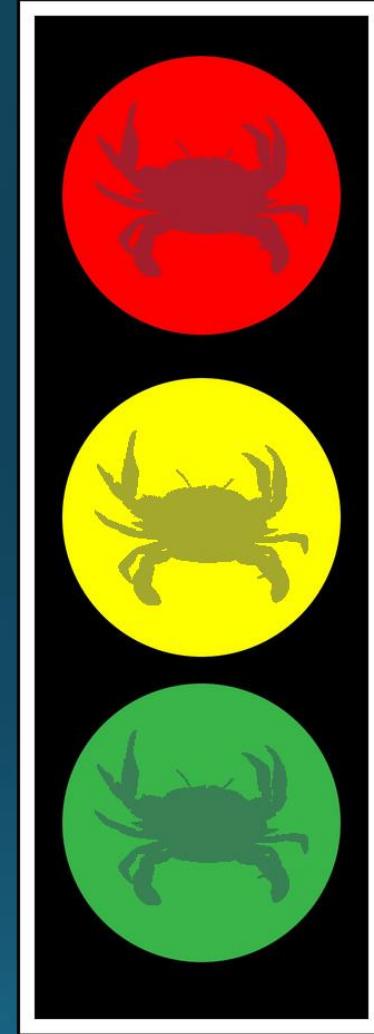


19 March 2019

Gulf States Marine Fisheries Commission TCC Crab
Subcommittee

New Orleans, LA

Traffic Light Analysis of North Carolina's Blue Crab Stock



Traffic Light—Background

- Reduces reliance on data intensive models
- Can result in more timely fisheries management decisions
- Often fewer assumptions than traditional models
- Simple representation of multiple data sources (both quantitative and qualitative)
- Not unique to N.C. blue crab
 - Invertebrates (e.g., Northern shrimp, broadtail shortfin squid, snow crab)
 - Finfish (e.g., Atlantic croaker and spot as management trigger)

Outline

- Dimensions
- Attributes & indicators
- Scaling
- Integration into characteristics

Dimensions

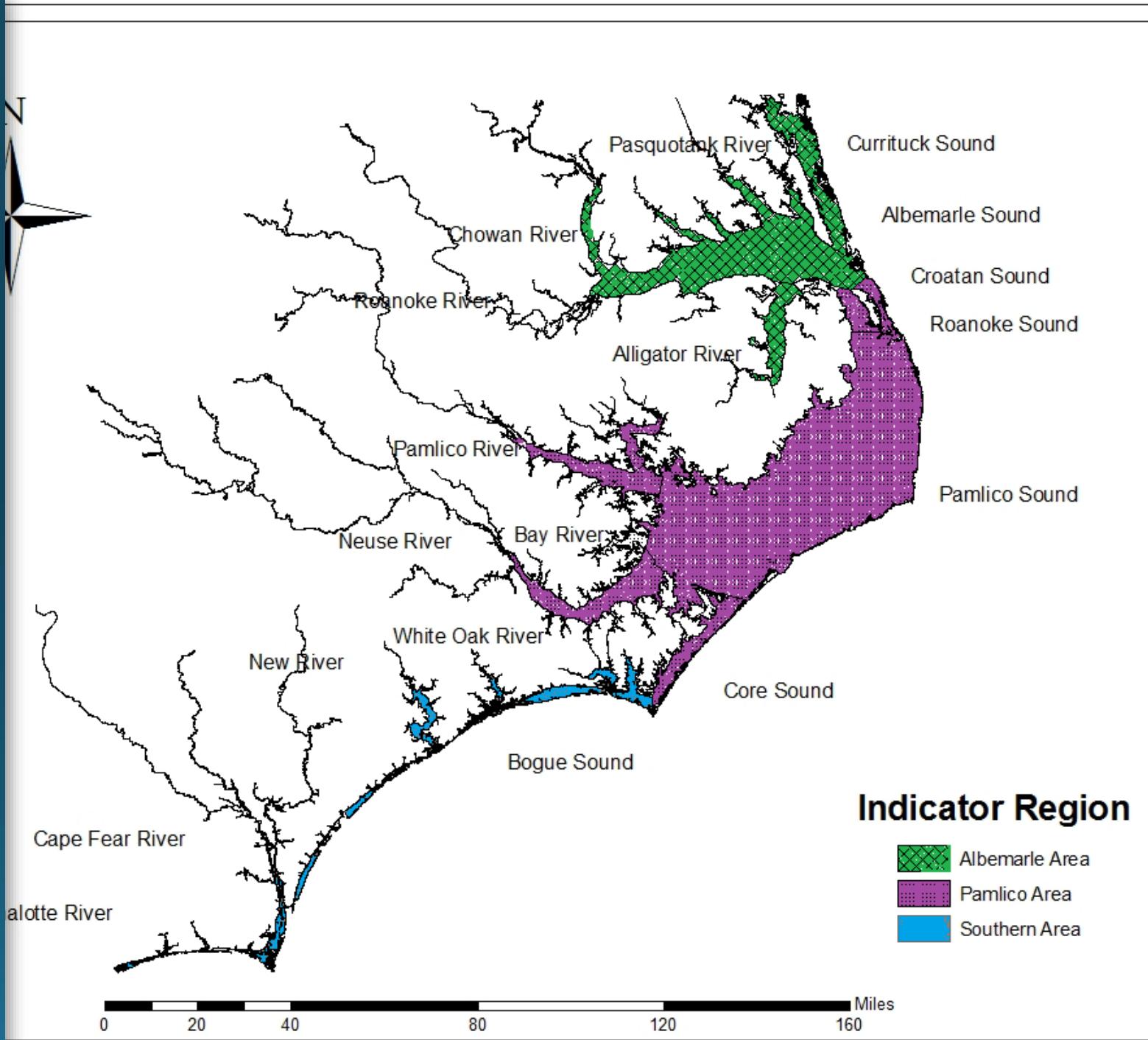
- Time series
- Geographic range

Dimensions—Time Series

- Baseline: 1987 through 2009
- Baseline time period should ideally be representative of range of stock dynamics
- Color assignment is relative to baseline time period

Dimensions— Geographic Range

- Unit stock: all blue crabs occurring within North Carolina coastal fishing waters
- Three regions
 - Albemarle (27%)
 - Pamlico (66%)
 - Southern (7.0%)



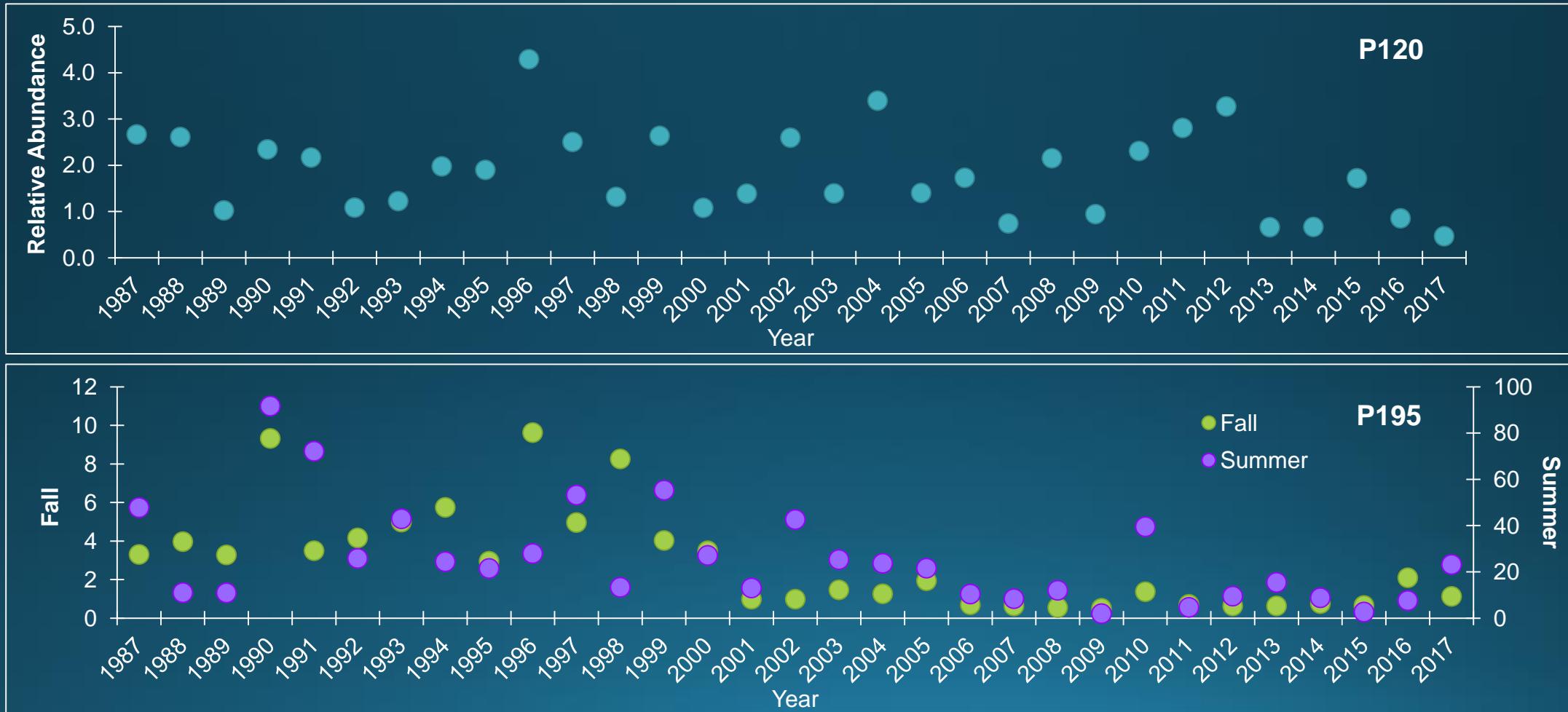
Attributes & Indicators

- An **indicator** is a measure of some **attribute** of the population; often based on a time series
- Typically calculated from raw data
- Multiple indicators may be available for a single attribute

