Plan for the worst, hope for the best:

Using pilot data and simulation to design telemetry studies

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Acknowledgements

Great Lakes Restoration Initiative

Accountability – Action – Urgency

Telemetry Study Design

Hypotheses

- advance scientific knowledge
- relevant to resource management

Study Objectives

Analyses

Study Design
(telemetry system)

- system performance

Inferences

Telemetry Study Design

Hypotheses

- advance scientific knowledge
- relevant to resource management

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Study Objectives

↓

Analyses

↓

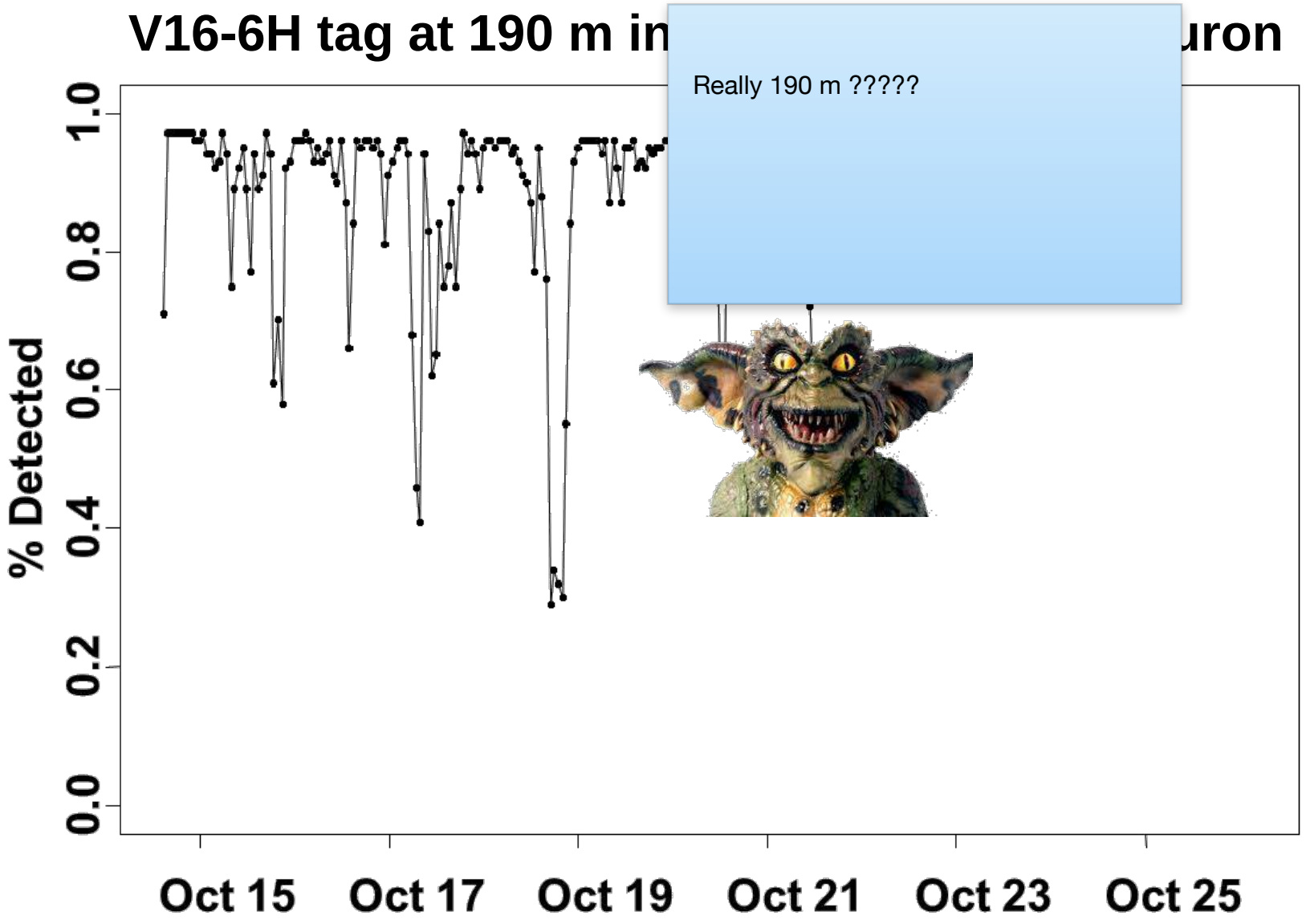
Study Design
(telemetry system)

