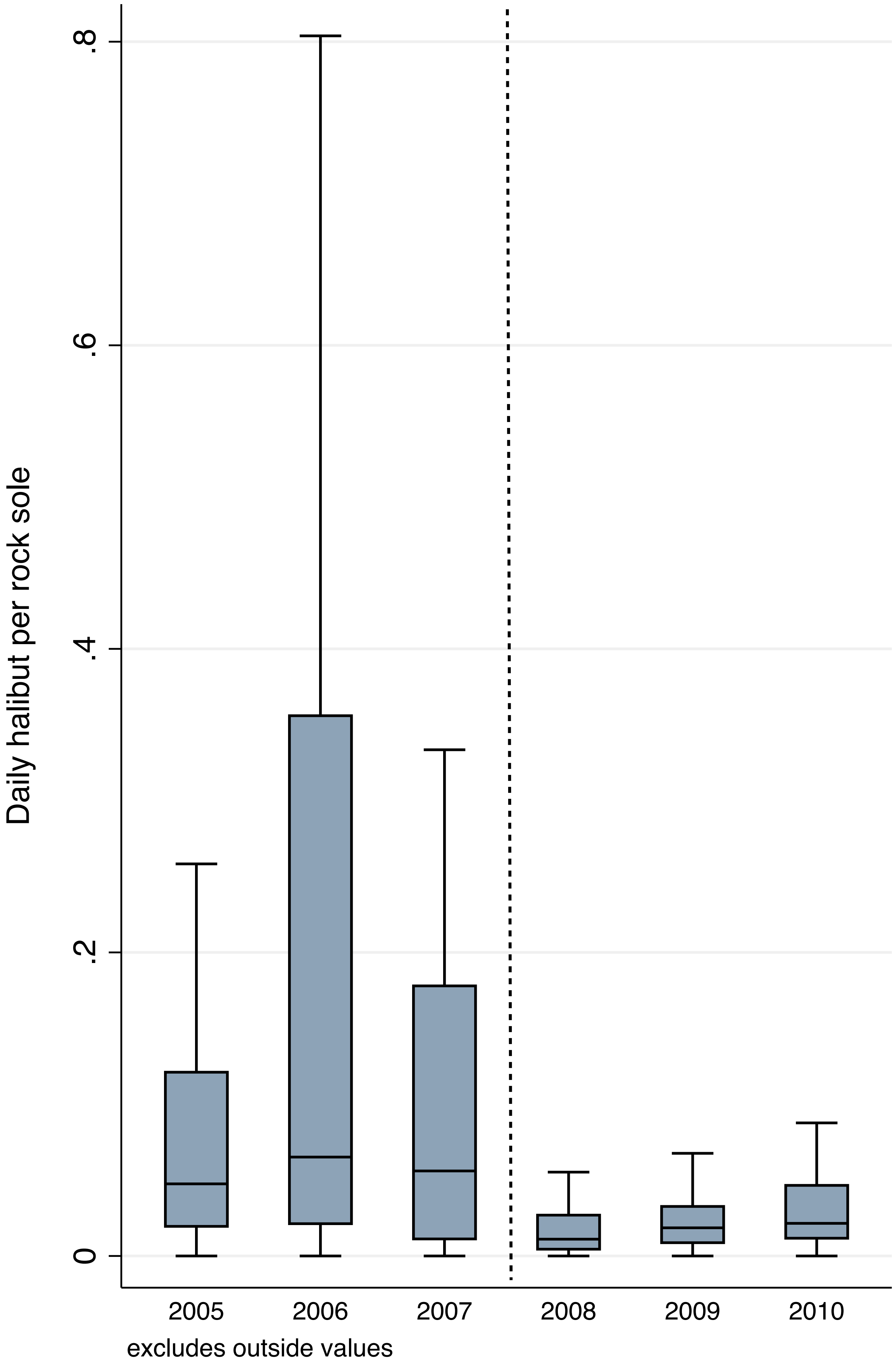
Abbott et al. (2013) found:

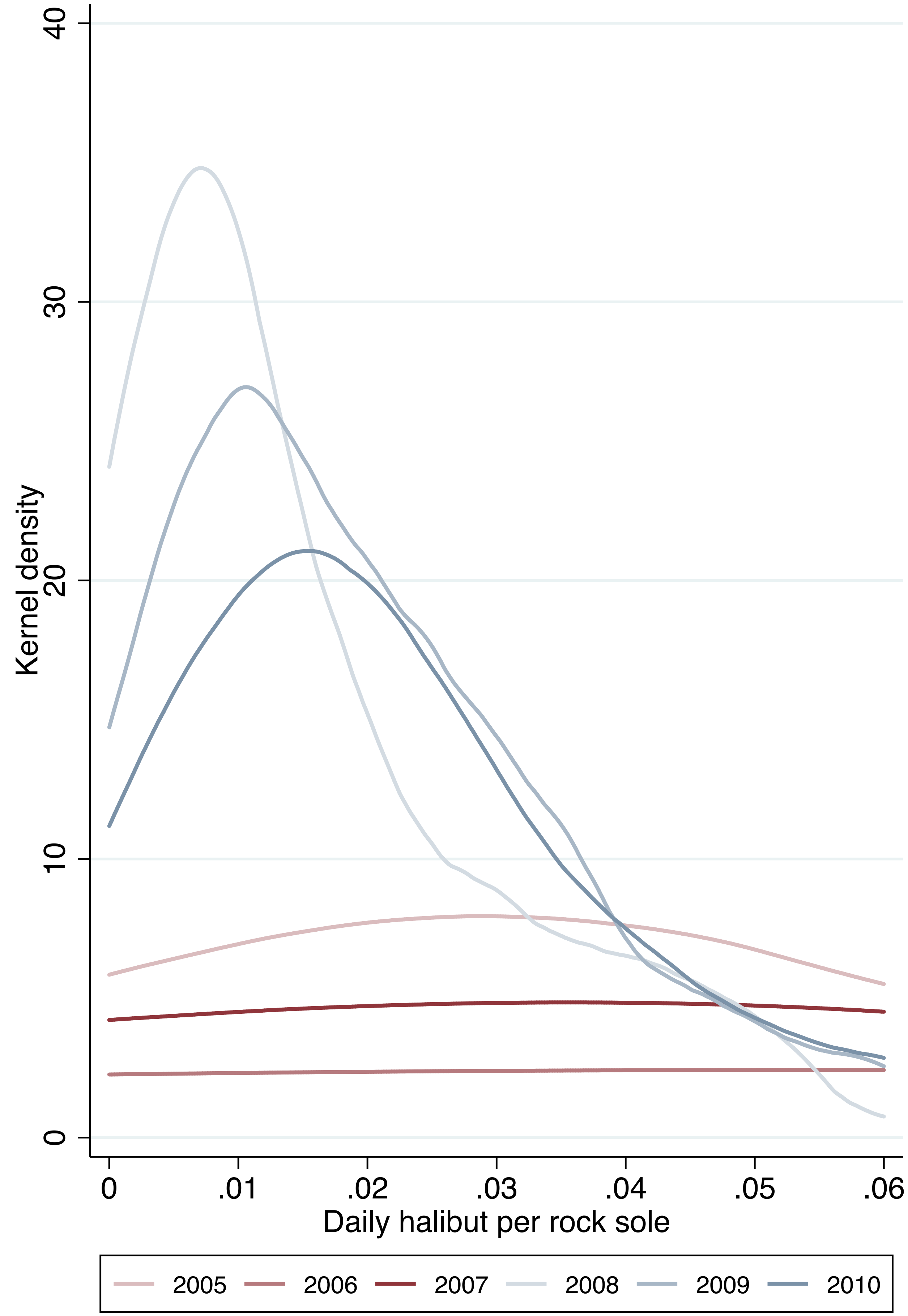
- large scale movements out of halibut-rich areas

- finer scale movements after hauls with a large proportion of halibut

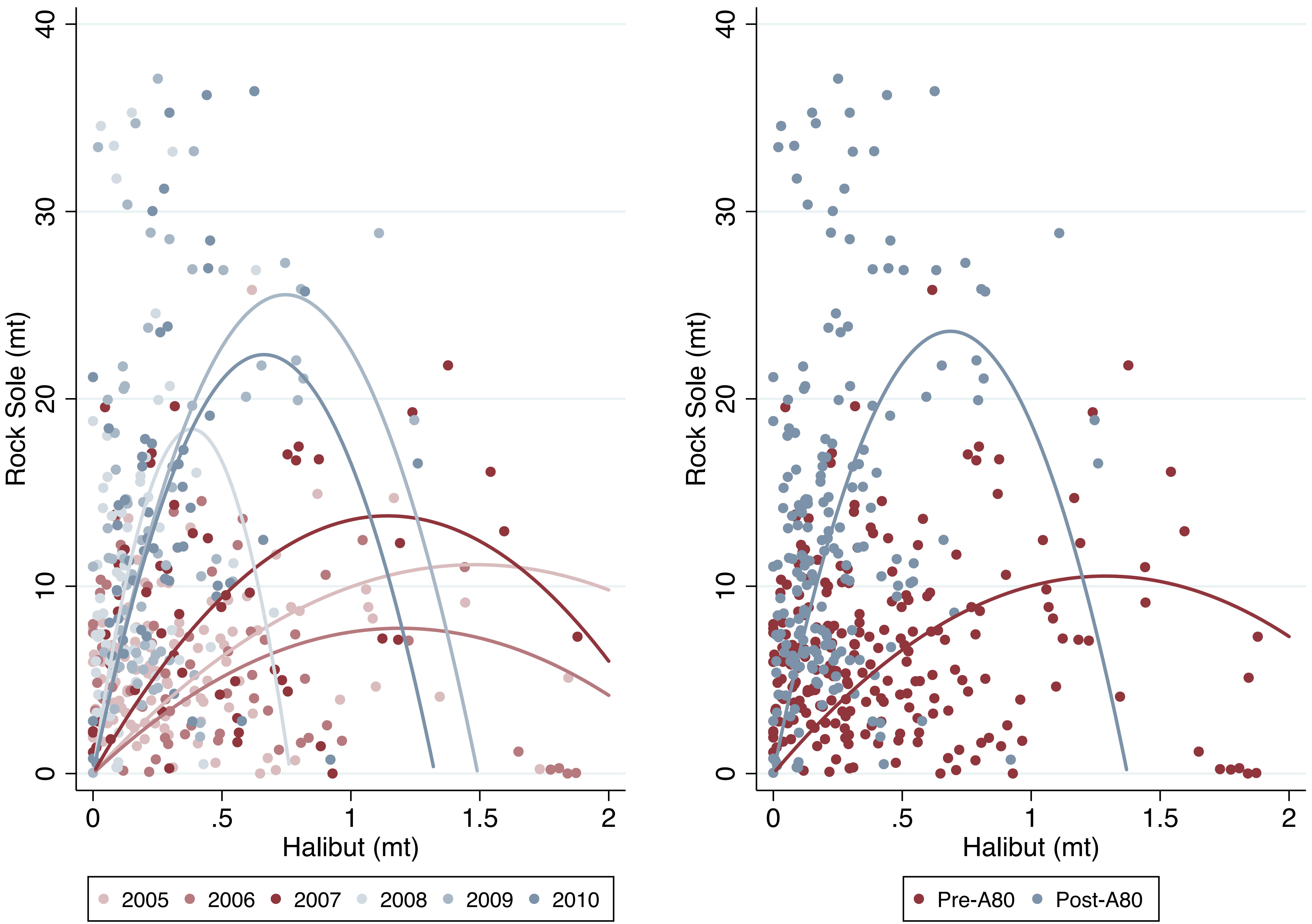
- less fishing at night when halibut bycatch is more prevalent