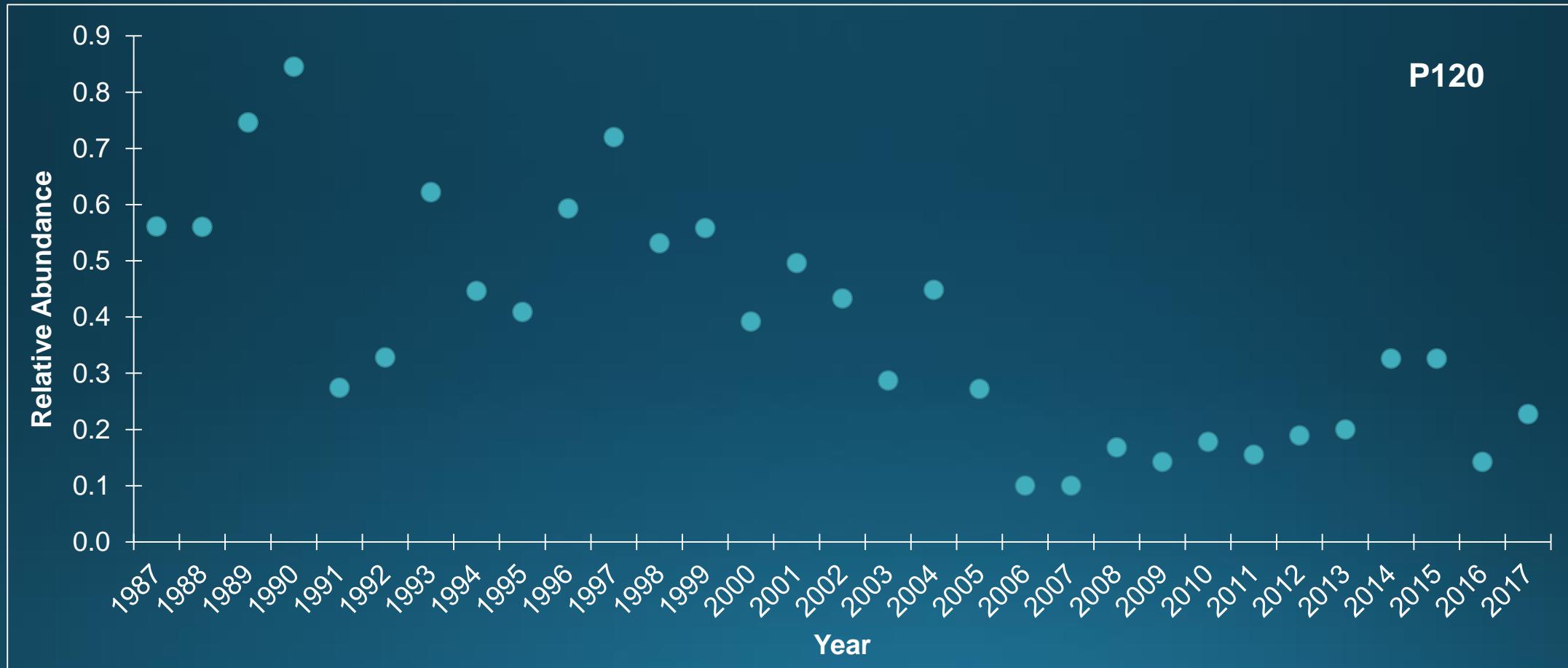
Indicators—Recruitment

- Albemarle
 - None
- Pamlico
 - Program 120
 - Program 195 summer
 - Program 195 fall
- Southern
 - Program 120

Indicators—Recruitment (Pamlico)



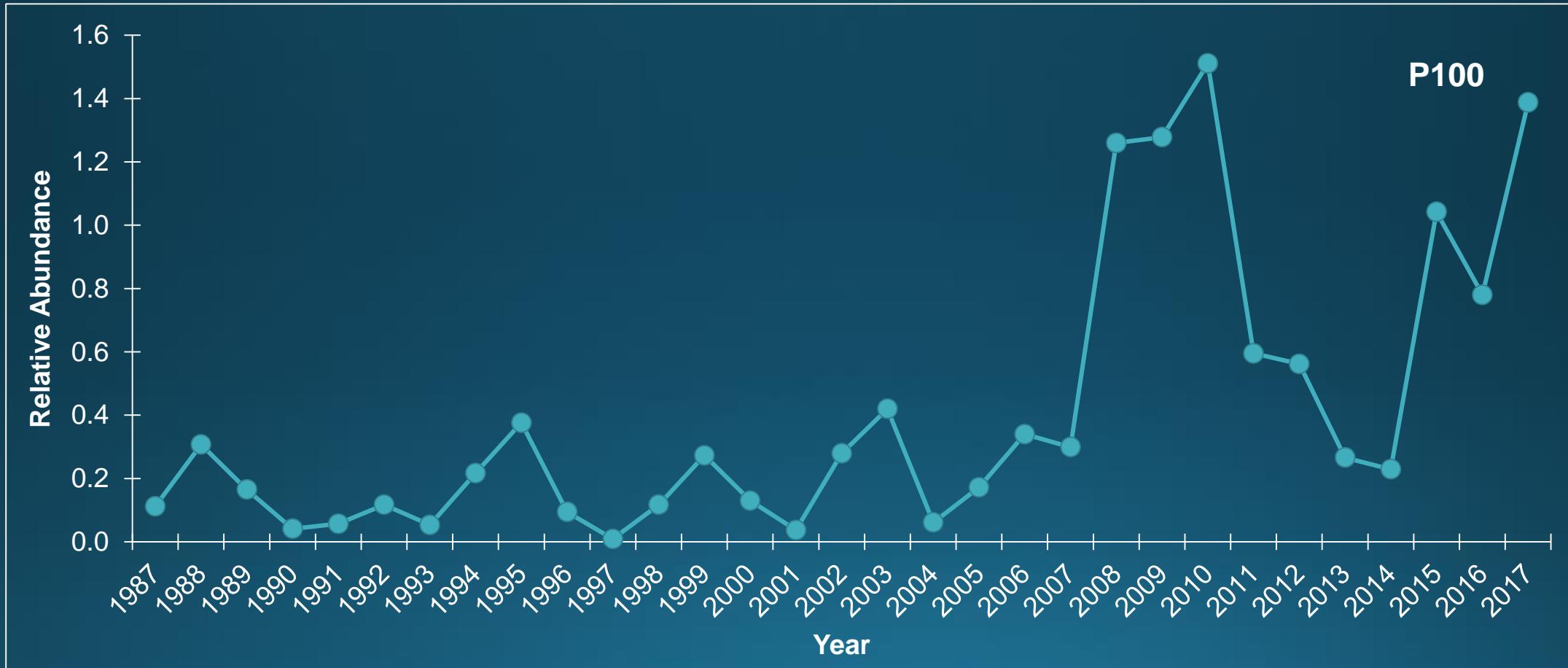
Indicators—Recruitment (Southern)



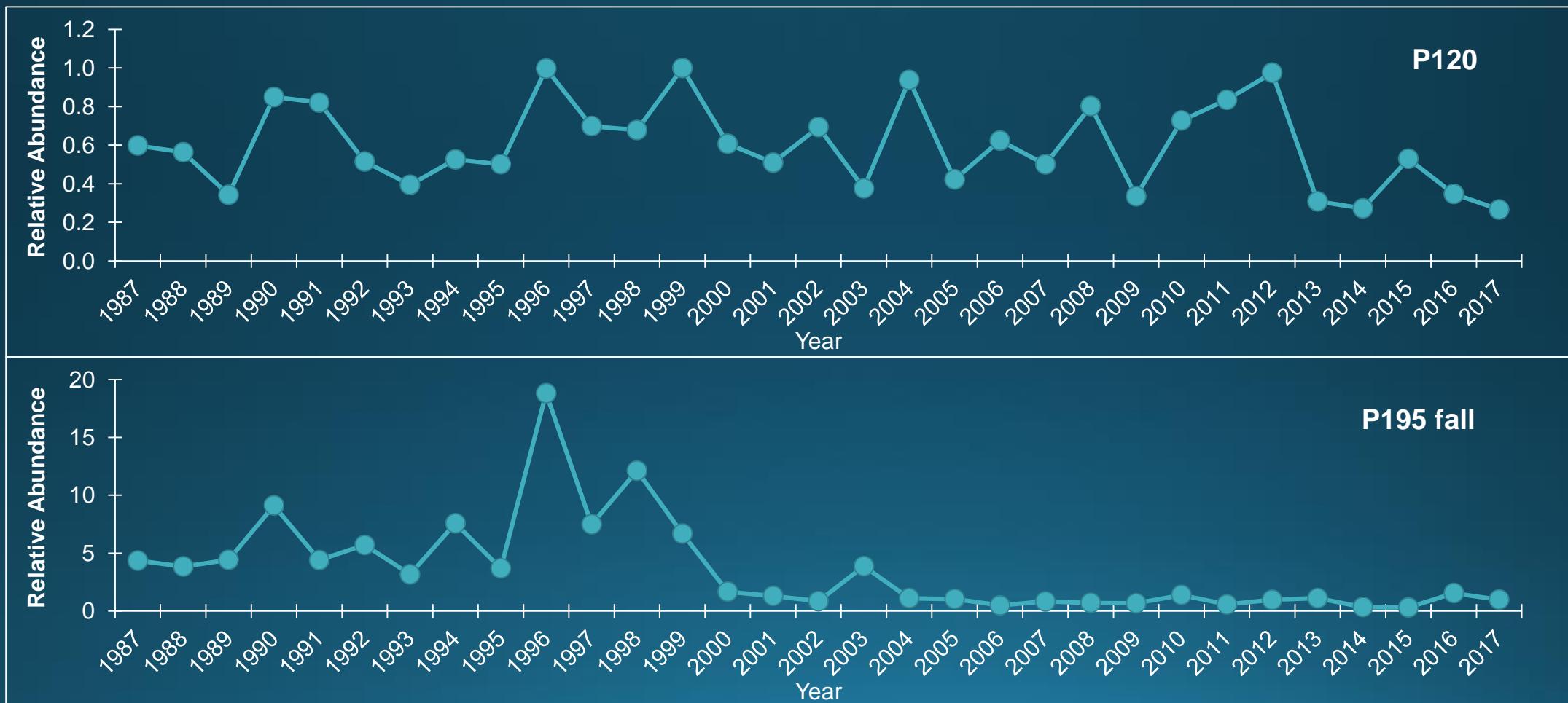
Indicators—Adult

- Albemarle
 - Program 100
- Pamlico
 - Program 120
 - Program 195 fall
- Southern
 - Program 120

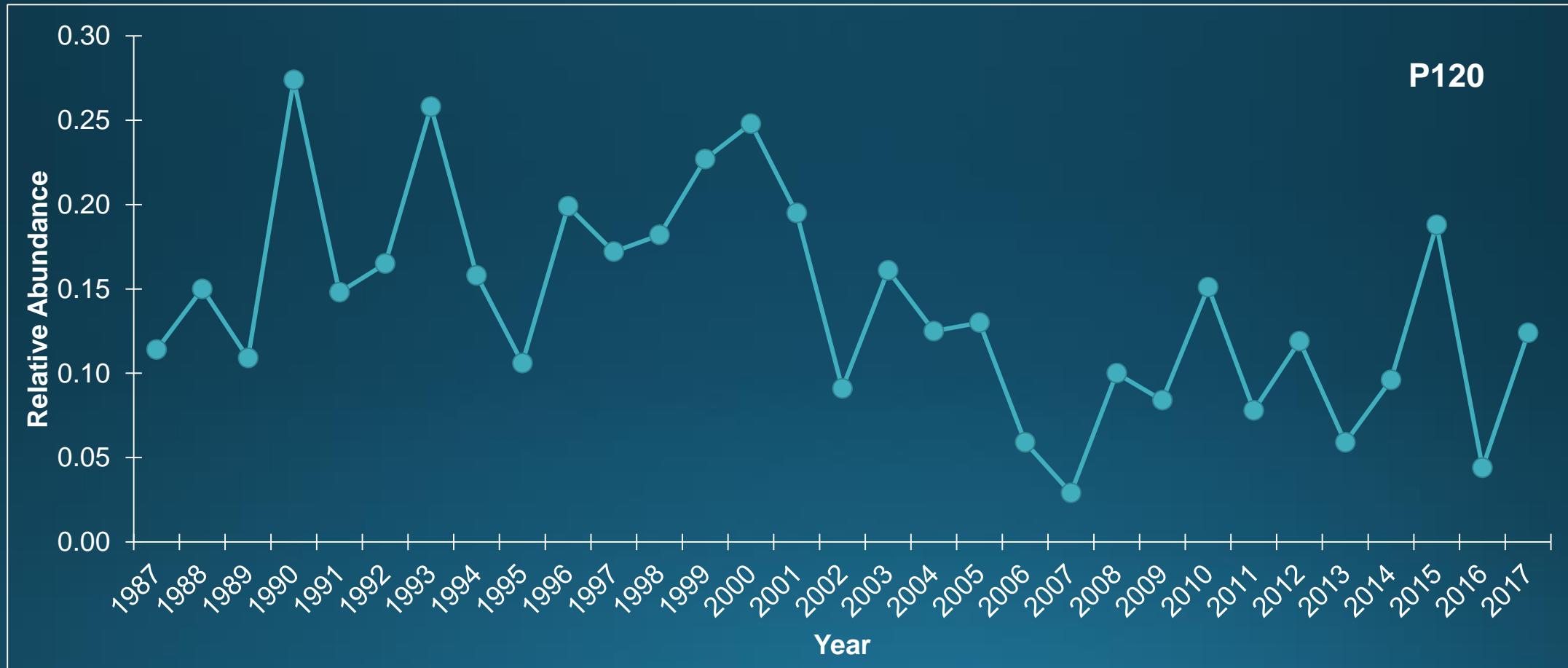
Indicators—Adult (Albemarle)



