What impact has climate change had on Irish fisheries?

Rodney Beard
Groupe Sup de Co-CEREGE La Rochelle
France
Rodney.M.Beard@gmail.com
http://rbeard.sdf.org

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)
- Sea temperatures are warming — North atlantic had warmed by 0.479 degrees (2004) (0.298 in 2011) above 1960–1990 average

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)
- Sea temperatures are warming — North atlantic had warmed by 0.479 degrees (2004) (0.298 in 2011) above 1960–1990 average
- What impact has this had on fishing industry?

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)
- Sea temperatures are warming — North atlantic had warmed by 0.479 degrees (2004) (0.298 in 2011) above 1960–1990 average
- What impact has this had on fishing industry?
- Are demand side effects on fishing more important than changes in the ecosystem?

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)
- Sea temperatures are warming — North atlantic had warmed by 0.479 degrees (2004) (0.298 in 2011) above 1960–1990 average
- What impact has this had on fishing industry?
- Are demand side effects on fishing more important than changes in the ecosystem?
- Will concentrate on the impact on Irish fisheries 1994-2004 (due primarily to data availability)

Background

- Evidence of increased temperatures over a long period of time based on variety of data sources (Hadley centre , NOAA)
- Increased warming appears to be due to human activity, in particular greenhouse gas emissions (CO2,CH4, etc)
- Sea temperatures are warming — North atlantic had warmed by 0.479 degrees (2004) (0.298 in 2011) above 1960–1990 average
- What impact has this had on fishing industry?
- Are demand side effects on fishing more important than changes in the ecosystem?
- Will concentrate on the impact on Irish fisheries 1994-2004 (due primarily to data availability)
- Irish fishery is the largest in EU generates 700million annual revenue and employs approx. 11000 people (% fishermen).

Climate change and fisheries

- Impact of climate change on fisheries is uncertain

Climate change and fisheries

- Impact of climate change on fisheries is uncertain
- Some literature suggest positive impacts Arnason (2007), Link and Tol (2009), Lorentzen and Hannesson (2005) (Economists)

