

A Bioeconomic Model for the Lobster (*Homarus americanus*) Fishery in Canada

By

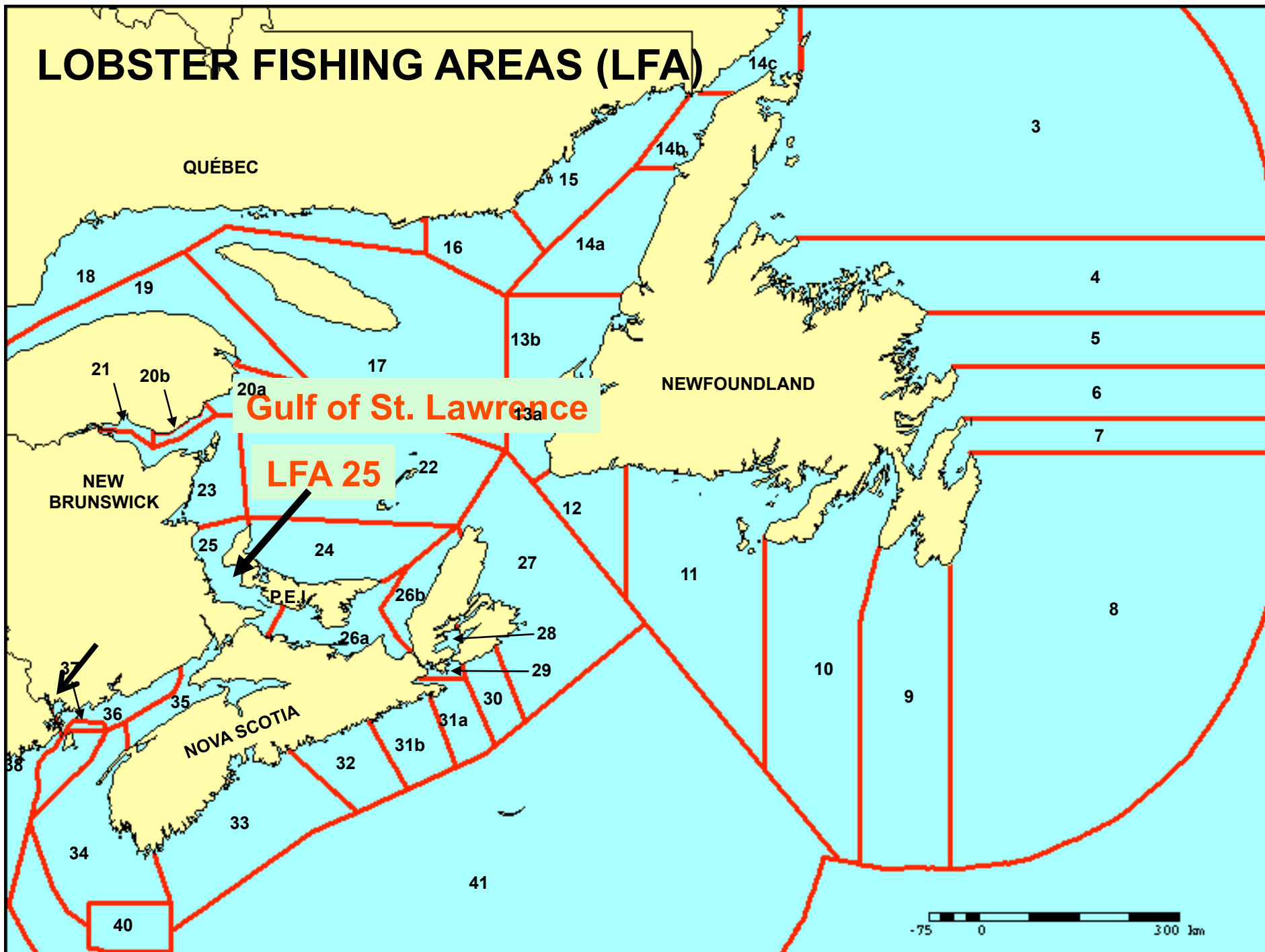
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Outline

- **Management of the summer lobster fishery in southern Gulf of St. Lawrence (LFA 25)**
- **DFO mandate and the Atlantic Lobster Sustainability Measures Program**
- **Bioeconomic Model (i) Lobster Population Dynamics (ii) Socio-Economic (iii) Link**
- **Results, Discussion & Conclusions**

LOBSTER FISHING AREAS (LFA)



Management regime for the lobster fishery

Input fishery (or “adaptive management”, i.e. no Quota):

The management of an input fishery is based on the use of various restraints on fishing.

