Multiple Stable Points in Oyster Populations

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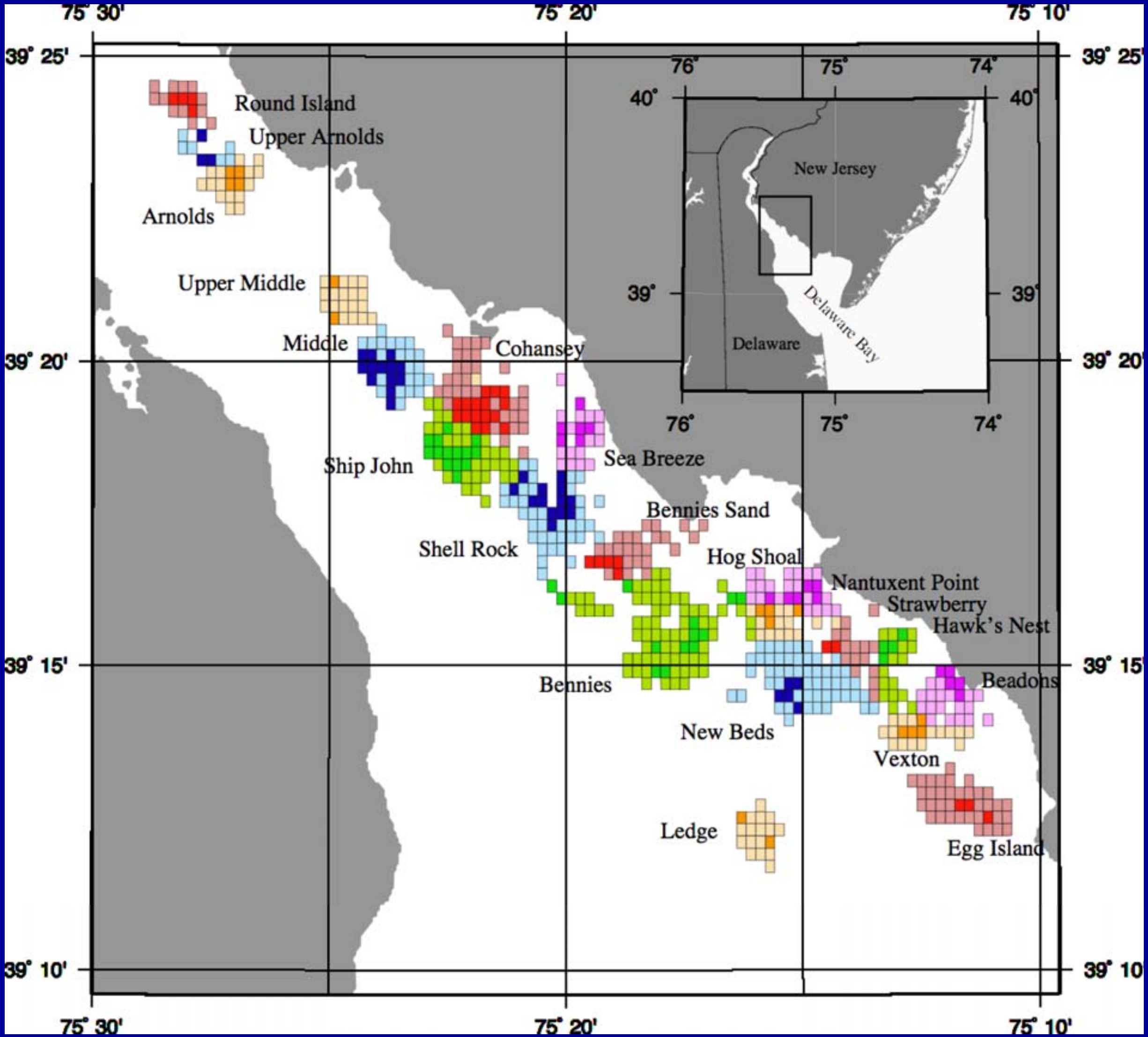
and Biological Reference Points

Delaware Bay Oyster Beds



The Impossible Dream?

Sustainable management of an exploited oyster stock

Is there any hope of it?

The Impossible Hope?

Rebuilding an oyster stock, exploited or not, to historical high abundance

Should we even try?

Oyster Management in Delaware Bay

Database:	Fishery Independent Survey Fishery Dependent Landings Data
Assessment Process:	Terms of Reference Set Stock Assessment Review Committee Identified Stock Assessment Workshop Conducted Advisory Document Released
Management Approach:	Reference Point Based Constant-Abundance Reference Point Used Fisheries Model with One-Year Forward Prediction

The search for biological reference points and rebuilding goals for oyster populations

What Reference Points Are Needed?

msy abundance goals

msy fishing limits

Rebuilding thresholds

What do we need?

Reference based on a relationship between abundance and surplus production!

Why?

Because msy occurs when surplus production is maximal

msy = Maximum Sustainable Yield

Required Facts

A time series of abundance, recruitment and mortality, from which can be derived:

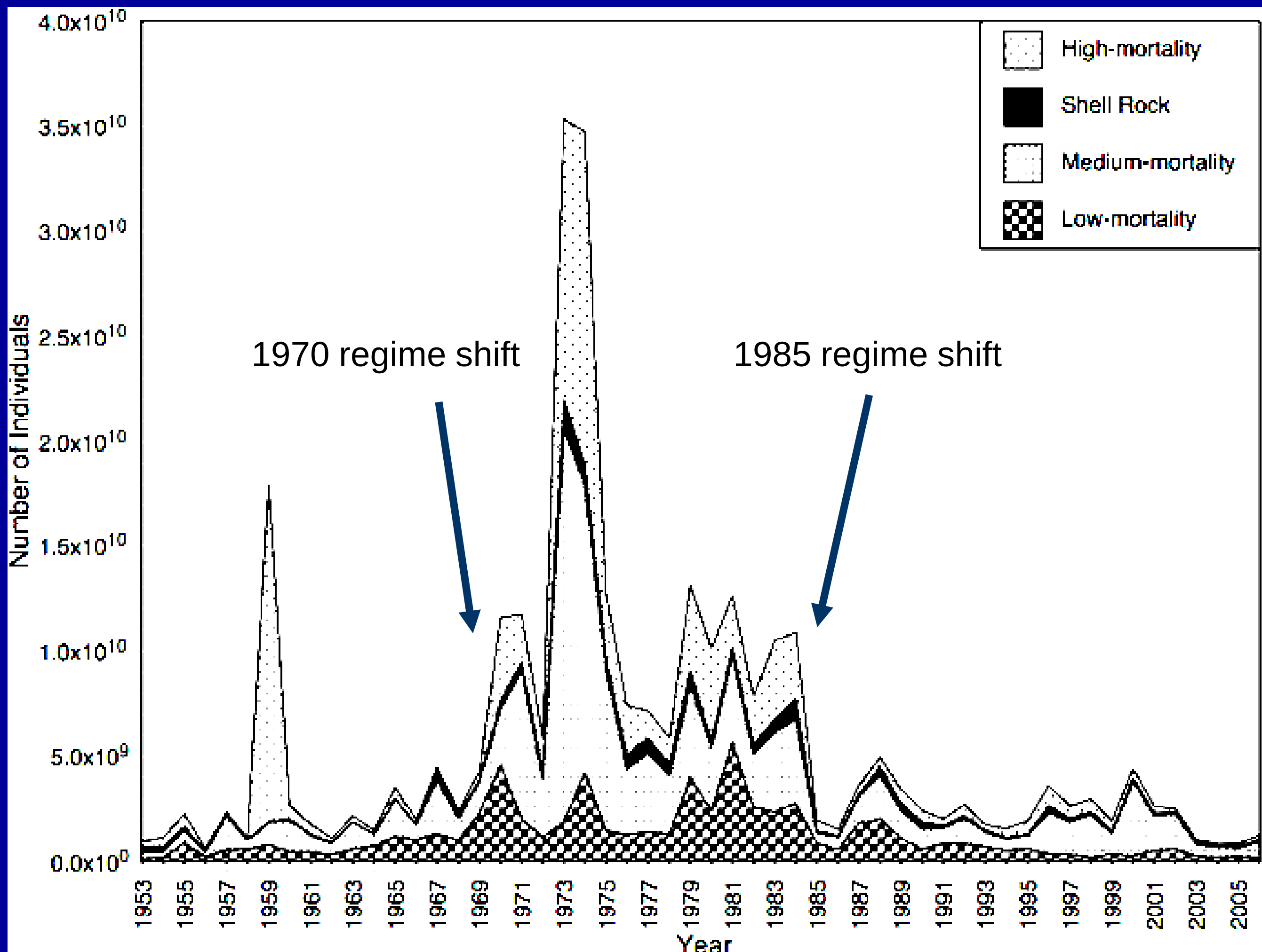
A relationship between abundance and recruitment

A relationship between abundance and adult mortality

A relationship for yearling mortality

The Impediment:

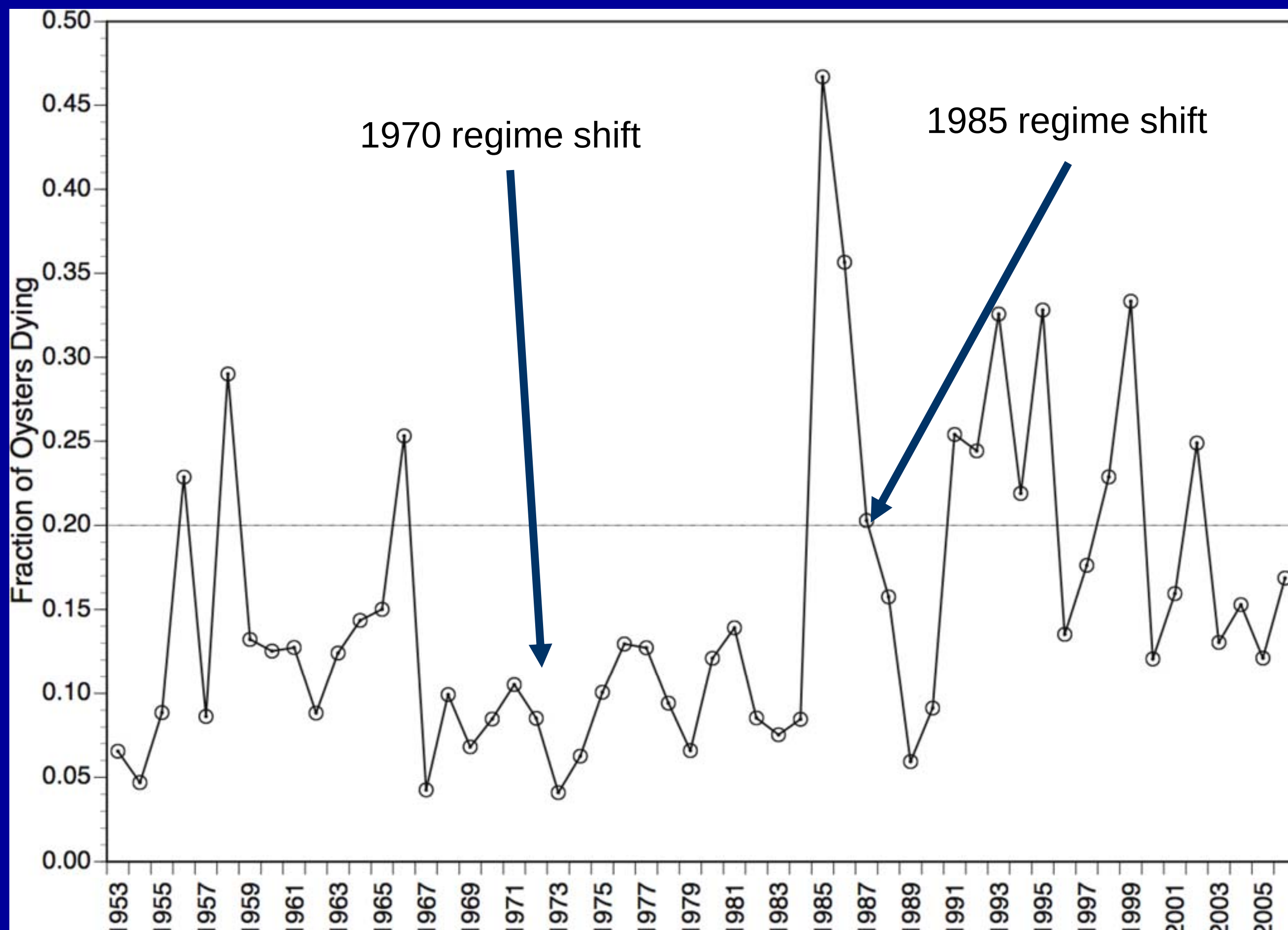
Multiple Stable Points
exist in oyster populations influenced by MSX or Dermo disease