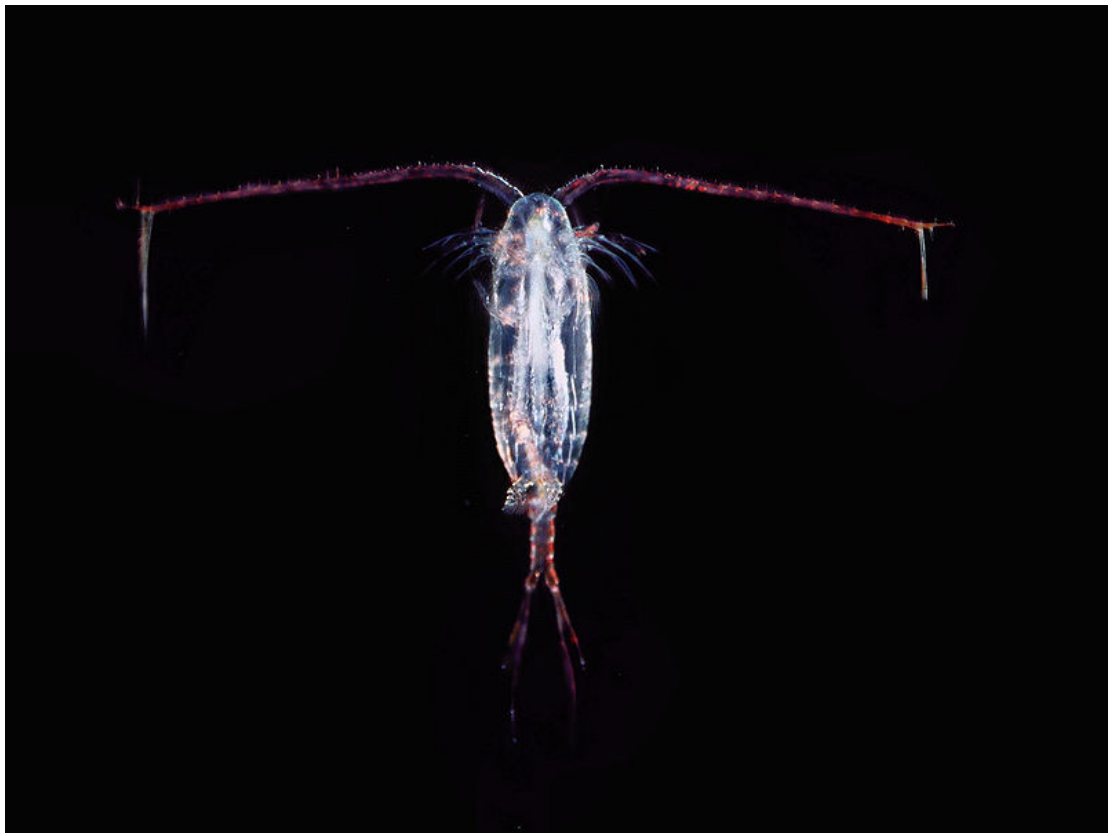
Climate change and fisheries

- Impact of climate change on fisheries is uncertain
- Some literature suggest positive impacts Arnason (2007), Link and Tol (2009), Lorentzen and Hannesson (2005) (Economists)
- Other literature suggest negative impacts (Drinkwater, 2005, Stenevik and Sundby, 2007, Sundby and Nakken, 2008) (Scientists)

Climate change and fisheries

- Impact of climate change on fisheries is uncertain
- Some literature suggest positive impacts Arnason (2007), Link and Tol (2009), Lorentzen and Hannesson (2005) (Economists)
- Other literature suggest negative impacts (Drinkwater, 2005, Stenevik and Sundby, 2007, Sundby and Nakken, 2008) (Scientists)
- Broad split between the scientific literature and the economics literature

Copepod



Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)

Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)
- Data consist of 11 years of data on landings at 46 Irish ports (plus other Irish ports and Irish landings at foreign ports)

Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)
- Data consist of 11 years of data on landings at 46 Irish ports (plus other Irish ports and Irish landings at foreign ports)
- Other variables include the value of landings

Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)
- Data consist of 11 years of data on landings at 46 Irish ports (plus other Irish ports and Irish landings at foreign ports)
- Other variables include the value of landings
- Total size of the Irish fleet

Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)
- Data consist of 11 years of data on landings at 46 Irish ports (plus other Irish ports and Irish landings at foreign ports)
- Other variables include the value of landings
- Total size of the Irish fleet
- Total tonnage of the Irish fleet

Fisheries Data

- Data were taken from the Irish central statistics office — Fisheries Landings Survey (data are available from 1994-2004)
- Data consist of 11 years of data on landings at 46 Irish ports (plus other Irish ports and Irish landings at foreign ports)
- Other variables include the value of landings
- Total size of the Irish fleet
- Total tonnage of the Irish fleet
- Energy consumption of the Irish fleet

Climate data

- Data used were the Hadley centre data obtained from the climatic research unit at the University of East Anglia