1) Control on type and size of lobsters

What portion of the lobster population can be caught (while insuring a sustainable fishery)

2) Control of effort



Control of fishing effort

Management measures

Descriptions/Explanation

Management measures	Descriptions/Explanation				
Division of the coastal area in Lobster Fishing Areas (LFA)	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B
Fishing season	May - June	May - June	Beg. Aug. beg. Oct	May - June	May - June
Number of license holders	749	637	709	767	256
Number of traps/license holder	300	300	250	300	300
Restriction of gear type	Traps (no restrictions on internal design)				
Trap overall dimension	Length = 125 cm, Width = 90 cm, Height = 50 cm				

Control on type / size of lobsters

Lobster Fishing Area (LFA)

Management measures	LFA 23	LFA 24	LFA 25	LFA 26A	LFA 26B
Minimum legal carapace size	range	70 mm	70 mm	range	range
Landing of egg-bearing females is prohibited	Common to all LFAs				
Landing of females between 115 and 129 mm CL is prohibited	All LFAs, except in LFA 25 max size of 114 mm ♀				
Rectangular escape mechanism in the parlor section of the trap	All LFAs Dimensions: adjusted to the minimum legal size				
Biodegradable mechanism in the parlor section of the trap	Common to all LFAs Dimensions of unobstructed opening not less than 89 mm in height and 152 mm in width				

Fisheries Resource Conservation Council

FRCC first report in 1995

Recommendations

- **Increase productivity (egg production)**
- **Reduce fishing effort**
- **Egg production per recruit (E/R) target of 5%**

FRCC second report in 2007

Recommendations

- **Increase productivity (egg production)**
- **Reduce fishing effort**
- **Minimum legal size adjusted to SOM_{50}**

n.b. Reducing fishing effort; no measure implemented

Minimum legal size (CL in mm)

SOM₅₀ = 72 mm CL		Lobster Fishing Area					
Year	23	24	25	26A	26A-3 (West)	26A-2 (East)	26B
1957	63.5	63.5	63.5	63.5			63.5
1990	65.1	63.5	65.1	63.5			70
1997	66.7	63.5	66.7	65.1	70	66.7	70
1998	67.5	65.1	67.5	65.9	70	68.3	70
1999	67.5	65.9	67.5	65.9	70	70	70
2003	68.5	68.5	68.5	68.5	70	70	72
2004	70	69.5	70	69.5	70	71.5	73
2005	70	70	70	70	73	71.5	74
2006	70	70	70	70	76	71.5	75
2007	70	70	70	70	76	71.5	76
2008	71-71-70-70	70	70	70	76	73	77-76
2009	72-72-72-70	70	70	70	76	73	78-76
2010	73-73-72-70	70	70	70	76	73	79-76

Atlantic Lobster Sustainability Measures Program

Purpose

Improve economic prosperity & long-term sustainability of lobster industry

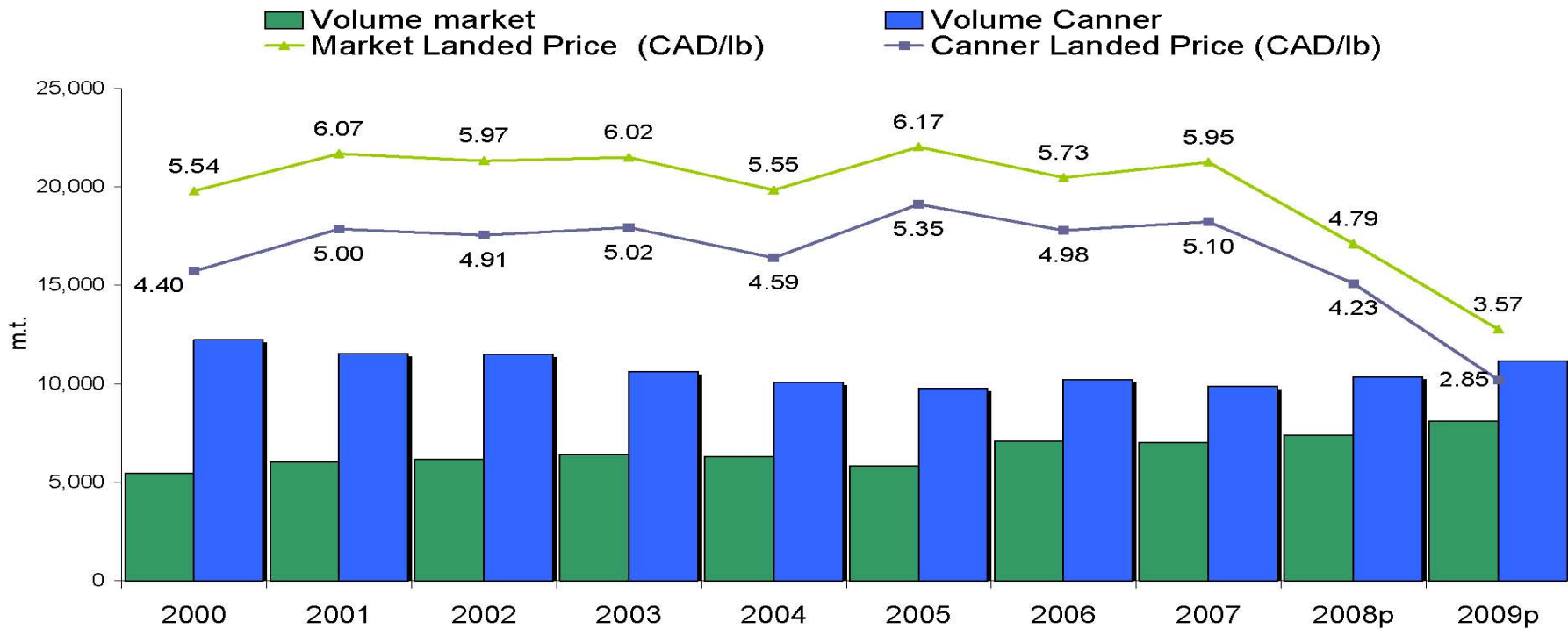
Elements (or steps, *i.e.*, *Plans*)