Changes in Bycatch Intensity





Changes in Bycatch Intensity



Reduced Form Fishery Production Function

A Hyperbolic Distance Function Approach

Transformation Function: $T(x, y, b) = 0$

$x =$ *inputs* $y =$ *good outputs* $b =$ *bad outputs*

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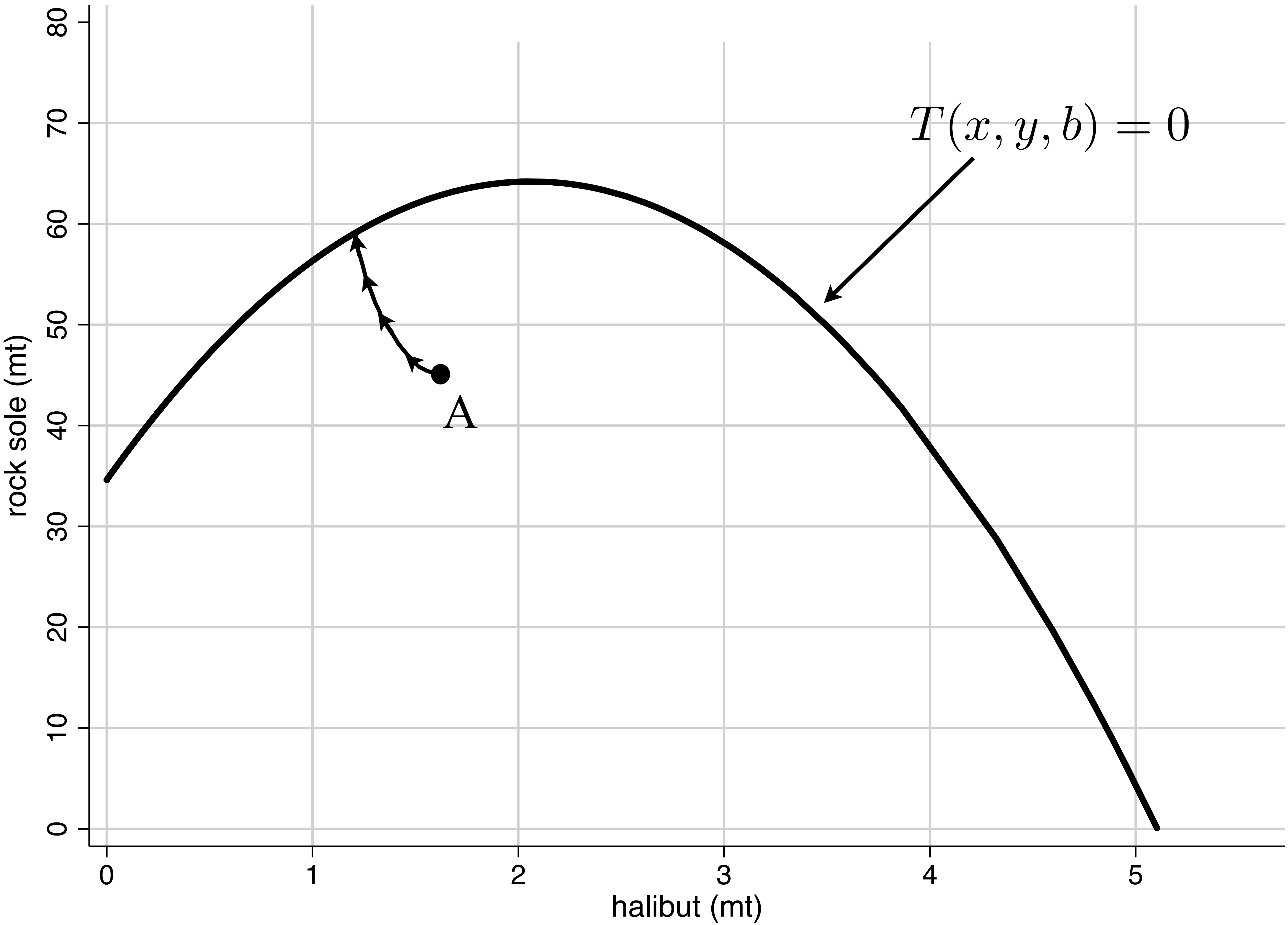
Hyperbolic Output Distance Function:

