RED ABALONE EGG PRODUCTION ESTIMATES AS INDICATORS FOR FISHERIES AND RESTORATION IN A WARMING OCEAN: CLIMATE READY

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EGG PRODUCTION: TALK OUTLINE

• Climate Change: Need For Indicators
• Egg Production Indicator
• Indicators for Management Triggers
• Indicators for Recovery Targets
• Methods
• Results Management and Restoration
• Climate Ready Strategies
• Future Directions
FISHERY IMPACTS ON ABALONE
EXTREME MARINE HEAT WAVES
FRÖLICHER AND LAUFKÖTTER 2018

CLIMATE CHANGE IMPACTS ON ABALONE
PREDATOR IMPACTS ON ABALONE

Photo Athena Maguire

Photo M Brigadier
Disease – 90-95% of the population dead
Black fishery Closed 1993
Multiple Stressors: Kelp Decline

- Sea Star Wasting Syndrome (2013)
- Persistent Warm Water (2014 - )
- Purple Urchin Explosion (2014 - )
CLIMATE CHANGE INTENSIFIES POPULATION VULNERABILITIES
(ROGERS-BENNETT AND CATTON 2022 FRONTIERS IN CLIMATE, ECOLOGY AND PEOPLE)

- Mass Mortality
- Gonad Decline
- Storm impacts
- Recruitment Failure
Marine Heat Wave

Kelp Forest Collapse

Abalone Mass Mortality

Increased Vulnerability to Fishing Pressure

Adaptive Management

Rogers-Bennett and Catton 2022 Cascading Impacts
Rains killed abalone 2019, 2021, 2022

Photos Esquivel
WHAT INDICATORS DO WE USE FOR A CHANGING CLIMATE?

- Abundance surveys
  - Transects
  - Nearest neighbor distance
  - Timed swims
- Size frequency
  - Spawning potential ratio
- Catch and CPUE
- Recruitment monitoring
Egg Production Indicator
Data Needs:
Length Weight Relationship
Weight Egg Production
Density estimate
Size frequency distribution
Weight (g) = 0.0001286 Shell Length ^ 3.014
Weight Frequency x Density / 2 = Female Biomass/Hectare within each weight category
1 gram of female body weight = 4712.432 eggs
\[ \sum (\text{biomass (g/hectare)} \times 4712.432 \text{ eggs/g}) = \text{eggs/hectare} \]
Weight freq. multiplied by site density and divide by 2 for females only.

\[ \sum \text{Sum female biomass across all weight categories.} \]

FEMALE BIOMASS CALCULATION USING DENSITY
1 gram of female body weight = 4712.432 eggs \hspace{1cm} (Eq. 2)

TOTAL EGG PRODUCTION FOR A SITE = CONVERSION OF TOTAL BIOMASS TO TOTAL EGGS USING EQ. 2
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**MANAGEMENT RESULTS**
• Theoretical Method: Density of 0.25 abalone /m²
• Empirical Method: Set a density based on experience with the fishery

MANAGEMENT REFERENCE POINTS
Idealized length frequency distribution based on baseline (2003-2007) surveys

**Limit**
- Density = 0.25 abalone/m$^2$

**Target**
- Density = 0.4 abalone/m$^2$

- 5000 million eggs/hectare
- 8000 million eggs/hectare
Theoretical Targets

Empirical Targets Determined from
- Approx. 40% of Baseline values
- Baseline Values for a site as measured in the past

Explore Spatial Aspects of the Recovering Population
- Could set a value that 75% of the sites must reach the target

SETTING RESTORATION TARGETS
We have presented a Method for established Management and Restoration Targets that is built on information about BOTH Density as well as the Size Freq. Distribution.
Density is responsive to Mass Mortality events and Climate Impacts but is variable due to patchy distributions.

Densities are rough estimates but are useful for impacts to all size classes

DISCUSSION: DENSITY
DISCUSSION: SIZE FREQUENCY

- Size Frequency: Fishing Impacts
  Large sizes (But poaching can impact small sizes)

- Size frequencies combined with density can give a better picture of potential reproductive output.

- Recovering populations will have large numbers of small individuals
FUTURE DIRECTIONS

- Explore uncertainties in Estimates and Sensitivities
- Examine How Patchy distribution Impacts Estimates – especially as densities increase
- Explore Spatial Resolution
- Explore Responsiveness
- **Egg Production** is a powerful tool for setting abalone management reference points as well as recovery targets.

- **Data Requirements:** Density, Size Freq. and reproductive info.

- **Egg Production Method** is sensitive to Climate Change.
THANK YOU
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