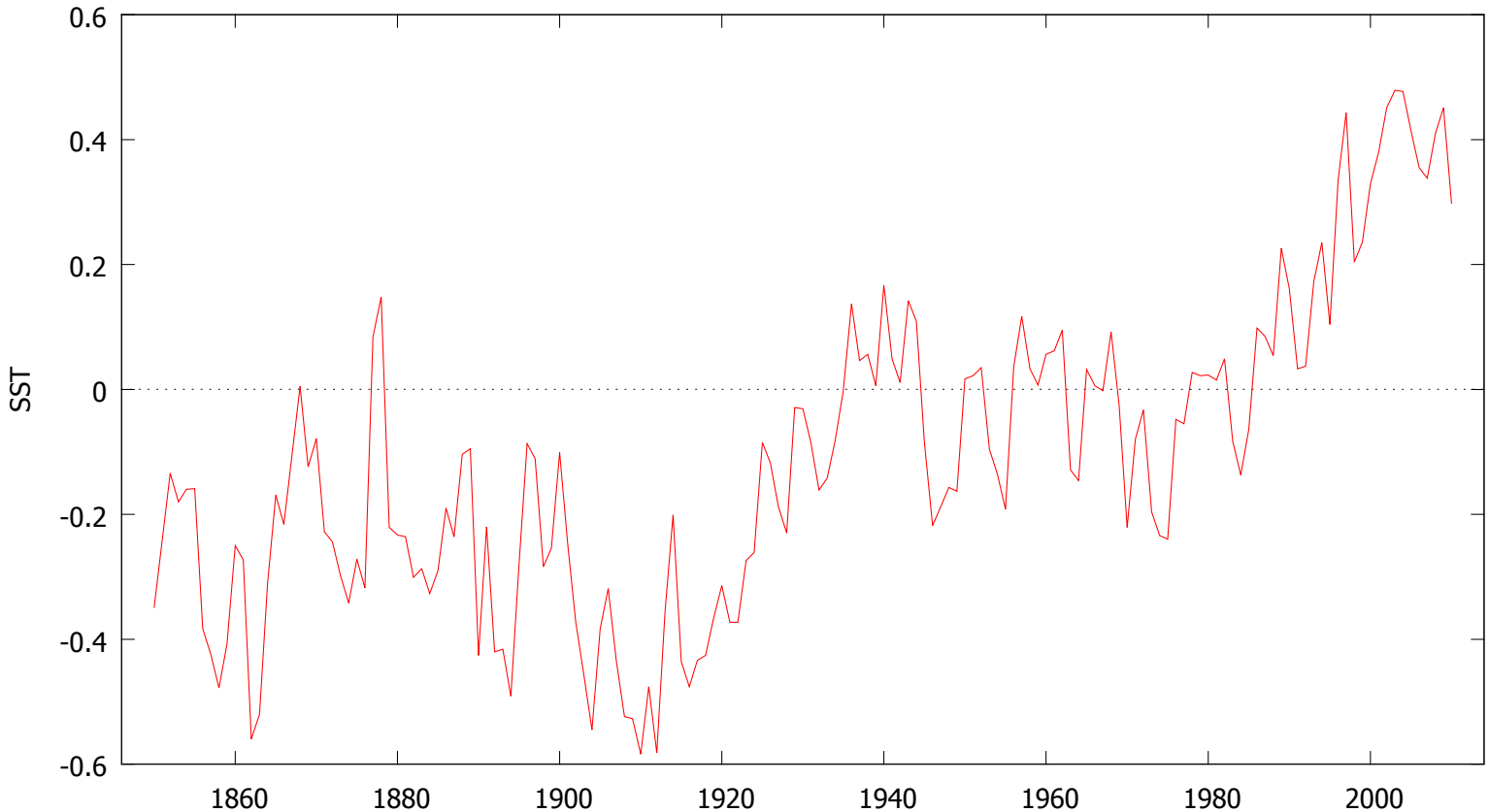
Climate data

- Data used were the Hadley centre data obtained from the climatic research unit at the University of East Anglia
- North atlantic sea surface temperature anomaly data were used (HadSST2) (Rayner, 2006)

Climate data

- Data used were the Hadley centre data obtained from the climatic research unit at the University of East Anglia
- North atlantic sea surface temperature anomaly data were used (HadSST2) (Rayner, 2006)
- Average annual deviations in sea surface temperature for the North atlantic from the 1960–1990 annual average