1. Conservation: (1) biological productivity (2) reliable monitoring (3) ecosystem
2. Restructuring: funds for rationalization (trap and/or license reduction)

Atlantic Lobster Sustainability Measures Program

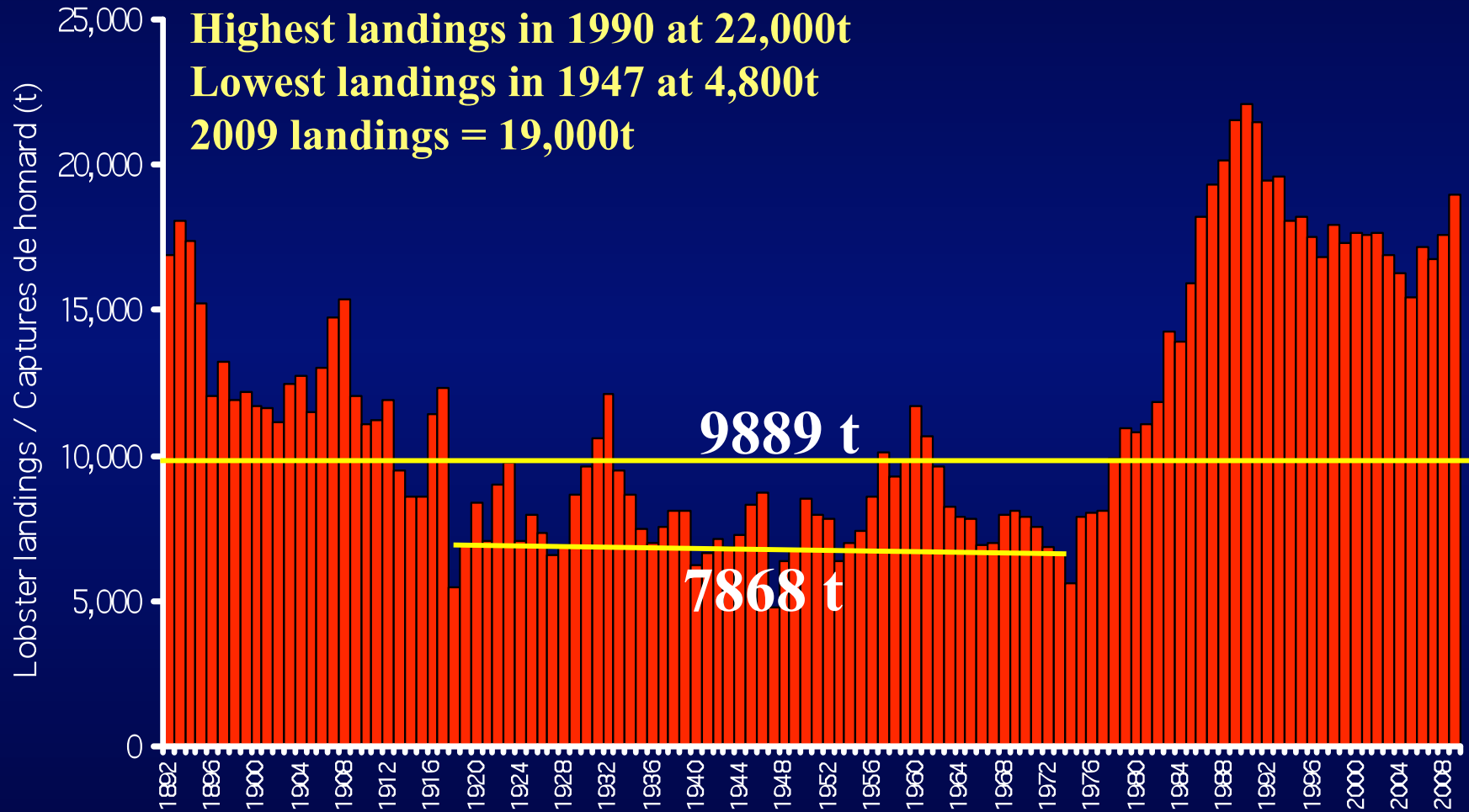
Fisheries and Oceans Canada / Pêches et Océans Canada

