Management Strategy Evaluation and Valuing NOAA: An Example Using Fishery Stock Assessments

NOAA FISHERIES

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Silver Spring, MD

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A Programming Note

The underlying original study for this presentation was developed for other purposes, so the presentation has been modified to address the NOAA SAB topic of Valuation of NOAA (and to fit your screen).

Today's Question: How do we value a NOAA activity or investment of resources?

Original Question: What is the impact on a fishery of conducting more frequent stock assessment updates or assimilating data more quickly?

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NRC Research Press

ARTICLE

An evaluation of acceptable biological catch (ABC) harvest control rules designed to limit overfishing

John Wiedenmann, Michael Wilberg, Andrea Sylvia, and Thomas Miller

Adding An Economist's Perspective

Results in #'s, not $

Table 6. Median performance measures across control rules and exploitation scenarios.

Control rule	Exploitation history	Long-term biomass (S/S_{MSY})	Prob. of overfishing (P_{OF})	Overfishing magnitude (F/F_{lim})	Initial catch (C/MSY)	Long-term catch (C/MSY)	Catch AAV	Rebuilding years
OFL	Light	0.63	0.51	1.61	1.08	0.66	0.16	—
	Moderate	0.62	0.49	1.45	0.69	0.65	0.13	—
	Heavy	0.63	0.46	1.55	0.33	0.58	0.13	16
	All	0.63	0.49	1.53	0.64	0.63	0.14	16

A FINE KETTLE OF FISH, OR IS IT?

Management Strategy Evaluation

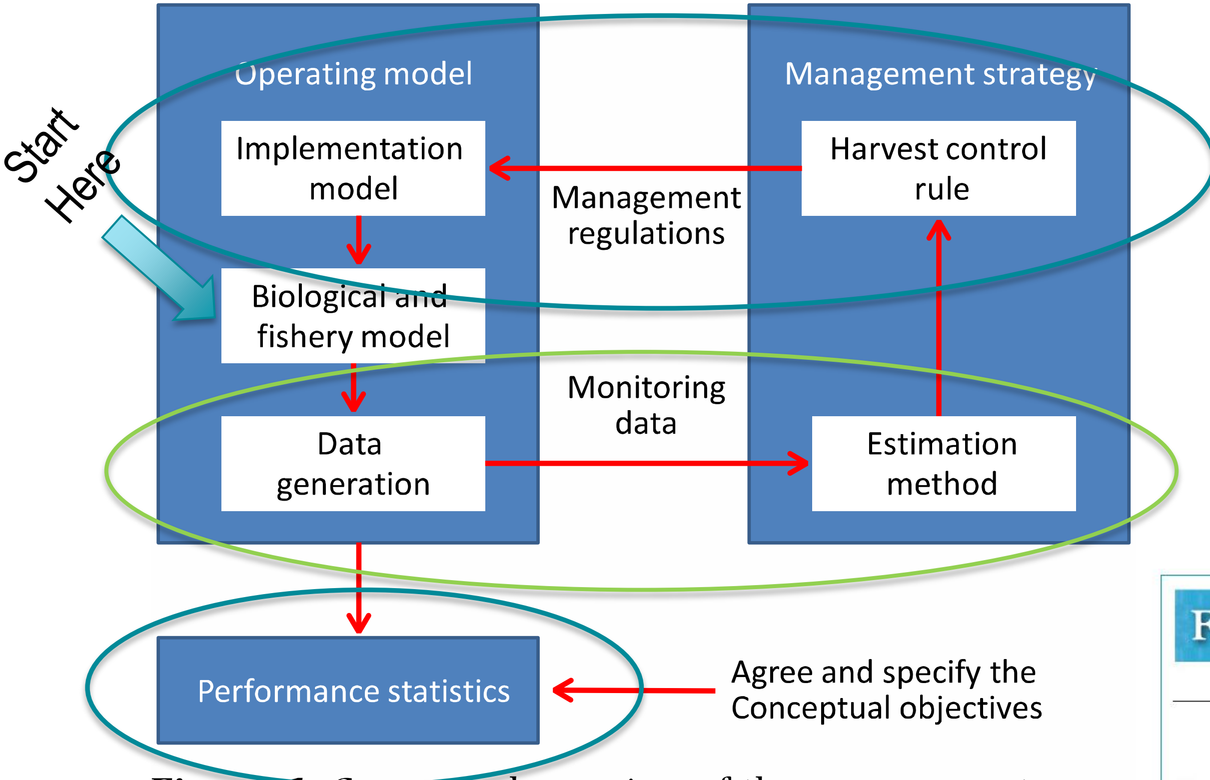

Figure 1 Conceptual overview of the management strategy evaluation modelling process.

This Is Where NOAA's Investment Comes In

- Ships
- Surveys
- Data Collection
  - Data Quality
    - Precision
    - Accuracy
  - Data Timeliness

Behavior in Response to Quality of Data Clearly Defined

- Quotas
- Regulations

Greater the Uncertainty in the Stock Assessment, The Lower the Quota

The Valuation Piece

FISH and FISHERIES

FISH and FISHERIES, 2016, 17, 303–334

Management strategy evaluation: best practices

André E Punt[1,2], Doug S Butterworth[3], Carryn L de Moor[3], José A A De Oliveira[4] & Malcolm Haddon[2]

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Summer Flounder Demonstration: Stock Assessment Updates and Data Lags