- **system performance**
  - **code collisions**
  - **receiver spacing**

↓

Inferences

Telemetry System Performance



Telemetry System Performance

Environment

Attenuation
- Turbidity
- Entrained air
- Thermocline
- Bathymetry
- Vegetation

Noise
- Waves
- Current
- Precipitation
- Human activity
- Animals

Biology
- Swim speed
- Elevation
- Space use
- Survival
- Aggregation
- Tag effects

Receivers
- Location (x,y,z)
- Orientation
- Rigging

Transmitters
- Power (SPL)
- Delay
- Coding scheme
- Tag life
- Size and shape

Telemetry System Performance

2 concerns (of many)

1. **Collisions**

   Objective:

   Determine min. tag delay & max. number of tagged fish to minimize destructive tag code collisions.

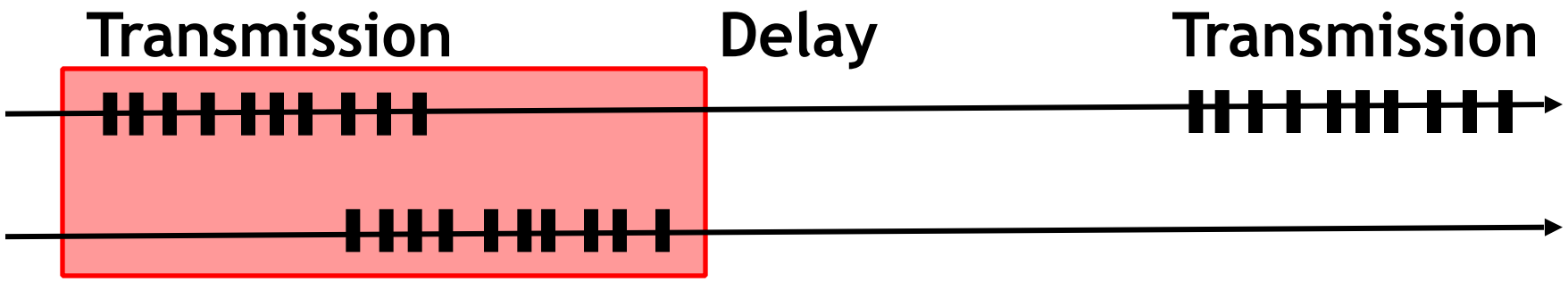
2. **Receiver spacing (detection range)**

   Objective:

   Determine max. receiver spacing to detect all fish passing a receiver line.

