Evaluating the Impact of Rights-based Fisheries Management: Evidence from the New England Groundfish Fishery

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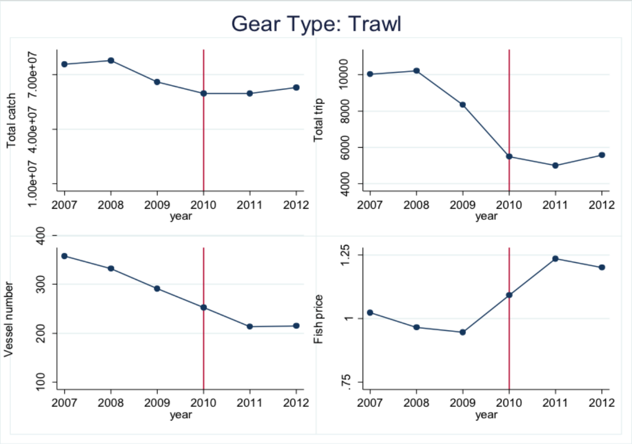
Policy background

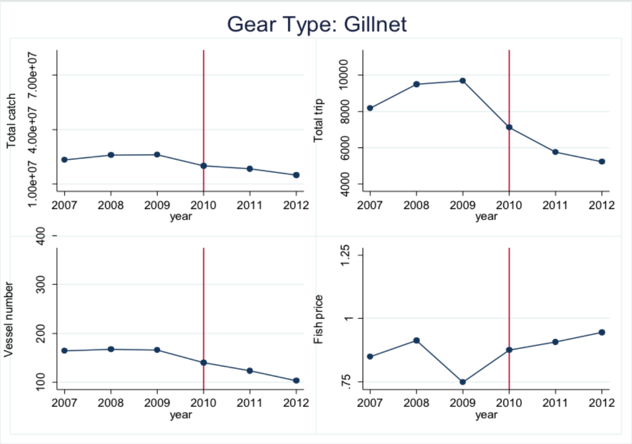
- Common Pool in the New England groundfish fisheries
  - Allocation of days at sea
  - Area closures
  - Gear restricted areas
- Sector management: rights-based approach

New regime in the New England groundfish fisheries

- Started from May 1, 2010
- Voluntarily formed sectors
- Annual catch limits (ACLs)
- Annual Catch Entitlements (ACEs)
- Each member has the potential sector contributions (PSC) to the sector's ACEs
- Based on their catch history for a fixed period (1996-2006)
- ACEs transferable within the sector and across sectors
- Joint liability
- Overage could impact next year's ACEs and lead to penalties



Gear Type: Trawl
Total catch
1.00e+07
4.00e+07
7.00e+07
2007
2008
2009
2010
2011
2012
year
Total trip
4000
6000
8000
10000
2007
2008
2009
2010
2011
2012
year
Vessel number
100
200
300
400
2007
2008
2009
2010
2011
2012
year
Fish price
.75
1
1.25
2007
2008
2009
2010
2011
2012
year



Gear Type: Gillnet
Total catch
1.00e+07 4.00e+07 7.00e+07
Total trip
4000 6000 8000 10000
Vessel number
100 200 300 400
Fish price
.75 1 1.25
2007 2008 2009 2010 2011 2012
year

Research outline

- What do we gain from forming sectors?
- Does cooperation exist?

Literature review

- A recent survey by Morrison Paul et al. (2010)
- Two primary methods: productivity indices and frontiers
- Total factor productivity (TFP) measurement for the Pacific Coast trawl fishing industry (Squires, 1992)
- TFP in the New England groundfish fishery (Jin et al., 2002) (TFP increased from 1964 to 1982, but declined from 1983 to 1993 mainly due to more stringent output and effort controls.)
- Productivity change in the Mid-Atlantic surfclam and ocean quahog fishery under ITQ management (Walden et al., 2012) (productivity increased immediately after ITQ implementation, but the gains were not sustained for multiple reasons)

Main Dataset

- Logbook data from 2007 to 2012 for the New England groundfish fisheries
  - weight of catch
  - price by species and trip
  - catch region by vessel, species and trip
  - trip length
  - crew size
  - gear type by vessel and trip and location
- Individual vessel characteristics
  - Vessel tonnage
  - Vessel size
  - Vessel power

