Critical reproduction density and resilience in abalone: A South Australian case study

Ben Stobart and Stephen Mayfield
IAS Auckland – March 2023
South Australian species

**Greenlip Abalone**
*Haliotis laevigata*

**Blacklip Abalone**
*Haliotis rubra rubra*
Fertilisation may fail at densities below 0.3 – 0.15 m$^{-2}$

California estimate of 0.34 m$^{-2}$ for *H. cracherodii*

Or nearest-neighbour distances 1-2m
Resilience

The capacity to recover quickly from difficulties, toughness

- Relatively long lived – longer recovery and risk of temporal lag of Allee effect (Gascoigne & Lipcius 2004)
- Synchrony – poor?
- Reproduction not guaranteed – variation between years
- Limited larval dispersal
- Settlement issues once habitats change?
- High numbers may be critical for successful reproduction
- In SA greenlip may be more vulnerable – no refuge?

- Any resilience falls over if reproduction is compromised
Critical Reproduction Threshold - Density

<table>
<thead>
<tr>
<th>SAU</th>
<th>Max of Legal.Density</th>
<th>Min of Legal.Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>THE_GAP</td>
<td>0.17</td>
<td>0.03</td>
</tr>
<tr>
<td>ANXIOUS BAY</td>
<td>0.11</td>
<td>0.02</td>
</tr>
<tr>
<td>AVOID BAY</td>
<td>0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>HOTSPOT</td>
<td>0.23</td>
<td>0.04</td>
</tr>
<tr>
<td>WARD ISLAND</td>
<td>0.19</td>
<td>0.06</td>
</tr>
<tr>
<td>TIPARRA REEF</td>
<td>0.18</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Average minimum density \( WZ = 0.04 \text{ m}^2 \)
Average maximum density \( WZ = 0.16 \text{ m}^2 \)
Critical Reproduction Threshold - Density

‘They were plastered everywhere over the bottom of the gutter, and about 3 or 4 high up the sides – it was a genuine “stuffer”’

‘They were rumoured to have quickly taken over 100 tons of abalone, in the virgin grounds’
Elliston and Waterloo Bay, 1966

‘With up to 40 boats regularly working in and out of Elliston at a sustained pace, it was only a matter of time before the resource was being tested and over-fished and catch rates started to decline’
Elliston 1968
• We have been using ZebraTech UW callipers since 2016
• Not only measure size, also depth and time stamped
• While density is low there is clearly aggregation (as expected)
• Pockets of abalone may still be able to breed (likely)
• Clusters 3 or more measured \(\leq 10\) seconds
• 15 clusters in 2016 - 7 in 2022
Number of clusters decreased at all Western Zone Sites between 2016 and 2022.

Clusters also decreased in the Central Zone, Tiparra Reef being the exception.

Most clusters were relatively small (average 3-4 abalone).

### Cluster size

<table>
<thead>
<tr>
<th>Locations</th>
<th>2016 Average</th>
<th>2016 Max</th>
<th>2022 Average</th>
<th>2022 Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anxious Bay</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Avoid Bay</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The Gap</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Corny Point</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hardwicke Bay</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Port Victoria</td>
<td>4</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tiparra Reef</td>
<td>4</td>
<td>14</td>
<td>4</td>
<td>16</td>
</tr>
</tbody>
</table>
• Time between measurements may be a useful proxy for reproductive potential?
• Reproductive potential decreased between 2016 and 2022 (Tiparra Reef exception)
Critical Reproduction Threshold

Are we already below the reproduction threshold in South Australia?

- Likely yes in many locations
- Aggregation complicates using a single threshold density estimate
- Probably differs between species
- Being above threshold does not guarantee reproduction
- More work is required

- What can we do where we think we are below the threshold?
We conclude that the best way to protect the viability of a fishery on broadcast spawning, long-lived marine invertebrates is through protection of brood stock in closed areas. If established at the correct spatial scale for recruitment, these protected areas may act as a reserve in periods of over-exploitation and a source area for continued sustainability.
Critical Reproduction Threshold – Solutions

1) Tasmania solution - The Dr Craig Mundy “Love Boat”
   • Vessel moves around collecting local abalone and spawning – releasing
   • Increases probability of successful reproduction – reduces natural failure