Delaware Bay time series of oyster abundance

Proximate Causes of Regime Shifts
Mortality Events

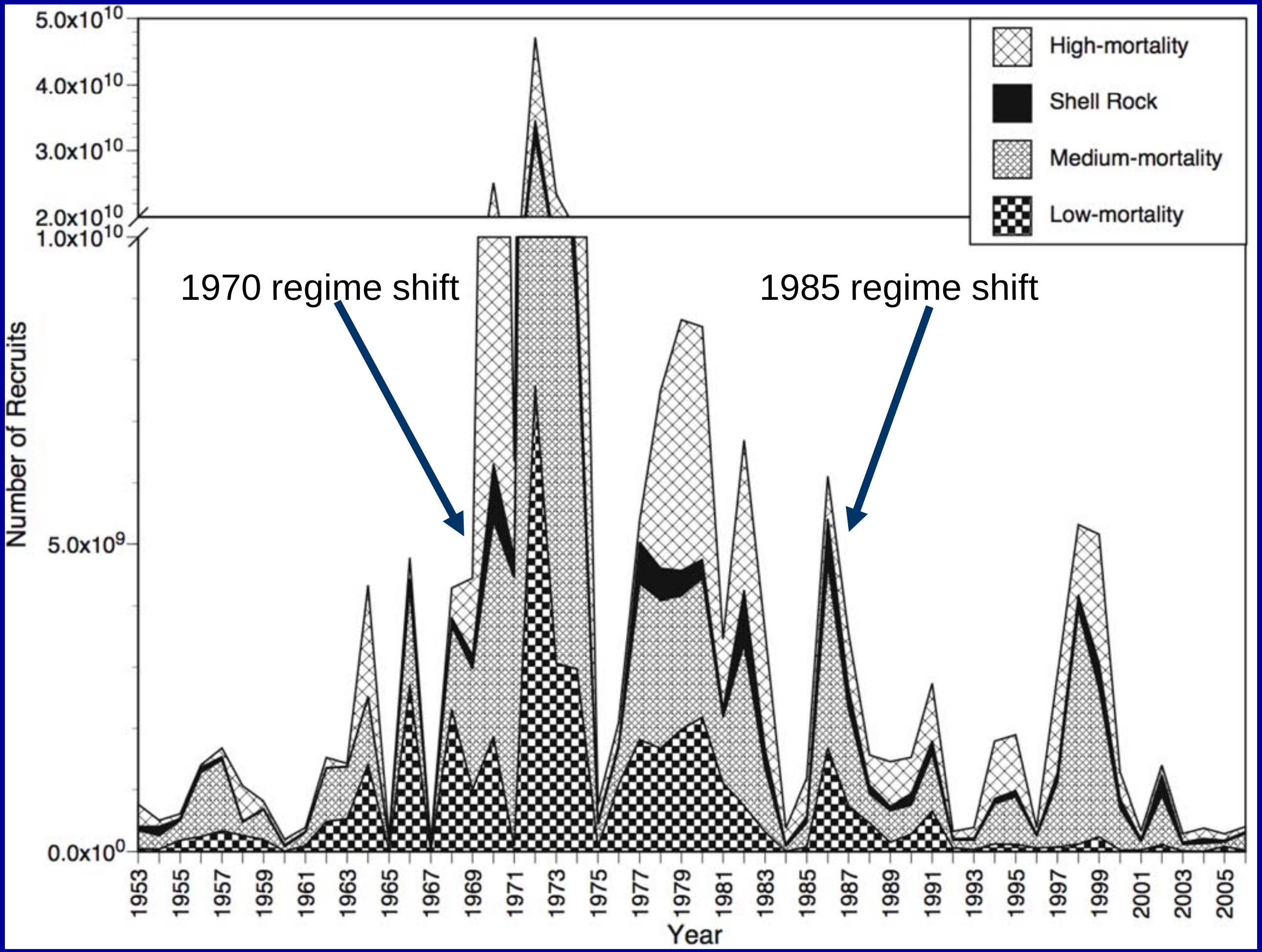
Note that only the 1985 regime shift is apparent



Delaware Bay time series of box-count mortality

Proximate Causes of Regime Shifts
Recruitment Events

Note that the 1970 regime shift is most apparent



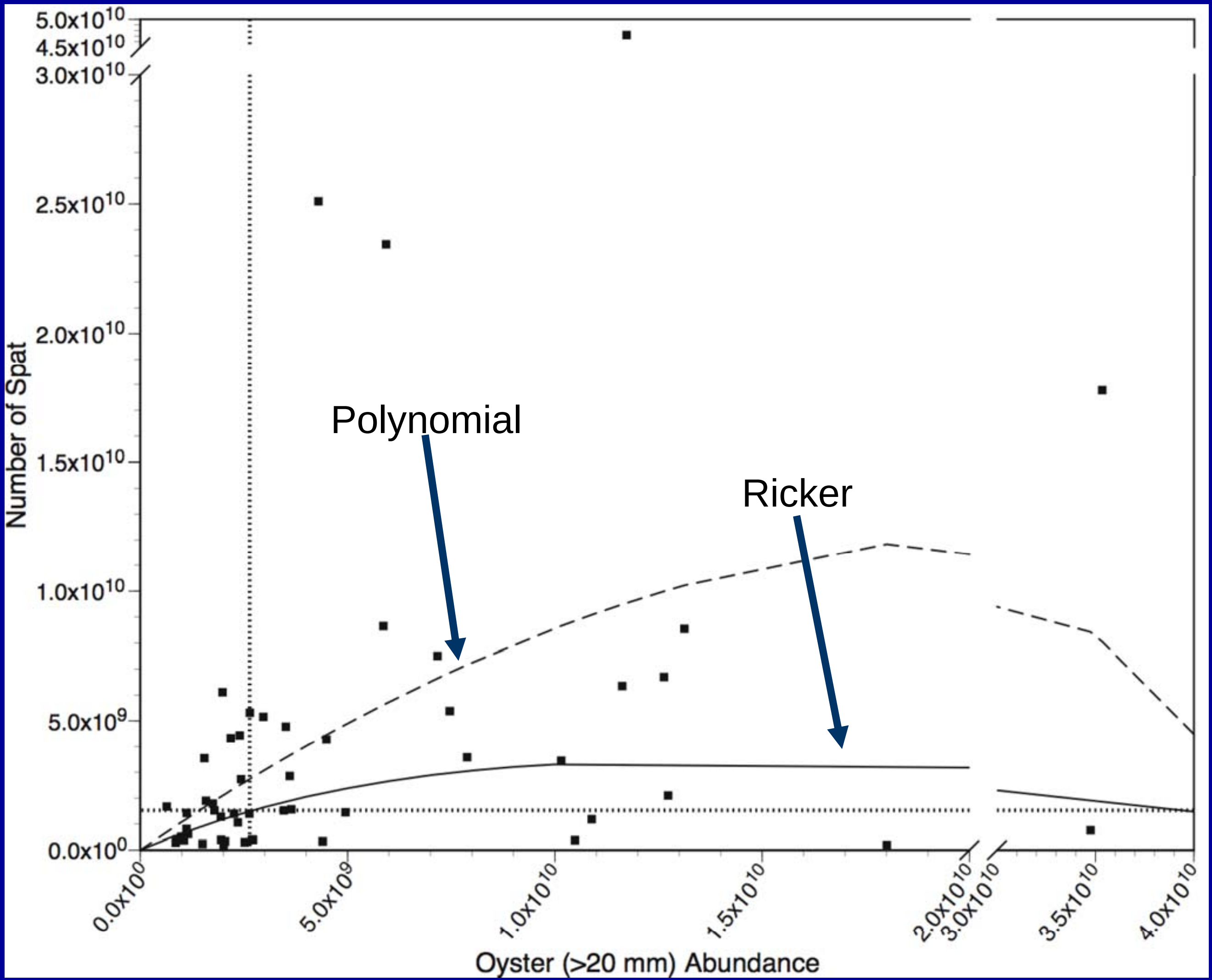
Delaware Bay time series of recruitment

Modeling of Surplus Production

The Goal: To simulate the tendency of the population to expand and contract over a range of abundances?