Indicators—Adult (Pamlico)



Indicators—Adult (Southern)



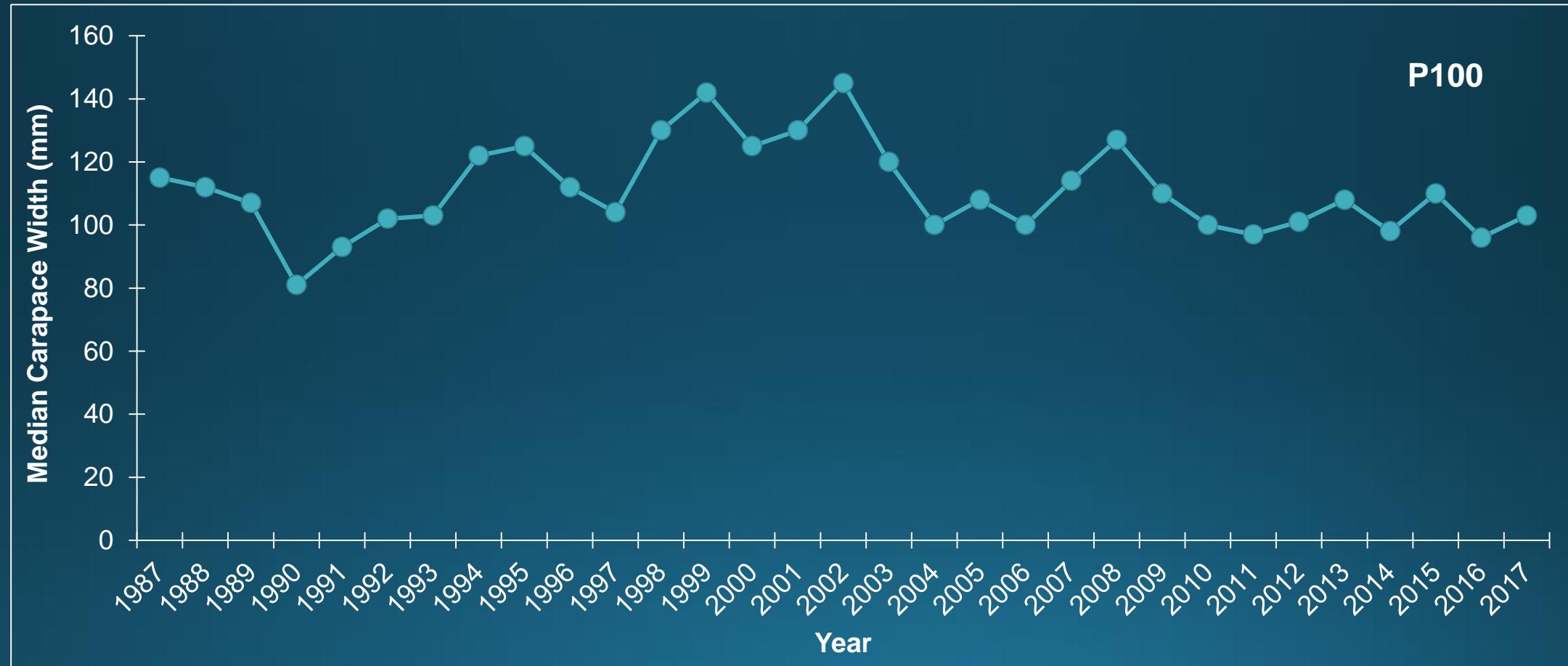
Indicators—Production

- Median size
- Spawning stock indices
- Frequency of occurrence of mature females
- Pre-recruit index
- Size at maturity

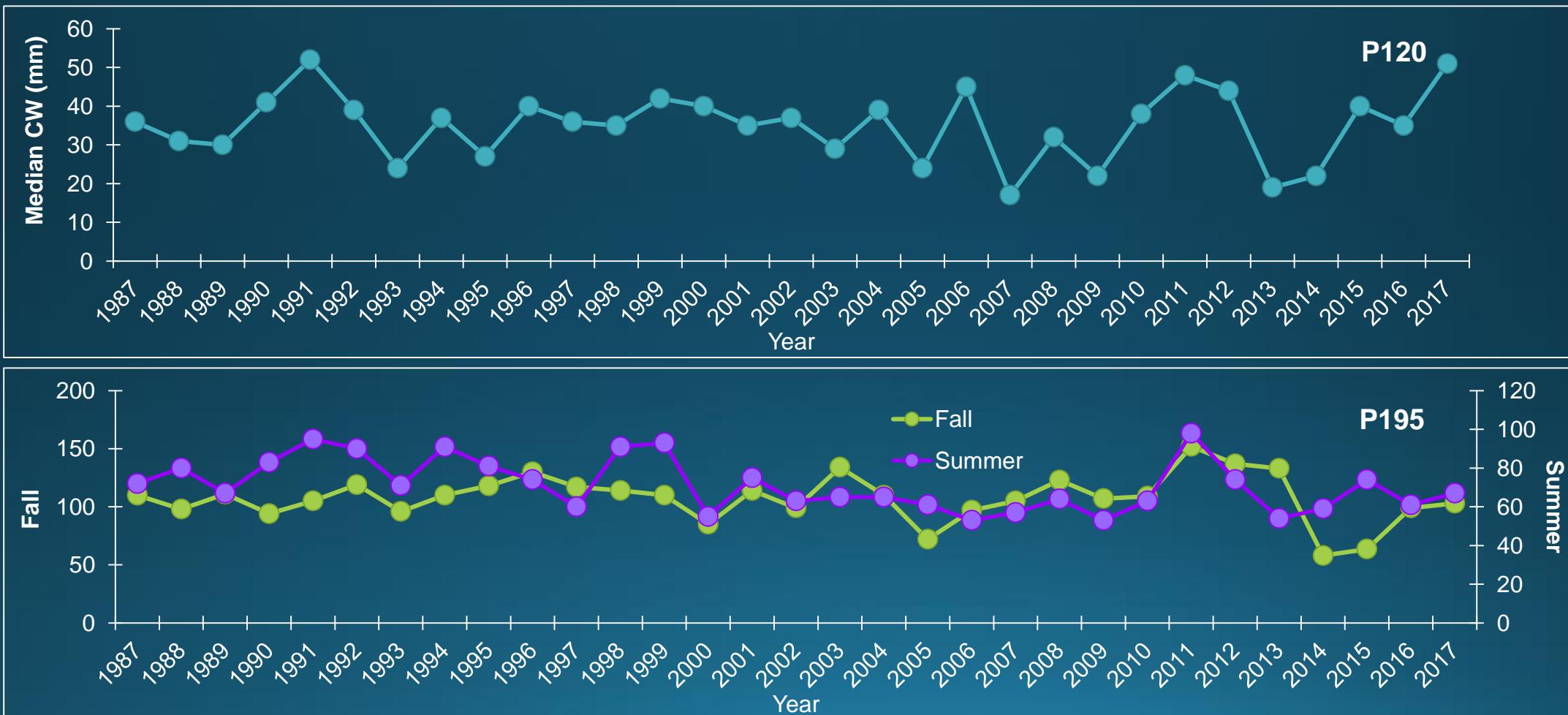
Production—Median Size

- Albemarle
 - Program 100
- Pamlico
 - Program 120
 - Program 195 summer
 - Program 195 fall
- Southern
 - Program 120

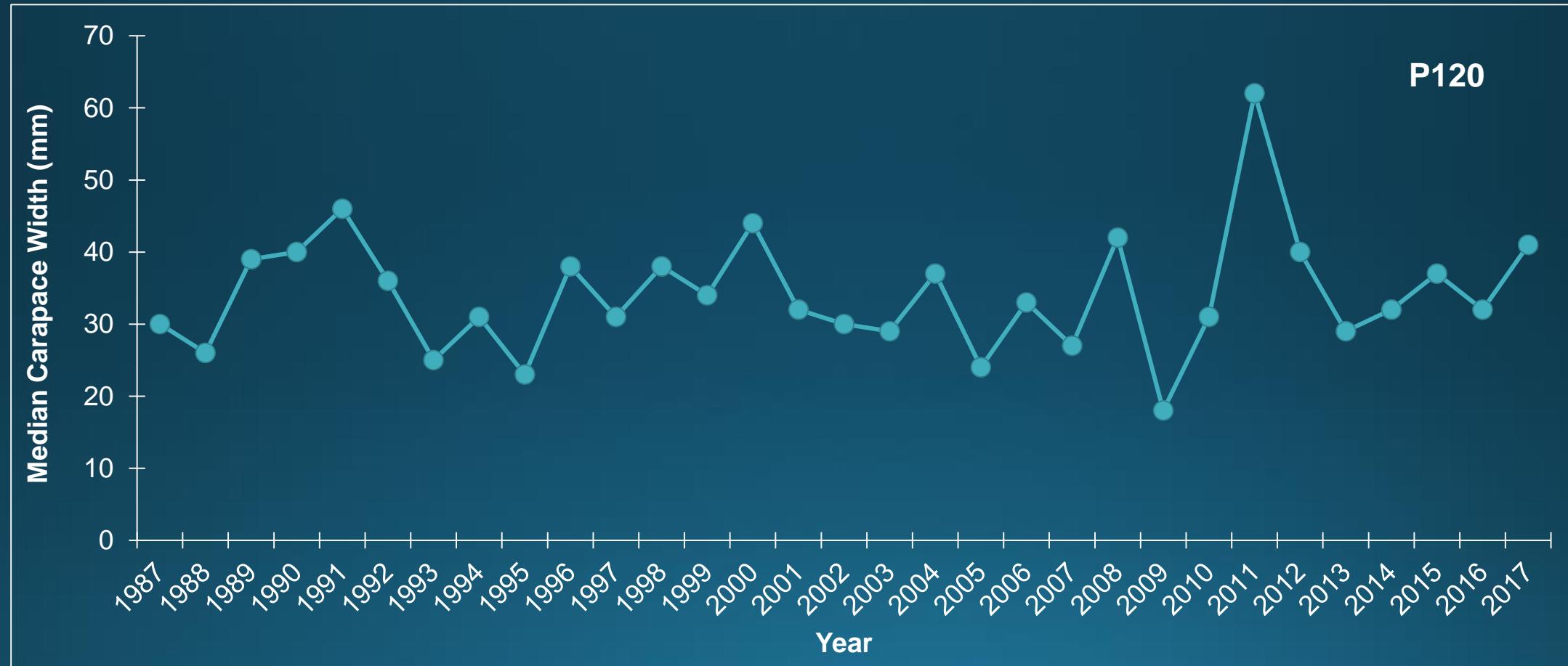
Production—Median Size (Albemarle)