North atlantic sea surface temperature anomalies 1850-2010



Data

Table: 1: Descriptive statistics of some key variables

	Landings	Value	Price	SST	Boats	Tonnes	Kw
Mean	4988.00	3138.00	1.53732	0.306273	1742.18	69141.0	213780
Median	912.500	1235.00	1.48829	0.329000	1689.00	64836.0	212680
Maximum	173022	39037.0	6.21739	0.479000	2105.00	86862.0	229093
Minimum	0	0	0.100206	0.104000	1436.00	59047.0	205956
St dev	17378.4	5516.99	0.972625	0.118978	210.925	10518.0	6862.50
CV	3.48405	1.75812	0.632675	0.388471	0.121069	0.152124	0.0321008
Skew	6.33863	3.77433	1.37914	-0.0673918	0.296907	0.666854	0.986092
Kurtosis	43.4422	16.7460	3.56991	-1.24287	-1.16279	-1.20906	0.0110204
N	478	478	450	11	506	506	506

The idea

- estimate a **supply relationship**

The idea

- estimate a **supply relationship**
- treat sea surface temperature anomaly as a supply shifter

The idea

- estimate a **supply relationship**
- treat sea surface temperature anomaly as a supply shifter
- compare two situations:

The idea

- estimate a **supply relationship**
- treat sea surface temperature anomaly as a supply shifter
- compare two situations:
  - supply curve with climate change

The idea

- estimate a **supply relationship**
- treat sea surface temperature anomaly as a supply shifter
- compare two situations:
  - supply curve with climate change
  - supply curve in absence of climate change (counterfactual)

The idea

- estimate a **supply relationship**
- treat sea surface temperature anomaly as a supply shifter
- compare two situations:
  - supply curve with climate change
  - supply curve in absence of climate change (counterfactual)
- impact of climate change on the supply curve (leftward or rightward shift)

The model

$$y_{it} = \alpha + x_{it}^{'}\beta + D_{i}^{'}\gamma + \mu_i + \nu_{it}, i = 1 \ldots N, t = 1 \ldots T$$

- y_{it} are log landings of fish at port i in period t
- $x_{it}^{'}$ is a $1 \times K$ vector of explanatory variables including price; sea surface temperature (SST), fishing effort variable such as the number of boats, tonnage and energy consumption of the fleet (kW)
- $D_{i}^{'}$ is a $1 \times J$ vector of dummy variables representing time independent policy factors such as whether or not a port is a designated landing port of a particular type of fish (demersal, pelagic or deepwater species)

Initial results

Table: 2: Pooled OLS estimates of log landings

	Dependent variable is log of landings in each case			
	Model 1-1	Model 1- 2	Model 1-3	Model 1-4
Intercept	8.05842***	22.5155***	7.66907***	28.9942***
	(2.50158)	(7.118)	(1.7425)	(10.2166)
Price	-0.859157***	-0.633377***	-0.625002***	-0.869782***
	(0.0660971)	(0.0475912)	(0.047486)	(0.0662509)
SST	-1.03597	1.34411	-0.819544*	2.08191
	(0.705519)	(1.17201)	(0.491512)	(1.68299)
Boats	-0.00140648*	-0.0069146**	-0.00106308**	-0.00963031**
	(0.0007676)	(0.00298146)	(0.000534918)	(0.0042792)
Tonnes	-1.18828e-05	-8.47124e-05*	-1.336e-05	-0.000118287*
	(2.16963e-05)	(4.5569e-05)	(1.51121e-05)	(6.54252e-05)
Kilowatts	1.84097e-05	4.78035e-05*	1.24538e-05	7.24317e-05*
	(1.76766e-05)	(2.76691e-05)	(1.23154e-05)	(3.97135e-05)
Deepwater (dummy)		0.662316***	0.661851***	
		(0.12967)	(0.129869)	
Demersal (dummy)		0.886725***	0.890996***	
		(0.107515)	(0.107657)	
Pelagic (dummy)		1.16137***	1.16729***	
		(0.124929)	(0.125088)	
Commercial		0.00146793*		0.00186305
		(0.000885219)		(0.00127148)
Drift		-0.011561**		-0.0162768**
		(0.00540887)		(0.0077639)
Draft		0.00209471		0.00220587
		(0.00232591)		(0.00334156)
Other		Collinearity		Collinearity
Rod		-6.94695e-05		-9.20162e-05
		(8.46415e-05)		(0.000121591)
R-squared	0.279284	0.656935	0.652723	0.287045
F	34.41076	69.73439	103.6100	19.68331
Akaike criterion	1529.772	1209.725	1207.216	1532.899

