Factors Affecting Distribution of the Atlantic Surfclam (*Spisula solidissima*), A Continental Shelf Biomass Dominant, During a Period of Climate Change

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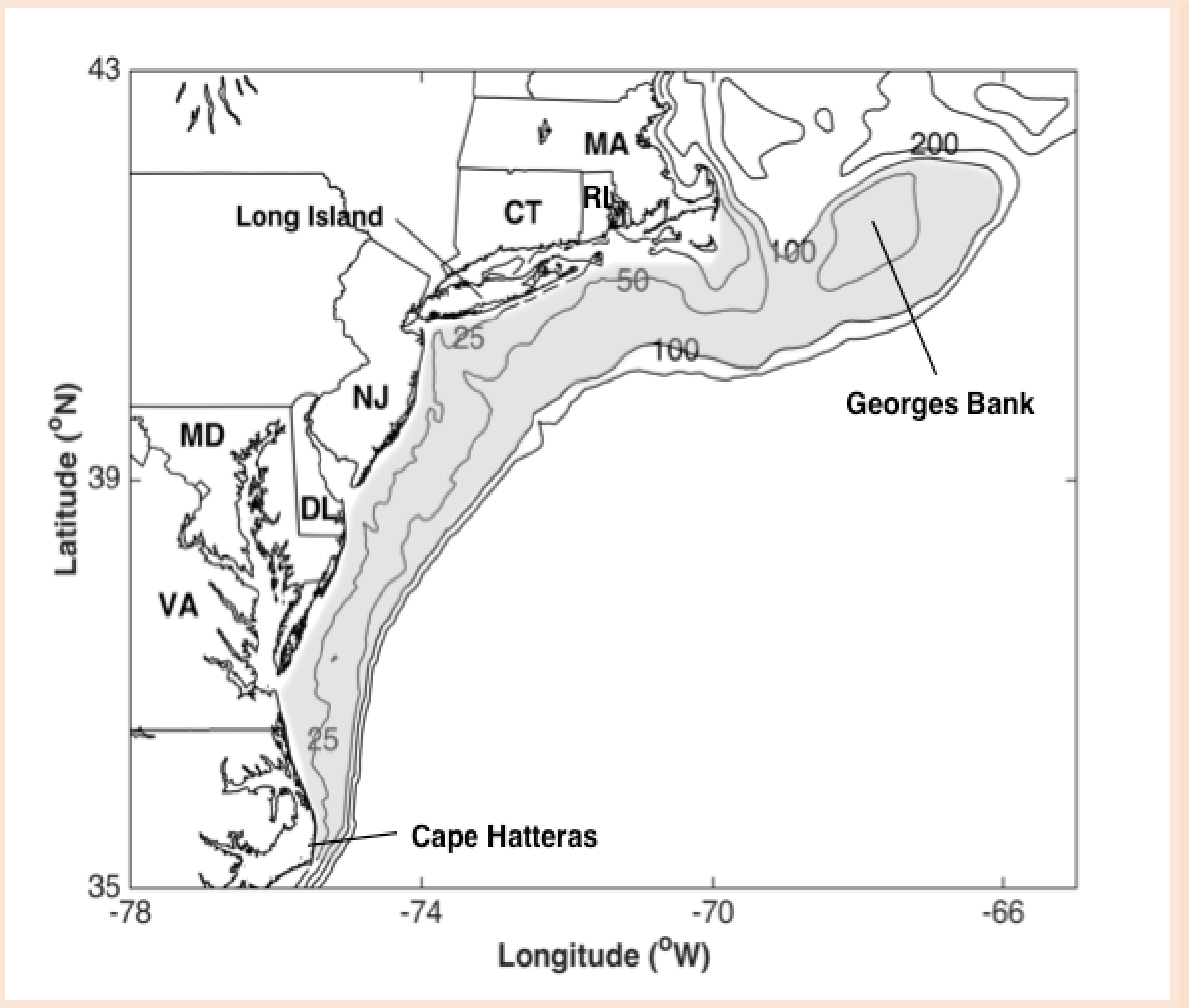
Presentation Outline

- Motivation for study
  - surfclam distribution change
- Management Strategy Evaluation
  - approach
- Surfclam Management Strategy Evaluation
  - mortality gradient
  - dispersion gradient
- Future extensions

