Size-At Maturity of Jonah Crab (*Cancer borealis*) in New England Waters

Derek Perry, Tracy Pugh, Elizabeth Morrissey, and Robert Glenn
Massachusetts Division of Marine Fisheries

September 6, 2018
Rank among MA fisheries in 2017

<table>
<thead>
<tr>
<th>Species</th>
<th>Pounds (Whole)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sea Scallop</td>
<td>269,186,626</td>
<td>$327,572,502</td>
</tr>
<tr>
<td>Lobster</td>
<td>16,509,226</td>
<td>$81,243,096</td>
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<tr>
<td>Oyster</td>
<td>9,239,891</td>
<td>$23,826,075</td>
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<tr>
<td>Goosefish</td>
<td>17,173,991</td>
<td>$11,350,401</td>
</tr>
<tr>
<td><strong>Jonah Crab</strong></td>
<td><strong>11,680,714</strong></td>
<td><strong>$11,281,714</strong></td>
</tr>
<tr>
<td>Haddock</td>
<td>11,706,654</td>
<td>$11,241,448</td>
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<tr>
<td>Soft Clam</td>
<td>3,831,415</td>
<td>$6,168,657</td>
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<td>Redfish</td>
<td>11,111,369</td>
<td>$5,933,712</td>
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<td>Winter Flounder</td>
<td>1,924,189</td>
<td>$5,662,768</td>
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<tr>
<td>Atlantic Herring</td>
<td>31,327,894</td>
<td>$5,644,980</td>
</tr>
</tbody>
</table>
Background

- 2015 Jonah crab FMP
  - 4.75” (121 mm) CW MLS

- MA DMF Port Sampling
  - >35,000 crabs sampled
  - 99.8% male
  - 98% of catch is >4.75”
  - Largest male 175 mm CW
  - Largest female 145 mm CW
• Determine if MLS allows at least half of population to reproduce

• Stock assessment
  – Need for maturity status for models
Previous Studies

• Carpenter 1978 (1)
  – Male maturity
    • Did not detect morphometric change at maturity
    • Gonadal 90-100 mm CW
    • Limited seasonal development
  – Female maturity
    • Morph 80-90 mm CW
    • Gonadal 90-100 CW
    • Ovarian development varied seasonally
Previous Studies

• Ordzie and Satchwill 1983 (2)
  – Male maturity
    • Morph not reported
    • Gonadal 50-60 mm CW
    • Gonads translucent for all crabs below 45 mm CW
  – Female maturity
    • Morph 40-50 mm CW
    • Gonadal 67 mm CW
    • Gonads translucent for all crabs below 55 mm CW
Previous Studies

• Moriyasu et al. 2002 (3)
  – Male maturity
    • Morph 128 mm CW
    • Gonadal 69 mm CW
    • No spermatophores in crabs below 53 mm CW
  – Female maturity
    • Not reported
Methods

- Five geographic regions
- Samples collected opportunistically year-round
- Grouped seasonally
  - Jan-Mar (winter), Apr-Jun (spring), Jul-Sep (summer), Oct-Dec (fall)
- Over 2,300 crabs analyzed
- Gonadal maturity
- Morphometric maturity
Methods

• Gonadal Maturity
  – Capable of producing sperm or eggs
Methods

• Morphometric Maturity
  – Allometry
    • Relative growth of parts
  – Mating of small physiologically mature, morphometrically immature crabs has not been documented
Methods

• Morphometric maturity
  – Chelae height and length, body depth, carapace depth, and abdominal width (females)
  – Male Ch-CW and female Ap-CW most informative
  – Piecewise regression used to look for “breakpoints”
  – Two-staged segmented models compared to linear model
  – Tested for parsimony
    • Bayesian Information Criterion (BIC)
    • Akaike’s Information Criterion (AIC)
Methods