$$D^H(x, y, b) = \min_{\theta} \{\theta > 0 : T(x, y/\theta, b\theta) \leq 0\}$$

$$0 < D^H(x, y, b) \leq 1$$



$T(x, y, b) = 0$
A
rock sole (mt)
halibut (mt)
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5

Reduced Form Fishery Production Function

Hyperbolic Distance Function: Identification

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Distance is latent, so.....

$$y = y^* e^{v-u} \quad and \quad b = b^* e^{u-v} \quad where \quad D^H(x, y^*, b^*) = 1$$

$$\implies D^H(x, ye^{u-v}, be^{v-u}) = 1$$

$$\implies D^H(x, y, b) = e^{v-u}$$

since $D^H(x, y, b)$ is almost homogeneous of degrees 1,1,-1,1

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$$v \sim N(0, \sigma_v) \qquad u \sim \Gamma(1, \sigma_u)$$

Reduced Form Fishery Production Function

A Hyperbolic Distance Function Approach

$$
\begin{aligned}
\ln D^H_{its}(\mathbf{x}_{its}, \mathbf{y}_{its}, \mathbf{b}_{its}) &= \alpha_o^{is} + \alpha_{\mathbf{x}}^{s\prime}\ln\mathbf{x}_{its} + \alpha_{\mathbf{y}}^{s\prime}\ln\mathbf{y}_{its} + \alpha_{\mathbf{b}}^{s\prime}\ln\mathbf{b}_{its} \\
&+ \frac{1}{2}\ln\mathbf{x}'_{its}\mathbf{A}^s_{\mathbf{xx}}\ln\mathbf{x}_{its} + \frac{1}{2}\ln\mathbf{y}'_{its}\mathbf{A}^s_{\mathbf{yy}}\ln\mathbf{y}_{its} + \frac{1}{2}\ln\mathbf{b}'_{its}\mathbf{A}^s_{\mathbf{bb}}\ln\mathbf{b}_{its} \\
&+ \ln\mathbf{y}'_{its}\mathbf{A}^s_{\mathbf{yb}}\ln\mathbf{b}_{its} + \ln\mathbf{x}'_{its}\mathbf{A}^s_{\mathbf{xy}}\ln\mathbf{y}_{its} + \ln\mathbf{x}'_{its}\mathbf{A}^s_{\mathbf{xb}}\ln\mathbf{b}_{its} \\
&= \varepsilon_{its} = v_{its} - u_{its},
\end{aligned}
$$