Production—Median Size (Pamlico)



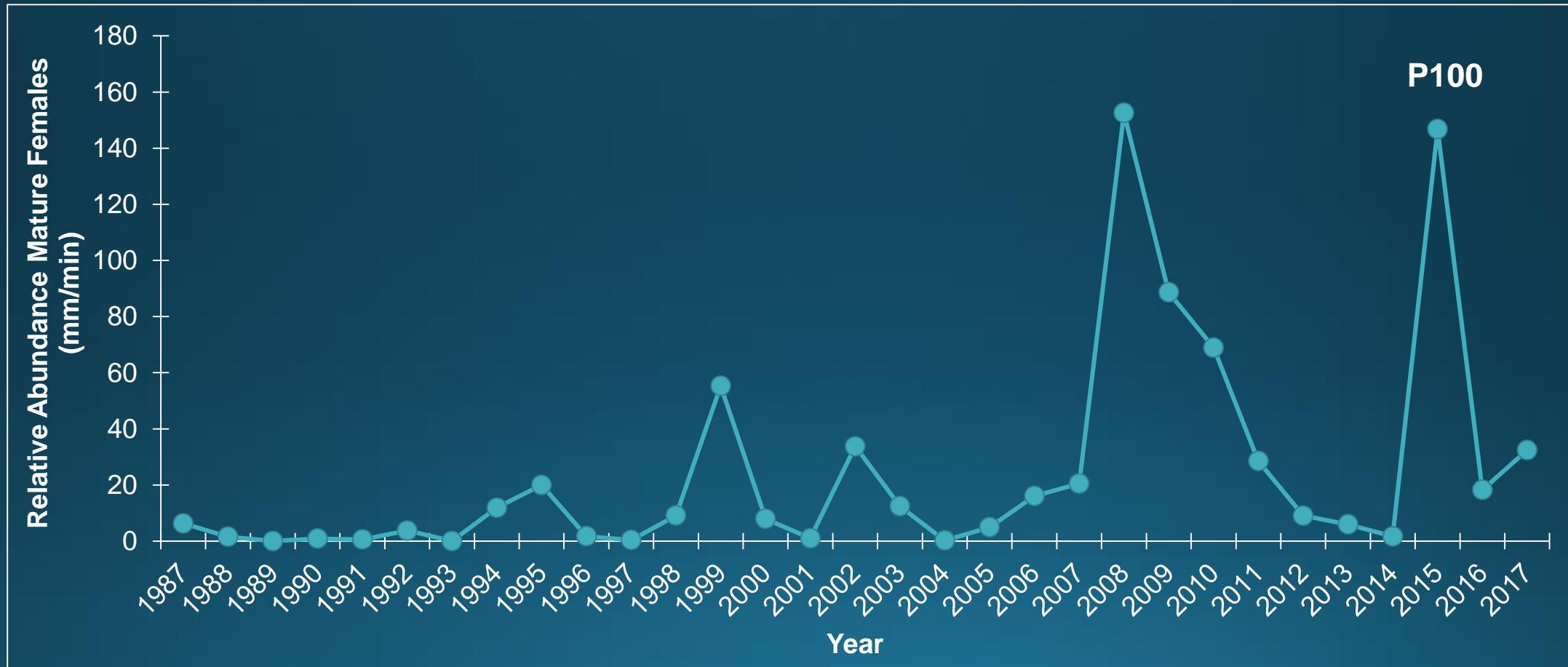
Production—Median Size (Southern)



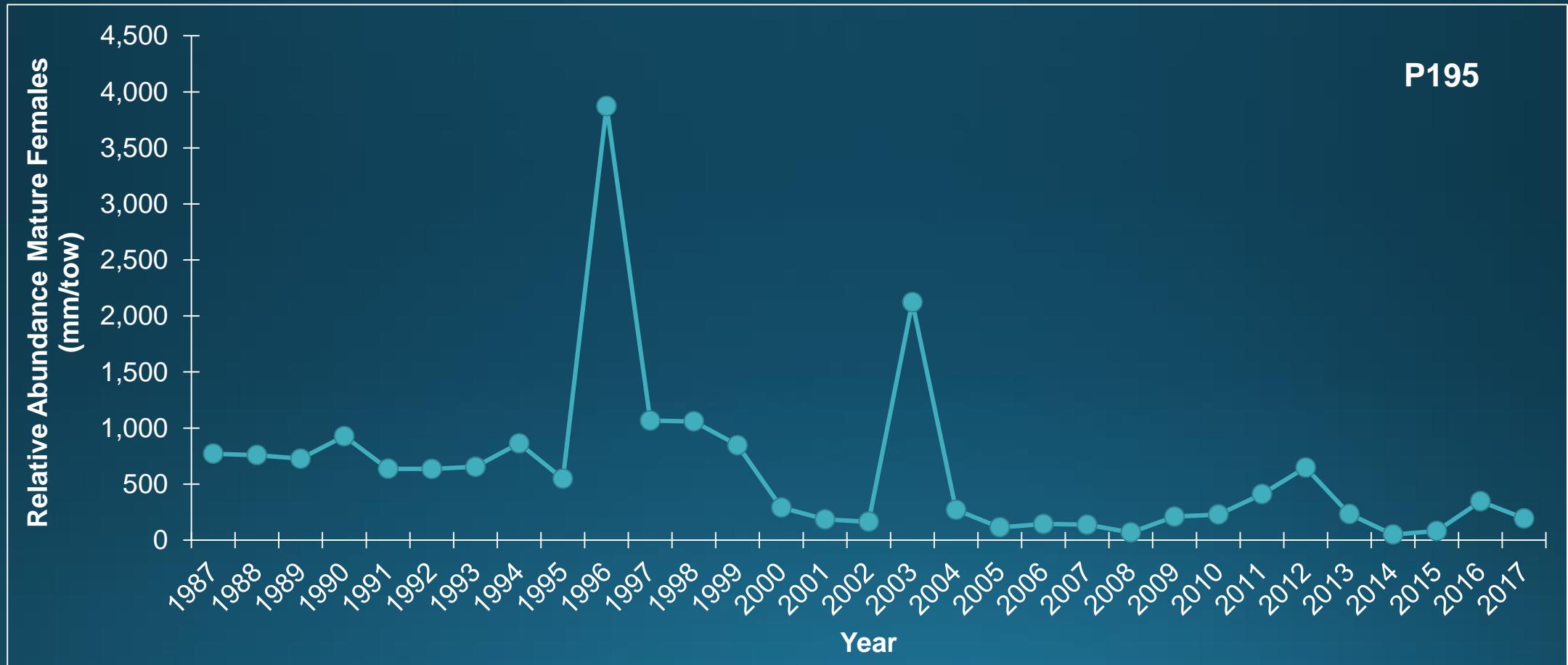
Production—Spawning Stock

- Albemarle
 - Program 100
- Pamlico
 - Program 195
- Southern
 - None

Production—Spawning Stock (Albemarle)



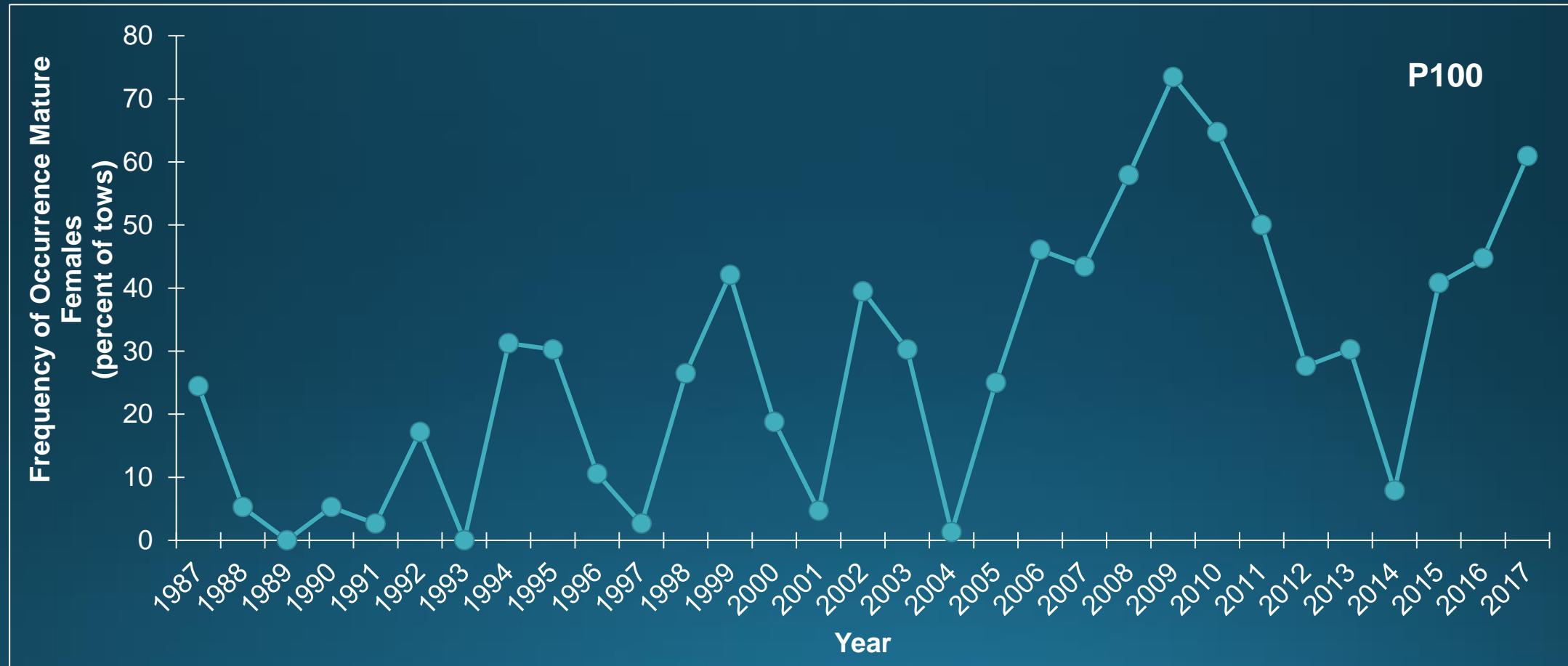
Production—Spawning Stock (Pamlico)