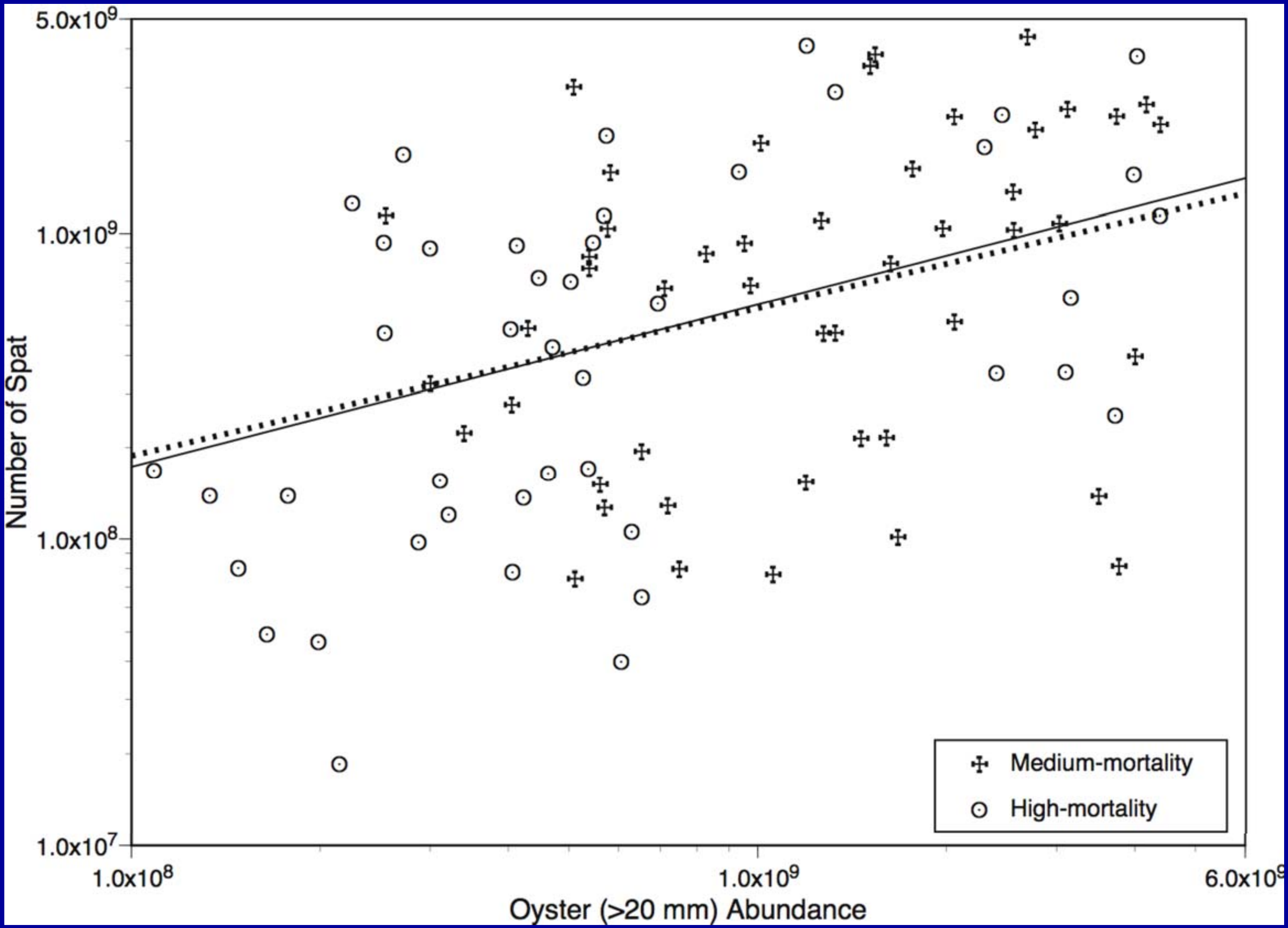
What Are the Necessary Relationships?