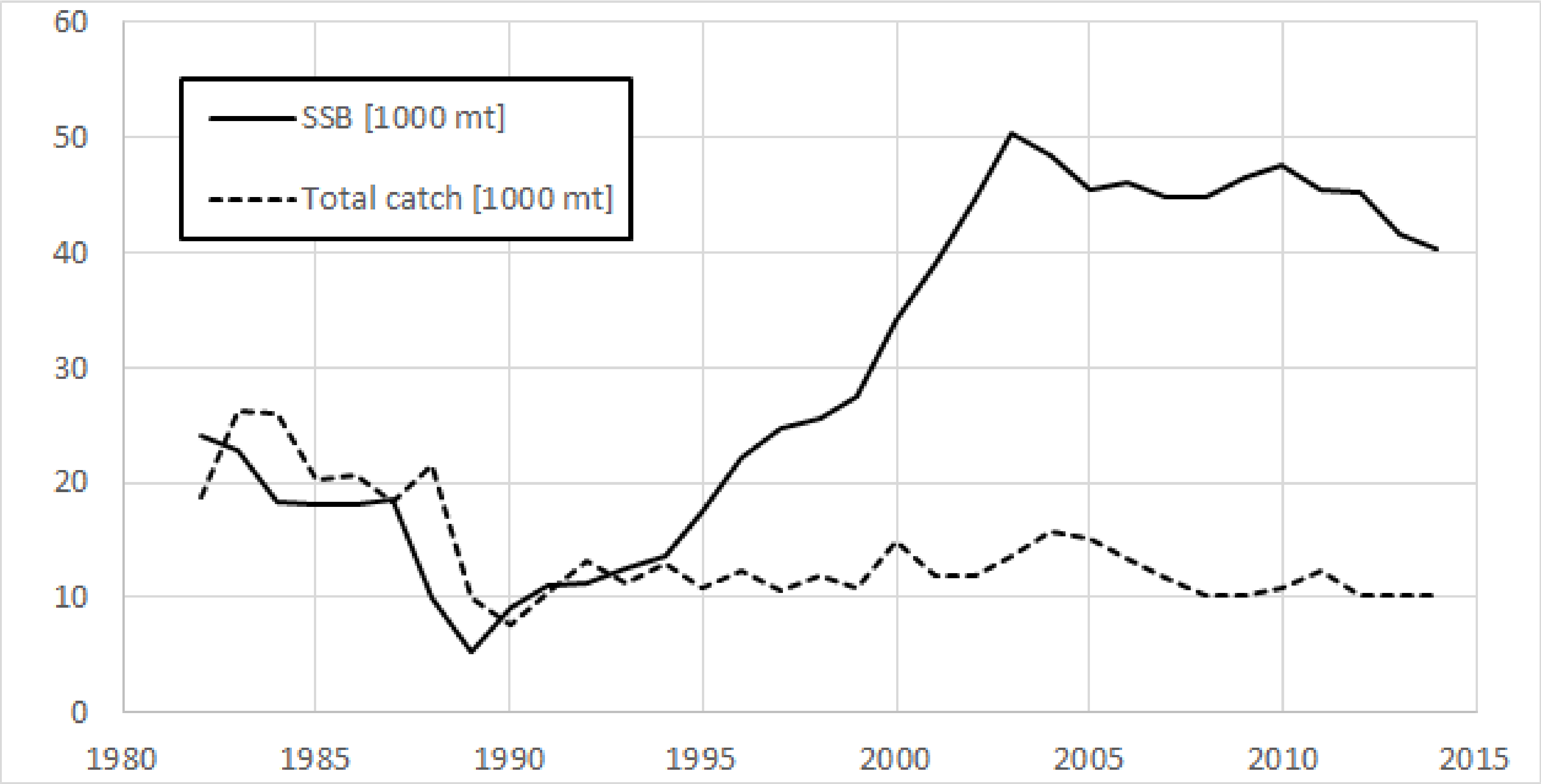
- Currently 3 year quota specification
  - What if
    - 2, 3, 5 or 7 years?
- Data lag
    - 1 or 2 years?

Sum of Catches (2014-2040) Under Different Scenarios

SA Interval	DML	Catch [1000mt]	(5%)	(95%)
2	1	234.2	209.4	269.7
2	2	222.9	197.3	258.1
3	**1**	**232.9**	**206.2**	**267.7**
3	2	222.1	197.6	256.8
5	1	231.5	201.6	268.1
5	2	221.1	193.0	258.5
7	1	228.1	199.7	270.1
7	**2**	**219.8**	**192.4**	**259.4**

Our 2 Kettles of Fish

Summer Flounder Harvest & SSB



Some Simulation Results 2014-2040

Relative biomass

Relative catch

2014 used as reference year (biomass=catch=1)

Scenario:

SA interval = 3 years

DML = 1 year

Comparing Two Scenarios (Stock Assessment Update/Data Lag)

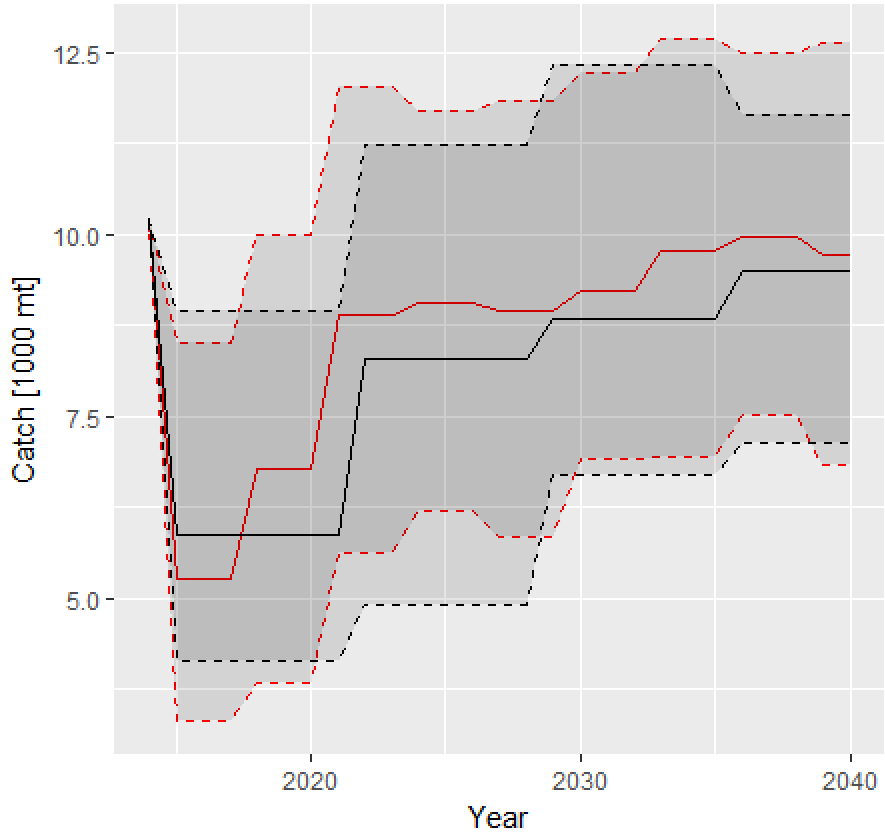
Catch for two scenarios

Scenario 3/1

Total Catch 234.2 mt

Scenario 7/2

Total Catch 219.8 mt



Deconstructing the Economics

- Revenues
- Discounting
- Demand
- Production Costs
- Producer & Consumer Welfare
- Recreational Value

Why Not Express in Revenues?

- What price do I use?

SPECIES: FLOUNDER, SUMMER

YEAR RANGE:

FROM: 2000 (Earliest Year)

TO: 2015 (Latest Year)

Choose the year(
sometimes are hi

GEOGRAPHICAL AREA

STATE/AREA:

All States

Areas are arrang
give you the total
surveys. Florida e
(west+east+inlan

OUTPUT FORM:

TABLE

The summarized
"ASCII File" optio

NMFS Landings Query Results

You Asked For the Following:

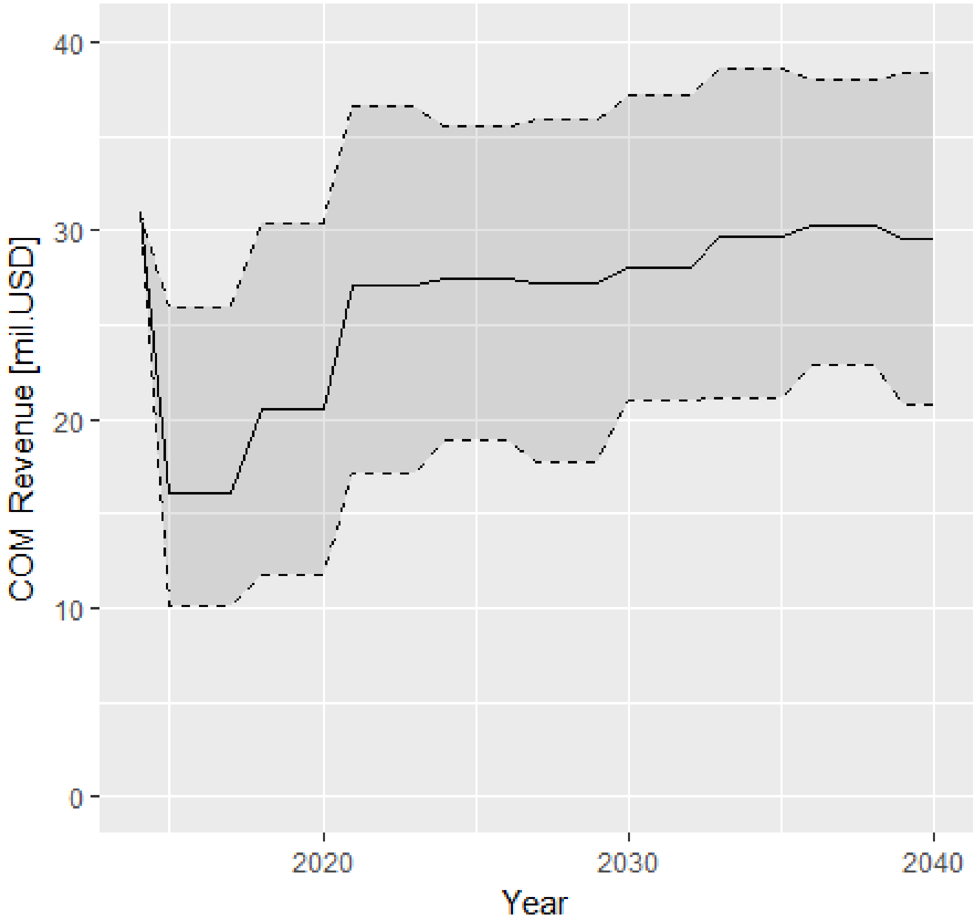
- Year : From: 2000 To: 2015
- Species : FLOUNDER, SUMMER
- State : All States

Year	Species	Metric Tons	Pounds	$
2000	FLOUNDER, SUMMER	4,998.3	11,019,193	19,692,892
2001	FLOUNDER, SUMMER	4,860.6	10,715,630	17,331,869
2002	FLOUNDER, SUMMER	6,453.5	14,227,332	21,071,477
2003	FLOUNDER, SUMMER	6,499.2	14,328,181	23,188,120
2004	FLOUNDER, SUMMER	8,139.8	17,945,026	28,882,286
2005	FLOUNDER, SUMMER	7,749.1	17,083,575	30,118,259
2006	FLOUNDER, SUMMER	6,331.9	13,959,339	29,764,388
2007	FLOUNDER, SUMMER	4,445.5	9,800,522	23,848,565
2008	FLOUNDER, SUMMER	4,096.1	9,030,351	21,926,159
2009	FLOUNDER, SUMMER	4,896.6	10,795,138	22,358,627
2010	FLOUNDER, SUMMER	5,971.1	13,163,869	28,562,911
2011	FLOUNDER, SUMMER	7,218.0	15,912,725	31,775,642
2012	FLOUNDER, SUMMER	5,672.2	12,504,943	30,389,195
2013	FLOUNDER, SUMMER	5,395.3	11,894,469	28,613,269
2014	FLOUNDER, SUMMER	4,910.7	10,826,204	31,390,069
2015	FLOUNDER, SUMMER	4,839.3	10,668,732	33,641,535
GRAND TOTALS:	-	92,477.2	203,875,229	422,555,263

Time Series of Future Revenues (3/1)

- Revenue at constant price, recent average price

SUM 2014-2040: $708.9 million



Discounting – When the fish go in the kettle matters.

Economic Translator

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n}$$

$CF = $ Cash Flow

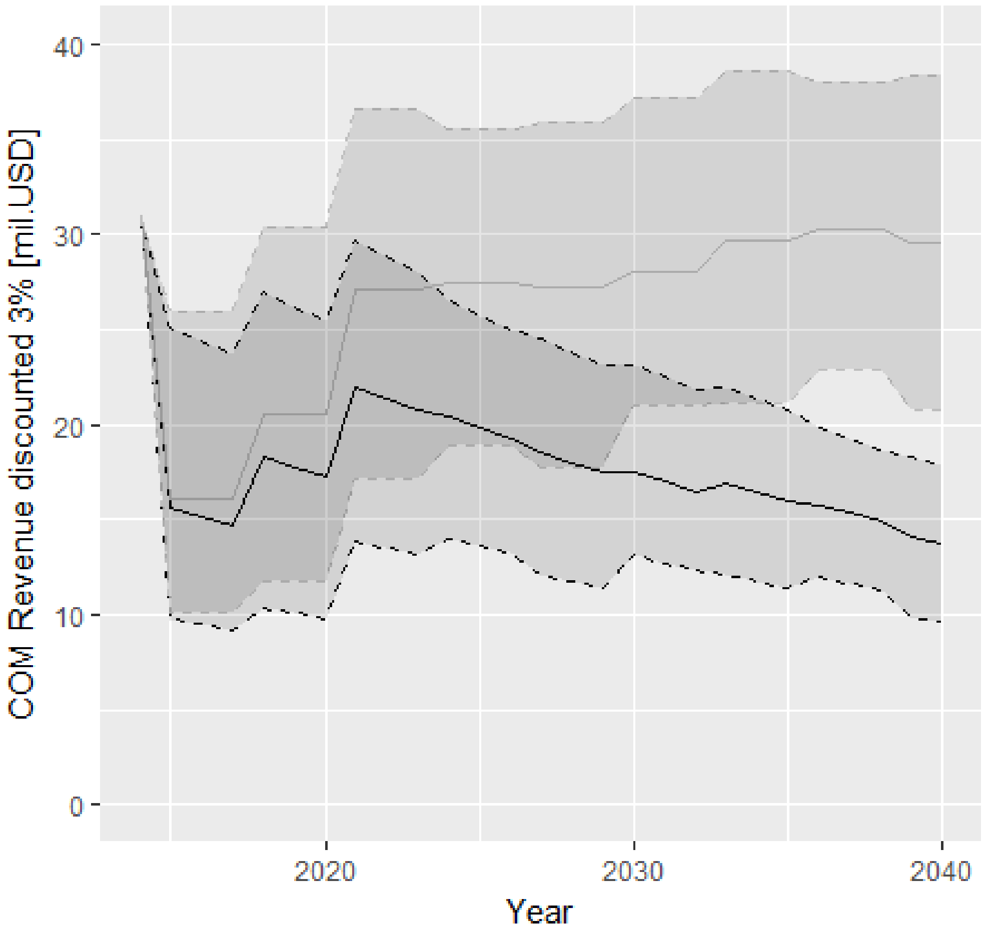
$r = $ discount rate (WACC)

- A lot of fish revenue at the end of the period, not as valuable as more fish revenue early on.

Discounted Revenues (3/1 Scenario)

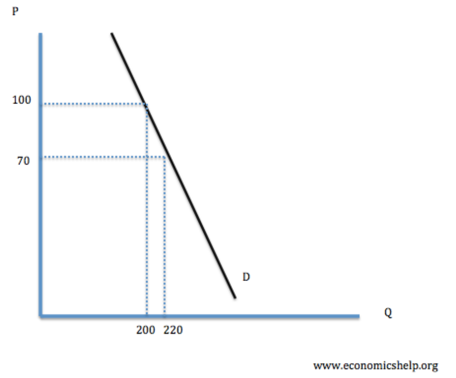
- Revenue at constant price
- Revenue discounted (r=3%)

SUM 2014-2040:
$481.2 million



Add Realism - Demand

- Prices Fluctuate With Landings
  - Tends to dampen impact on fisher's revenues
  - Reflects consumer benefits
- How elastic is demand for summer flounder?