$x =$ *Fishing Time, Vessel Length*

$y =$ *Rock Sole, Yellowfin Sole, Cod, Other*

$b =$ *Halibut*

$i =$ *Individual*

$t =$ *Day of season*

$s =$ *Season*

Reform-induced "technological" change left latent

Stochastic Production Function

Measures of Substitution

$$y = rock\ sole \quad b = halibut$$

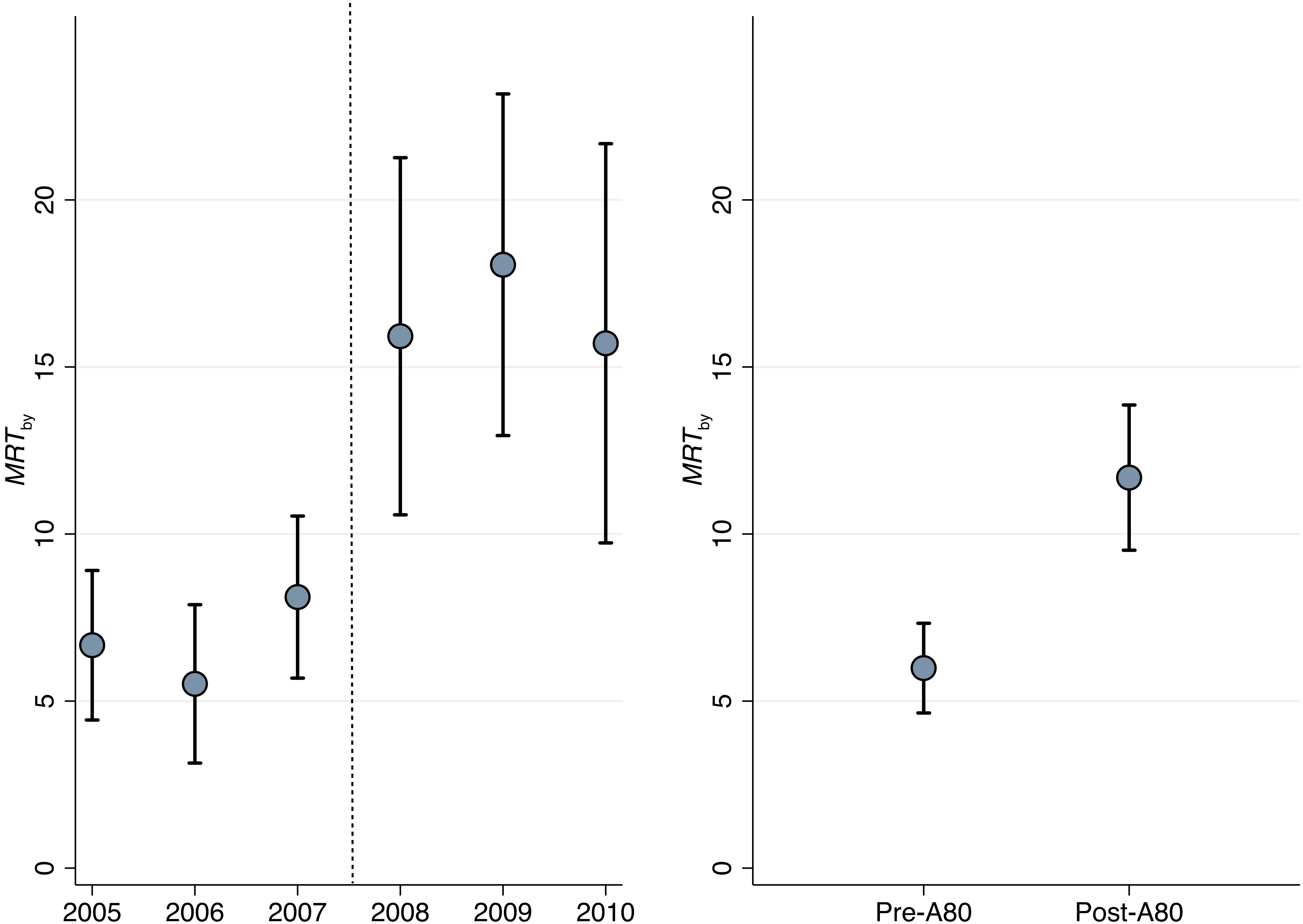