Basic Relationship 1: Abundance and Recruitment

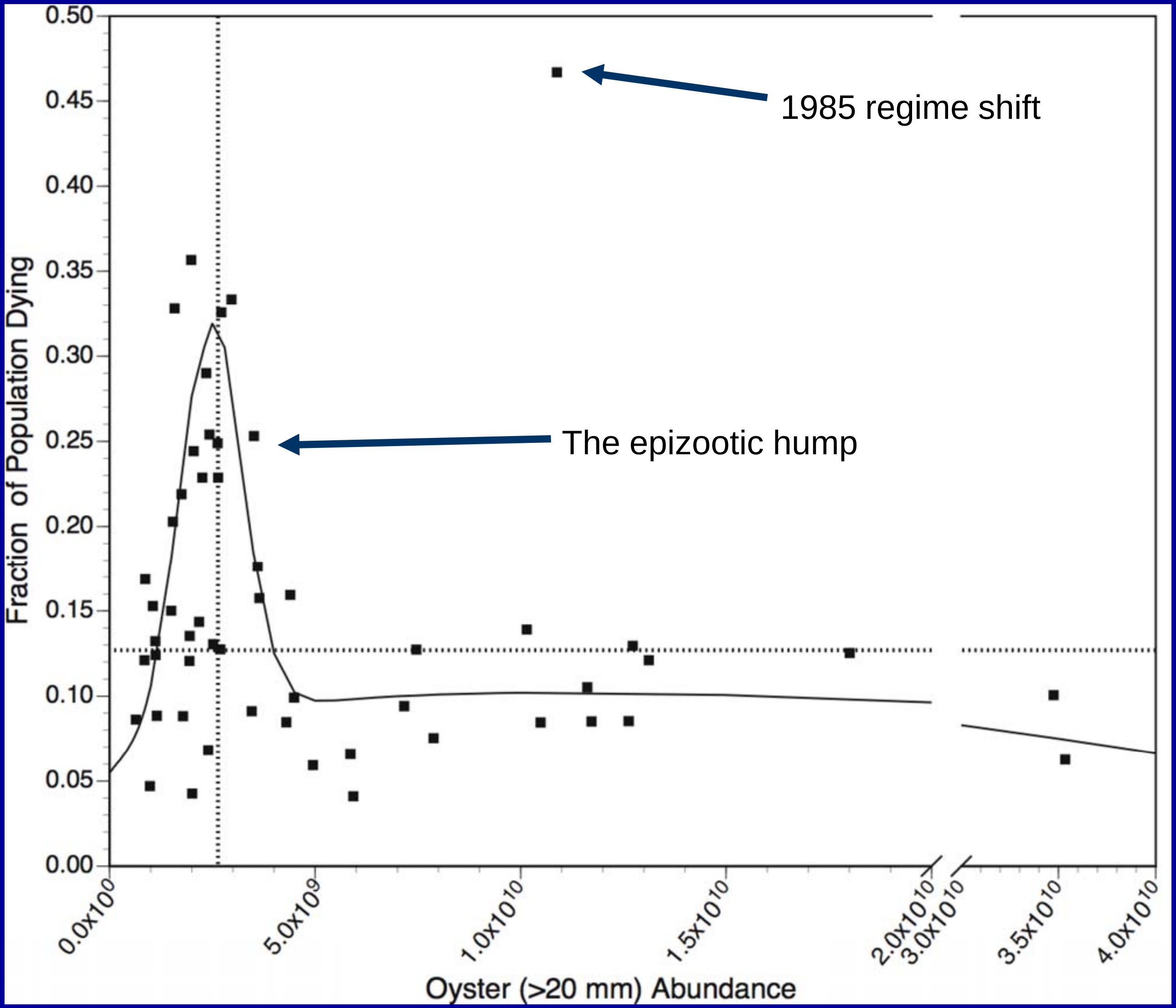


Dotted lines = 54-yr medians

A close-up of the low abundance segment

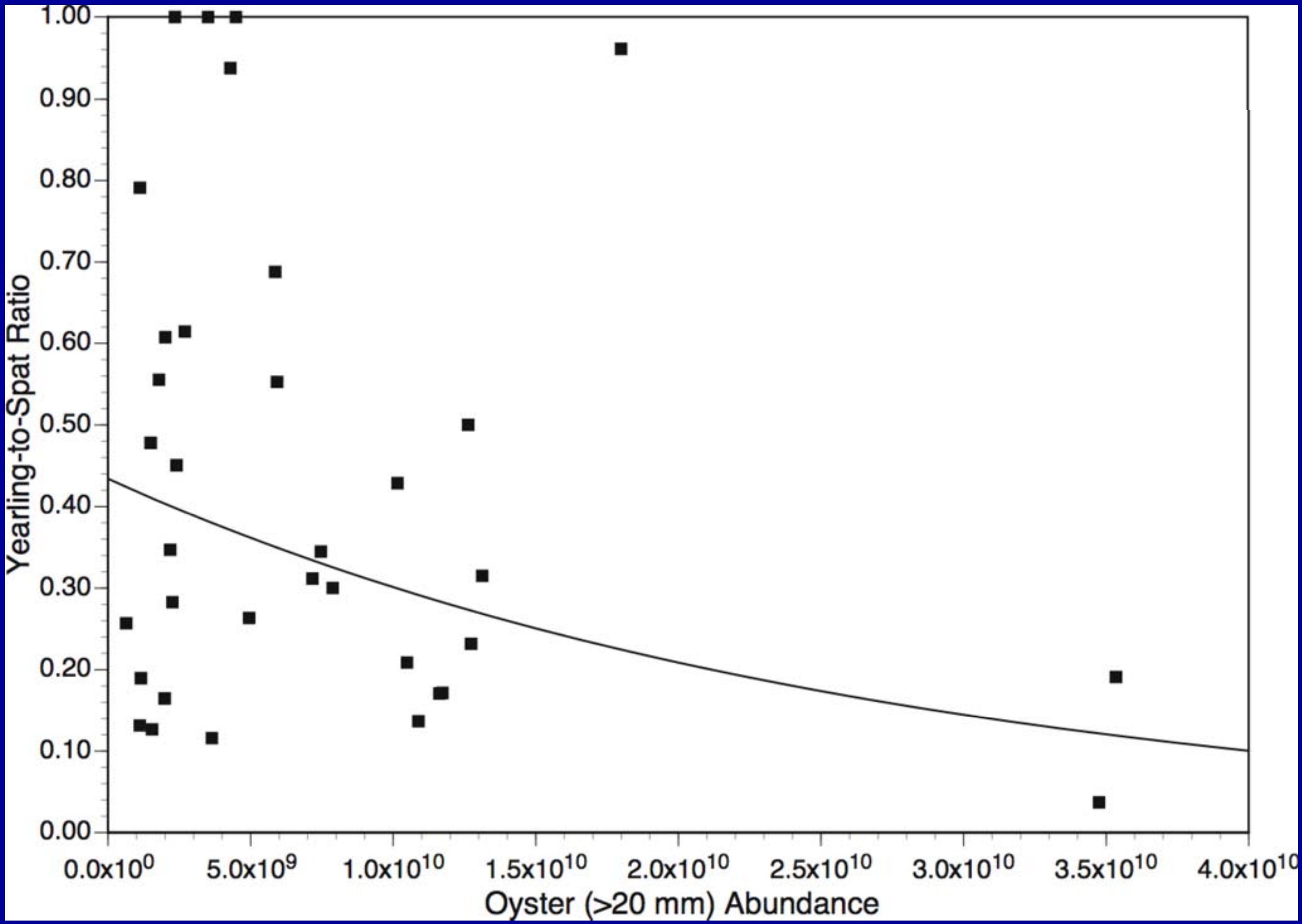


Basic Relationship 2: Abundance and Mortality



Dotted lines = 54-yr medians

Basic Relationship 3: Yearling Mortality

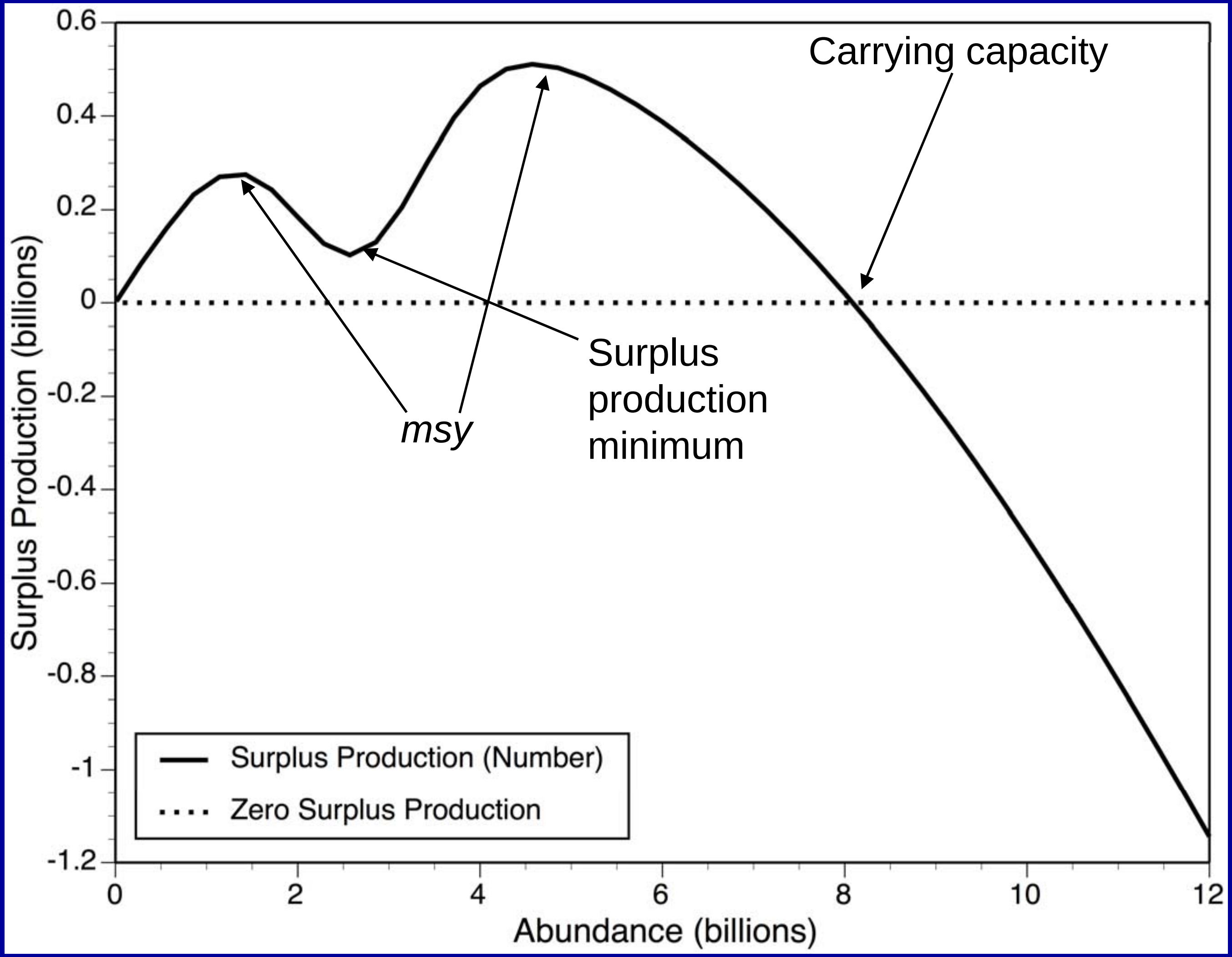


Yearling survivorship

Surplus Production Trajectory 1

- Average yearling survivorship