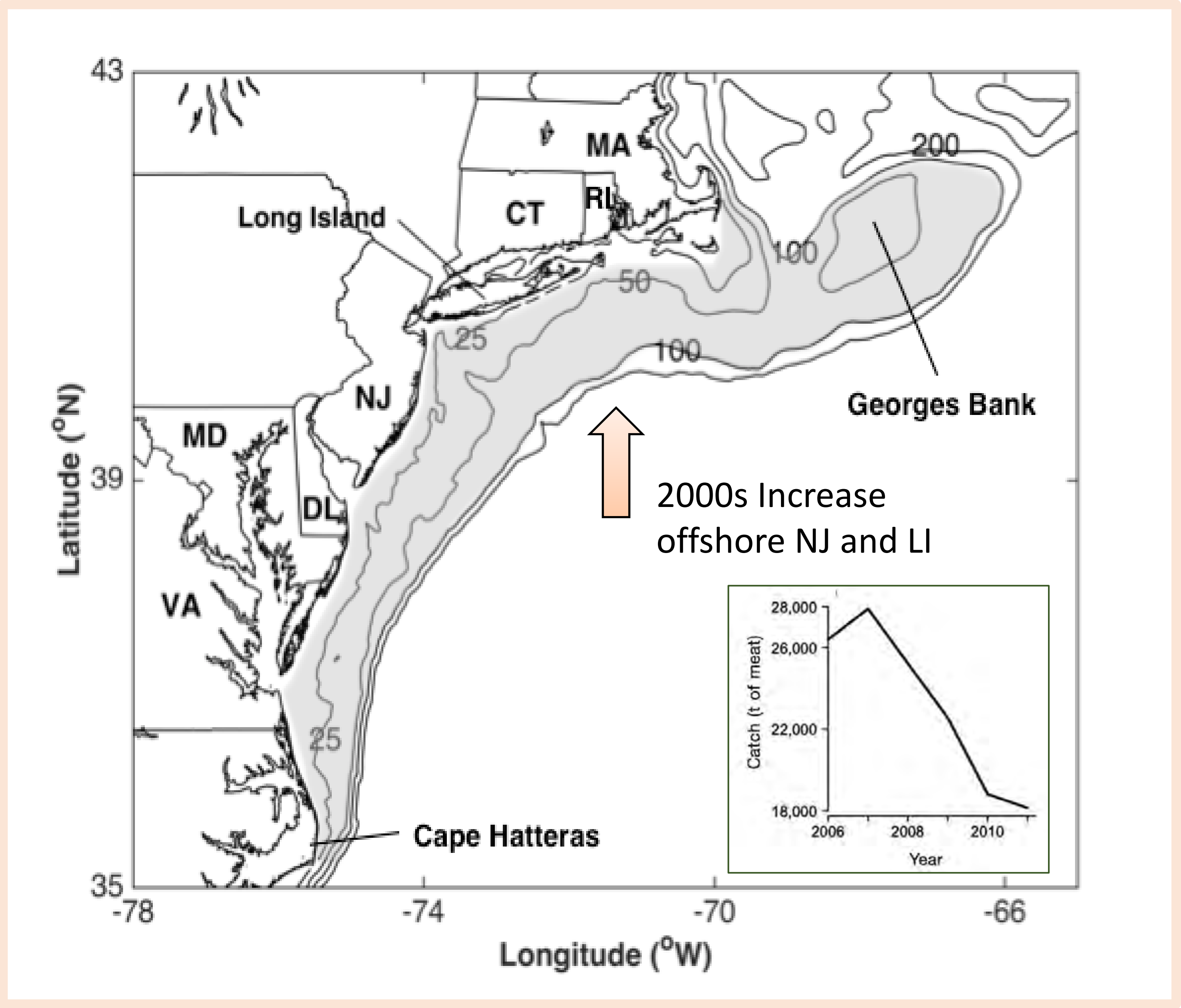


- Atlantic surfclam inhabits continental shelf of eastern North America from Canada to Cape Hatteras at depths of about 10 m to 50 m
- Benthic biomass dominant
- Supports commercial fishery