Gulf Region Historical Lobster Prices 2000-2009p



Source: DFO, compilation PEB, DFO Gulf Region

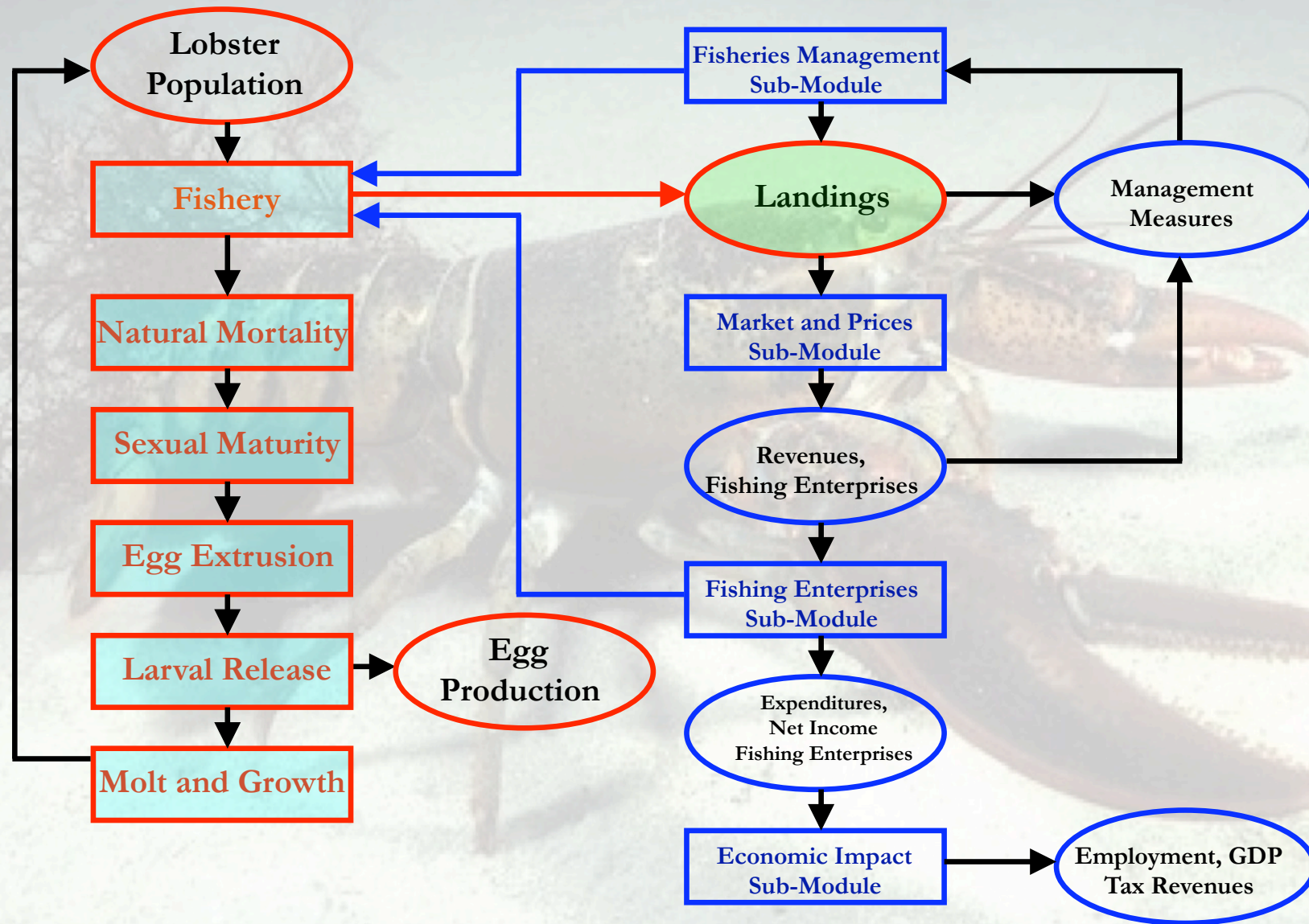
Southern Gulf of St. Lawrence Landings



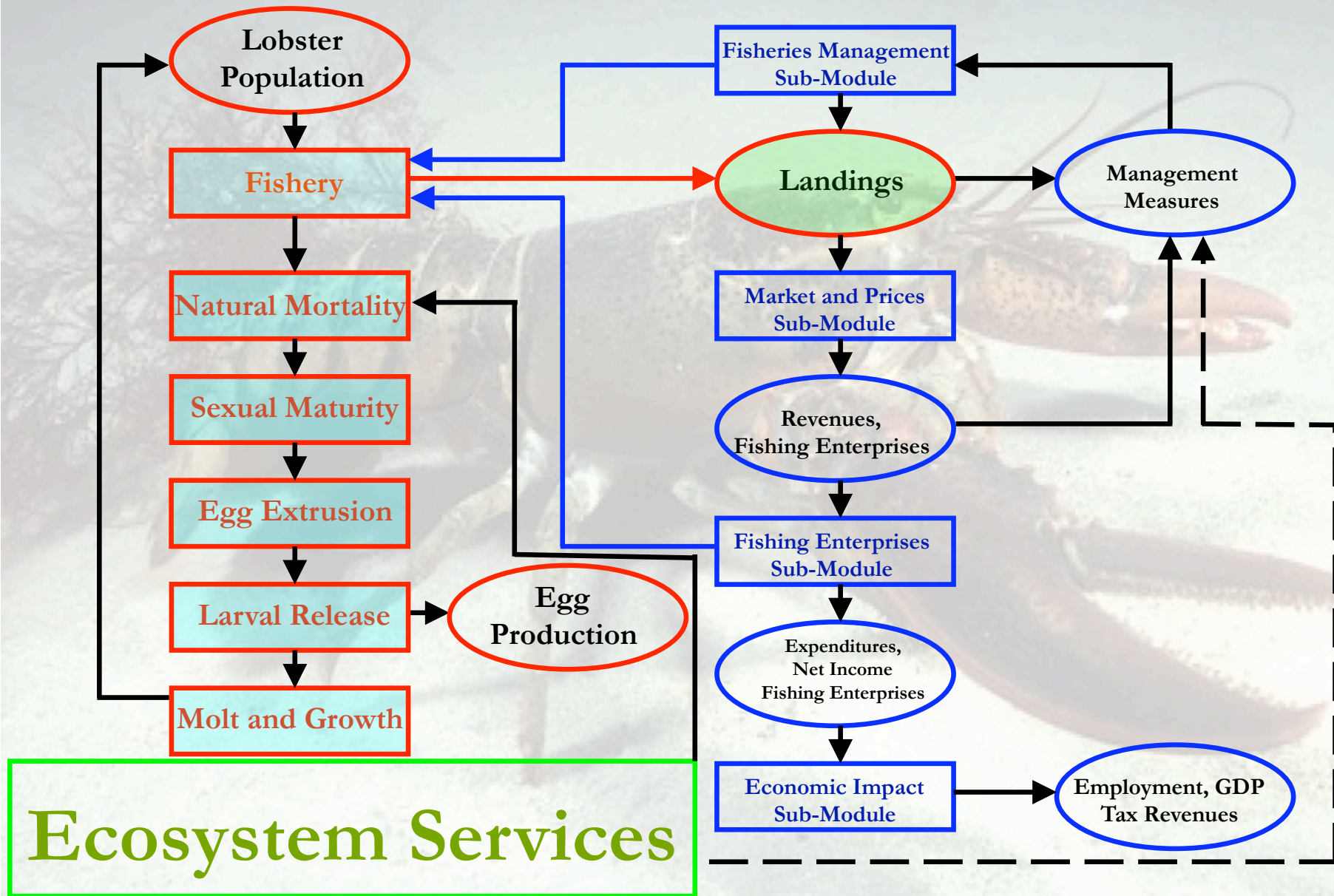
Purpose

- Describe a Bioeconomic Model (i) Lobster Population Dynamics module (ii) Socio-Economic module
- Provide biological (*i.e.*, landings and egg production) and economic (*i.e.*, expenditures and net benefits) outputs
- Associated with (1) increase of the MLS from 70 to 72 mm CL and (2) a reduction of the number of traps per harvester from 250 to 200