Marginal Rate of Transformation: $$MRT_{by} = \frac{\partial y}{\partial b} = -\frac{\partial D(\cdot)/\partial b}{\partial D(\cdot)/\partial y}$$

Larger MRT implies a greater shadow value of halibut reduction.

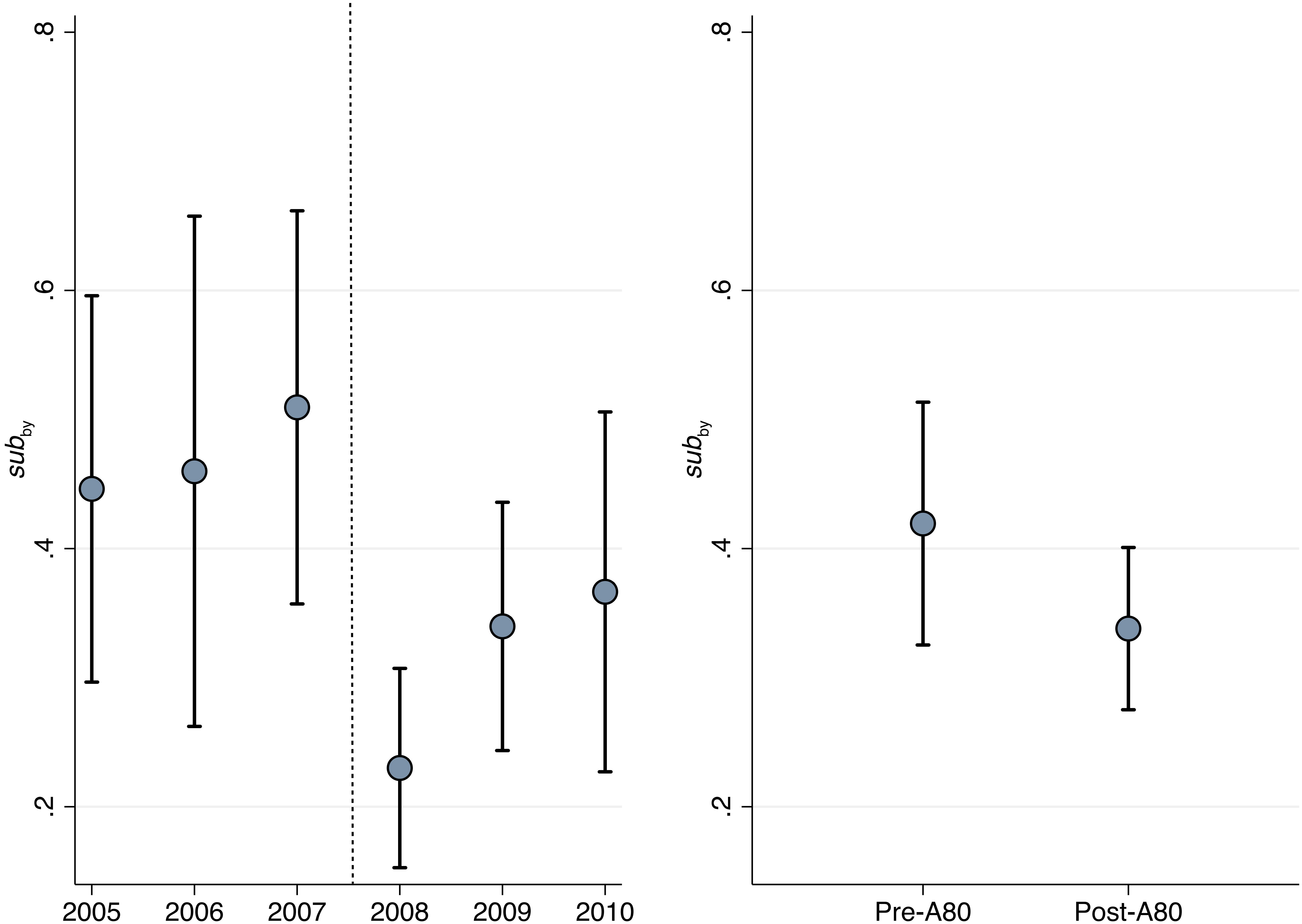
Transformation Elasticity: $$subs_{by} = \frac{\partial \ln y}{\partial \ln b} = -\frac{\partial \ln D(\cdot)/\partial \ln b}{\partial \ln D(\cdot)/\partial \ln y}$$