Early 2000s
Inshore NJ

2000s
Delmarva

1970s to
1980s



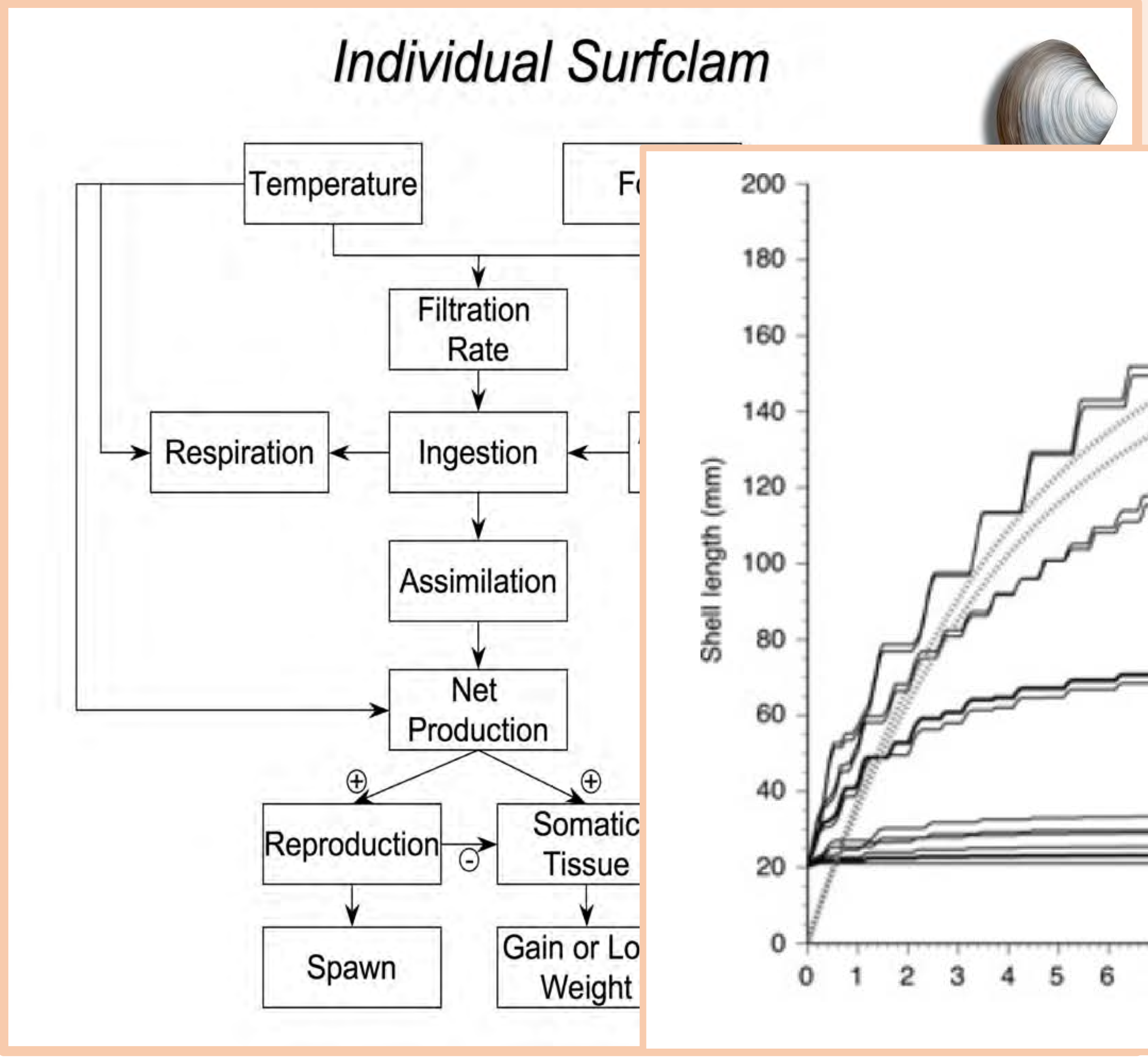
Southern
boundary
receded

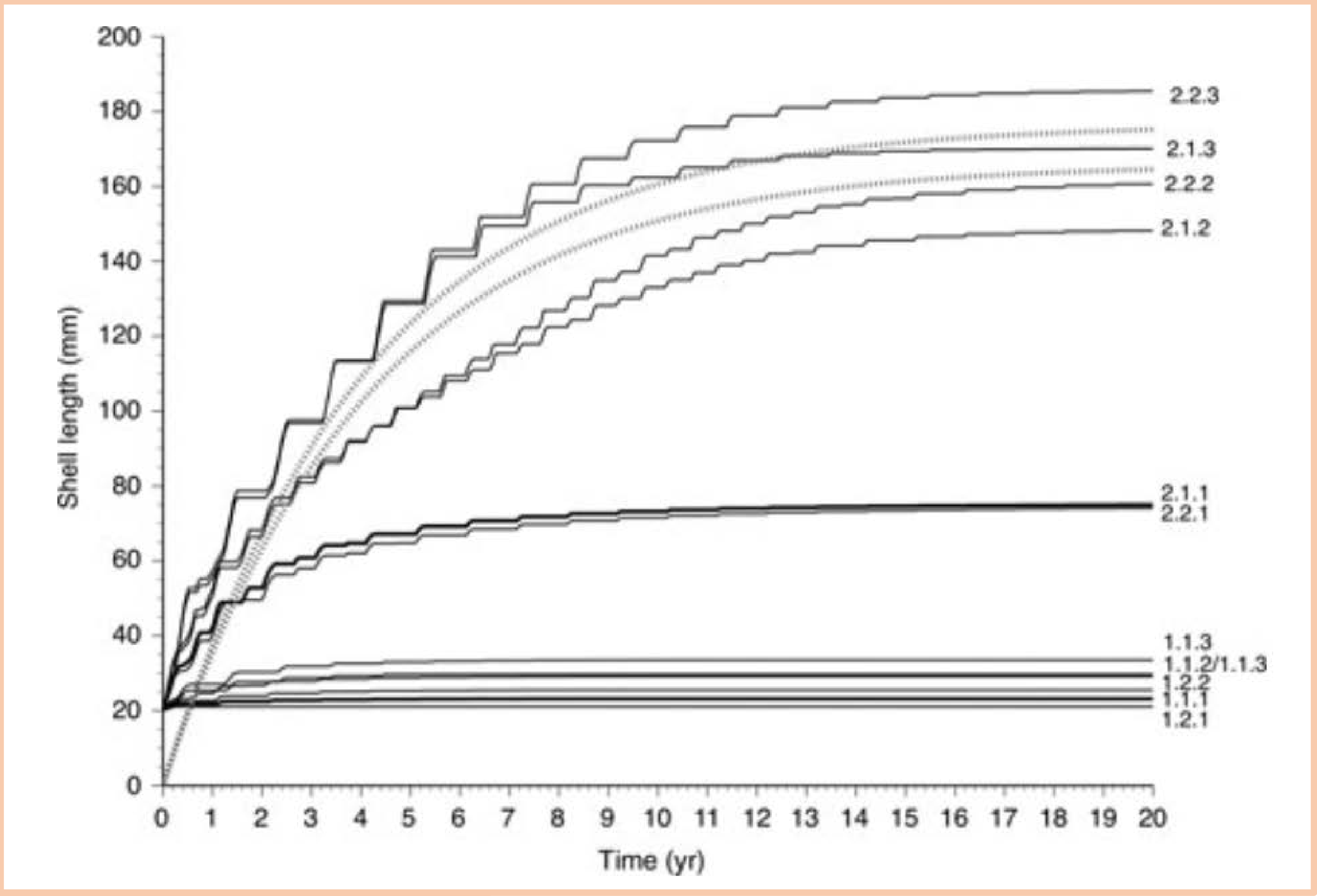
Expanded at
northern
boundary

Expanded
offshore

What Causes Range Change?