- Standard abundance-recruitment relationship
- Standard abundance-mortality relationship

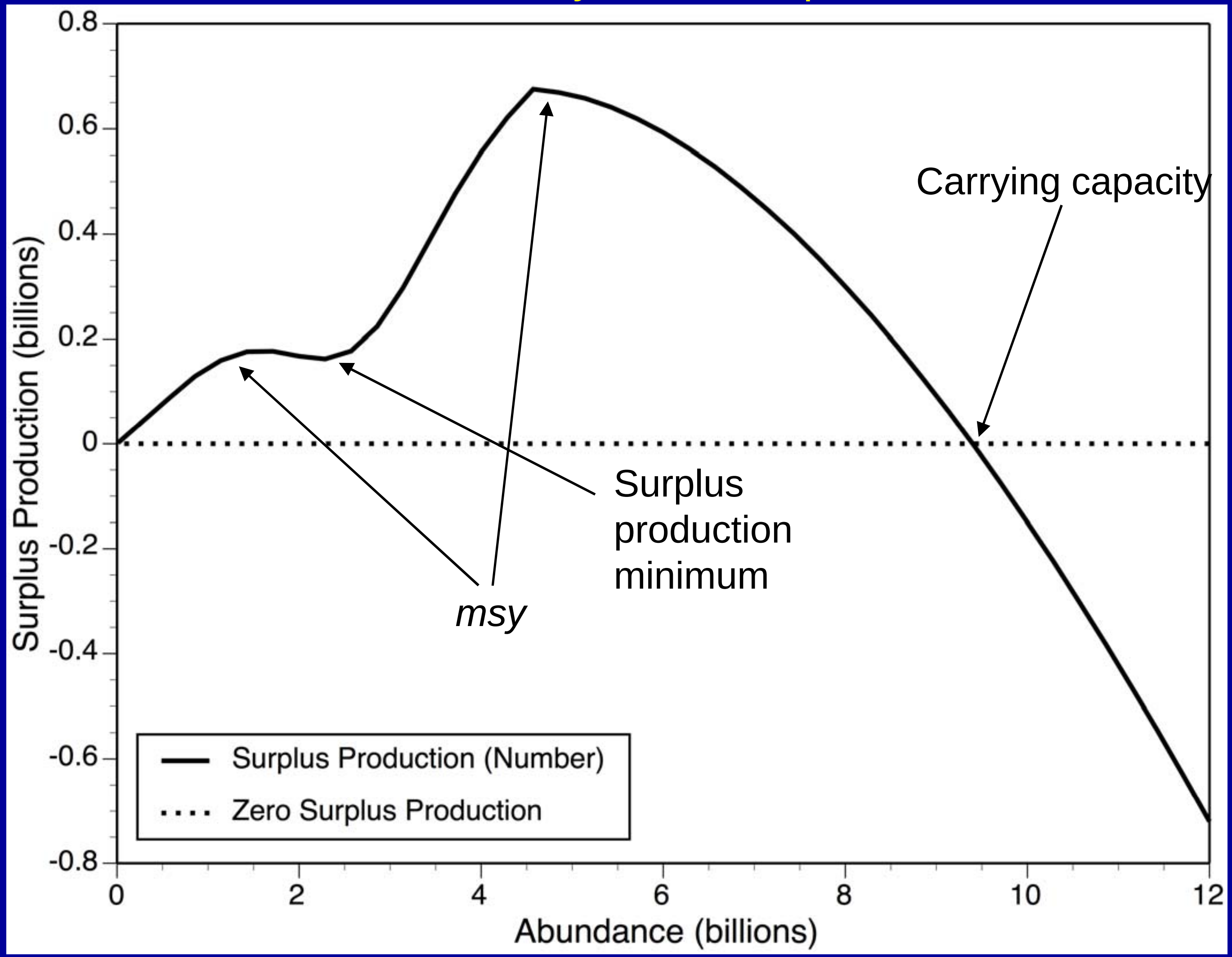
- A single carrying capacity: S = 0
- A minor and a major point of maximum surplus production: S > 0
- A single surplus production minimum: S > 0



Surplus Production Trajectory 2

- Median yearling survivorship
- Standard abundance-recruitment relationship
- Standard abundance-mortality relationship