Stochastic Production Frontiers (SPF) Model

- For multi-species

$$lny_{it1} = f(\frac{y_{it2}}{y_{it1}}, \frac{y_{it3}}{y_{it1}}, ..., \frac{y_{itK}}{y_{it1}}, x_{it}; \beta) + \varepsilon_{it} - u_{it}, u_{it} \geq 0 \quad (1)$$

  - y: output
  - i: individual vessel i
  - t: time
  - x: input
- Technical Efficiency

$$TE_i = E[e^{-u_{it}} | \varepsilon_{it}] \quad (2)$$

Table: Stochastic Production Frontier model result

Parameter	Coef.	Std. Err.	Parameter	Coef.	Std. Err.
Frontier			ln(y2/y1)*ln(vessel length)	0.028***	0.004
ln(y2/y1)	-0.511***	0.015	ln(y2/y1)*ln(crew size)	-0.011***	0.002
ln(y3/y1)	-0.127***	0.010	ln(y2/y1)*on(trip length)	-0.005***	0.001
ln (vessel length)	12.500***	0.870	ln(y2/y1)*lnstock	-0.060***	0.017
ln(crew size)	-1.417***	0.361	ln(y2/y1)*t	0.000***	0.000
ln(trip length)	-0.475***	0.130	ln(y3/y1)*ln (vessel length)	-0.003	0.003
$(\ln(y2/y1))^2$	-0.015***	0.000	ln(y3/y1)*ln(crew size)	0.010***	0.002
$(\ln(y3/y1))^2$	-0.005***	0.000	ln(y3/y1)*ln(trip length)	0.003***	0.001
$(\ln \text{(vessel length)})^2$	-1.496***	0.113	ln(y3/y1)*lnstock	0.071***	0.013
$(\ln(\text{crew size}))^2$	0.097***	0.036	ln(y3/y1)*t	0.000***	0.000
$(\ln(\text{trip length}))^2$	0.023***	0.006	ln (vessel length)*ln(crew size)	0.429***	0.098
lnstock	-2.524	2.514	ln (vessel length)*ln(trip length)	0.348***	0.034
t	0.041***	0.007	ln (vessel length)*lnstock	0.874	0.618
t^2	0.000***	0.000	ln (vessel length)*t	-0.012***	0.001
t^3	0.000***	0.000	ln(crew size)*ln(trip length)	-0.118***	0.021
Month2	-0.070***	0.020	ln(crew size)*lnstock	-0.950**	0.374
Month3	-0.020	0.019	ln(crew size)*t	0.001	0.001
Month4	-0.049**	0.023	ln(trip length)*lnstock	0.273**	0.133
Month5	0.150***	0.024	ln(trip length)*t	0.001***	0.000
Month6	0.111***	0.021	lnstock*t	-0.027**	0.014
Month7	0.054**	0.023	after	-0.071	0.119
Month8	-0.072***	0.025	cons	-18.962***	1.684
Month9	-0.059**	0.027	Inefficiency model		
Month10	-0.135***	0.029	$\ln(\sigma(u_{it})^2)$		
Month11	-0.018	0.029	after	0.498***	0.042
Month12	0.052*	0.027	ln(vessel length)	-0.489***	0.048
location2	0.036	0.022	Crowding	-0.022***	0.001
location3	-0.374***	0.019	Sector size	-0.023***	0.001
location4	-0.481***	0.027	Shannon location	-0.465***	0.022
ln(y2/y1)*ln(y3/y1)	0.004***	0.000	cons	3.264***	0.190
			$\ln(\sigma(v_{it})^2)$	-1.599***	0.022
			# of obs.	38881	

Table: The inefficiency model

Parameter	Coef.	Std. Err.
$\ln(\sigma(u_{it})^2)$		
after	0.498***	0.042
ln(vessel length)	-0.489***	0.048
Crowding	-0.022***	0.001
Sector size	-0.023***	0.001
Shannon location	-0.465***	0.022
cons	3.264***	0.190
$\ln(\sigma(v_{it})^2)$	-1.599***	0.022