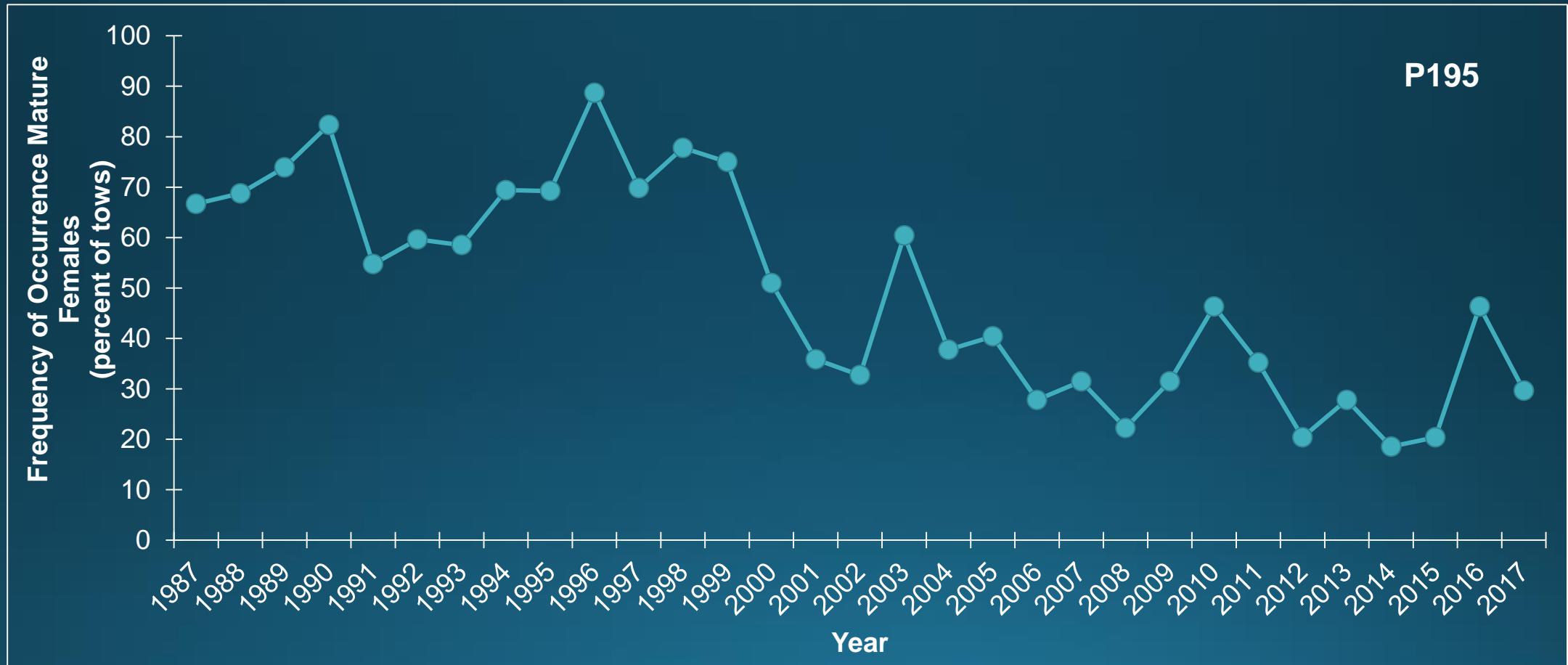
Production—Mature Females

- Albemarle
 - Program 100
- Pamlico
 - Program 195
- Southern
 - None

Production—Mature Females (Albemarle)



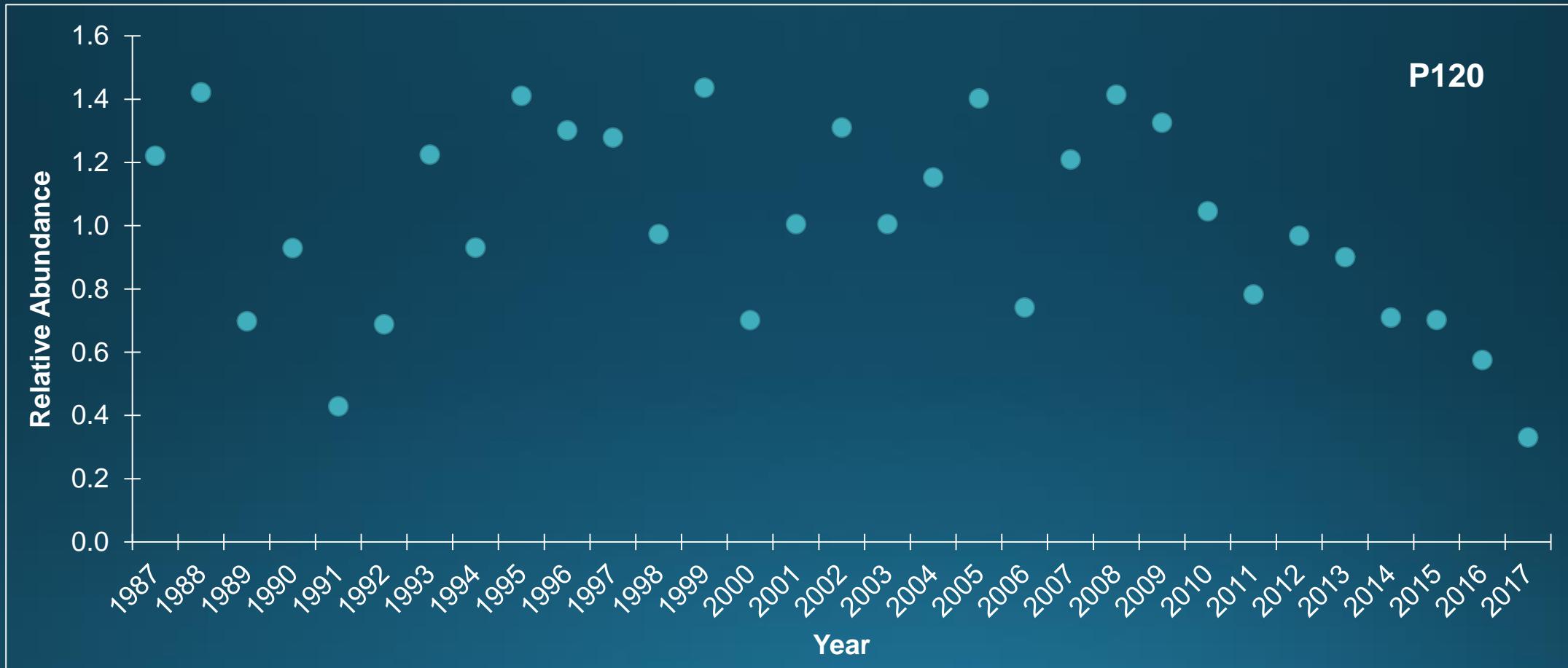
Production—Mature Females (Pamlico)



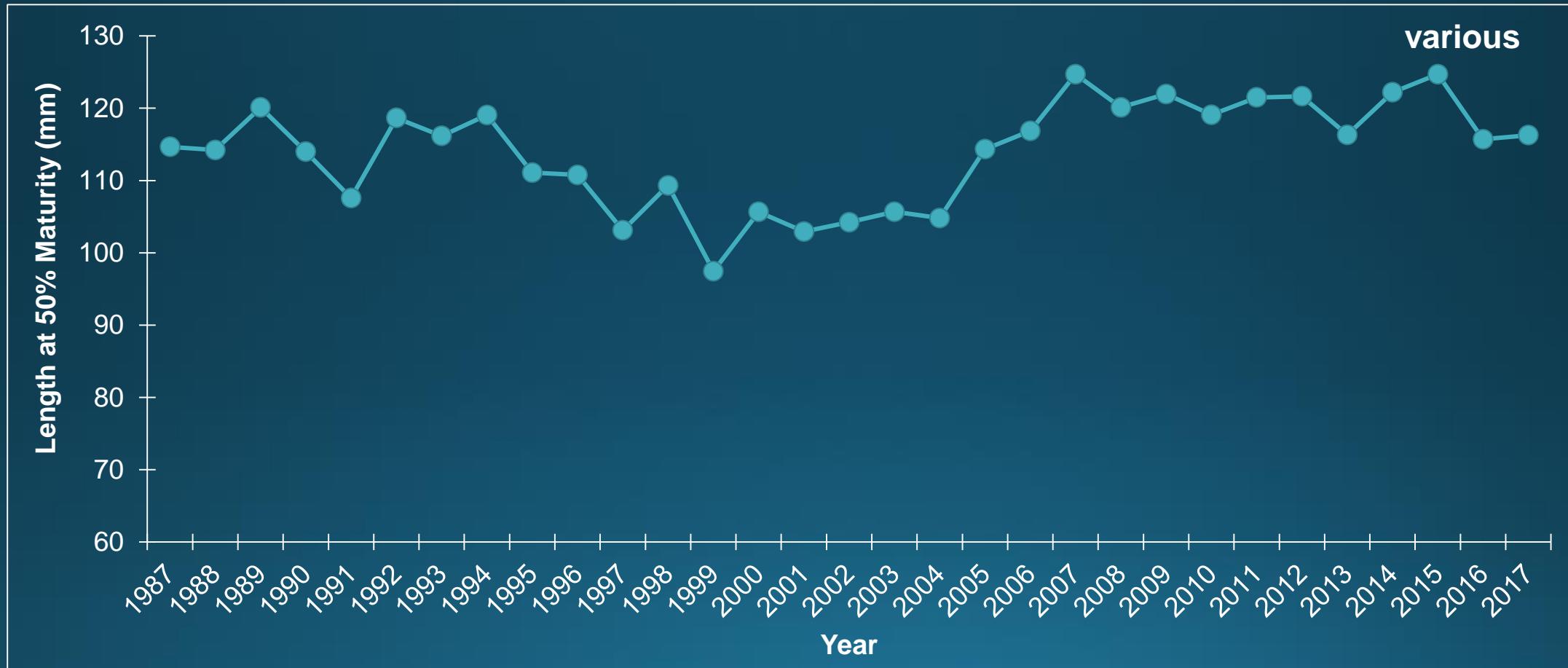
Production—Other

- Statewide
 - Pre-recruit index (Program 120)
 - Size at maturity (various)

Production—Pre-Recruit Index



Production—Size at Maturity



Scaling

- **Scaling** is the assignment of colors, or “traffic lights”, to make indicators comparable
 - Use of colors not required; could use numbers or combination
 - Three-color system used here, though more or less possible

Scaling—Simple Approach

- Colors assigned based on where indicator lies relative to pre-determined boundaries
- Boundaries determined relative to baseline time period
- Baseline time period should ideally be representative of range of stock dynamics