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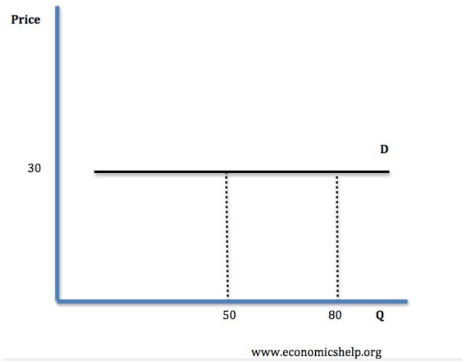


Synthetic Inverse Demand System

$$w_{it}\Delta \ln v_{it} = \alpha_i + \sum_j \pi_{ij}\Delta \ln q_{jt} + \pi_i \Delta \ln Q_t - \theta_1 w_{it} \Delta \ln Q_t - \theta_2 w_{it} \Delta \ln(q_{it}/Q_t) + \varepsilon_{it} \quad (1)$$

Insert Fancy Economic Equation Here

Table 2: Demand data summary (monthly averages).

Variable	Mean	STD	Min	Max
Summer flounder landings	14.56	11.00	0.22	59.97
Other flatfish landings	32.97	18.19	6.77	83.95
Groundfish landings	81.63	36.00	35.97	245.31
Flatfish imports	33.92	9.79	11.44	65.01
Groundfish imports	172.64	50.55	40.23	313.30
Summer flounder price	3.07	0.81	1.52	6.93
Other flatfish price	2.12	0.46	0.90	3.31
Groundfish price	1.17	0.18	0.77	1.72
Flatfish imports price	3.54	0.85	2.06	5.43
Groundfish imports price	2.98	0.58	1.95	4.93

Table 5: Coefficients of the SIDS model.

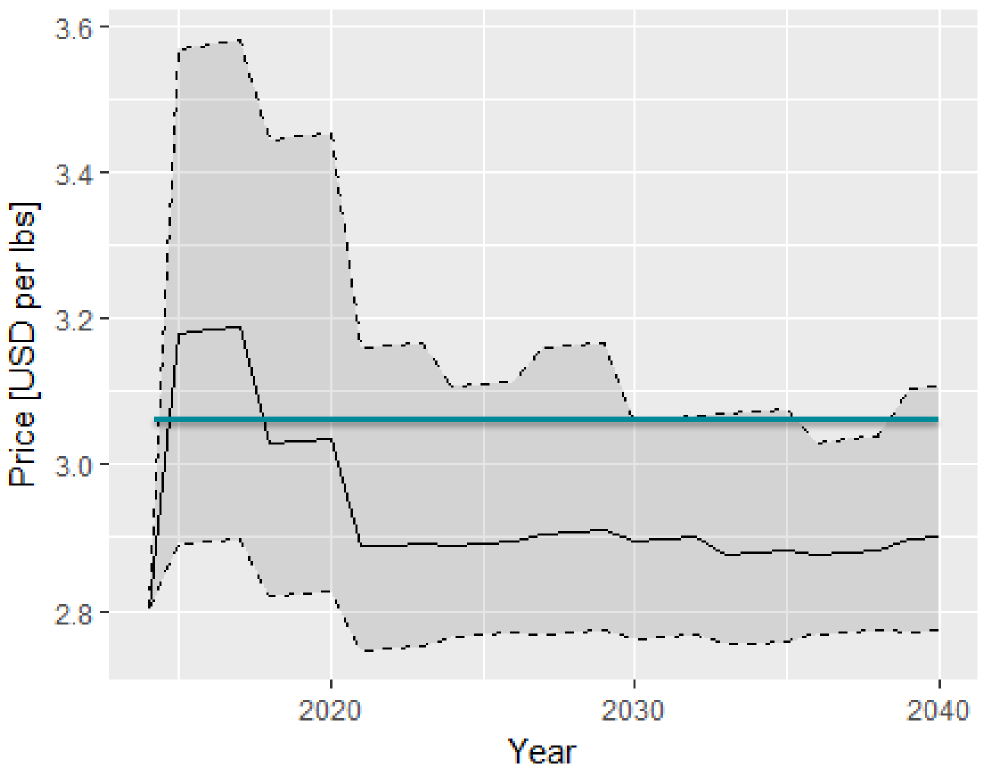
Coefficient	Estimate	SE	p
α_1	-0.0002	0.0002	0.298
α_2	0.0006	0.0002	0.003
α_3	0.0000	0.0003	0.935
α_4	-0.0001	0.0002	0.515
α_5	*-0.0003*	*0.0004*	*0.547*
π_1	-0.0094	0.0032	0.003
π_2	-0.0241	0.0057	0
π_3	-0.0033	0.0071	0.643
π_4	-0.0113	0.0081	0.164
π_5	*-0.0574*	*0.0329*	*0.081*
π_{11}	-0.0041	0.0008	0
π_{12}	-0.0068	0.0007	0
π_{13}	-0.0002	0.0006	0.792
π_{14}	-0.0043	0.0008	0
π_{15}	*0.0154*	*0.0010*	*0*
π_{22}	-0.0214	0.0024	0
π_{23}	-0.0041	0.0012	0.001
π_{24}	0.0035	0.0014	0.010
π_{25}	*0.0289*	*0.0020*	*0*
π_{33}	-0.0147	0.0027	0
π_{34}	0.0049	0.0017	0.004
π_{35}	*0.0141*	*0.0026*	*0*
π_{44}	-0.0223	0.0032	0
π_{45}	*0.0182*	*0.0029*	*0*
π_{55}	*-0.0767*	*0.0067*	*0*
θ_1	0.8945	0.0535	0
θ_2	0.0948	0.0199	0

Table 6: Compensated price flexibilities evaluated at mean quantities and prices.

	Summer flounder - domestic (G1)	Other flatfish - domestic (G2)	Groundfish - domestic (G3)	Flatfish import (G4)	Groundfish import (G5)	SCALE
G1	-0.175	-0.132	*0.008*	-0.075	0.375	-1.087
	(0.013)	(0.013)	*(0.013)*	(0.017)	(0.019)	(0.040)
G2	-0.077	-0.344	*-0.039*	0.55	0.405	-1.184
	(0.008)	(0.027)	*(0.015)*	(0.016)	(0.024)	(0.033)
G3	*0.003*	-0.028	-0.211	0.056	0.179	-0.923
	(0.005)	(0.010)	(0.017)	(0.014)	(0.020)	(0.032)
G4	-0.026	0.032	0.046	-0.238	0.186	-0.974
	(0.006)	(0.009)	(0.012)	(0.011)	(0.014)	(0.021)
G5	0.030	0.055	0.034	0.043	-0.163	-0.989
	(0.002)	(0.003)	(0.004)	(0.003)	(0.008)	(0.009)