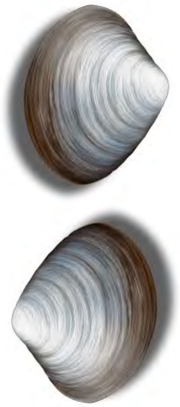
- Fishing mortality (fishery)
- Overfishing (management)
- Long term warming trend of MAB bottom waters (climate)
- Increased mortality and poor animal condition (physiology and environment)
- Increased frequency of episodic warm years (oceanography and meteorology)
- Thermal stress (physiology and environment)
- Assess the role of each factor and interactions


Individual Surfclam
Temperature
Filtration Rate
Respiration
Ingestion
Assimilation
Net Production
Reproduction
Somatic Tissue
Spawn
Gain or Lo
Weight

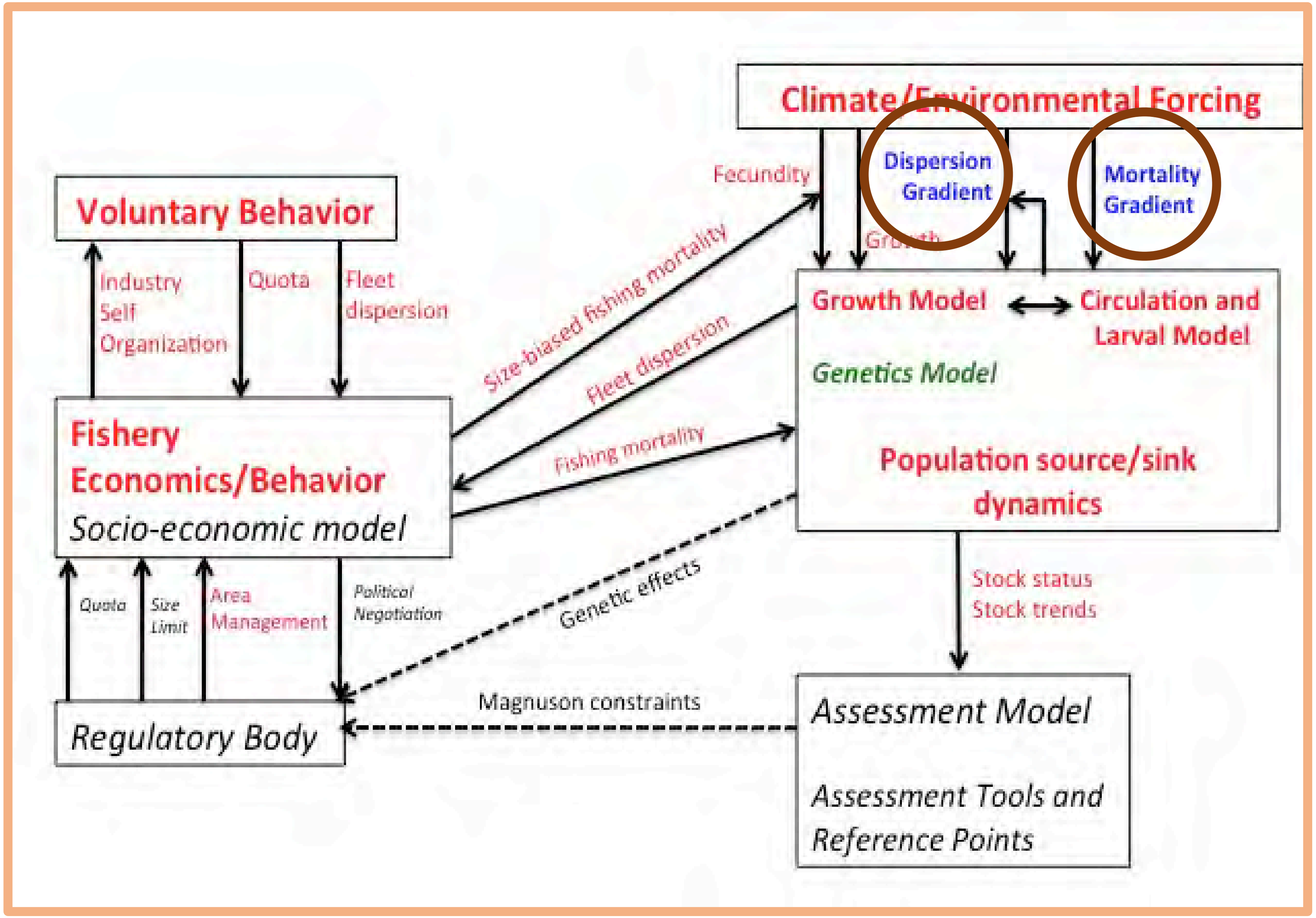

Shell length (mm)
Time (yr)
0
20
40
60
80
100
120
140
160
180
200
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
2.2.3
2.1.3
2.2.2
2.1.2
2.1.1
2.2.1
1.1.3
1.1.2/1.1.3
1.2.2
1.1.1
1.2.1