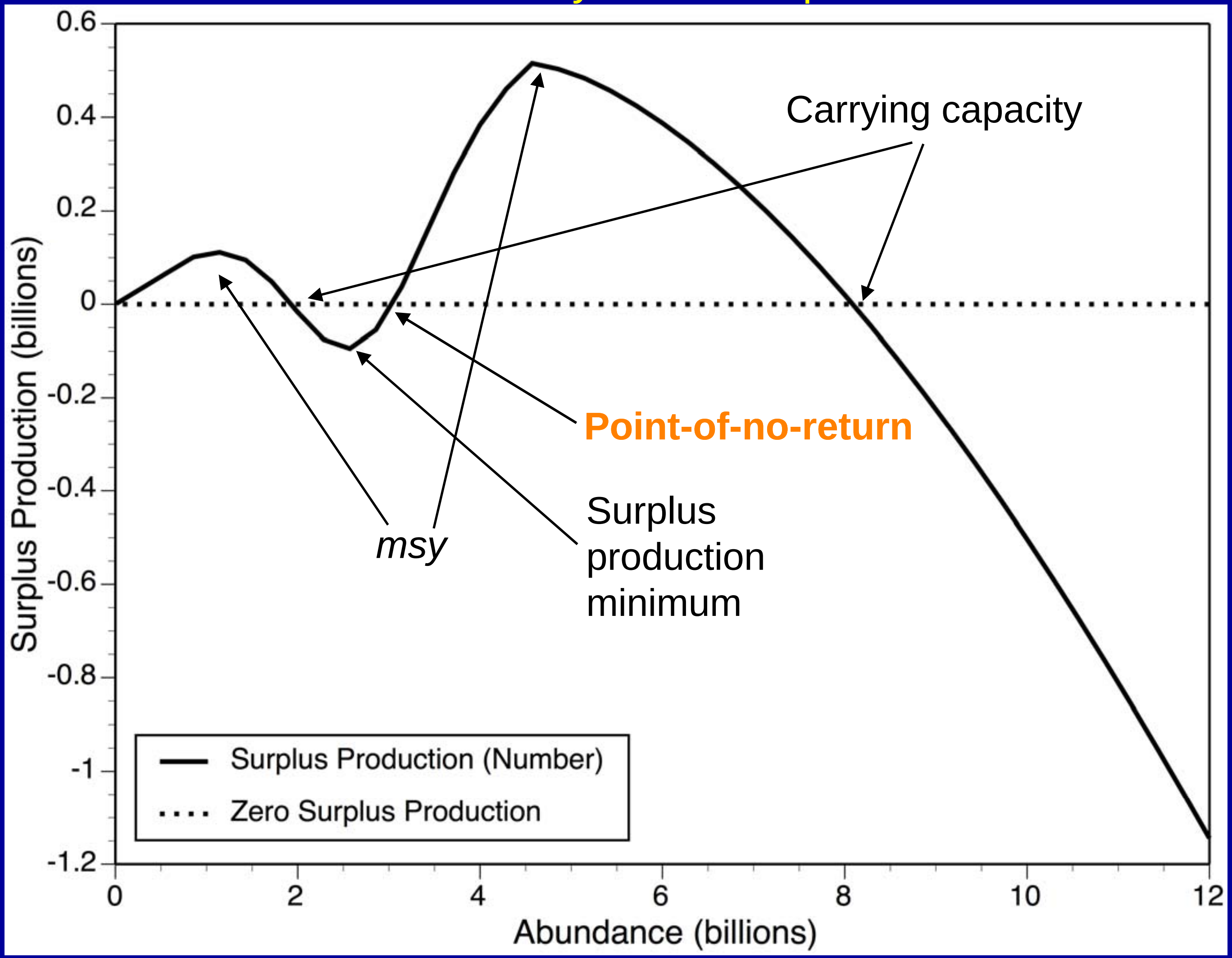
- A single carrying capacity: S = 0
- A minor and a major point of maximum surplus production: S > 0
- A single surplus production minimum nearly equal to the minor *msy*: S > 0



Surplus Production Trajectory 3

- Median yearling survivorship
- Modified abundance-recruitment relationship: slightly reduced recruitment at low abundance
- Standard abundance-mortality relationship

- Two carrying capacities: S = 0
- A minor and a major point of maximum surplus production: S> 0
- A single surplus production minimum: but in this case S < 0
- ***A point-of-no-return: S=0***