- Gonadal maturity
  - Digital images taken of dissected crabs
  - Compared gonad size relative to carapace outline (ImageJ)
  - Characterized gonad color
  - Generated maturity ogives
## Methods

### Male Gonad Color

<table>
<thead>
<tr>
<th>Male Gonad Color</th>
<th>Maturity Status</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>Immature/Resting</td>
<td>Undetectable or translucent gonadal tract present and flat on hepatopancreas</td>
</tr>
<tr>
<td>White</td>
<td>Developing/Mature</td>
<td>Vas deferens and/or testes thin, relatively small, ~10% or less of the body cavity surface area</td>
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<tr>
<td>White</td>
<td>Well-developed/Mature</td>
<td>Vas deferens and testes enlarged or swollen, relatively large, ~10% of or more of the body cavity surface area</td>
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</tbody>
</table>

### Female Gonad Color

<table>
<thead>
<tr>
<th>Female Gonad Color</th>
<th>Maturity Status</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear</td>
<td>Immature/Resting</td>
<td>Undetectable ovary to a non-lobed ovary present flat on hepatopancreas. Colorless; no vitellogenesis</td>
</tr>
<tr>
<td>Tan</td>
<td>Mature/Developing</td>
<td>A few lobes are visible but ovary remains small. Color ranges from beige to light peach.</td>
</tr>
<tr>
<td>Peach</td>
<td>Mature/Late developing</td>
<td>Small, lobed ovaries. Color ranges from peach to medium orange</td>
</tr>
<tr>
<td>Orange</td>
<td>Mature/Developed</td>
<td>Large, lobed ovaries, tract is enlarged. Color ranges from medium orange to red</td>
</tr>
</tbody>
</table>
Results - Males

![Box plot showing percent cover of gonad against carapace width for males.](image-url)
Results - Males

- GB
- GOMO
- GOMI
- SNEO
- SNEI

Percent Cover vs. Carapace Width (mm)

Category: Clear, White & <10%, White & >10%
Results - Males

Offshore Southern New England

Inshore Southern New England

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>BIC</th>
<th>AIC</th>
<th>$r^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>simple</td>
<td>3</td>
<td>1184</td>
<td>1173</td>
<td>0.97</td>
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<tr>
<td>piecewise</td>
<td>6</td>
<td>1070</td>
<td>1048</td>
<td>0.98</td>
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</table>

<table>
<thead>
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<th>Model</th>
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<tr>
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<td>1470</td>
<td>1458</td>
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<tr>
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<td>1480</td>
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<td>0.90</td>
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Results - Males

Georges Bank

109 mm CW

<table>
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<tr>
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<td>1059</td>
<td>1049</td>
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<tr>
<td>piecewise</td>
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<td>1000</td>
<td>979</td>
<td>0.97</td>
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<table>
<thead>
<tr>
<th></th>
<th>Size at morphometric maturity (chela height)</th>
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<tr>
<td>SNEO</td>
<td>117</td>
</tr>
<tr>
<td>SNEI</td>
<td>NA</td>
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<tr>
<td>GB</td>
<td>109</td>
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<tr>
<td>GOMO</td>
<td>115</td>
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<tr>
<td>GOMI</td>
<td>103</td>
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</table>
Results - Females
Results - Females
Results - Females

GOMO

GB

98 mm CW

93 mm CW

SNEO

SNEI

89 mm CW

86 mm CW

Proportion

Carapace Width (mm)
Results-Females

### Offshore Southern New England

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>BIC</th>
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<td>914</td>
<td>904</td>
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<tr>
<td>piecewise</td>
<td>6</td>
<td>872</td>
<td>851</td>
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### Inshore Southern New England

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>BIC</th>
<th>AIC</th>
<th>$r^2$</th>
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<tbody>
<tr>
<td>simple</td>
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<td>891</td>
<td>881</td>
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<td>893</td>
<td>872</td>
<td>0.85</td>
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</table>
Results - Females

Georges Bank

![Graph showing Abdomen Width (mm) vs Carapace Width (mm) with a trend line at 94 mm CW.]