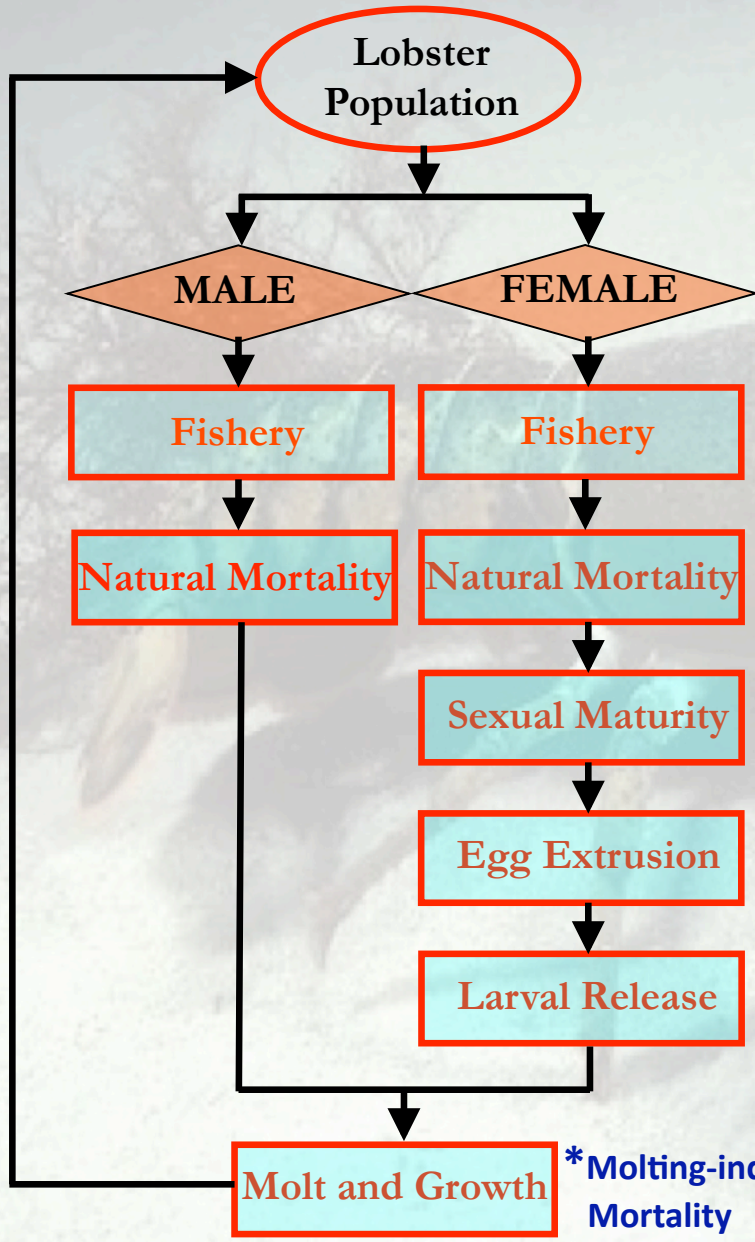
Flowchart of Bioeconomic Model



Flowchart of Bioeconomic Model



Lobster Population Dynamics Module



100,000 Lobsters from 60-69 mm CL

Mgt Measures **MLS 70 mm CL**
 No Berried Female
 114 mm CL Max Size Female

Fishing Mortality 70% → **Landings**

Natural Mortality 5%

Sexual Maturity & Egg Extrusion **Maturity Curve-logistic**
 2-yr Reproductive Cycle
 Fecundity Curve-exponential

Larval Release July-August → **Egg Production**

Growth 16.2% Male
 15.2% Immature Female
 12.0% Mature Female

* Molting-induced Mortality 5%

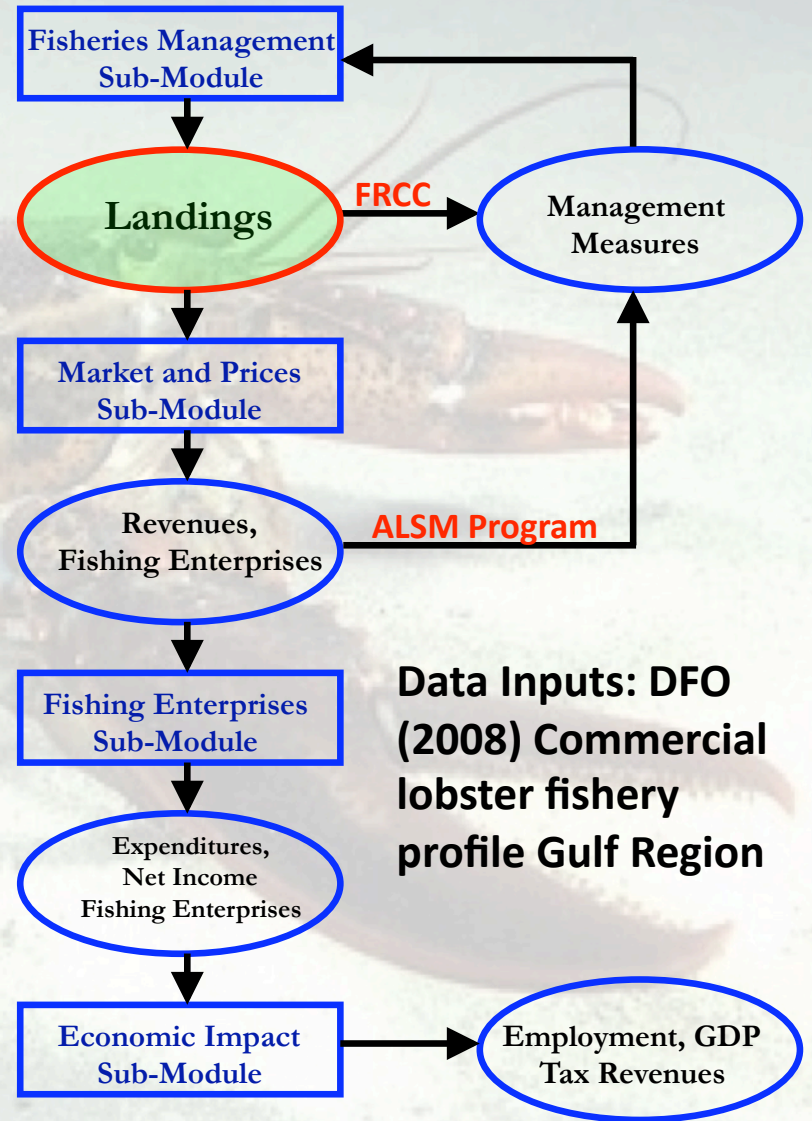
Socio-Economic Module

Mgt Measures **MLS 70 mm CL**
No Berried Female
114 mm CL Max Size Female
250 trap limit/harvester