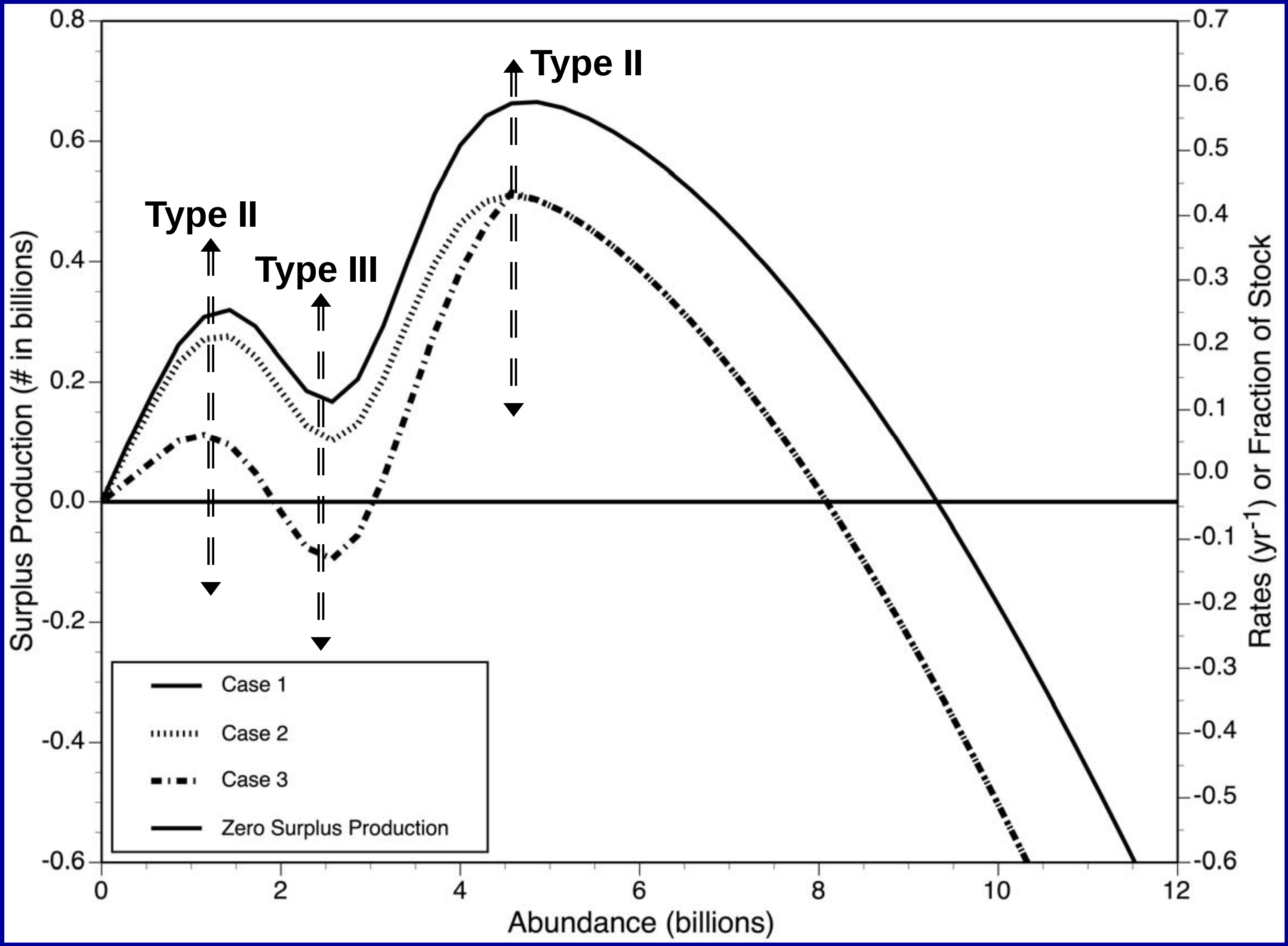
Reference Point Types

- Type I: Carrying capacity: S = 0
- Type II: Surplus production maxima (*msy*): S > 0
- Type III: Surplus production minima: S <, =, or > 0
- Type IV: Point-of-no-return: S = 0

Surplus Production Trajectory Comparison

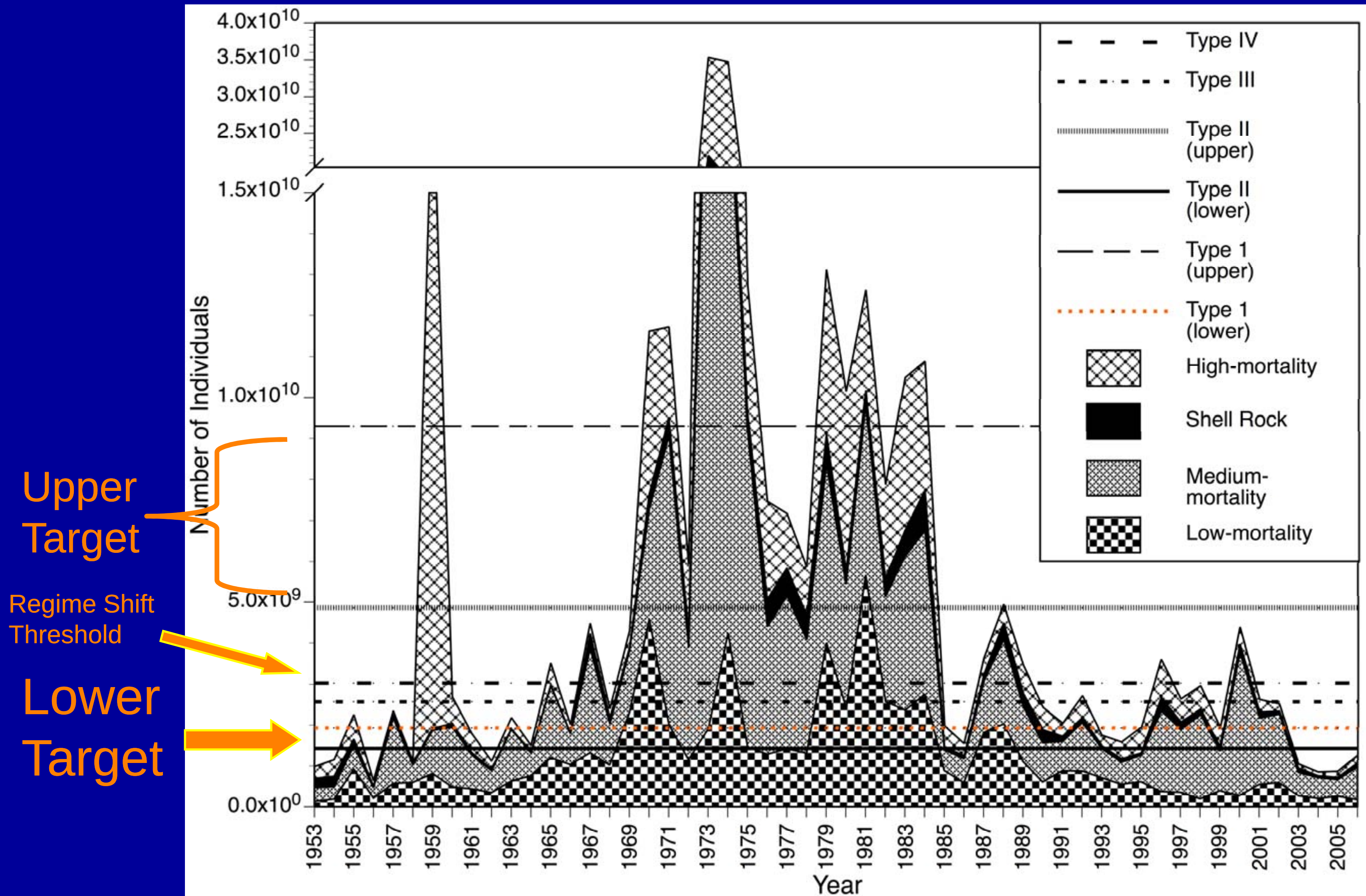
What is certain: Abundance is stable regardless of assumptions

What is uncertain: Surplus production is uncertain for Types II and III (maxima and minima) -- assumption-dependent



Status of the Delaware Oyster Stock

2007 Stock is near *msy* and rebuilding



Conclusions and Management Implications

- The Delaware Bay oyster stock is characterized by multiple stable points. This imposes a series of conundrums for management.
- The amplitude of the differential between the Type II and Type III reference points is a measure of the difficulty of rebuilding and the sensitivity of the population to collapse at high abundance.
- The stability of the two regimes in Delaware Bay suggests that the intervening low in surplus production between the two stable states must be near or below zero. Precautionary management is required at high abundance if a point-of-no-return exists.

Conclusions and Management Implications

- The Type III reference point imposes a conundrum to management in that rebuilding of abundance would require a reduction in fishery yield as abundance increases over a substantive abundance range.

- Abundances defining the four types of reference points are relatively stable over a wide range of uncertainties in recruitment and mortality rates.

- The surplus production values associated with the Type II and Type III reference points are much more uncertain. Thus, different models are needed for short-term forecasts of catch and for establishing long-term abundance goals.

So what does this mean for the Delaware Bay oyster fishery?

- 1996-2006 average catch = 70,300 bu
- 1996-2006 average exploitation rate < 2% of abundance
- 2006-2007 catch (~80,000 bu) exceeds long-term average despite seven years of low recruitment

- Catch at *msy* abundance at F = 2% = 107,000 bu
- Catch☐ at carrying capacity at F = 2% = 144,000 bu