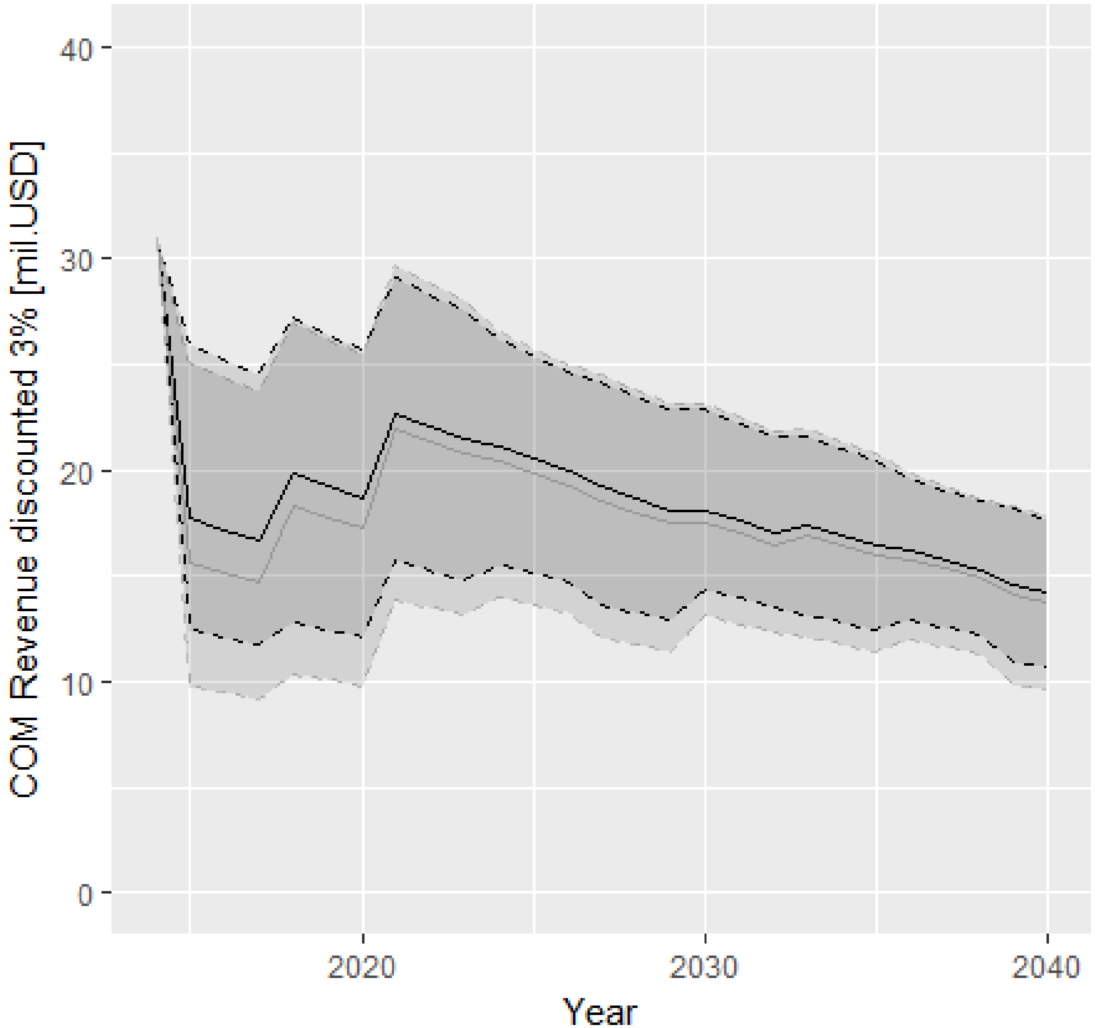
Note: Standard errors in parentheses; not significant ($p > 0.05$) in italics.

Some Results: Simulated Prices From Demand Estimate (3/1 Scenario)



Demand Adjusted Revenues (3/1)

- Revenue discounted (r=3%)
- Revenue discounted (r=3%) with demand driven price



SUM 2014-2040:
$503.3 million

Not Done Yet: Really Want Profits Or At Least Revenues Net of Costs (Quasi-Rents)

$$\Delta D_{nt} = \beta_0 + \sum_{i \in I} \Delta y_{int} \left(\beta_i + \beta_{ki} k_n + \beta_{bi} b_{it} + \beta_{si} ST_{nt} \right) + \epsilon_{nt}$$

Table 3: Fleet data summary.

Variable	Mean	SD	Min	Max
Days at sea - D	113	74	1	421
Landings of summer flounder [lbs]- y_{SF}	22895	32045	0	272450
Landings of other bottom fish [lbs]- y_{FL}	93732	146133	0	1727766
Landings of bait fish [lbs] - y_{BT}	67194	342143	0	9140000
Landings of shellfish [lbs] - y_{SH}	110450	486541	0	9896700
Landings of other fish species [lbs] - y_{OT}	67008	213086	0	3599206
Vessel tonnage [Gt] - k	96	51	1	201
Biomass index for summer flounder - b_{SF}	0.962	0.195	0.690	1.337
Cost [1000 2014 USD]	97.59	106.47	0.27	765.72

Table 8: Effort first-difference regression results.

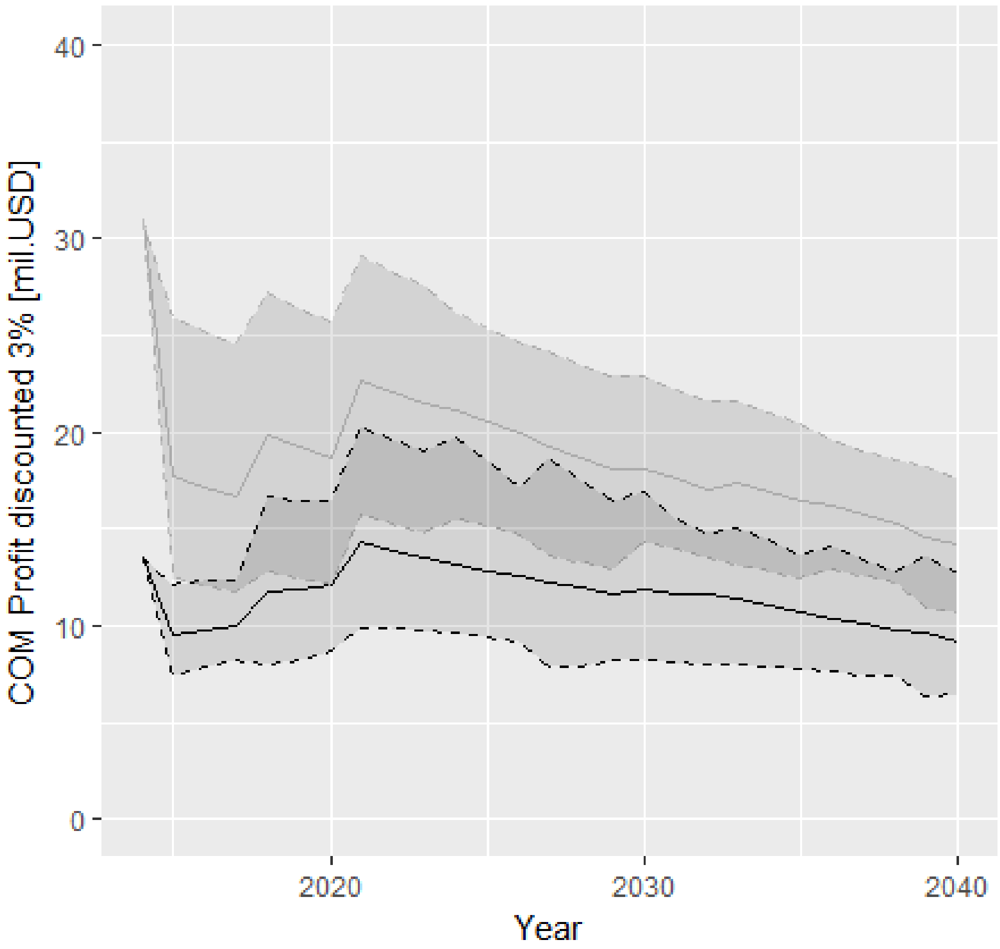
Coefficient	Estimate	SE	p
β_0	-2.573167	0.397958	0
β_{SF}	0.001867	0.000278	0
β_{FL}	0.000503	0.000060	0
β_{BT}	0.000021	0.000032	0.509
β_{SH}	0.000283	0.000040	0
β_{OT}	0.000149	0.000025	0
β_{kSF}	-0.000006	0.000001	0
β_{kFL}	-0.000002	0.000000	0
β_{kBT}	0.000000	0.000000	0
β_{kSH}	-0.000001	0.000000	0
β_{kOT}	0.000000	0.000000	0.001
β_{bSF}	-0.000400	0.000115	0