Pooled OLS

Table: 3: Pooled OLS estimates with interaction terms

	Dependent variable is log of landings in each case			
	Model 2-1	Model 2-2	Model 2-3	Model 2-4
Intercept	7.98116*	5.81039**	8.83419***	7.72022***
	(4.6444)	(2.5767)	(0.224236)	(0.163651)
Price	-0.265708	0.806916	0.610336*	0.413664*
	(2.40907)	(0.531076)	(0.337276)	(0.234199)
SST	-0.972093	-0.99974	-1.18942*	-1.14964***
	(0.699947)	(0.698575)	(0.60629)	(0.420759)
Boats	0.000820133	-0.00030897		
	(0.00141241)	(0.000835489)		
Tonnes	0.00141241	-2.13266e-05		
	(3.6592e-05)	(2.16866e-05)		
Kilowatts	-6.56949e-06	2.33575e-05		
	(3.06359e-05)	(1.75701e-05)		
Deepwater (dummy)				0.645844***
				(0.127971)
Demersal (dummy)				0.894177***
				(0.105985)
Pelagic (dummy)				1.1593***
				(0.123173)
Price x Boats	-0.00167808**	-0.00100472***	-0.000884398***	-0.000629548***
	(0.000781037)	(0.000317824)	(0.000205557)	(0.000143131)
Price x Tonnes	-1.84726e-05			
	(1.7471e-05)			
Price x Kilowatts	1.64797e-05			
	(1.38445e-05)			
R-squared	0.297598	0.295184	0.292105	0.661466
F	23.35572	30.92207	61.34551	144.2636
Akaike criterion	1524.189	1521.733	1517.695	1191.743

Fixed effects with interaction terms

Table: 4: Initial fixed effect results with interaction terms

	Dependent variable is log of landings in each case		
	Model 1	Model 2	Model 3
Intercept	7.08214***	7.49057***	7.82651***
	(1.69301)	(1.37976)	(0.143842)
Price	0.940891	0.473878	0.0339317
	(1.0806)	(0.403611)	(0.170926)
SST	-0.614757**	-0.650699**	-1.04657***
	(0.000731436)	(0.312165)	(0.291272)
Boats	0.00118849	6.60897e-05	
	(0.000731436)	(0.000555872)	
Tonnes	1.37536e-05	-1.5096e-05*	
	(1.35083e-05)	(8.39063e-06)	
Kilowatts	-1.12839e-05	5.45469e-06	
	(9.48463e-06)	(5.93546e-06)	
Price x Boats	-0.0011425***	-0.000451681	-0.000184591
	(0.000417385)	(0.000280314)	(0.000115275)
Price x Tonnes	-1.71494e-05***		
	(5.46512e-06)		
Price x Kilowatts	9.05784e-06*		
	(4.99573e-06)		
R-squared	0.859563	0.858067	0.855912
F	45.73141	47.17937	49.62531
Akaike criterion	889.8036	890.5698	891.3532

