Modelling the Effectiveness of Searches for Invasive Tunicates in a Prince Edward Island Estuary

ICAIS
2009

Lisa Kanary
University of New Brunswick
Andrea Locke
Department of Fisheries and Oceans
James Watmough
University of New Brunswick

Introduction

Tunicates

Mussel Farming Industry

Introduction

AIS Rapid Response: Process

1. Tunicate is suspected in a bay
2. Report to AIS Rapid Response Toll Free Phone Number
3. DFO begins a search for reported tunicate

Introduction

AIS Rapid Response: Management

How to deal with an infestation?

- **Discovery:**

  Identify location

- **Risk Assessment:**

  Assess quantity

- **Management Options:**

  Isolate area and manage aquacultural vectors

Introduction

AIS Rapid Response: Search Methods

SCUBA Search

Plankton Pump

- visual
- molecular

Sock Lift

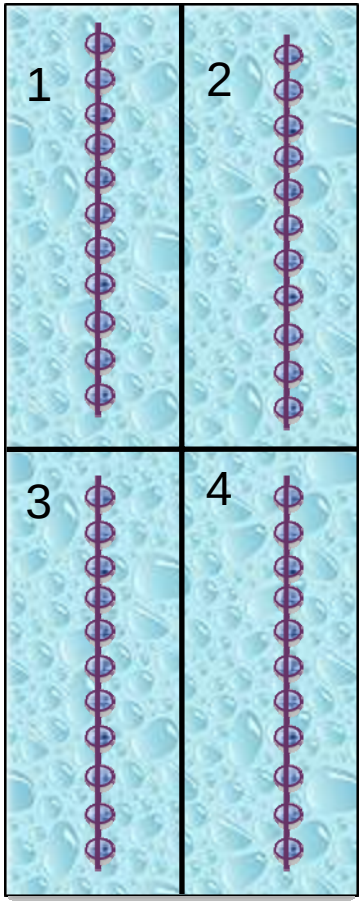
Eelgrass search

Buoy inspection

Shore and dock search

PVC settlement plates

Experiment



- 9 divers
- 4 sequences
- 11 socks in each sequence
- 6 single and 6 cluster decoys in each sequence

Each diver searched each sequence and reported the number of tunicates they viewed

Total: 72 reports

Experiment

AIS Rapid Response: Hypothesis Testing

	Decoy Detected	**Decoy not Detected**
Decoy Present	Correct	**Type II Error**
Decoy not Present	Type I Error	Correct

Model

Binomial and Poisson Distributions

$$P(i) = \frac{n!\, p^i (1-p)^{(n-i)}}{i!(n-i)!}$$

p is the chance of finding a real tunicate

$$P(j) = \frac{e^{-\lambda} \lambda^j}{j!}$$

λ is the rate of finding 'false positives' (wrongly identified)

$$P(k) = \sum_{i+j=k} P(i)P(j)$$

Model

Number of Tunicates	Observed Values per Diving Event
0	0
1	0
2	0
3	3
4	4
5	19
6	35
7	7

Use a Maximum Likelihood Function to find a λ and a p that best fit the model to the observed data

Results

λ=0.18

p=0.89

Model

Number of Tunicates	Observed Values per Diving Event	Expected Values per Diving Event
0	0	0
1	0	0
2	0	0
3	3	1
4	4	6
5	19	21
6	35	33
7	7	6