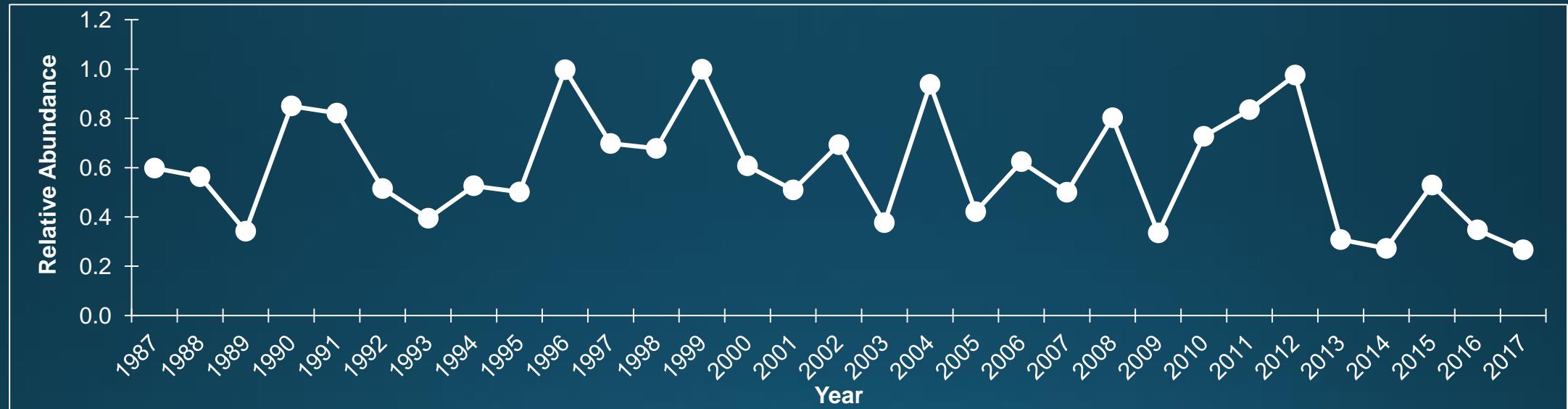
Scaling—Simple Approach

 = Good

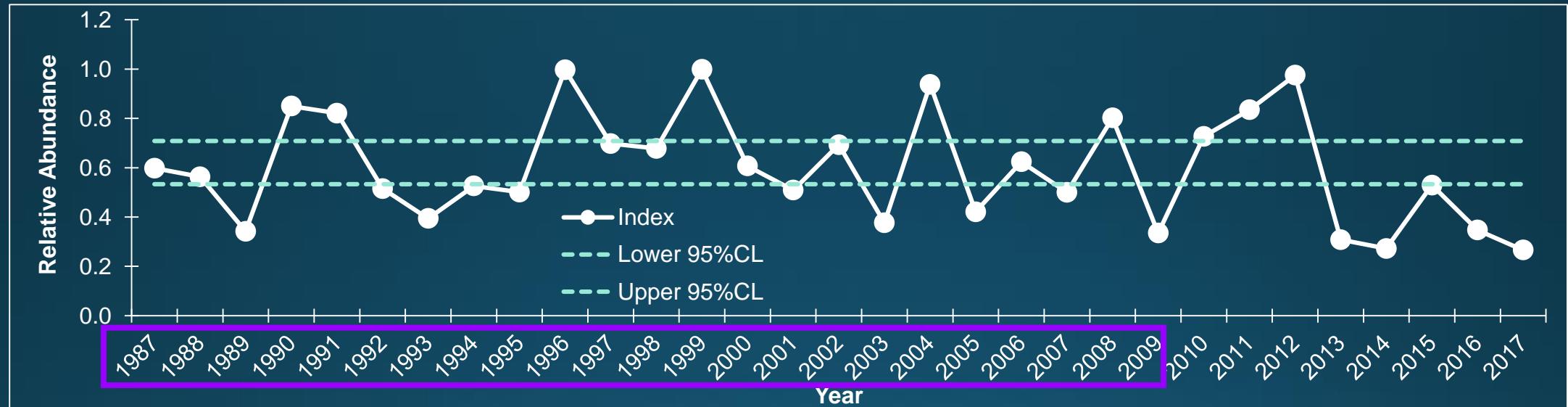
 = Uncertain or Transition

 = Bad

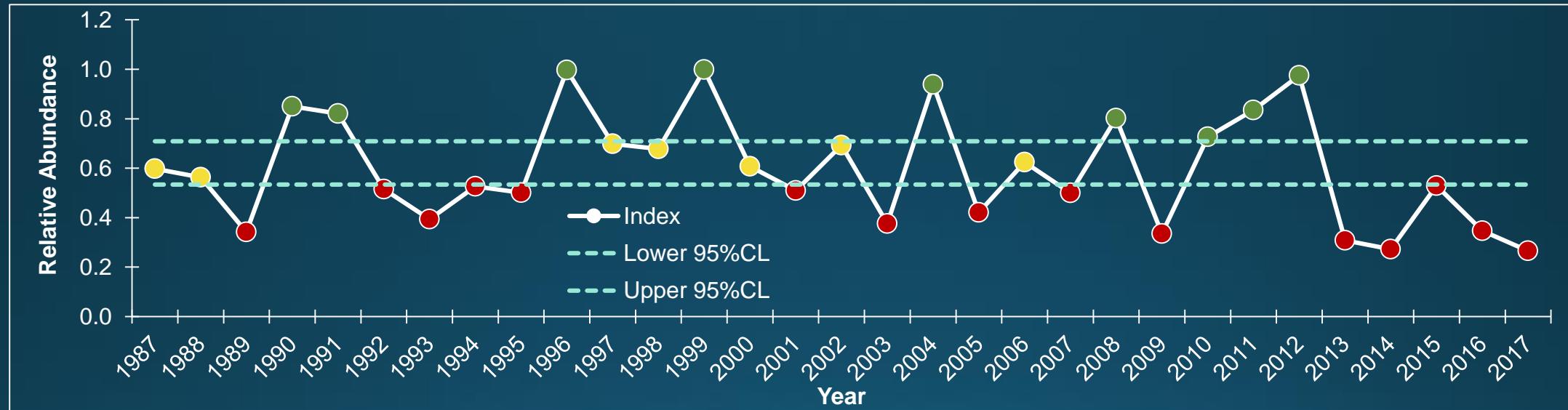
Scaling—Simple Approach (example)



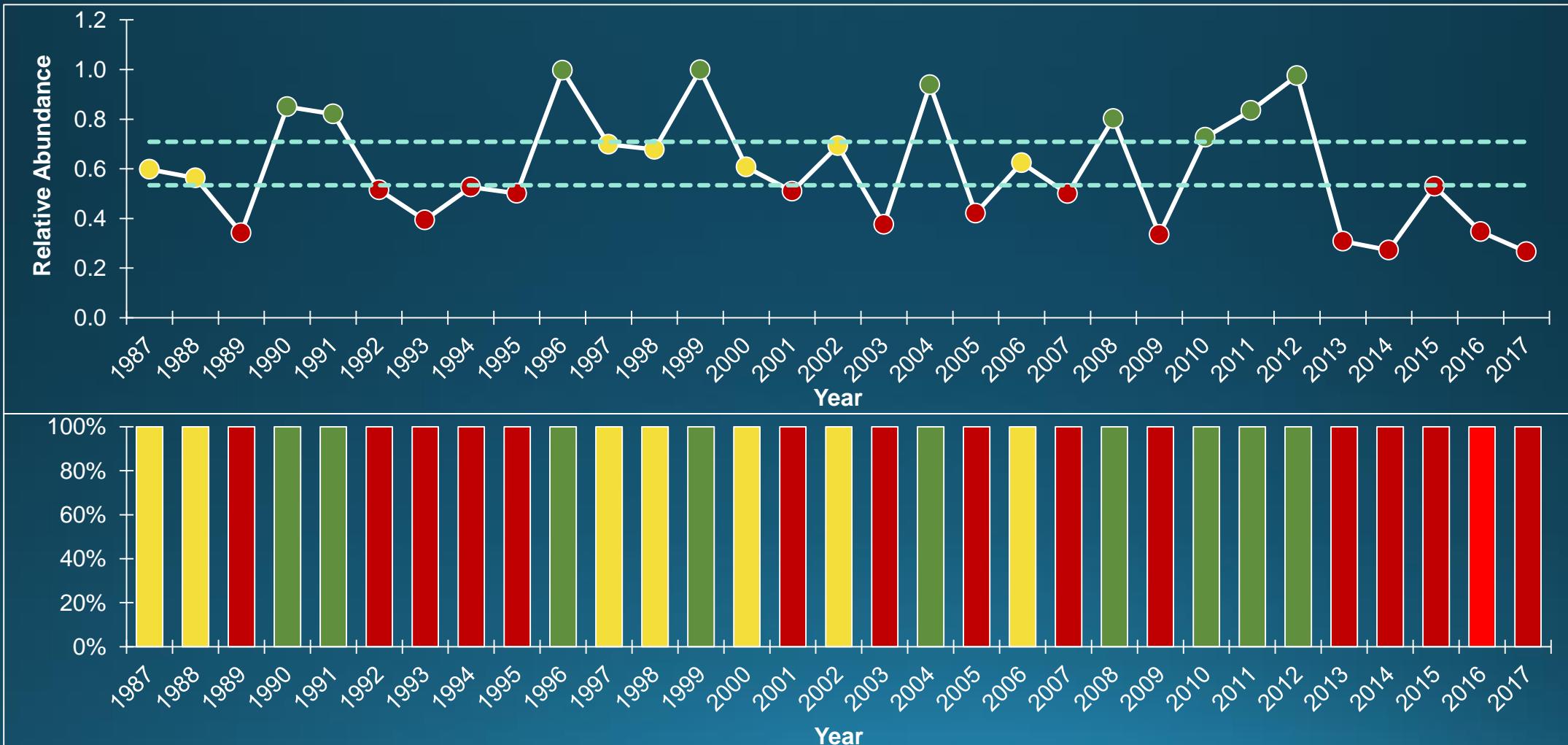
Scaling—Simple Approach (example)



Scaling—Simple Approach (example)



Scaling—Simple Approach (example)



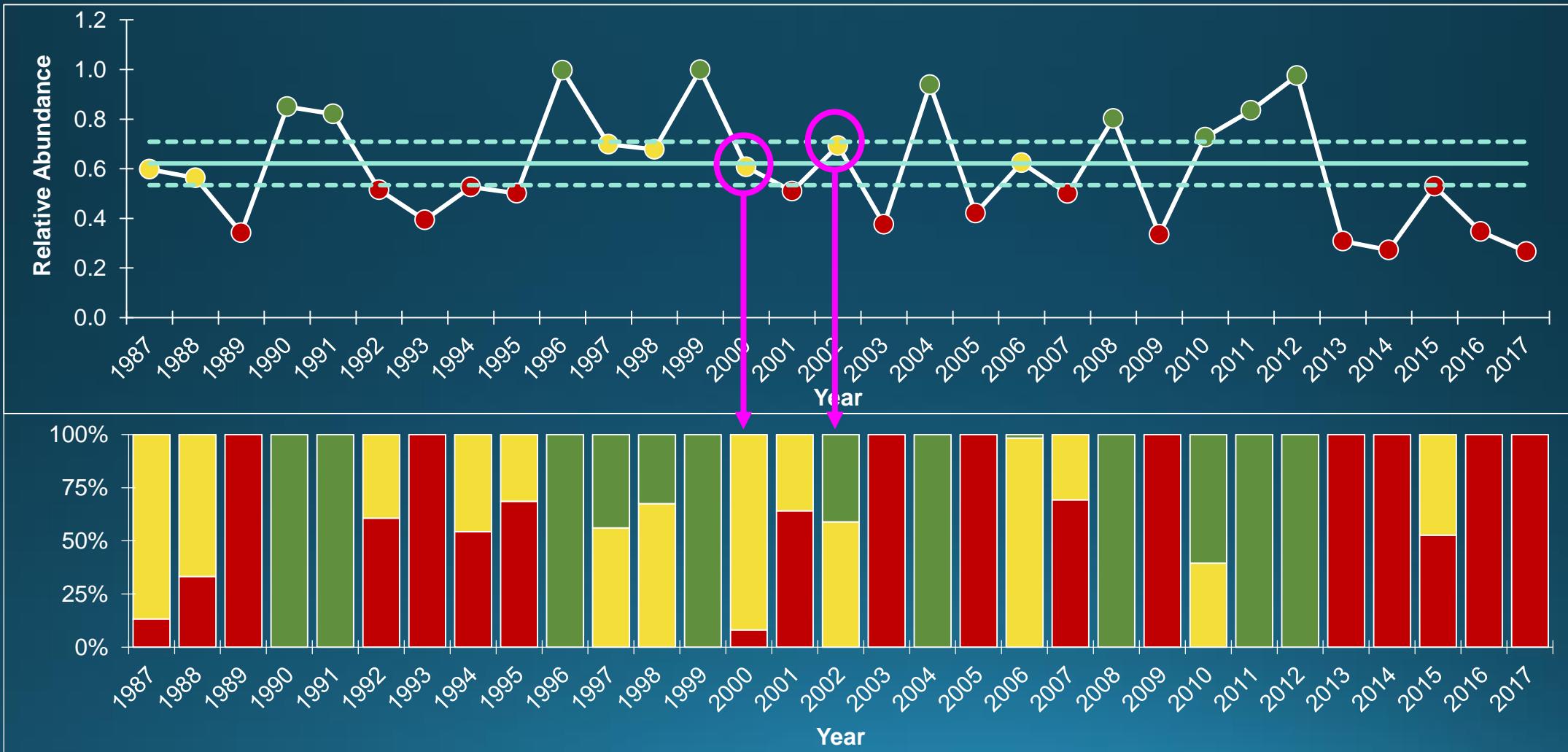
Scaling—Simple Approach (example)