Table: 5: Final Fixed effect results with interaction terms

	Dependent variable is log of landings in each case			
	Model 3-1	Model 3-2	Model 3-3	Model 3-4
Intercept	7.75096***	6.54658***	8.38101***	5.866***
	(0.149922)	(0.565432)	(0.646848)	(1.54451)
Price	0.825942*	1.53886**	0.609881	1.8635**
	(0.486612)	(0.582014)	(0.632946)	(0.901542)
SST	-0.911326***	-0.631538**	-0.702119**	-0.650686**
	(0.300784)	(0.325047)	(0.331533)	(0.308)
Boats		0.00065369		0.00085261
		(0.000296016)		(0.000624294)
Tonnes			-9.71426e-06	4.84251e-06
			(7.82488e-06)	(9.71967e-06)
Price x Boats	-0.000404418**	-0.000761901**	-0.000430117**	-0.000857873**
	(0.00017095)	(0.000234839)	(0.000183848)	(0.000367361)
Price x Tonnes	-5.58606e-06*	-7.23007e-06*	-2.13185e-06	-9.45225e-06*
	(3.21452e-06)	(3.28454e-06)	(5.2109e-06)	(5.20795e-06)
R-squared	0.856991	0.858718	0.857909	0.858786
F	48.91903	48.50280	48.18111	47.45922
Akaike criterion	889.9687	886.5022	889.0724	888.2852

Instrumental variable estimates

Table: 6: Comparison of Instrumental variables estimates

	Dependent variable is log of landings in each case			
	Pooled OLS	Pooled IV	Panel IV	Panel IV with interaction terms
Intercept	8.28119***	7.107***	7.54397***	7.59934***
	(0.346776)	(0.505161)	(0.247395)	(0.620370)
Price	-0.814515***	0.268053	-0.0113763	0.483649
	(0.162251)	(0.337303)	(0.240330)	(0.584482)
SST	0.14236	-1.46908**	-1.49339***	-0.932147**
	(0.442367)	(0.57124)	(0.555274)	(0.379489)
Time		Instrument	Instrument	Instrument
Boats		Instrument	Instrument	Instrument
Tonnes				Instrument
kw				Instrument
Price x Boats				-0.000184778
				(0.000294366)
Price x Tonnes				-4.62632e-06
				(4.15688e-06)
R-squared	0.262724	0.175104	0.045613	0.084063
F	79.64280	3.325332	31.9077	32.4512
Akaike criterion	1533.994	6785.962		

Assessing the impact of climate change

- Two scenarios considered:

Assessing the impact of climate change

- Two scenarios considered:
  - Predicted landings and value of landings (revenue) 1994-2004 with ocean warming

Assessing the impact of climate change

- Two scenarios considered:
  - Predicted landings and value of landings (revenue) 1994-2004 with ocean warming
  - Predicted landings and value of landings (revenue) 1994-2004 without ocean warming (counterfactual)

Assessing the impact of climate change

- Two scenarios considered:
  - Predicted landings and value of landings (revenue) 1994-2004 with ocean warming
  - Predicted landings and value of landings (revenue) 1994-2004 without ocean warming (counterfactual)
- Difference in predicted values calculated for each port

Assessing the impact of climate change

- Two scenarios considered:
  - Predicted landings and value of landings (revenue) 1994-2004 with ocean warming
  - Predicted landings and value of landings (revenue) 1994-2004 without ocean warming (counterfactual)
- Difference in predicted values calculated for each port
- Value of difference used as an estimate of damage cost of climate change

Top 10 most affected ports

Table: 12: Rank ordering of ports by percentage revenue lost

Rank	Port	% change in revenue from counterfactual
1	Wicklow	-40.69272304
2	Portmagee	-36.67449513
3	Bantry	-33.777793
4	Moville	-33.29792883
5	Fenit	-32.80437168
6	Achill	-32.57707588
7	Burtonport	-32.39876129
8	Aran Islands	-31.41672685
9	Helvick	-31.40522437
10	Dunmore East	-31.38607148

Bottom 10 most affected ports

Table: 12: Rank ordering of ports by percentage revenue lost

Rank	Port	% change in revenue from counterfactual
36	Dingle	-29.08157479
37	Baltimore	-28.79389382
38	Wexford	-28.24628323
39	Bunbeg	-20.23807779
40	Carlingford	-19.9456652
41	Ballyglass	-17.20571098
42	Lettermore/Lettermullen	-15.71796686
43	Kincasslagh	-15.66304798
44	Cleggan/Clifden	-15.63034779
45	Foynes	-15.57798139
46	Galway	-13.03553762

Are these impacts large?