Figure: Average Technical Efficiency Over Years

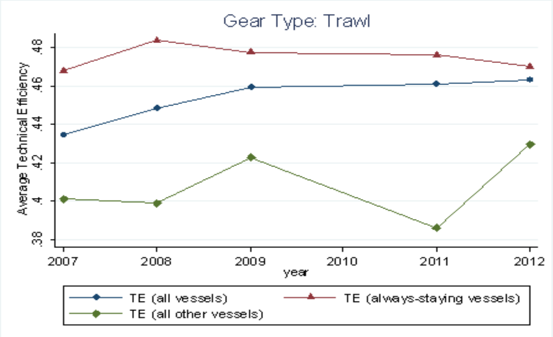


Table: Change in Probability of Choosing the Same Location

Sector	Vessel pair	Constant	(Std. Err.)	After	(Std. Err.)	# of obs	Before(%)	After(%)	Change(%)
1	(1, 2)	1.279***	(0.124)	-2.793 ***	(0.254)	266	89.9	6.5	-83.5***
2	(3, 4)								
2	(3, 5)	1.905***	(0.152)	0.610	(0.383)	450	97.2	99.4	2.2
2	(3, 6)	1.666***	(0.148)	0.270	(0.241)	398	95.2	97.4	2.1
2	(3, 7)								
2	(4, 5)	1.607***	(0.107)	0.574*	(0.297)	507	94.6	98.5	3.9*
2	(4, 6)	1.805***	(0.149)	0.665*	(0.386)	401	96.4	99.3	2.9*
2	(4, 7)								
2	(5, 6)	2.336***	(0.215)	-0.445*	(0.255)	649	99.0	97.1	-2.0*
2	(5, 7)	1.952***	(0.141)	0.624*	(0.373)	553	97.5	99.5	2.0*
2	(6, 7)	2.630***	(0.339)	-0.624	(0.387)	457	99.6	97.8	-1.8
3	(8, 9)	-0.665***	(0.149)	1.497***	(0.190)	231	25.3	79.7	54.4***
3	(8, 10)	-0.454***	(0.103)	0.937***	(0.146)	319	32.5	68.6	36.1***
3	(8, 11)	-0.443***	(0.108)	1.300***	(0.161)	289	32.9	80.4	47.5***
3	(9, 10)	1.171***	(0.170)	-0.505**	(0.198)	273	87.9	74.7	-13.2**
3	(9, 11)								
3	(10, 11)	1.391***	(0.156)	-0.571***	(0.192)	299	91.8	79.4	-12.4***
4	(12, 13)	1.691***	(0.124)	-0.750***	(0.173)	458	95.5	82.7	-12.8***
4	(12, 14)	2.007***	(0.240)	-1.140***	(0.275)	248	97.8	80.7	-17.1***
4	(12, 15)	1.556***	(0.130)	-0.723***	(0.203)	318	94.0	79.8	-14.3***
4	(12, 16)	1.677***	(0.141)	-0.462**	(0.219)	333	95.3	88.8	-6.5**
4	(12, 17)	1.728***	(0.145)	-0.601***	(0.232)	315	95.8	87.0	-8.8***
4	(12, 18)	1.660***	(0.166)	0.706*	(0.404)	276	95.2	99.1	3.9*
4	(13, 14)	1.640***	(0.150)	0.920***	(0.287)	580	94.9	99.5	4.5***
4	(13, 15)	1.381***	(0.100)	0.817***	(0.246)	538	91.6	98.6	7.0***
4	(13, 16)	2.066***	(0.166)	-0.466**	(0.205)	601	98.1	94.5	-3.5**
4	(13, 17)	1.873***	(0.131)	0.017	(0.253)	496	96.9	97.1	0.1
4	(13, 18)	1.620***	(0.127)	0.984***	(0.365)	483	94.7	99.5	4.8***
4	(14, 15)								
4	(14, 16)	1.519***	(0.149)	0.121	(0.202)	409	93.6	95.0	1.4
4	(14, 17)	1.691***	(0.164)	0.712*	(0.400)	299	95.5	99.2	3.7*
4	(14, 18)								
4	(15, 16)	1.457***	(0.119)	-0.043	(0.202)	375	92.7	92.1	-0.6
4	(15, 17)								
4	(15, 18)								
4	(16, 17)	1.730***	(0.138)	0.039	(0.265)	367	95.8	96.2 0	.3
4	(16, 18)	1.547***	(0.155)	0.685**	(0.313)	320	93.9	98.7	4.8**
4	(17, 18)	2.028***	(0.206)	0.053	(0.353)	295	97.9	98.1	0.3
5	(19, 20)	-0.700***	(0.174)	-1.414***	(0.333)	178	24.2	1.7	-22.5***
5	(19, 21)								
5	(20, 21)	1.017***	(0.145)	1.083***	(0.274)	278	84.5	98.2	13.7***