2) Micro MPA’s/spawning enhancement areas (SEA’s)
   • Small marked reproduction reserves (e.g. 50 * 50m) within fishing grounds
   • Fishers actively enhance and never take fish from the SEA
   • Increases chance of maximum reproductive success when conditions favourable
   • In SA could implement and monitor within areas that already have FIS

Both as an insurance against complete recruitment failure (hopefully!)
Protecting spawning potential is important! – Workshop 1

Ukaipōtanga/Ahikātanga

1. Natural nursery specific knowledge,
2. Circumstances specific to the sensitive factors needed to support spawning grounds.
3. Knowledge of Biotic and Abiotic factors crucial for reproduction and population stability of a species
4. Husbandry - organic or ecosystem services that support intergenerational succession
5. Specific to people, taonga species and spaces (in rohe)
Summary

- Abalone are unlikely to be resilient, less so when densities are low
- Density and nearest neighbour information are both important
- Lack of historical fisheries information – what is the appropriate natural density?
- Many South Australian Greenlip Abalone stocks are likely below reproductive threshold
- Time stamped survey information may provide a valuable tool to monitor threshold
- Small protected areas may be a good mechanism to help restore depleted stocks?
Acknowledgements:

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Thanks to:

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Critical Reproduction Threshold - Density

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</tr>
<tr>
<td>AVOID BAY</td>
<td>0.21</td>
<td>0.14</td>
</tr>
<tr>
<td>DRUMMOND SOUTH</td>
<td>0.38</td>
<td>0.23</td>
</tr>
<tr>
<td>HOTSPOT</td>
<td>0.54</td>
<td>0.13</td>
</tr>
<tr>
<td>POINT WESTALL</td>
<td>0.42</td>
<td>0.25</td>
</tr>
<tr>
<td>SHERINGA</td>
<td>0.30</td>
<td>0.11</td>
</tr>
<tr>
<td>WARD ISLAND</td>
<td>0.63</td>
<td>0.30</td>
</tr>
<tr>
<td>GERLOFFS BAY</td>
<td>0.93</td>
<td>0.29</td>
</tr>
<tr>
<td>MIDDLE POINT</td>
<td>0.68</td>
<td>0.29</td>
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<tr>
<td>NUMBER 2 ROCKS</td>
<td>0.48</td>
<td>0.41</td>
</tr>
<tr>
<td>RIVOLI BAY</td>
<td>1.32</td>
<td>0.45</td>
</tr>
<tr>
<td>PORT MACDONNELL</td>
<td>1.13</td>
<td>0.80</td>
</tr>
</tbody>
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Average minimum density
WZ = 0.20 m\(^2\)
SZ = 0.45 m\(^2\)

CPUE in WZ is about 60kg/hr vs 120kg/hr in SZ (whole wt)
Critical Reproduction Threshold - Density

- BL density appears higher but inflated by more 3D habitat?
- More BL live in confined spaces, could that aid reproduction/recruitment?
Critical Reproduction Threshold – Clustering (Separation)

- Evidence short times between measurements is decreasing at all sites except Tiparra
Critical Reproduction Density - Greenlip
Critical Reproduction Density - Blacklip
Critical Reproduction Density
No-take marine reserves can enhance population persistence and support the fishery of abalone

Marisa Rossetto, Fiorenza Micheli, Andrea Saenz-Arroyo, Jose Antonio Espinoza Montes, and Giulio Alessandro De Leo

In addition, our modeling exercise indicates MR networks could be established without dramatic losses in fishery performance, provided that the size of individual reserves is adjusted to the species’ dispersal ability. In particular, our analysis suggests that the best outcomes for *H. fulgens*, in terms of fishery output, would be achieved with small reserves ~100 m wide. Under these management scenarios, reproductive individuals protected inside the reserves can substantially contribute to recruitment in the fishable areas, thereby supporting yields comparable to MSY without MRs. With small re-
Critical Reproduction Density - Clustering

- 13 clusters in 2016 - 7 in 2022
Critical Reproduction Density - Clustering

- 8 clusters in 2017, 1 in 2022
- Anxious Bay contrasts The Gap and Avoid Bay, very few aggregations
- This site is almost certainly recruitment impaired and unlikely to recover fast