Log-Log equations **Landing Prices**
World Demand

Profits = f(E,R) **E; expenditures**
R; revenues from landings

Input-Output Core **Algorithms**
Econometric Blocks
Non-linear dynamic iterations
Energy Sub-sub-module

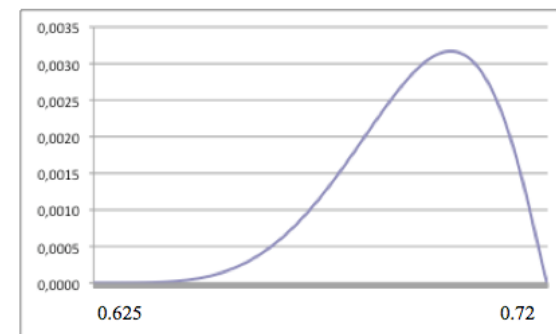


Data Inputs: DFO (2008) Commercial lobster fishery profile Gulf Region

Uncertainty (Monte-Carlo)

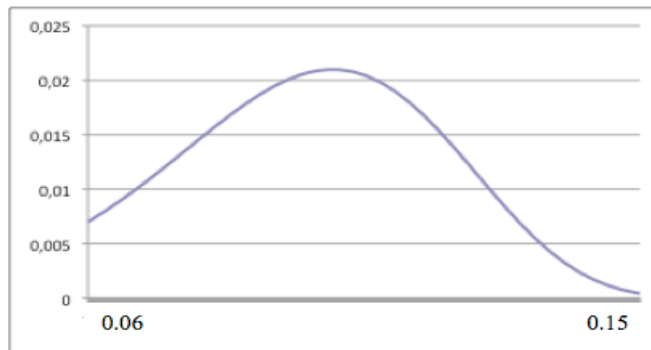
- Model for uncertainty in key variables
- Beta
 - Exploitation Rate (70%)
 - Lobster Prices
- Gamma
 - Natural Mortality (5%-10%)