<table>
<thead>
<tr>
<th>Model</th>
<th>df</th>
<th>BIC</th>
<th>AIC</th>
<th>$r^2$</th>
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<tbody>
<tr>
<td>GB</td>
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<tr>
<td>simple</td>
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<tr>
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<td>477</td>
<td>460</td>
<td>0.95</td>
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<table>
<thead>
<tr>
<th></th>
<th>Size at morphometric maturity (abdomen)</th>
<th>Size at 50% gonadal maturity (physiological)</th>
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</thead>
<tbody>
<tr>
<td>SNEO</td>
<td>88</td>
<td>89</td>
</tr>
<tr>
<td>SNEI</td>
<td>NA</td>
<td>86</td>
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<tr>
<td>GB</td>
<td>94</td>
<td>93</td>
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<tr>
<td>GOMO</td>
<td>NA</td>
<td>98</td>
</tr>
<tr>
<td>GOMI</td>
<td>NA</td>
<td>NA</td>
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</tbody>
</table>
### Results - Females

<table>
<thead>
<tr>
<th>Region</th>
<th>N</th>
<th>Range</th>
<th>Mean</th>
<th>SE</th>
<th>Median</th>
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<tr>
<td>SNEO</td>
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<td></td>
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<tr>
<td>CFRF commercial traps</td>
<td>19</td>
<td>82-120</td>
<td>101.2</td>
<td>2.5</td>
<td>102.0</td>
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<tr>
<td>CFRF ventless traps</td>
<td>6</td>
<td>94-121</td>
<td>105.5</td>
<td>3.8</td>
<td>103.5</td>
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<tr>
<td>SNEI</td>
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<tr>
<td>CFRF commercial traps</td>
<td>26</td>
<td>89-120</td>
<td>105.1</td>
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<tr>
<td>CFRF ventless traps</td>
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<td>106</td>
<td>106</td>
<td>NA</td>
<td>106.0</td>
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<tr>
<td>MADMF VTS</td>
<td>7</td>
<td>93-110</td>
<td>102.1</td>
<td>2.1</td>
<td>102.0</td>
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<tr>
<td>MADMF Tagging</td>
<td>6</td>
<td>105-129</td>
<td>114</td>
<td>3.8</td>
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<tr>
<td>GB</td>
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<tr>
<td>CFRF commercial traps</td>
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<td>2.4</td>
<td>106.5</td>
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<td>1.9</td>
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<tr>
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<td>0.9</td>
<td>116.0</td>
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<tr>
<td>GOMO</td>
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<tr>
<td>MADMF Tagging</td>
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<td>98-116</td>
<td>106.7</td>
<td>5.2</td>
<td>106.0</td>
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<td>GOMI</td>
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<tr>
<td>MADMF VTS</td>
<td>47</td>
<td>86-126</td>
<td>107.2</td>
<td>1.3</td>
<td>109.0</td>
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<tr>
<td>MADMF Tagging</td>
<td>5</td>
<td>101-127</td>
<td>110.6</td>
<td>4.6</td>
<td>110.0</td>
</tr>
</tbody>
</table>
Tagging Project
Tagging Project

Preliminary results

• Overall tag return rate of 2.4%

• Average male traveled 9.3 km (median 4.1)

• Average female traveled 1.6 km (median 0.7)

• Only two t-bar tagged crabs appear to have molted and reported with measurements upon recapture

• 18 recaptures have gone at least a year without molting (124-159 mm CW males, max 720 days)
Thank you


DMF staff: Ricky Alexander, Michael Auriemma, John Boardman, Theresa Burnham, Vincent Manfredi, Matt Roux, Brendan Reilly, Mark Szymanski, Mike Trainor, Mike Walsh, Kelly Whitmore, and Steve Wilcox

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