Other Factors and Controls

- Population is undergoing range shift (space)
- Climate provides external forcing
- Environmental modulation of physiological rates, mortality and dispersion
- Trends in population biomass, mortality, abundance and reproduction
- Fishery and management constraints (quotas)
- Integrate systems and interactions with a consistent set of rules that allow identification of primary pathways and critical linkages

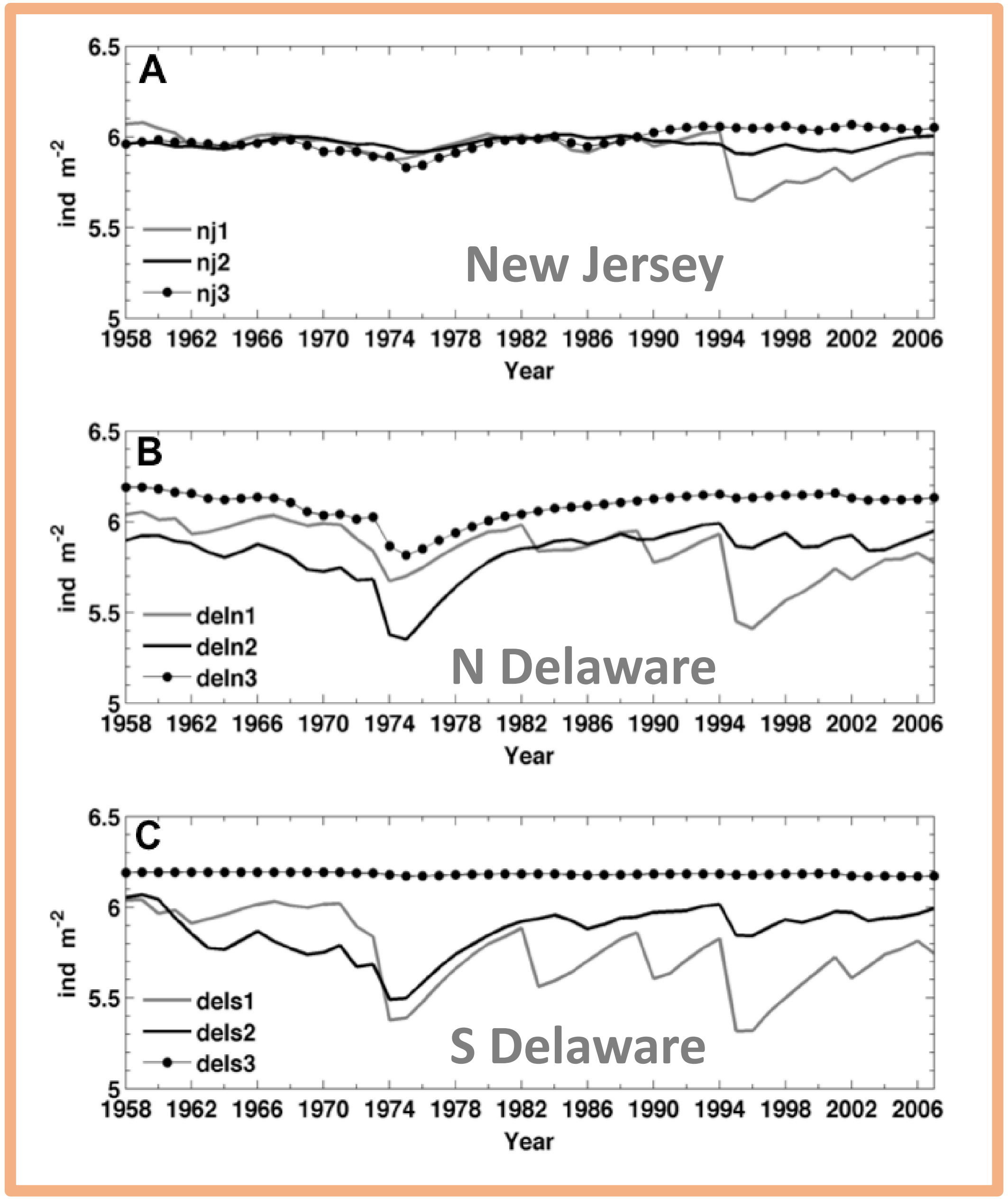


Management Strategy Evaluation

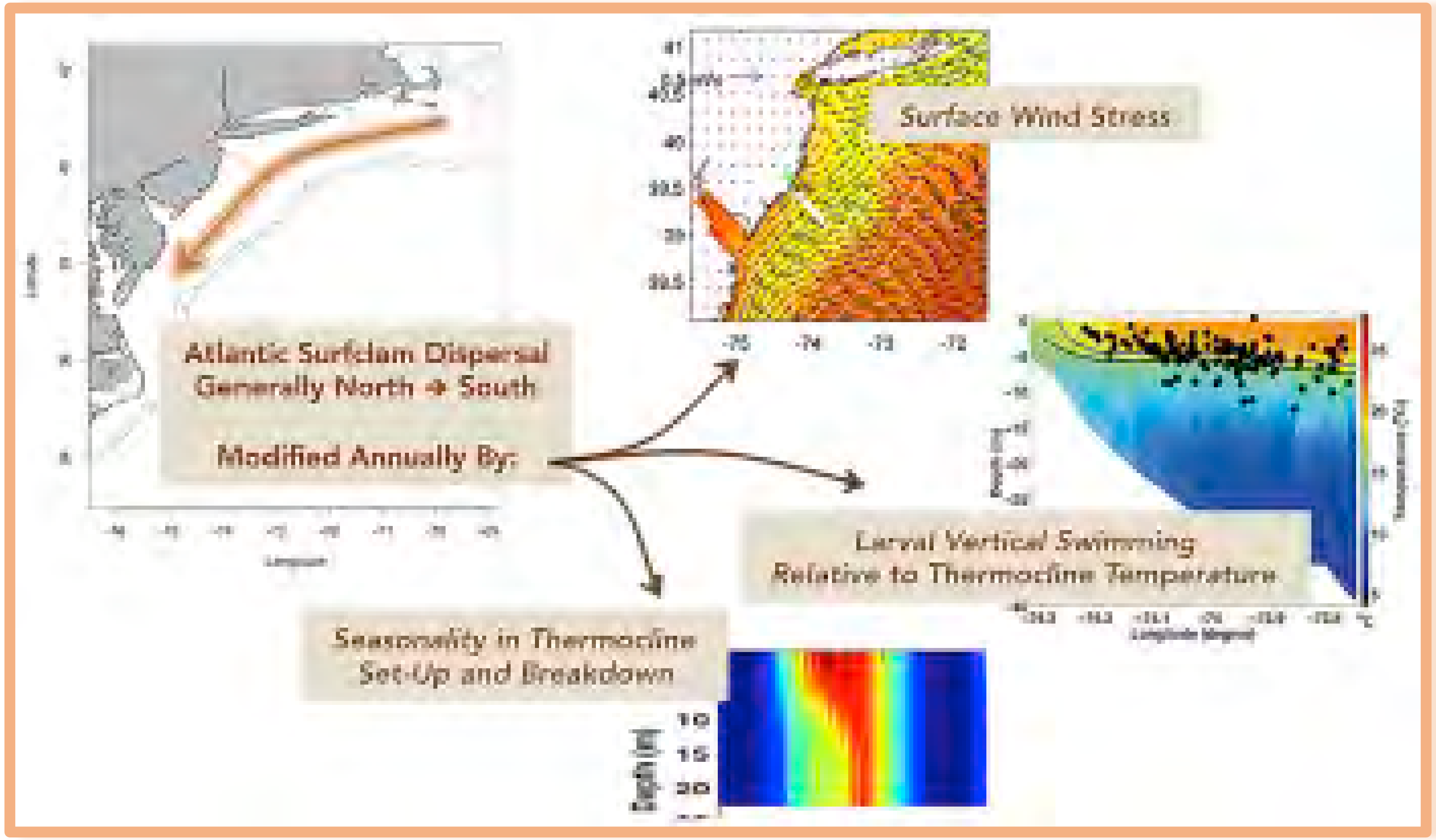