Beta Distribution, Exploitation Rate



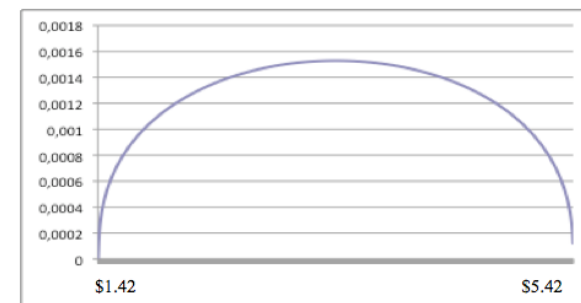
Source : EcoTec Consultants

Gamma Distribution, Molt-Related Mortality



Source : EcoTec Consultants

Beta Distribution, Lobster Prices, Canner, LFA 23

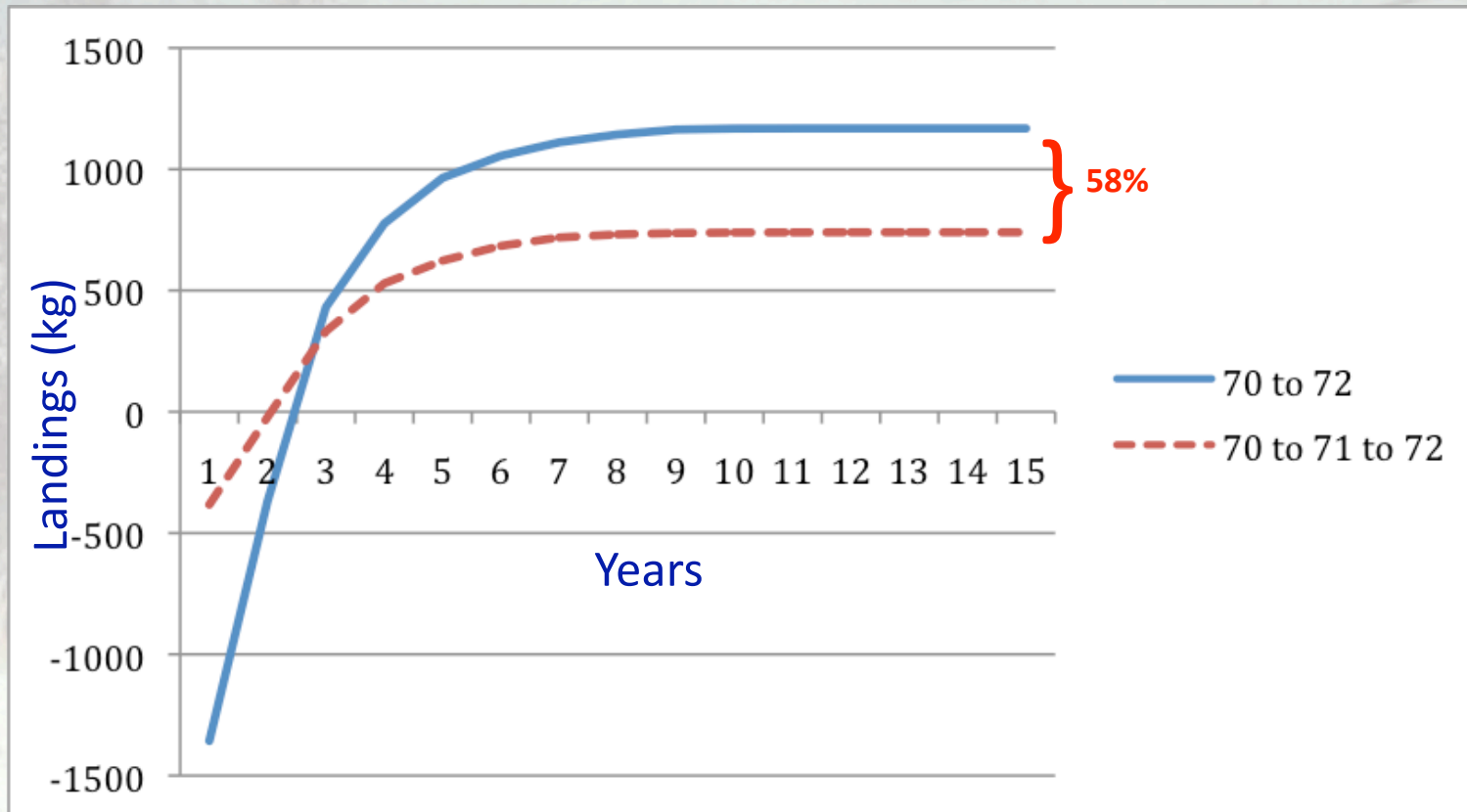


Source : EcoTec Consultants

Increasing the Minimum Legal Size

	Size and Size Increases		
	70 mm	71 mm and 72 mm	72mm
Landings (t)	42.0 (35.1 - 49.1)	42.7 (35.6 - 50.0)	43.1 (36.0 - 50.5)
Percentage difference (vs. 70 mm CL)	---	1.7% (1.5 - 1.8)	2.7% (2.5 - 3.0)
Egg production (in million)	188.9 (153.0 - 226.0)	209.3 (169.1 - 250.9)	222.9 (179.8 - 267.9)
Percentage difference (vs. 70 mm CL)	---	10.8% (10.5 - 11.0)	18.0% (17.5 - 18.5)
Revenues for Fishing Enterprises ('000 \$)	\$330.7 (215.4 - 445.8)	\$338.6 (219.9 - 457.4)	\$343.6 (223.1 - 464.5)
Percentage difference (vs. 70 mm CL)	---	2.4% (2.1 - 2.6)	3.9% (3.6 - 4.2)

Cumulative Differences in Landings



Reduction of the Number of Traps

	Number of Traps		Percentage Change
	250	200	
After-Tax Net Revenues	\$4.21	\$5.70	35.4%
Employment	443	421	-5.0%
Gross Domestic Product	\$12.18	\$13.60	11.6%
Tax Revenues	\$1.03	\$1.23	19.0%
Energy Consumed (GJ)	488.7	439.8	-10.0%
GHG Production (kT)	21.0	18.9	-10.0%

Uses for the Model

- **Bi-directional linkages between anthropogenic activities (including economic) and the lobster biology (= integrated approach)**
- **Bio-economic benefits of measures:**
 - ❖ **Increasing MLS**
 - ❖ **Changes in the fishery**
 - ❖ **Lobster seeding**
 - ❖ **Artificial reefs**

What's next?

- Value-added Sub-sub-module (SSM) for market-shore price links
- Include **Fishing** Employment Insurance
- Social anthropology SSM in the fishing enterprises SM due to the competitively nature of this input fishery (i.e., effective effort to *humanize* the model)
- Ecosystem services; information on land-based anthropogenic activities

Conclusion

Minimum Legal Size

Scenario 1: landings would increase 1.7% versus the *status quo*, with a 2.4% increase in revenues, and a 10.8% increase in the egg production

Scenario 2: BETTER with a 2.7% increase in landings, a 3.9% increase in revenues, and an 18.0% increase in egg production versus the *status quo*.

Conclusion

20% Trap Reduction

- **The 20% trap reduction = 35.4 % increase of net after-tax revenues for fishing enterprises**
- **Generating -5 % in employment**
- **Increase of 11.6% and 19.0% in GDP and Tax Revenues**
- **Better for the PLANET; reduction of 10% for both the energy consumed and greenhouse gas emission.**

Conclusion

Increasing MLS and reducing the number of traps had both biological and economic benefits demonstrating that an integrated approach for a successful Ecosystem-based Fisheries Management of the lobster fishery should include economic objectives in addition to the parameters traditionally included in fishery assessment models (better inputs to fisheries managers)

Questions

The background of the slide is a photograph of a crab on a sandy beach. The crab is positioned in the center-right of the frame, with its large claws and legs visible. To the left of the crab, there is a pile of dark, tangled seaweed. The sand is light-colored and textured. The overall scene is brightly lit, suggesting a sunny day at the beach.

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