Scaling—Fuzzy Set Approach

- Potential loss of information with simple approach
- Fuzzy set approach introduces transitions
- Proportion of neighboring colors reflected in Traffic Light based on boundaries
 - X% green, Y% yellow
 - X% red, Y% yellow
- Better representation of variability

Scaling—Fuzzy Set (example)



Integration

- Combines multiple indicators
- Similar indicators are combined into **characteristics**, e.g.,
 - Abundance
 - Production
 - Fishing mortality
 - Ecosystem/environment

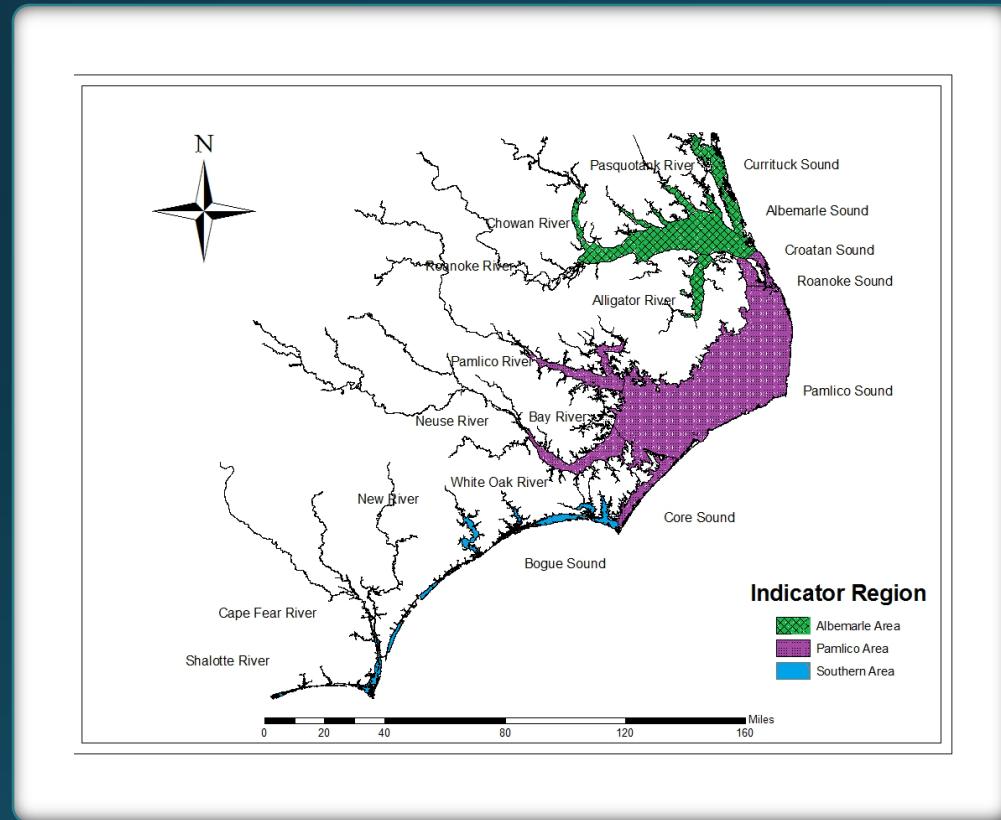
Integration—Characteristics

- Recruit abundance
- Adult abundance
- Production
 - Median size
 - Spawning stock indices
 - Frequency of occurrence of mature females
 - Pre-recruit index
 - Size at maturity

Integration—Steps

- Determine fuzzy set values for each indicator (i.e., proportion of each color assigned to indicator)
- Count number of indicators within a characteristic from each spatial area
- Divide spatial weight by number of indicators within characteristic from that spatial area
- Multiply adjusted spatial weight by fuzzy set value
- Sum new value within each color across indicators
- Normalize across colors to a scale of 0 to 1

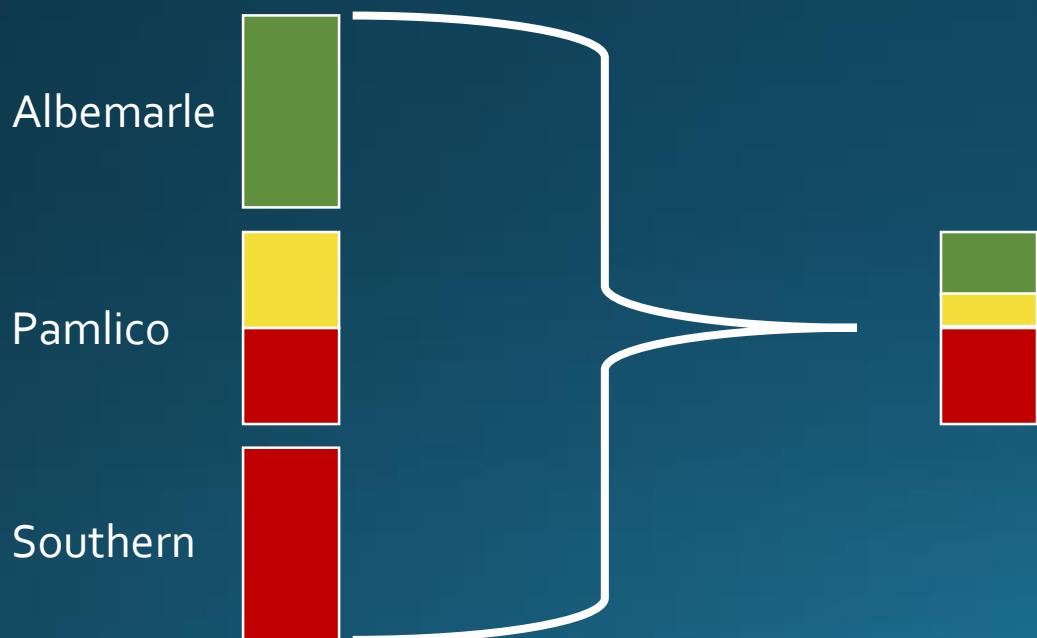
Integration—Spatial Weights



- Albemarle (27%)
- Pamlico (66%)
- Southern (7.0%)

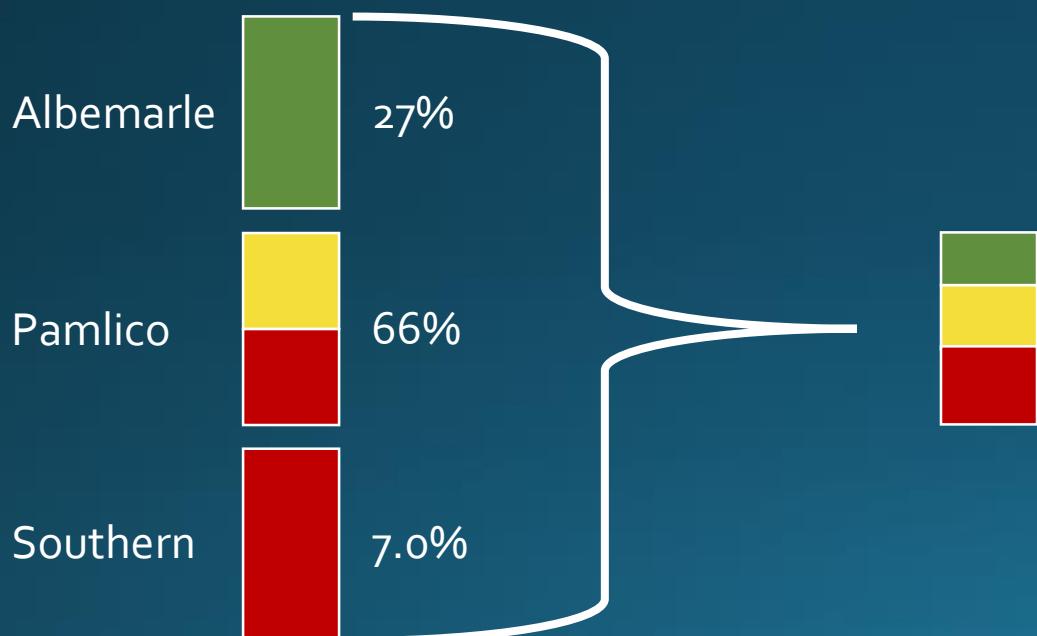
Integration—Spatial Weights (example)

- Without weighting



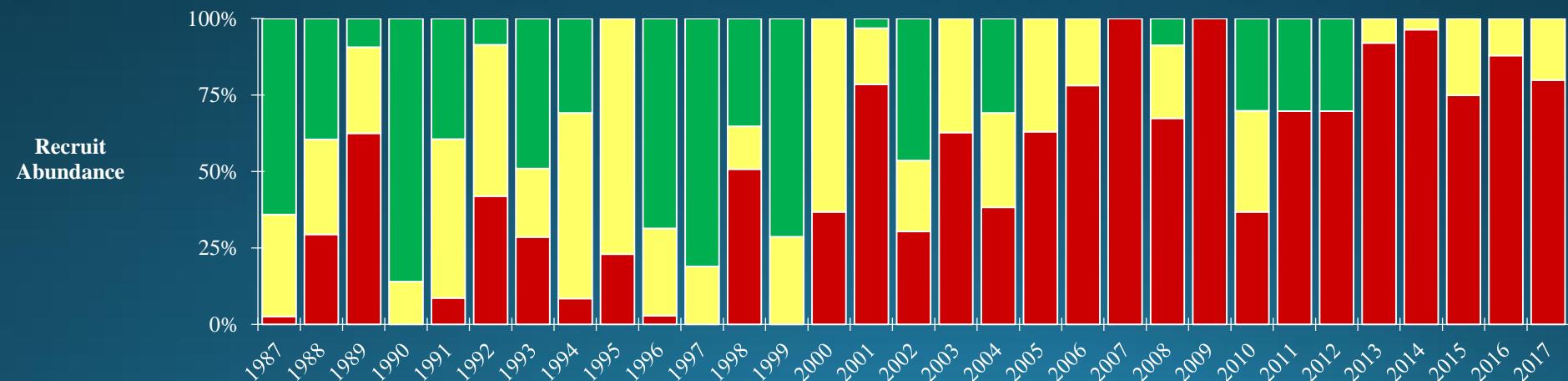
Integration—Spatial Weights (example)