Note: Coefficients for time and state dummies omitted.

How do days as sea change due to a change in SF biomass and TAC?

Producer Net Revenues (3/1)

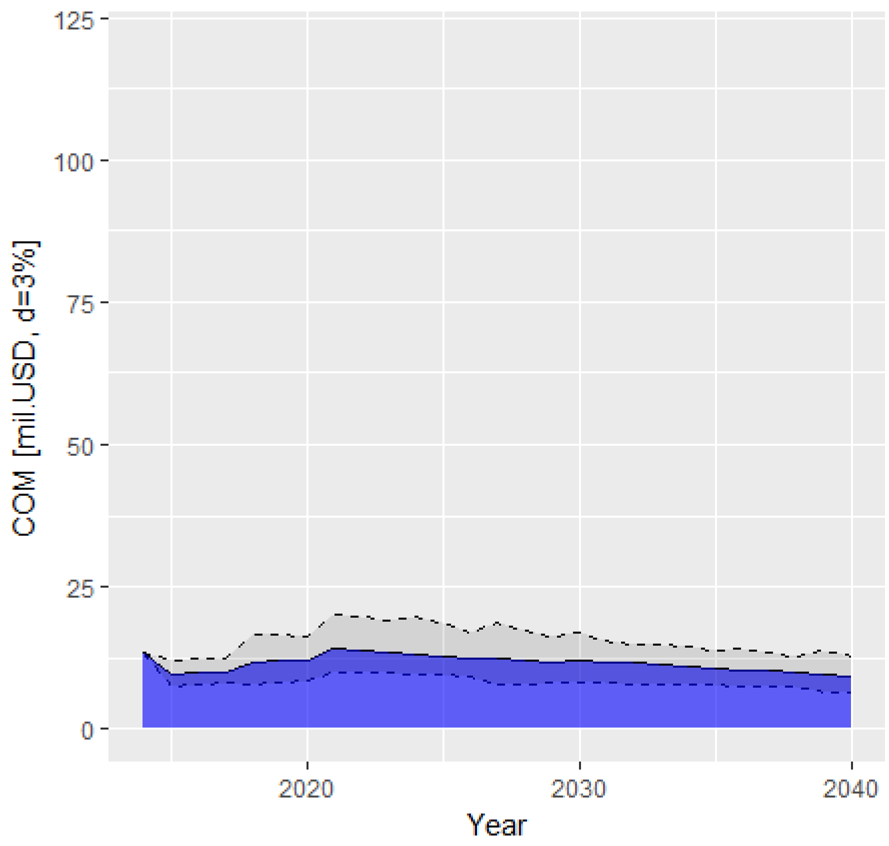
- Revenue discounted (r=3%) with demand driven price
- Net revenue discounted (r=3%) with demand driven price



SUM 2014-2040:
$311.8 million

An Accounting For One Scenario (3/1)

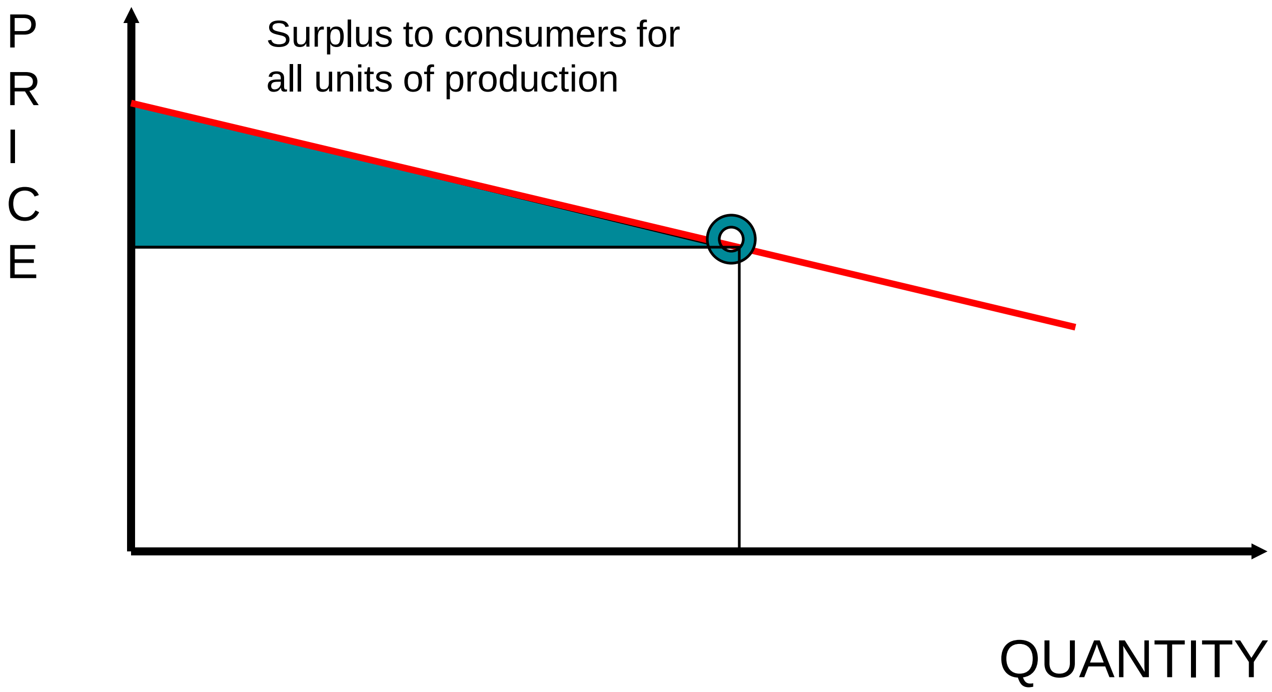
- Commercial Net Revenue



SUM 2014-2040:

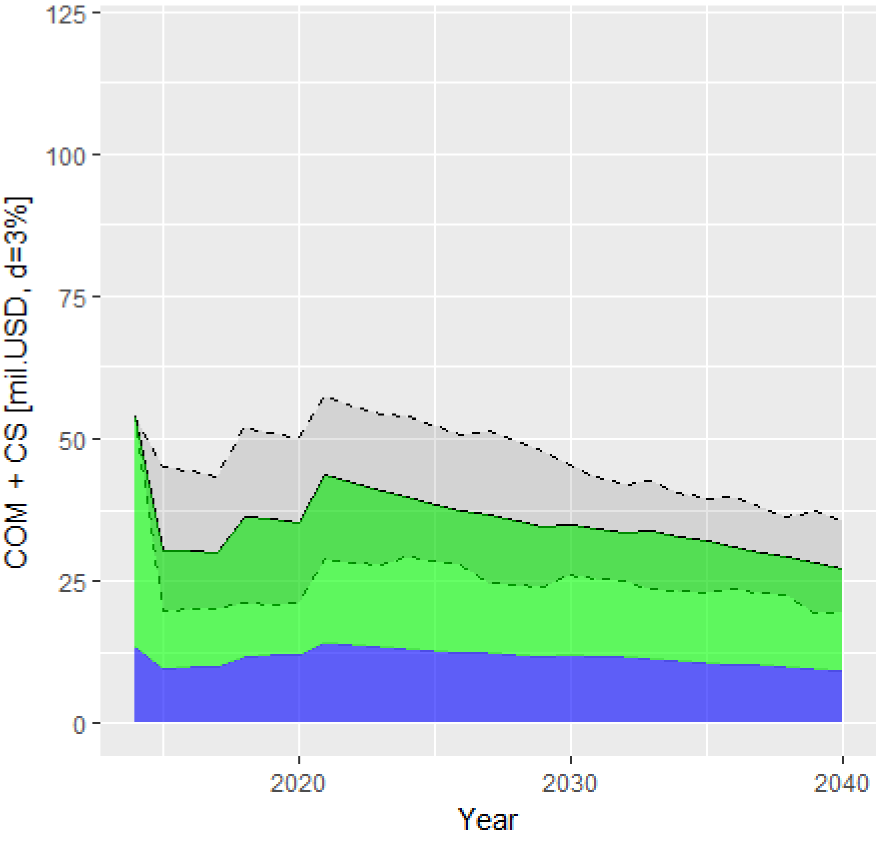
- $311.8 million

An Aside About Consumer Surplus



Commercial Net Revenue + Consumer Surplus (3/1)

- Commercial Net Revenue
- Consumer Surplus



SUM 2014-2040:

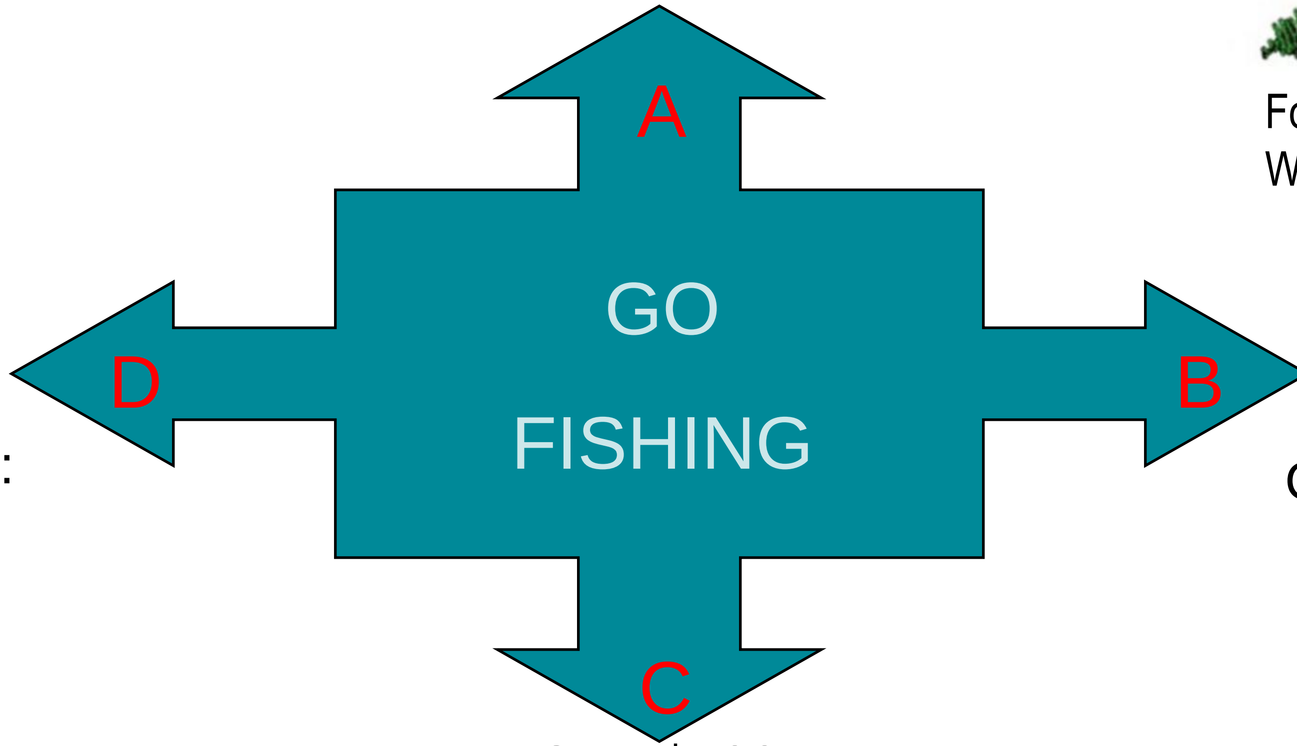
- $311.8 million
- $635.9 million

Recreational Values - Random Utility Concept

For What?
Where To?

Cost: $25

Catch Rate: 1 Fish



Cost: $50

Catch Rate:
3 Fish

Cost: $30

Catch Rate:

2 Fish

Cost $100

Catch Rate: 10 Fish

Recreational Values – Random Utility Model

$$v^i_{s,m,l} = \beta_{cost} cost^i_l + \sum_{s \in S} \beta_s c_{s,m,l} d_s + \sum_{m \in M} \beta_m d_m + \beta_{ns} ln(ns_l)$$

Table 4: Recreational data summary - used for two part model.

Variable	Mean	SD	Min	Max
Summer flounder (SF): 2004-2014				
Catch rate c	3.274	5.094	0	111
Hours of fishing hr	4.059	1.648	0.5	14
Experience - exp	23.898	34.688	1	365
Biomass [mt]	45026	2348	40323	48549
Small game fish (SG): 2014				
Catch rate c	2.425	6.074	0	210
Hours of fishing hr	3.911	2.043	0.5	14
Experience - exp	30.781	46.496	1	361
Other bottom fish (BT): 2014				
Catch rate c	11.578	16.453	0	200
Hours of fishing hr	4.173	1.822	0.5	12
Experience - exp	25.701	40.122	1	365

Table 9: Nested logit results for recreational harvest.