Smaller elasticity implies greater potential to substitute rock sole for halibut reduction.

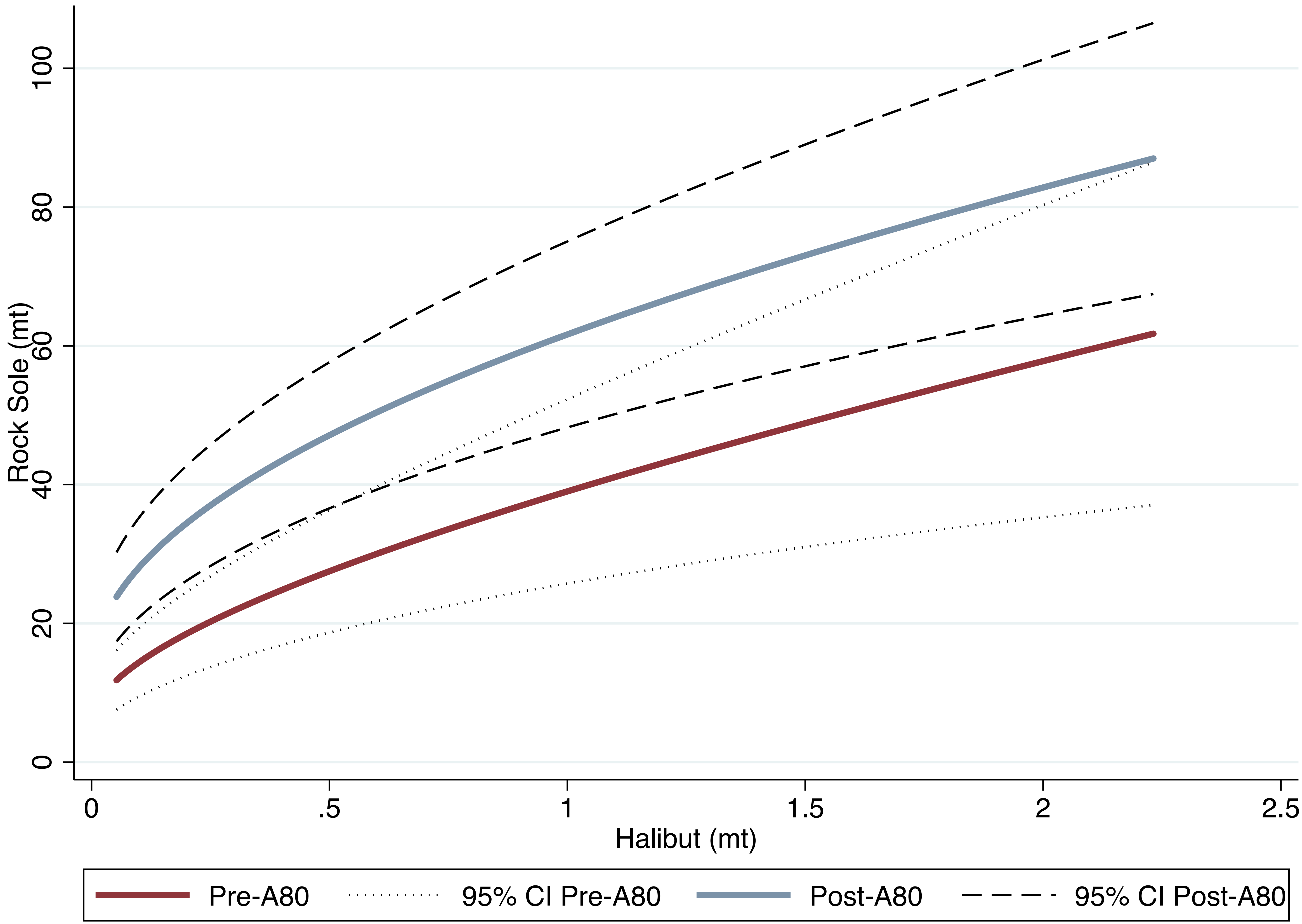
Marginal Rate of Transformation



Relative Substitutability



Frontiers: Rock sole-Halibut Space



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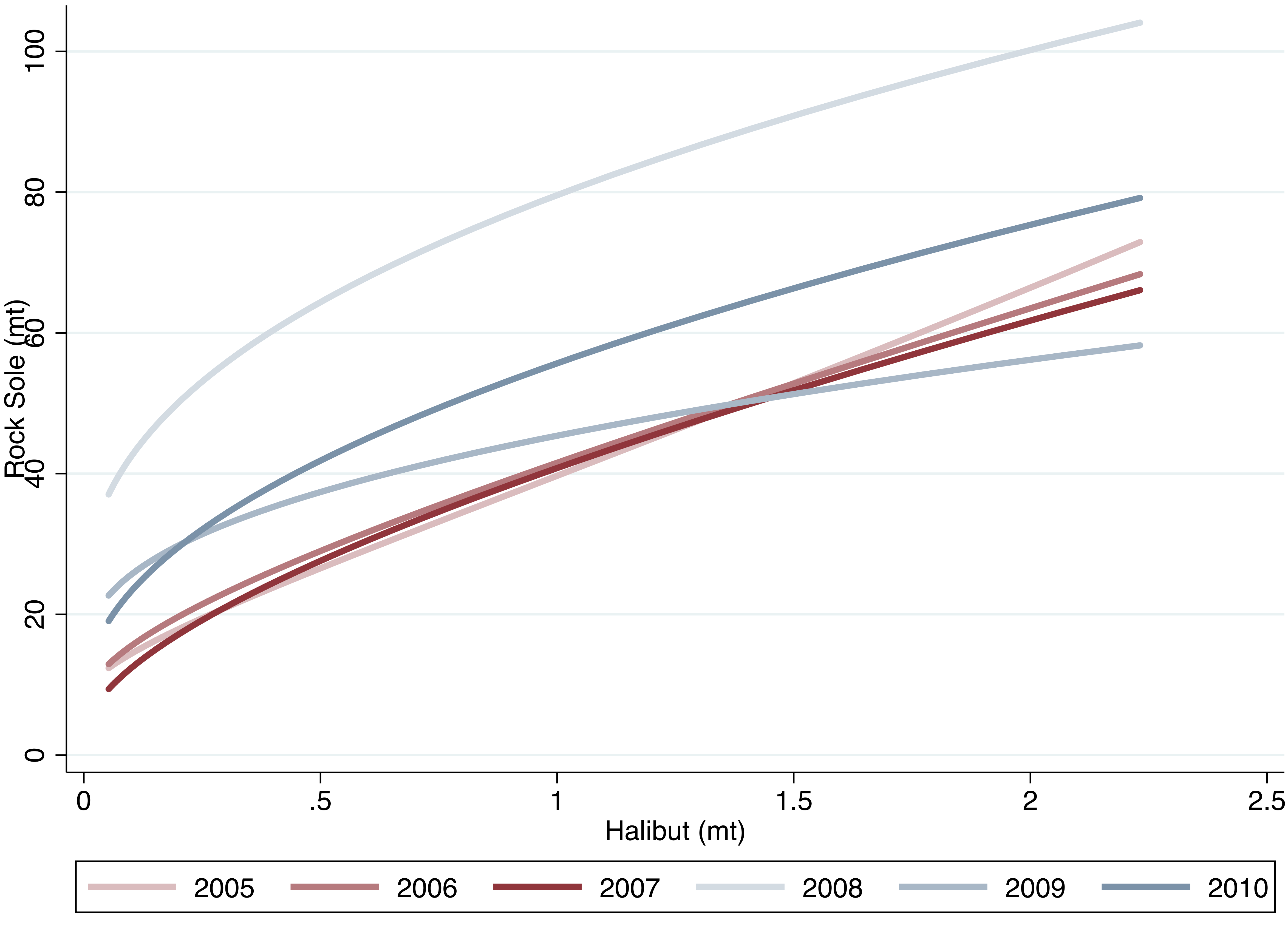


Conclusion

Targeting "ability" in prior to A80 primarily determined by lack of incentives to avoid halibut bycatch

- Ex ante predictions likely reflect far more about *incentives* for substitutability than *technological* possibilities for substitutability

- Need to understand what the relevant margins of production are, which are fishery and context specific

Acknowledgements

References

Abbott, J. K., Haynie, A. C., and Reimer, M. N. (2013). "Hidden Flexibility: Institutions, Incentives and the Margins of Selectivity in Fishing." *Working Paper*, 1–40.