- With weighting

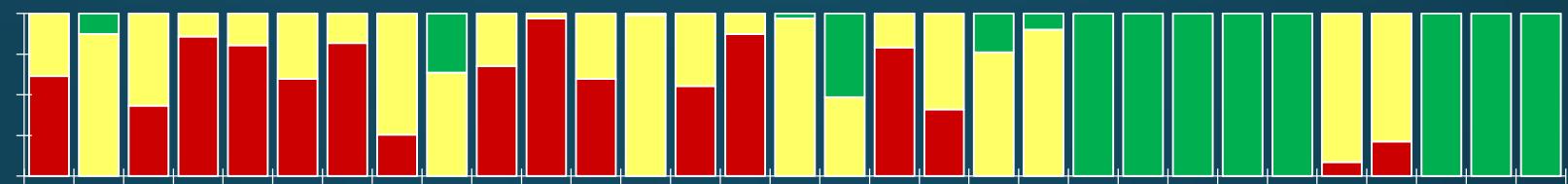


Normalization

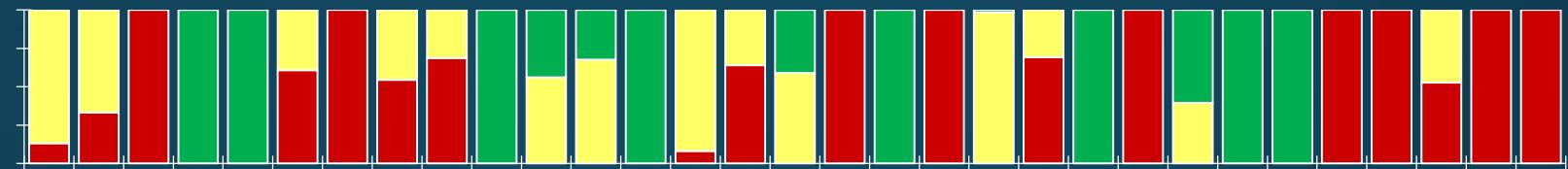
- **Normalization** is the rescaling of data values to a common scale
 - Here, indicators are normalized to a scale ranging from 0 to 1 after applying spatial weighting
 - Characteristics are displayed as proportions of colors over time



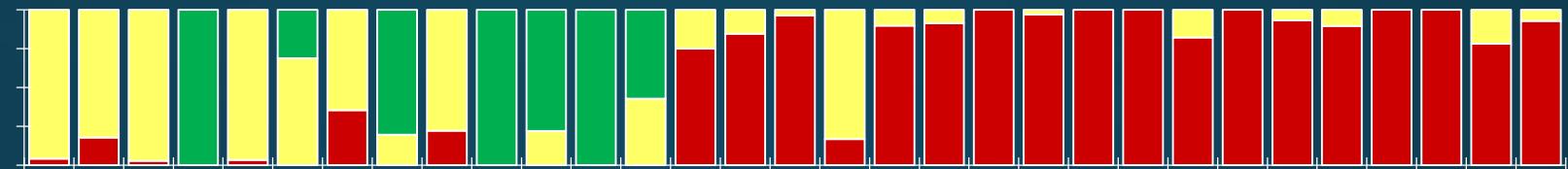
Total Abundance
(Albemarle, P100)



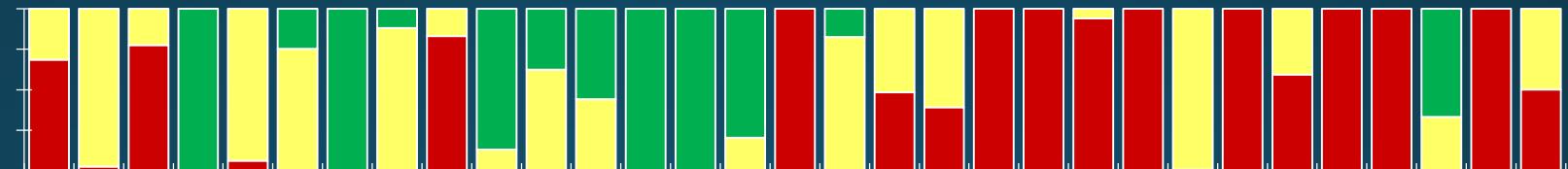
Adult Abundance
(Pamlico, P120)



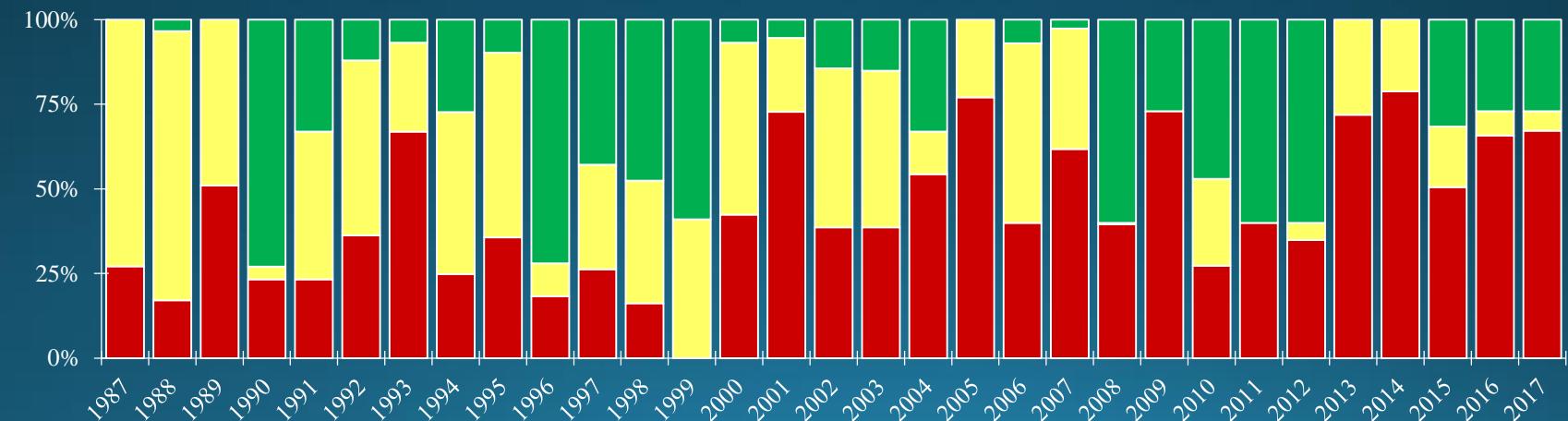
Adult Abundance
(Pamlico, P195 Fall)



Adult Abundance
(Southern, P120)

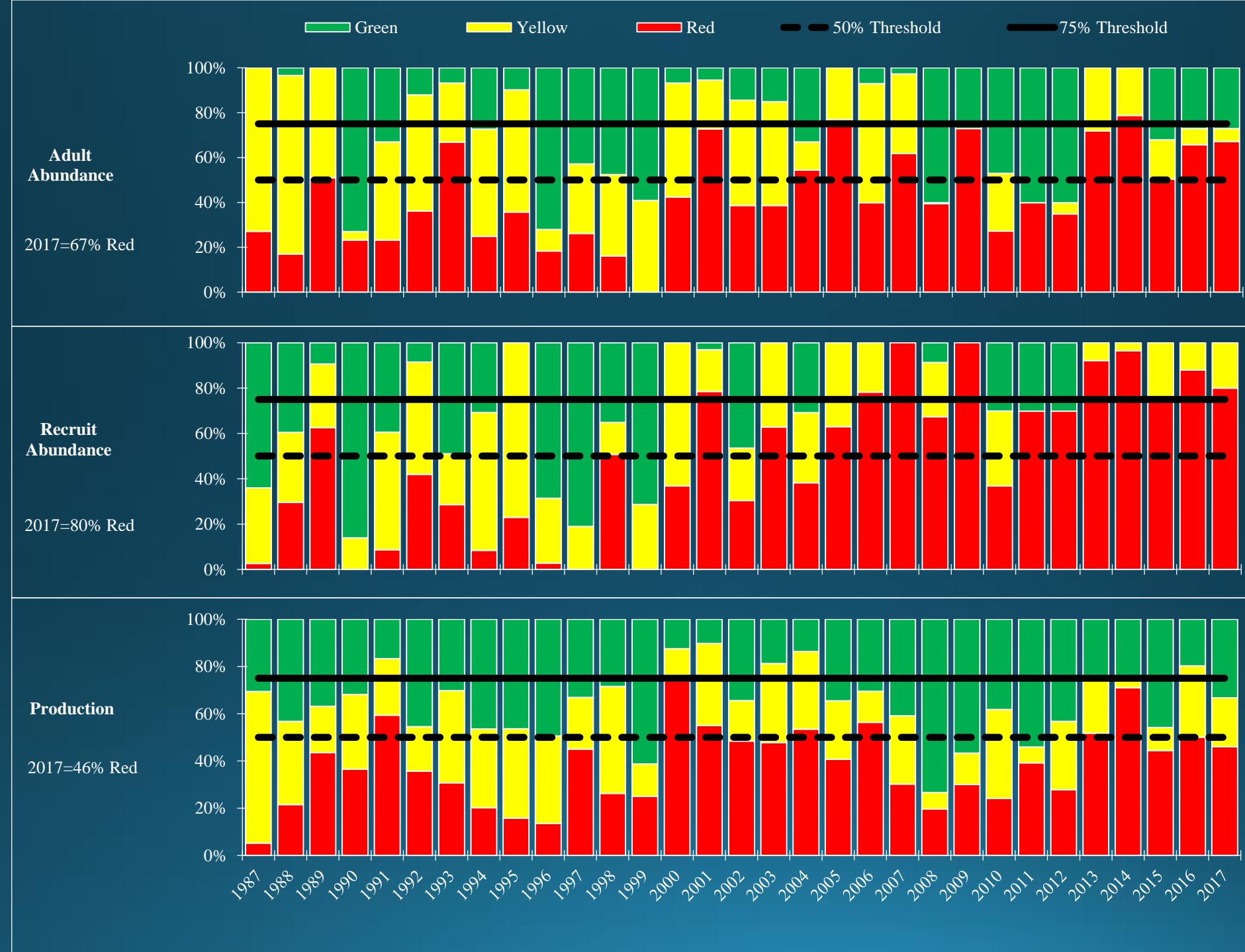


Adult
Abundance









Stock Status

- Overfishing
 - Insufficient data
- Overfished
 - Based on Production characteristic
 - When proportion of red $\geq 75\%$ for three consecutive years → overfished



Questions?