Managing Collisions

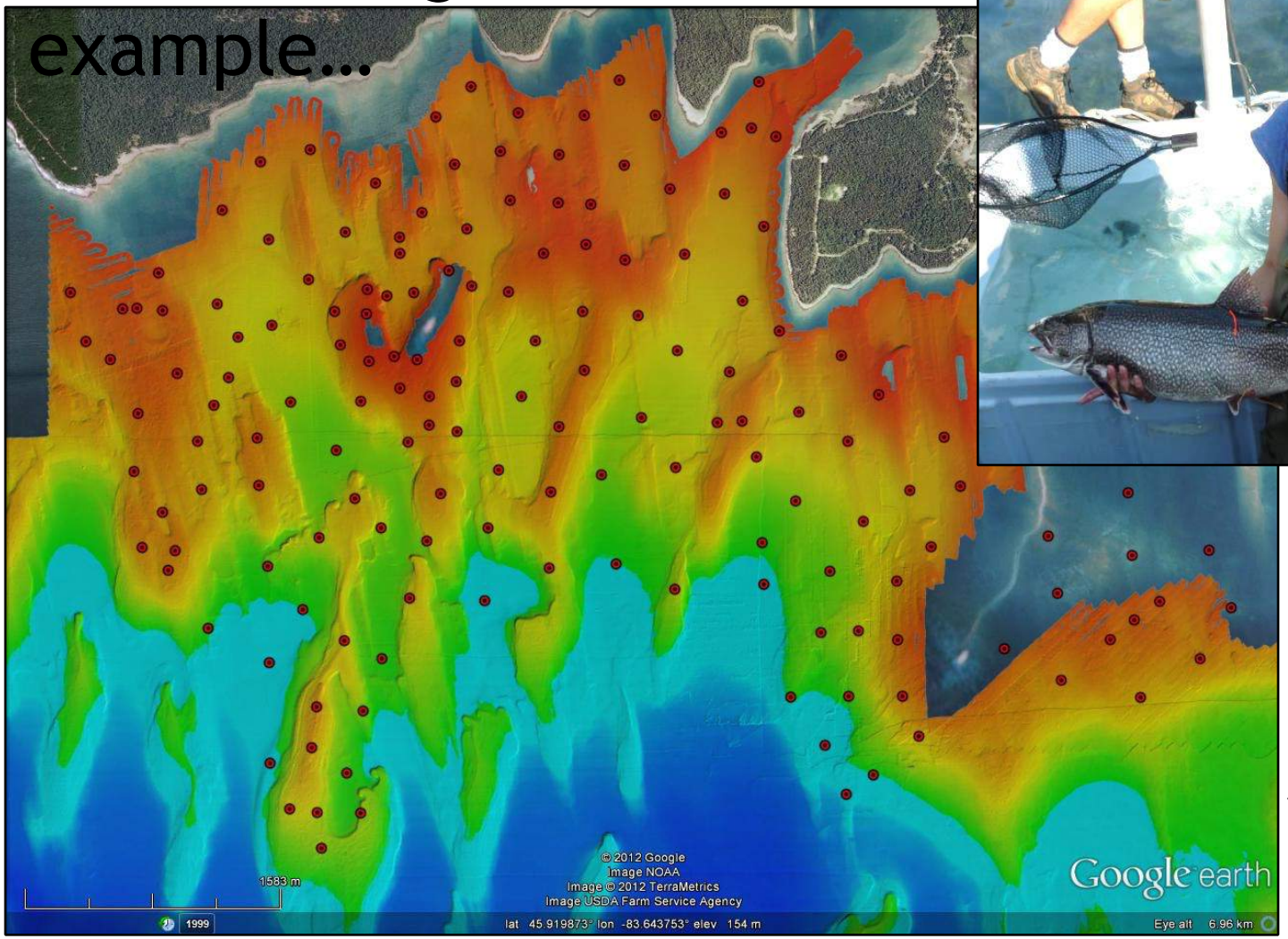
Multiple Pulse Coded Tags (e.g., Vemco Global coding)