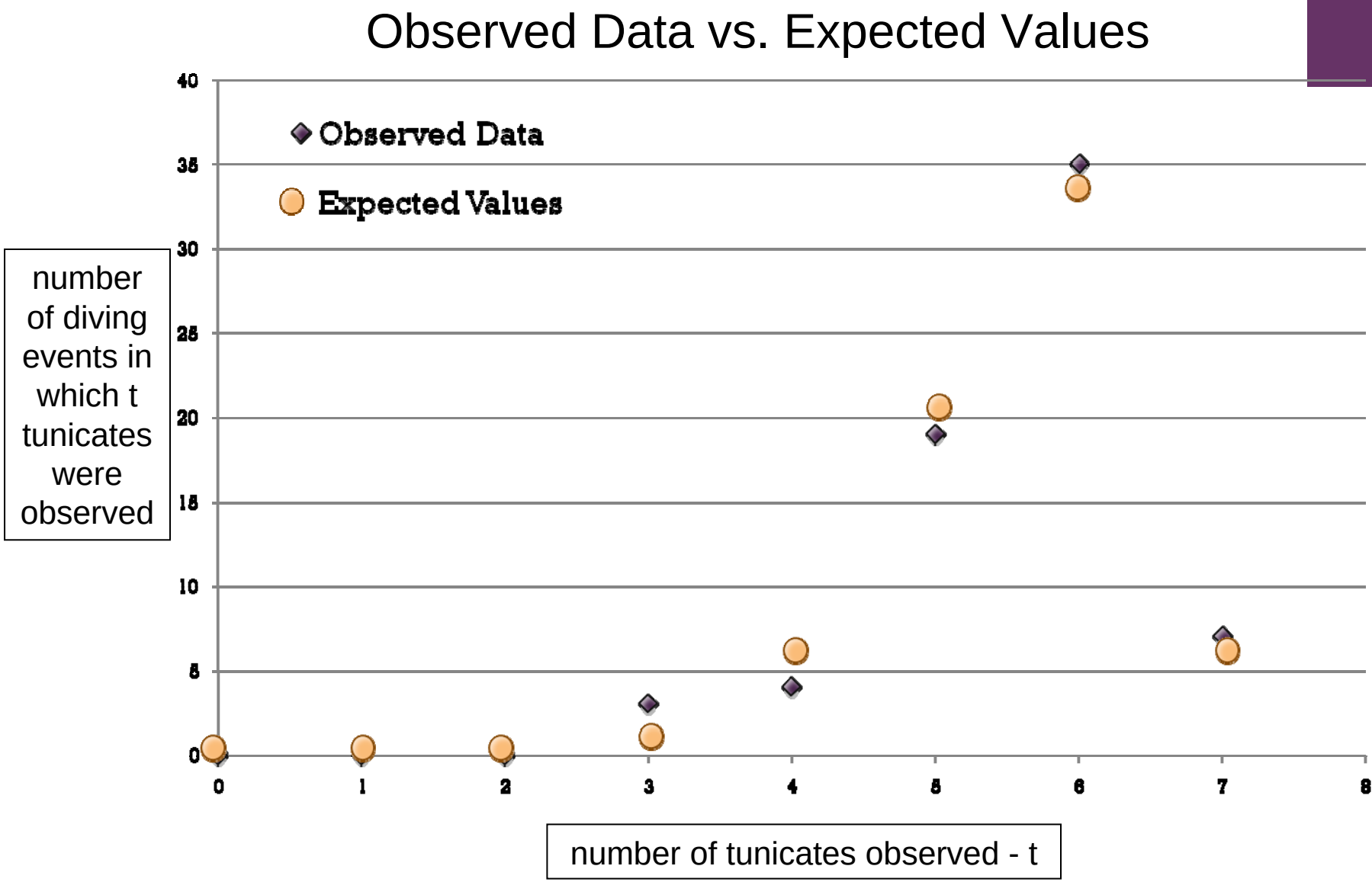
Use a Maximum Likelihood Function to find a λ and a p that best fit the model to the observed data

Results

λ=0.18

p=0.89

Model


Observed Data vs. Expected Values
Observed Data
Expected Values
number of diving events in which t tunicates were observed
number of tunicates observed - t
0
5
10
15
20
25
30
35
40
0
1
2
3
4
5
6
7
8

Results

What do these values mean?

$\lambda = 0.188$

Note: λ is equal to the expected number of false positives that occur during a given interval

i	$p_p(i)$
0	82.8 %
1	15.6 %
2	1.5 %
3	< 0.1 %
4	< 0.1 %
5	< 0.1 %
6	< 0.1 %
7	< 0.1 %

$p_p(i)$ is the probability of finding a false tunicate

Results

What do these values mean?

$$p = 0.898$$

Probability of finding a tunicate that is present

89.8 %

Probability of NOT finding a tunicate that is present

10.2%

Future Projects

Perform a cost analysis of all methods and compare their effectiveness

Model the population of the tunicate

Explore the Search Theory associated with the search methods used

Example using calculated value

Probability of finding at least one tunicate depends on

- probability of searching the sock with a tunicate
- number of socks searched, 176/hr
- probability tunicate is present, 18 tunicates/1000 socks (light infestation)
- probability of finding a tunicate given that it is there, 89.8%
- the distribution of the tunicate settlement

$$result \approx 96\%$$

Acknowledgements

Fisheries and Oceans Canada:
A. Smith, C. Barkhouse, M. Campbell, L. Comeau, D. Cairns, D. Bourque, J. Hill, T. Landry, A. LeBlanc, L. LeBlanc, C. Leger, G. MacCallum, L. MacLean, D. Mills, M. Ouellette, R. Sonier

University of New Brunswick:
T. Hasan

PEI Dept of Fisheries, Aquaculture and Rural Development :
B. Gillis, N. MacNair, A. Morrison

Atlantic Veterinary College:
G. Arseneault, J. Bakker, S. Clark, J. Davidson, J. Davidson, L. Ferguson, J. Fortier, S. Haines, C. Paetzold, A. Ramsay, M. Wodorski

PEI Aquaculture Alliance:
T. Cosh, L. Duncan, J. LaRosa, P. Warris

Laval & McGill University team:
D. Delaney, M. Becker, R. Descoteaux, L. Johnson

The mussel and oyster leaseholders of Hillsborough Bay

Model

Maximum Likelihood

$$f(p,\lambda) = p_j(0)^0\, p_j(1)^0\, p_j(2)^0\, p_j(3)^3\, p_j(4)^4\, p_j(5)^{19}\, p_j(6)^{35}\, p_j(7)^7$$

Results

$\lambda = 0.188$

$p = 0.898$

Future Projects

Example using calculated values

$$P(X \geq 1) = 1 - bin(0; n, p) = 1 - bin\left(0; 176, \left(1 - e^{-0.018}\right)(0.898)\right)$$

Probability of finding at least one tunicate

Probability of searching the sock with a tunicate

Number of socks searched

Probability tunicate is present

Previously computed probability of finding a tunicate given that it is present

$$= 95.9\%$$