Mortality Gradient

- Narrow optimal temperature range - thermal stress above 20C and growth ceases at 24C
- Temperature-induced starvation along southern boundary – large animals
- Imposes latitudinal and on-offshelf mortality
- Result of increased frequency of warm years along east coast



Narvaez et al. (2015)



Dispersion Gradient

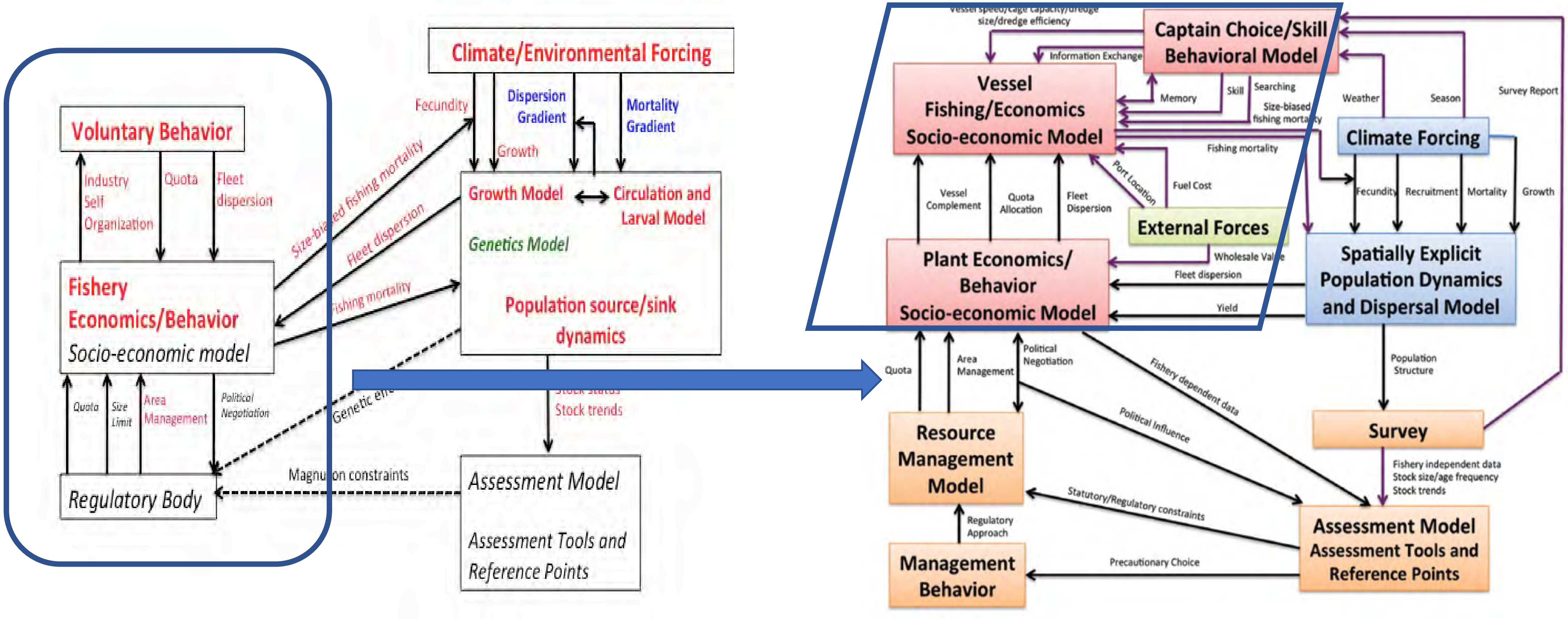
- Larval dispersion
- Connectivity
  - north to south
- Adequate larval supply
- Northward transport inhibited
- Seasonal transport offshore