Destructive collision

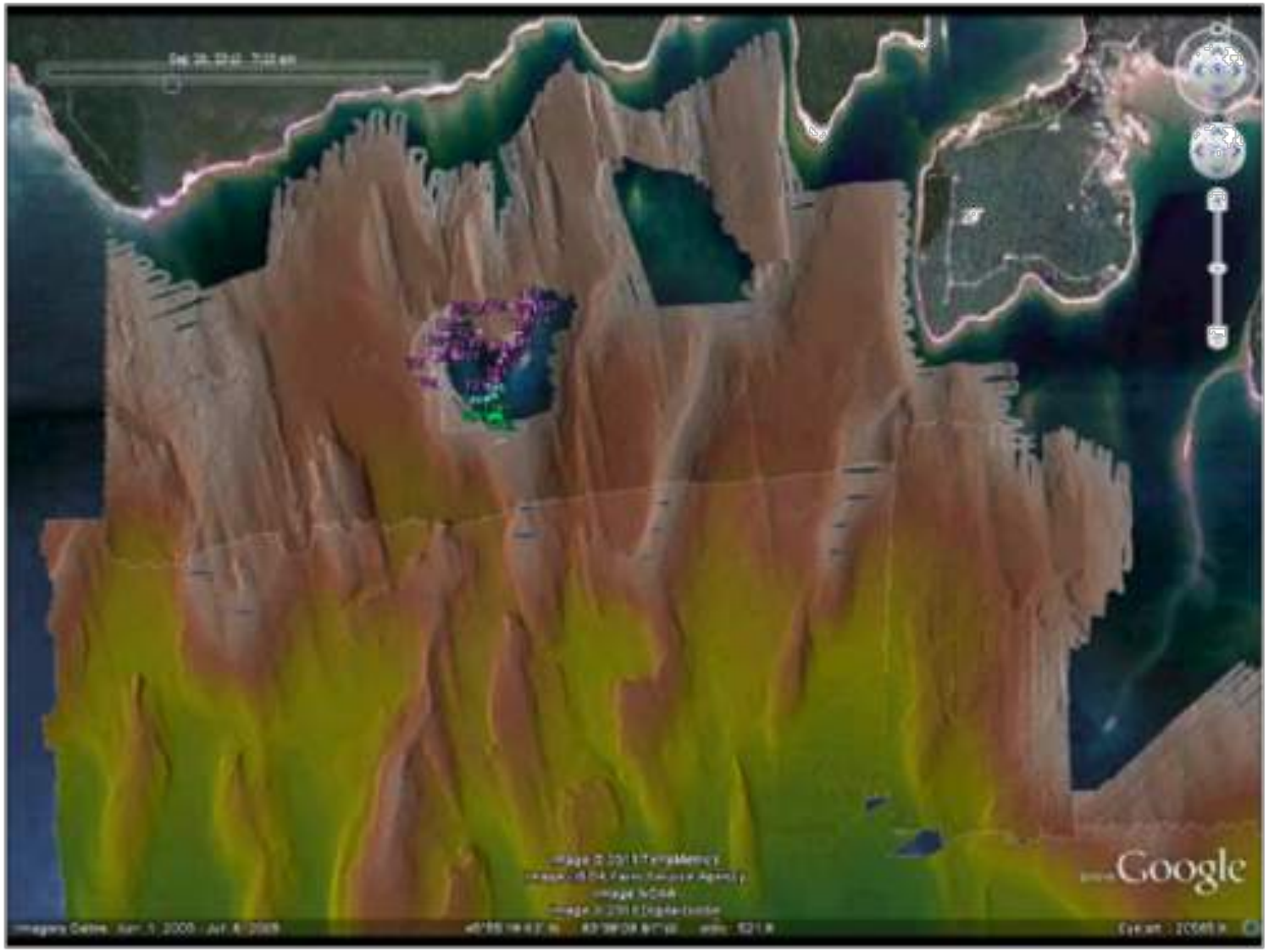
Managing Collisions

A motivating example…



- VPS array
- 27 km^2
- 149 VR2W

Managing Collisions



Managing Collisions

Managing Collisions

Objective 1:

Determine min. tag delay & max. number of tagged fish to minimize destructive tag code collisions.

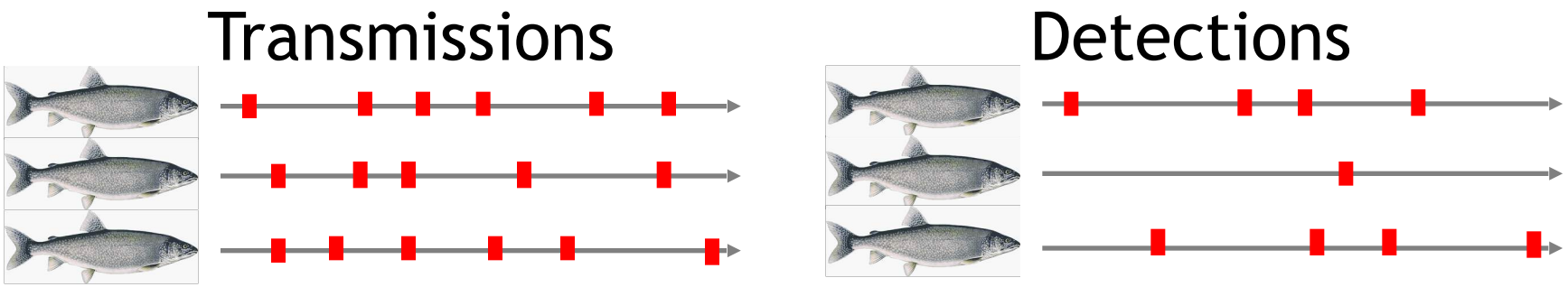
Managing Collisions

Choosing tag delay:

Simulate collisions (R function)

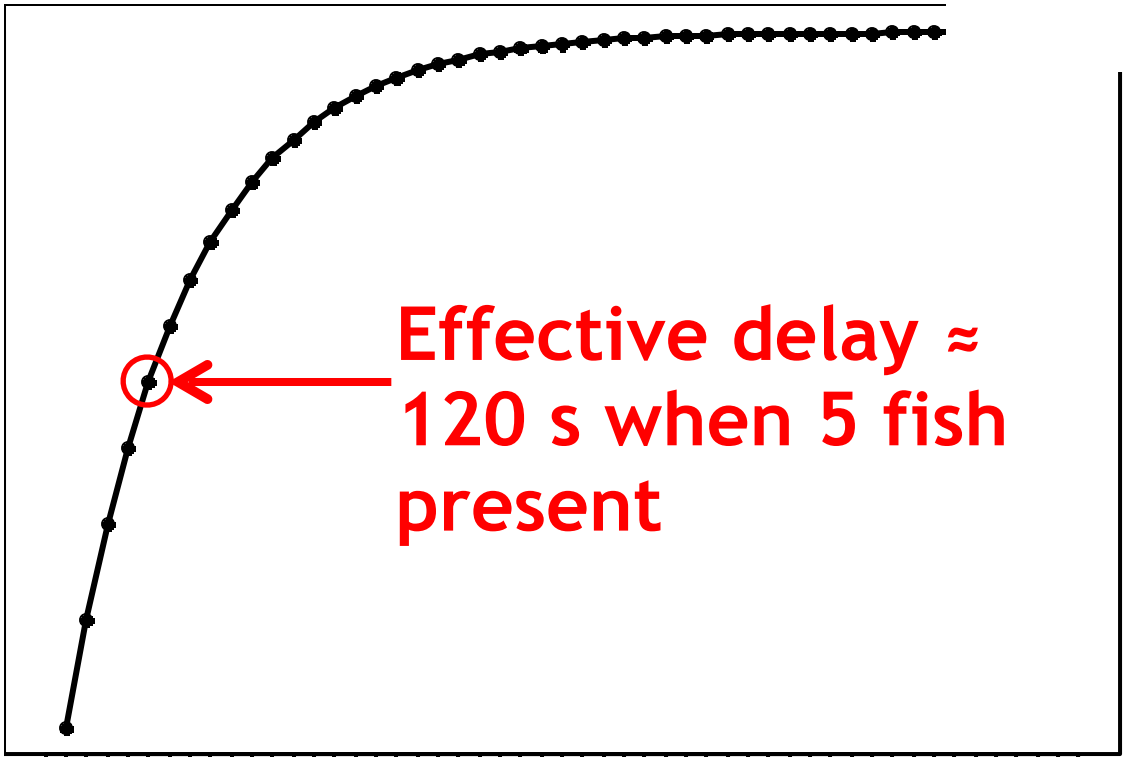
Prob. of collision ~ Burst duration
Tag delay (uniform dist.)
# of fish present

"Effective" delay



Managing Collisions

Choosing tag delay:



Managing Collisions

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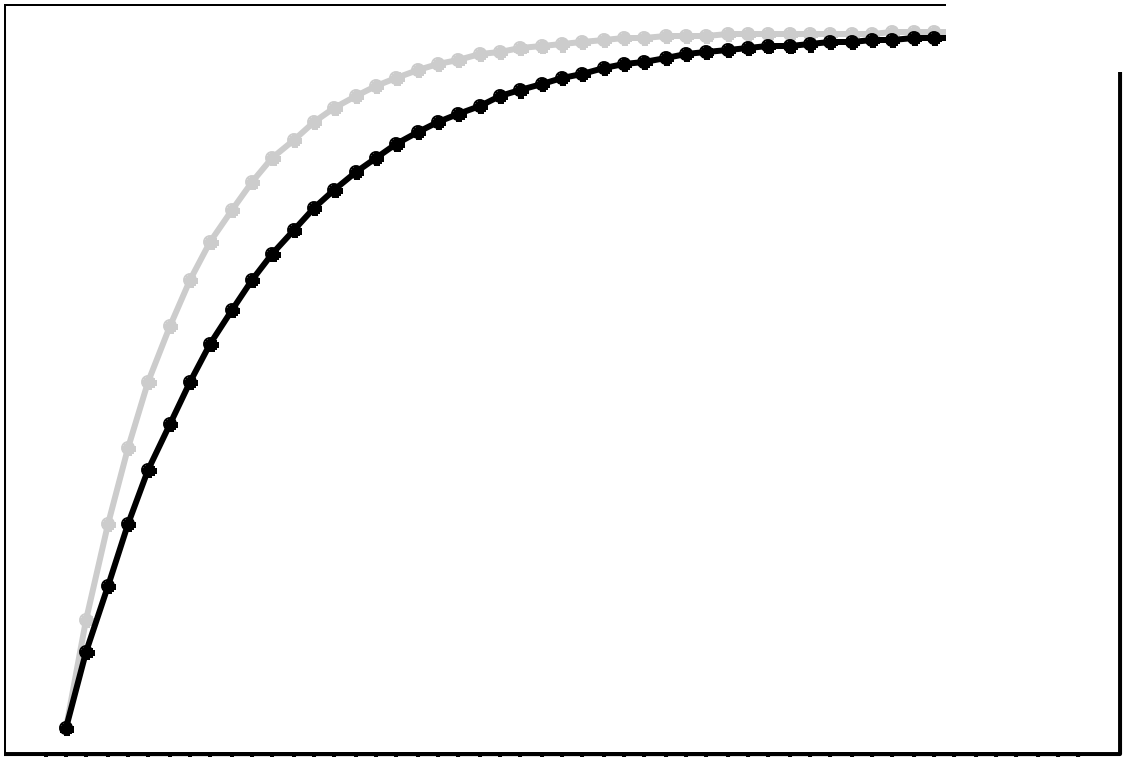

Managing Collisions

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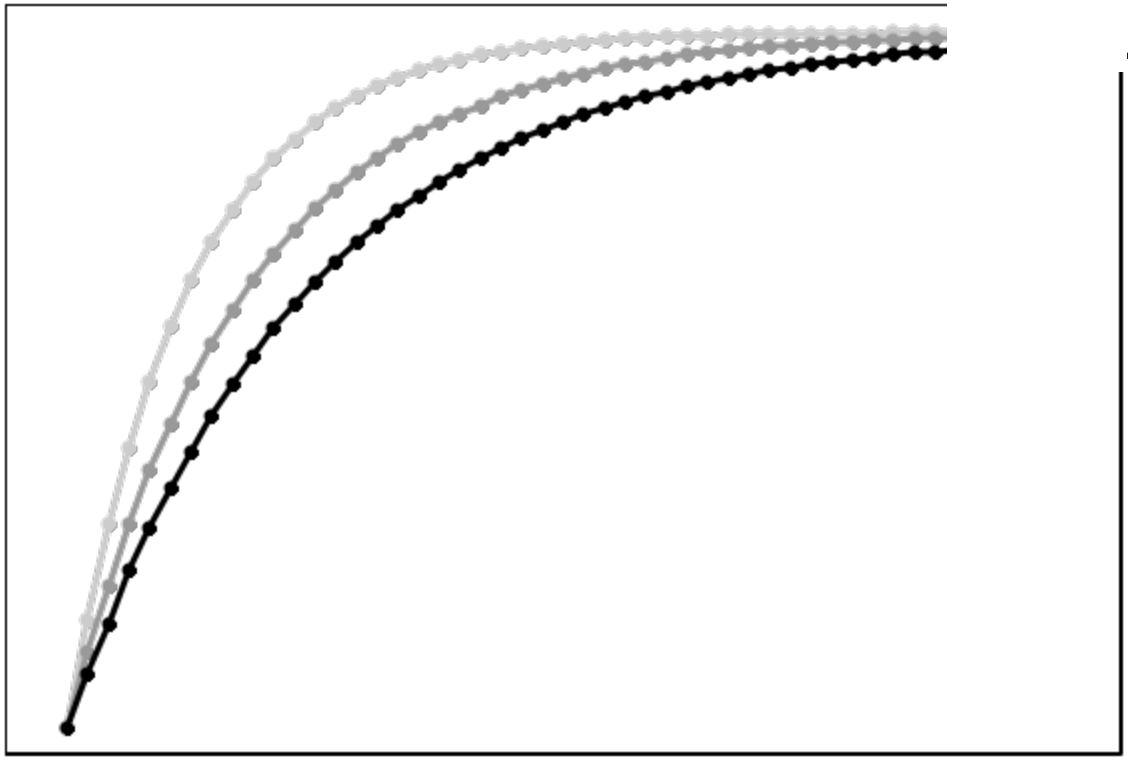