- In terms of impact on the fishery — yes

Are these impacts large?

- In terms of impact on the fishery — yes
- In terms of the impact on the towns — yes (local multipliers results in a doubling of impact for some communities)

Are these impacts large?

- In terms of impact on the fishery — yes
- In terms of the impact on the towns — yes (local multipliers results in a doubling of impact for some communities)
- In terms of the Irish economy as a whole 436 million euros in damages over 11 years is about 0.29 percent of Ireland's GDP in the year 2004

Are these impacts large?

- In terms of impact on the fishery — yes
- In terms of the impact on the towns — yes (local multipliers results in a doubling of impact for some communities)
- In terms of the Irish economy as a whole 436 million euros in damages over 11 years is about 0.29 percent of Ireland's GDP in the year 2004
- Are adaptation strategies possible? Yes

Extensions and work in progress

- Currently exploring use of a synthetic control approach (Abadie and Gardeazabal 2003, Abadie, Diamond, and Hainmueller,2010, Abadie, Diamond, and Hainmueller, 2011) and placebo treatments to place confidence intervals on deviations from counterfactual

Extensions and work in progress

- Currently exploring use of a synthetic control approach (Abadie and Gardeazabal 2003, Abadie, Diamond, and Hainmueller,2010, Abadie, Diamond, and Hainmueller, 2011) and placebo treatments to place confidence intervals on deviations from counterfactual
- Two directions for further research:

Extensions and work in progress

- Currently exploring use of a synthetic control approach (Abadie and Gardeazabal 2003, Abadie, Diamond, and Hainmueller,2010, Abadie, Diamond, and Hainmueller, 2011) and placebo treatments to place confidence intervals on deviations from counterfactual
- Two directions for further research:
  - more macro-analyses supranational analyses

Extensions and work in progress

- Currently exploring use of a synthetic control approach (Abadie and Gardeazabal 2003, Abadie, Diamond, and Hainmueller,2010, Abadie, Diamond, and Hainmueller, 2011) and placebo treatments to place confidence intervals on deviations from counterfactual
- Two directions for further research:
  - more macro-analyses supranational analyses
  - More micro level analyses (boat) level using a data set consisting of 8055 observations on Irish fishermen

Extensions and work in progress

- Currently exploring use of a synthetic control approach (Abadie and Gardeazabal 2003, Abadie, Diamond, and Hainmueller,2010, Abadie, Diamond, and Hainmueller, 2011) and placebo treatments to place confidence intervals on deviations from counterfactual
- Two directions for further research:
  - more macro-analyses supranational analyses
  - More micro level analyses (boat) level using a data set consisting of 8055 observations on Irish fishermen
- Development of a portfolio based policy model for effort reallocation

Conclusions

- Climate change has had significant impacts on Irish fisheries

Conclusions

- Climate change has had significant impacts on Irish fisheries
- The impact has been detrimental and this result differs from that of previous studies on climate change and fisheries

Conclusions

- Climate change has had significant impacts on Irish fisheries
- The impact has been detrimental and this result differs from that of previous studies on climate change and fisheries
- Result confirms scientific research describing northward movements of copepods and increased catches in the arctic northern subarctic waters and reduced catches in the southern subarctic and north atlantic

Conclusions

- Climate change has had significant impacts on Irish fisheries
- The impact has been detrimental and this result differs from that of previous studies on climate change and fisheries
- Result confirms scientific research describing northward movements of copepods and increased catches in the arctic northern subarctic waters and reduced catches in the southern subarctic and north atlantic
- There is sufficient data to tackle the impact of climate change empirically without resorting to simulation or speculation

Thanks for listening!

Contact: Rodney.M.Beard@gmail.com
http://rbeard.sdf.org
Groupe Sup de Co La Rochelle
La Rochelle, France
http://esc-larochelle.fr