The independece test

$$lnx_{it} = F_t + F_i + lnstock_{year} + \epsilon_{it} \tag{3}$$

- F_t: Fixed effect of time
- F_i: Fixed effect of individual vessel
- x_{it}: trip length

$$H_0 : \rho_{ij} = 0 \tag{4}$$

Table: Fisher's test of Conditional Independence

Sector	Vessel pair	Before		After		Change
		r	Z	r	Z	
1	(1, 2)	0.195	6.520***	0.037	1.006	DI
2	(3, 4)	0.151	5.035***	0.117	3.166***	DD
2	(3, 5)	0.213	7.146***	0.119	3.220***	DD
2	(3, 6)	0.112	3.702***	0.141	3.834***	DD
2	(3, 7)	0.249	8.417***	0.201	5.512***	DD
2	(4, 5)	0.594	22.589***	0.168	4.578***	DD
2	(4, 6)	0.269	9.103***	0.147	3.984***	DD
2	(4, 7)	0.577	21.750***	0.017	0.447	DI
2	(5, 6)	0.458	16.348***	0.632	20.086***	DD
2	(5, 7)	0.680	27.403***	0.317	8.855***	DD
2	(6, 7)	0.314	10.752***	0.330	9.251***	DD
3	(8, 9)	-0.048	-1.602	0.213	5.847***	ID
3	(8, 10)	0.236	7.966***	0.236	6.500***	DD
3	(8, 11)	-0.003	-0.099	0.203	5.556***	ID
3	(9, 10)	0.018	0.603	0.231	6.349***	ID
3	(9, 11)	0.012	0.386	0.150	4.081***	ID
3	(10, 11)	-0.047	-1.545	0.130	3.535***	ID
4	(12, 13)	0.283	9.604***	0.003	0.080	DI
4	(12, 14)	0.036	1.178	-0.113	-3.072***	ID
4	(12, 15)	0.116	3.851***	0.098	2.658***	DD
4	(12, 16)	0.057	1.896*	0.023	0.608	DI
4	(12, 17)	0.110	3.651***	0.271	7.507***	DD
4	(12, 18)	0.141	4.693***	0.335	9.401***	DD
4	(13, 14)	0.115	3.803***	0.170	4.628***	DD
4	(13, 15)	0.195	6.539***	0.017	0.452	DI
4	(13, 16)	0.062	2.046**	0.026	0.701	DI
4	(13, 17)	0.352	12.154***	-0.090	-2.426**	DD
4	(13, 18)	0.339	11.652***	0.086	2.326**	DD
4	(14, 15)	0.040	1.324	-0.006	-0.175	II
4	(14, 16)	0.071	2.357**	-0.017	-0.449	DI
4	(14, 17)	0.132	4.396***	-0.035	-0.941	DI
4	(14, 18)	0.177	5.901***	-0.026	-0.706	DI
4	(15, 16)	-0.030	-0.990	-0.088	-2.388**	ID
4	(15, 17)	0.105	3.478***	-0.076	-2.047**	DD
4	(15, 18)	0.144	4.793***	0.105	2.852***	DD
4	(16, 17)	0.012	0.410	0.076	2.042**	ID
4	(16, 18)	-0.021	-0.683	0.156	4.235***	ID
4	(17, 18)	0.130	4.319***	0.332	9.317***	DD
5	(19, 20)	-0.094	-3.118***	-0.123	-3.335***	DD
5	(19, 21)	-0.190	-6.368***	0.060	1.612	DI
5	(20, 21)	0.112	3.714***	0.064	1.733*	DD

Conclusion

- Technical Efficiency increases by 3.45% on average after 2010 for trawl vessels;
- Agglomeration effect, sector size, location specialization impact Technical Efficiency
- Multiple pieces of evidence supports that cooperation exists.