Evaluating the flexibility of a reflex action mortality predictor to determine bycatch mortality rates:

A case study of Tanner crab (Chionoecetes bairdi) bycaught in Alaska bottom trawls

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Bycatch mortality

• A component of fisheries mortality

• **Discard-mortality:** captured, brought on-deck, released
  • Capture process
  • Air and sunlight exposure
  • Handing/ injury on deck

• **Unobserved-mortality:** encounters gear, without capture
  • Injury from gear or from captured animals
Bycatch mortality

• Direct observation
  • Mark-recapture
  • Acoustic telemetry
  • Captive holding

• Physiological assessment (stress)
  • Metabolic
  • Biochemical
  • Immune response
RAMP

- Reflex Action Mortality Predictor
  - (Davis and Ottmar, 2006; Davis, 2007)

- Relates reflex impairment to probability of mortality
RAMP

• Quantify bycatch mortality
• Evaluate influences on mortality
• Conservation engineering

• Fishes and invertebrates
• Pot and trawl gear
Case Study: Bycaught Tanner Crab

- Alaska bottom trawl fishery
  - Bering Sea
  - Gulf of Alaska
- Tanner and snow crab bycatch
  - *Chionoecetes bairdi* and *C. opilio*
- Zero retention
- Prohibited fishing grounds
- Bycatch limits
Bycatch Mortality: Tanner crab

- **Unobserved Tanner and snow crab bycatch**
  - Stoner et al., 2008, Rose et al., 2013; Hammond et al., 2013
    - Bottom trawl fishery in the Bering Sea
    - RAMP
    - Gear modifications

- **Discarded Tanner crab**
  - Blackburn and Schmidt (1988)
    - 17%: bottom trawl fishery in the Gulf of Alaska
    - Viability assessments
  - Stevens (1990)
    - 78%: bottom trawl fishery in the Bering Sea
    - At-sea holding
RAMP Reflexes for Tanner and Snow Crab
Stoner et al., 2008

- Leg flare
- Leg retraction
- Chela closure
- Eye retraction
- Mouth closure
- “Kick”
Bycatch Mortality: Tanner crab

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Evaluation of RAMP: “Flexibility”

Graph showing the probability of mortality against reflex impairment score.

- Probability of Mortality
- Reflex Impairment Score

Points on the graph:
- Unobserved-mortality
- Discard-mortality
Evaluation of RAMP: “Flexibility”

“Unobserved-mortality”
- Hammond et al., 2013
- Bottom trawl fishery
- Research trip
- Bering Sea
- RAMP
- Auxiliary net
- Short tows
- Air exposure < 15 minutes
- Some recovery in water before assessment

“Discard-mortality”
- This study
- Bottom trawl fishery
- Commercial trip
- Gulf of Alaska
- RAMP
- Commercial fishing
- Commercial tow duration
- Average air exposure 90 minutes (9-230 minutes)
- No recovery in water
Discard-mortality Study: Data Collection

- May 2011
- F/V Sea Mac
- 3-day shallow-water flatfish bottom trawl fishery

• Tow information:
  • Water depth
  • Temperature at depth
  • Tow duration
  • Catch size
Discard-mortality Study: Data Collection

- Crab information:
  - Carapace width (mm)
  - Sex
  - Chela loss
  - Shell condition (0-5)
  - RAMP “Score” (0-6)
  - Time out of water prior to assessment
Discard-mortality Study: Holding

**On-board Tanks**
- Plumbed on-board tanks (1-3 days)
- Cable tie with RFID chip (Hallprint)
Discard-mortality Study: Holding

**At-sea Cages**
- 92 crab
- Mixed Score, size, and sex
- 11 days of holding

**Laboratory Tank**
- 28 crab
- Mixed Score, size, and sex
- 12 days of holding
- Fed
- Temperature controlled
Discard-mortality Study: Data Analysis

- **Logistic RAMP**: Binary logistic regression
  - Response: Mortality
  - Predictors: Fishing and biological variables
    - Score
    - Sex
    - Shell condition
    - Haul duration
    - Carapace width
      - Continuous
      - Binned: Small and large (≥90 mm)
  - Backward stepwise model selection

- **Discrete RAMP**
  - Actual proportion died
Study Comparison: Data Analysis

- Compare RAMPS
  - Visual
  - Fisher’s exact test
  - Mantel-Haenszel test
  - Logistic RAMP: Combined data
    - “Study” as a predictor
    - Interaction between “Study” and “Score”
    - Backward stepwise model selection
  - Mortality rate estimation
Discard-mortality Study: Results

- 261 discard crab
- Immediate mortality: 12 crab
- 68% held crab survived
Discard-mortality Study: Results

- 86% within 1 day
- 92% within 2 days
Discard-mortality Study: Results

- **Laboratory holding**
  - Mortality at 12 days
  - 3 Score-zero crab died

- **At-Sea Cage holding**
  - 3 crab died
  - Scores 1, 2, and 6
Study Comparison: Results

Selected predictors:

- Discard-mortality
  - Score

- Combined data
  - Score
  - Binned-width
  - Study
  - Study * Score
Study Comparison: Results

Selected predictors:

• Discard-mortality
  • Score

• Combined data
  • Score
  • Binned-width
  • Study
  • Study * Score

$Score_{50}: \sim 2$

$Score_{50}: 3$
Study Comparison: Results

Selected predictors:

- Discard-mortality
  - Score
- Combined data
  - Score
  - Binned-width
  - Study
  - Study * Score
Study Comparison: Results

![Bar chart showing comparison of discard-mortality RAMP and unobserved-mortality RAMP across Logistic and Discrete categories. The chart indicates that both categories show a 31% mortality rate, with Logistic having a discard-mortality RAMP of 24% and a unobserved-mortality RAMP of 31%. Discrete also shows a discard-mortality RAMP of 24% and a unobserved-mortality RAMP of 31%.]
Study Comparison: Conclusion

• Main difference:
  • Treatment of crab before assessment
    • Recovery period in water
      • Discard: No
      • Unobserved: Sometimes
  • Air exposure:
    • Discard: 90 minute average (9-230 minutes) of air exposure
    • Unobserved: <15 minutes
Study Comparison: Recommendations

• RAMP may produce more accurate mortality estimates when applied to animals experience similar stressors as those evaluated to create the RAMP, through similar methodology

• Especially important with large number of animals with intermediate Scores
Study Comparison: Recommendations

- Creating a RAMP:
  - Create well documented, repeatable methods
  - Collect data on all possible stressors and evaluate them for their contribution to mortality
  - In methods, make it clear what is meant by “absent” and how immediate mortalities are treated
- Reflexes:
  - Assess RAMP reflexes in a standardized order
  - If reflexes influence other reflexes, do last or not at all
  - If reflex is difficult to determine presence/absence do not use
Conclusions

• RAMP is an effective tool for quantifying and evaluating bycatch mortality

• RAMP from this study can be used to determine discard mortality rates for Tanner crab in the Alaska bottom trawl fishery

• Additional study needs to be done on the role of a recovery period in water and air exposure on determining a RAMP “Score” (in process)
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Questions?