Coefficient	Estimate	SE	p
γ_{cost}	-0.084	0.003	0.000
γ_{SF}	3.261	0.063	0.000
γ_{SG}	1.726	0.038	0.000
γ_{BT}	0.479	0.020	0.000
γ_{HD}	-1.269	0.064	0.000
γ_{PR}	0.712	0.041	0.000
γ_{ns}	3.209	0.107	0.000
Dissimilarity parameters			
$\tau_{SF,SH}$	1.593	0.064	
$\tau_{SF,HD}$	2.381	0.077	
$\tau_{SF,PR}$	1.756	0.063	
$\tau_{SG,SH}$	2.060	0.063	
$\tau_{SG,HD}$	2.239	0.071	
$\tau_{SG,PR}$	2.026	0.062	
$\tau_{BT,SH}$	1.614	0.060	
$\tau_{BT,HD}$	2.520	0.073	
$\tau_{BT,PR}$	1.434	0.058	

Note: LR test for IIA (τ=1): $\chi^2(9) = 2358.61$, $p > \chi^2 = 0.000$.

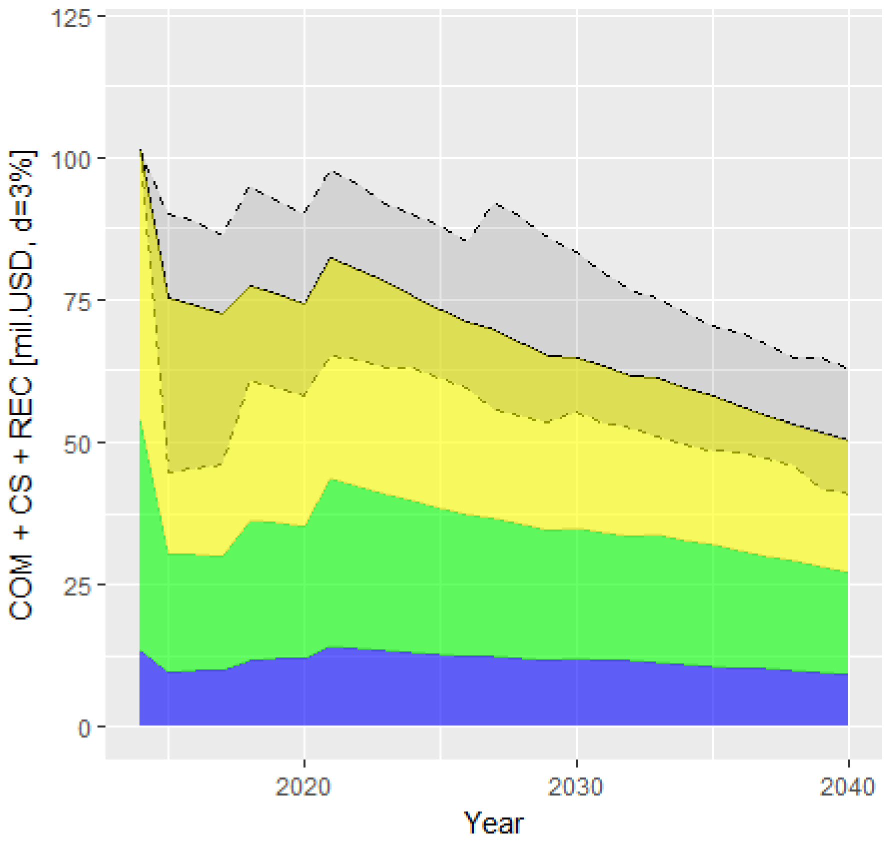
Adding Recreational Welfare (3/1)

- Commercial Net Revenue
- Consumer Surplus
- Recreational welfare – Compensating Variation

SUM 2014-2040:

- $311.8 million
- $635.9 million
- $901.3 million

= $1,849 million



Comparing Scenarios

Value for two scenarios:

Scenario 3/1

Total Catch 234.2 mt

Total Net Value:

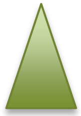
$1,849 Million

Scenario 7/2

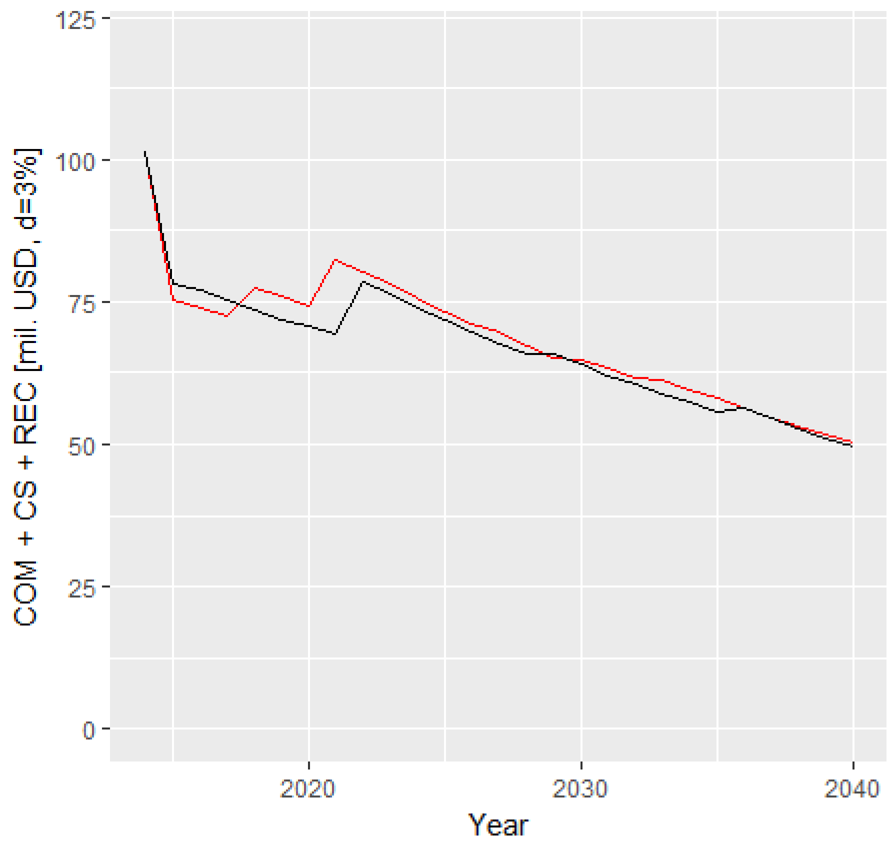
Total Catch 219.8 mt

Total Net Value:

$1,809 Million



= $40 Million



The Bottom Line

- Difference in # of Assessments
  - 9 versus 4 over 27 years
- Cost of 5 more stock assessments << $40 million
- National **<u>average</u>** cost of a stock assessment - $1.7 million (Merrick and Methot)
- Positive net benefit to society from conducting stock assessment every 3 years compared to 7
  - ≈ $32 million
  - Most of benefits accrue to commercial downstream firms, final consumers and recreational fishermen

Concluding Thoughts

- MSE’s Are Complex, Data Intensive, Time Consuming to Build
- Economic Component Too
- Once Built, Scenario Analysis Relatively Simple, Adaptable to Answer Multiple Questions
- Require Refreshment and Updating
- Powerful Tool For Valuation
- Applications Where Implementation Model (Other NOAA Products) Less Direct?

Questions?
Comments?

Thanks to Barbara Hutniczak