Graphical Abstract

Zhang et al. (2015)

Surfclam Fishery

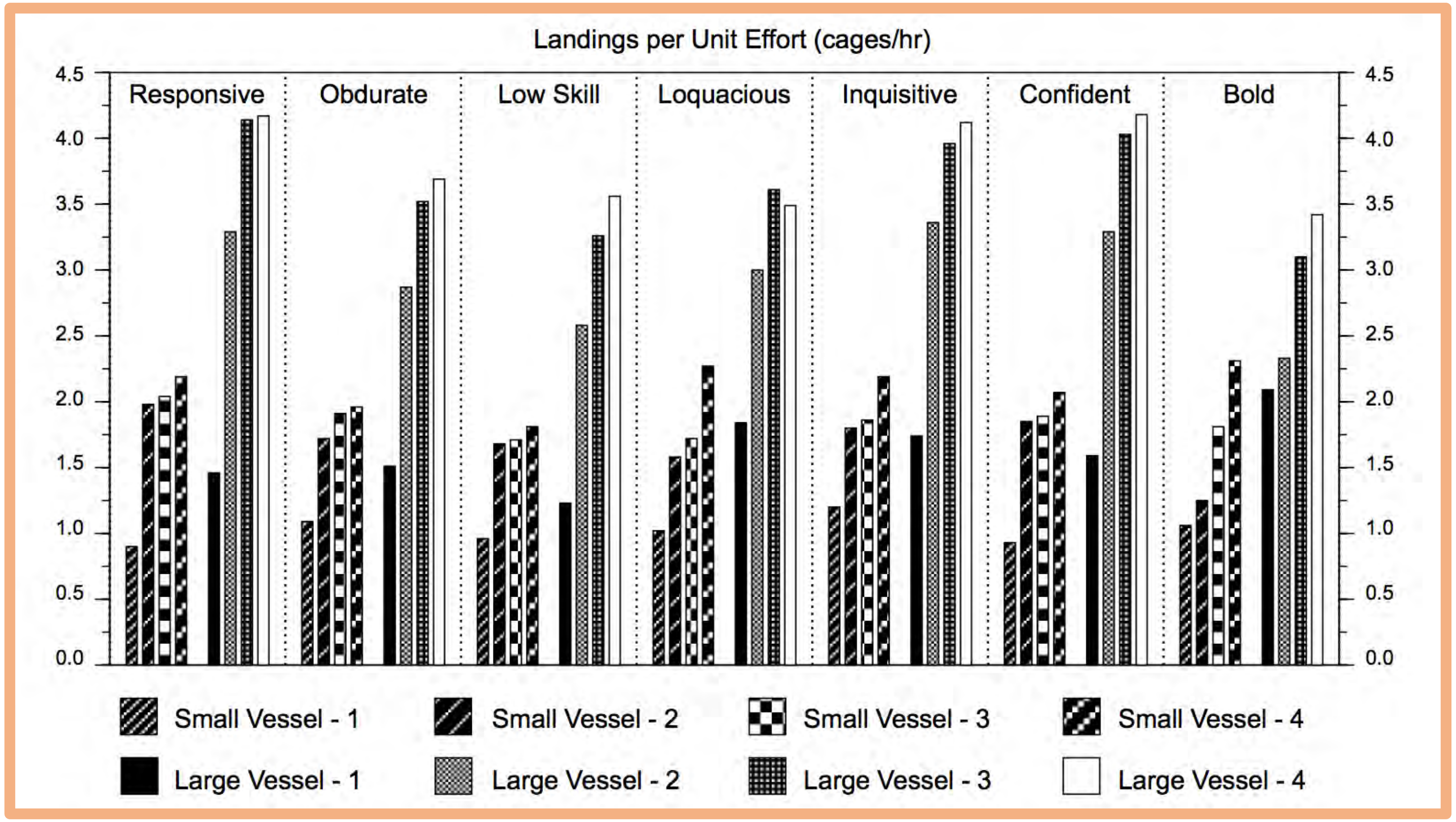
economic and sociological interconnections and responses