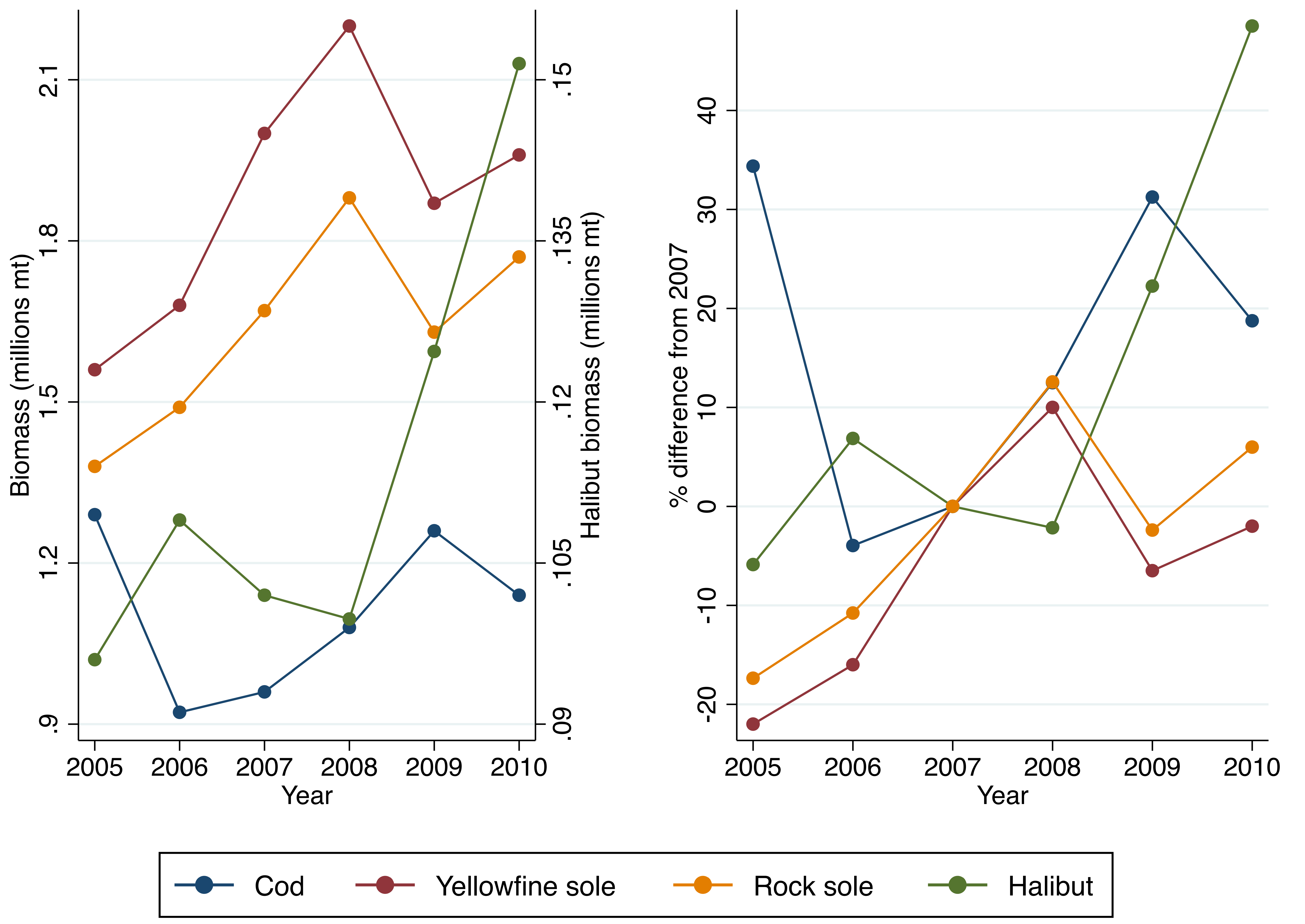
Branch, T., and Hilborn, R. (2008). "Matching Catches to Quotas in a Multispecies Trawl Fishery: Targeting and Avoidance Behavior Under Individual Transferable Quotas." *Canadian Journal of Fisheries and Aquatic Sciences*, *65*(7), 1435–1446.

Pascoe, S., Koundouri, P., and Bjørndal, T. (2007). "Estimating Targeting Ability in Multi-Species Fisheries: a Primal Multi-Output Distance Function Approach." *Land Economics*, *83*(3), 382–397.

Pascoe, S., Punt, A., and Dichmont, C. (2010). "Targeting Ability and Output Controls in Australia's Multi-Species Northern Prawn Fishery." *European Review of Agricultural Economics*, *37*(3), 313–334.

Sanchirico, J. N., Holland, D. S., Quigley, K., and Fina, M. (2006). "Catch-Quota Balancing in Multispecies Individual Fishing Quotas." *Marine Policy*, *30*(6), 767–785.

Squires, D. (1987). "Public Regulation and the Structure of Production in Multiproduct Industries: an Application to the New England Otter Trawl Industry." *The Rand Journal of Economics*, 232–247.



Biomass (millions mt)
Halibut biomass (millions mt)
% difference from 2007
Year
Year
.9
1.2
1.5
1.8
2.1
.09
.105
.12
.135
.15
-20
-10
0
10
20
30
40
2005
2006
2007
2008
2009
2010
Cod
Yellowfine sole
Rock sole
Halibut