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 (Pamlico)
Indicators—Adult (Southern)

Relative Abundance

Year


P120
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 (Pamlico)
Production—Mature Females

- Albemarle
  - Program 100
- Pamlico
  - Program 195
- Southern
  - None
Production—Mature Females (Pamlico)
Production—Other

- Statewide
  - Pre-recruit index (Program 120)
  - Size at maturity (various)
Production—Pre-Recruit Index
Production—Size at Maturity

![Graph showing length at 50% maturity (mm) over various years from 1987 to 2017.](image)
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

- Green circle = Good
- Yellow circle = Uncertain or Transition
- Red circle = 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

- Albemarle: 27%
- Pamlico: 66%
- Southern: 7.0%
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
Stock Status

• Overfishing
  • Insufficient data

• Overfished
  • Based on Production characteristic
  • When proportion of red $\geq 75\%$ for three consecutive years $\rightarrow$ overfished
Questions?