Powell et al. (2015)

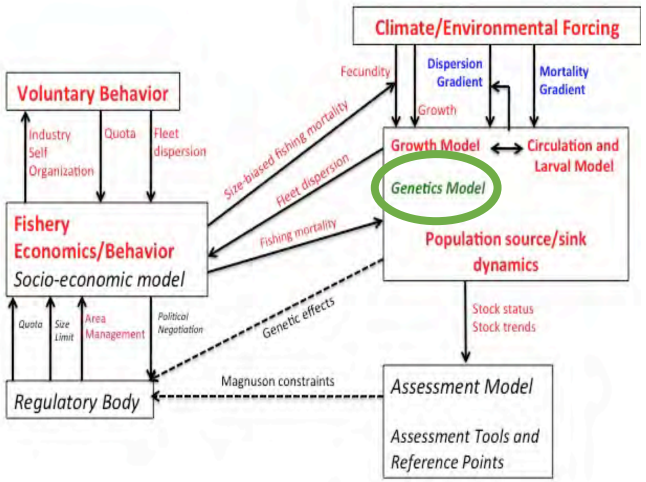
Expanded MSE – Fishing & Management

- Primary challenges facing sustainable management of the surfclam stock and fishery
  - range contraction limits stock abundance
  - decline in the number and density of dense surfclam patches - limits fishing
- Consequences of
  - human behavior
  - vessel type
  - vessel performance
  - port location



Powell et al. (2015)

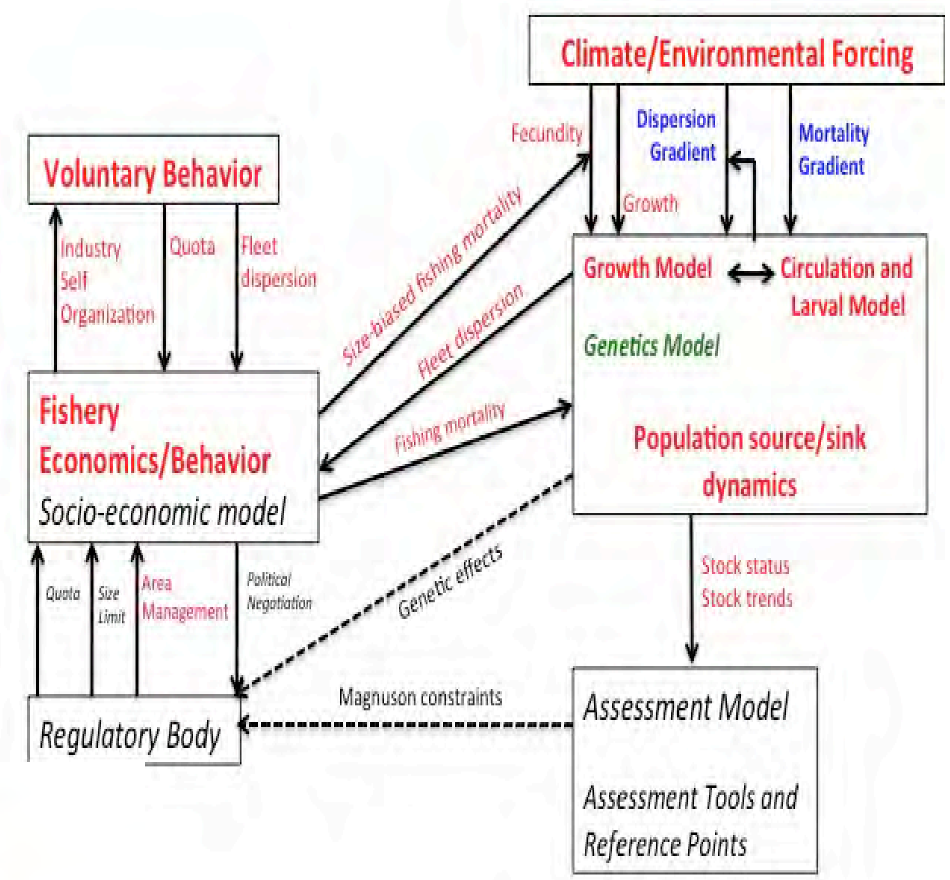
Conclusions



- MSE for shellfish is possible – surfclam
- Identify critical metrics
- Sustaining populations at the north end of the range is difficult because of lack of consistent connectivity
- Assess the impact of and responses to a changing surfclam stock and fishery
- Evaluate management strategies for maintaining a viable stock
- Genetics component - assess likelihood of survival for individual genotypes and evaluation of genetic bottlenecks and fishing in overall population genetic structure

Final Comments

- Models individually and collectively have the skill and robustness to allow scenario evaluation
- Strength of the MSE is linking outputs from many models
- Link scientific understanding and management to develop effective policies and regulations to support a sustainable surfclam fishery
- Effective communication of the range of potential impacts and responses
  - managers, policy makers, and the public



QUESTIONS?