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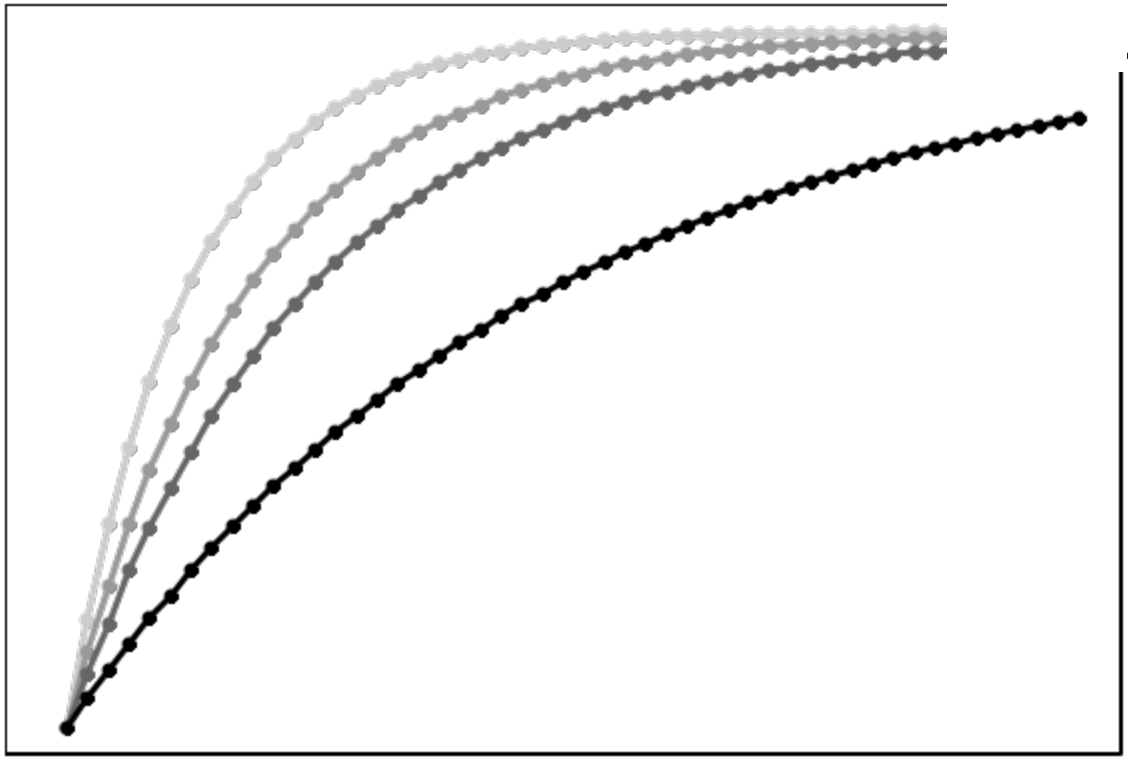

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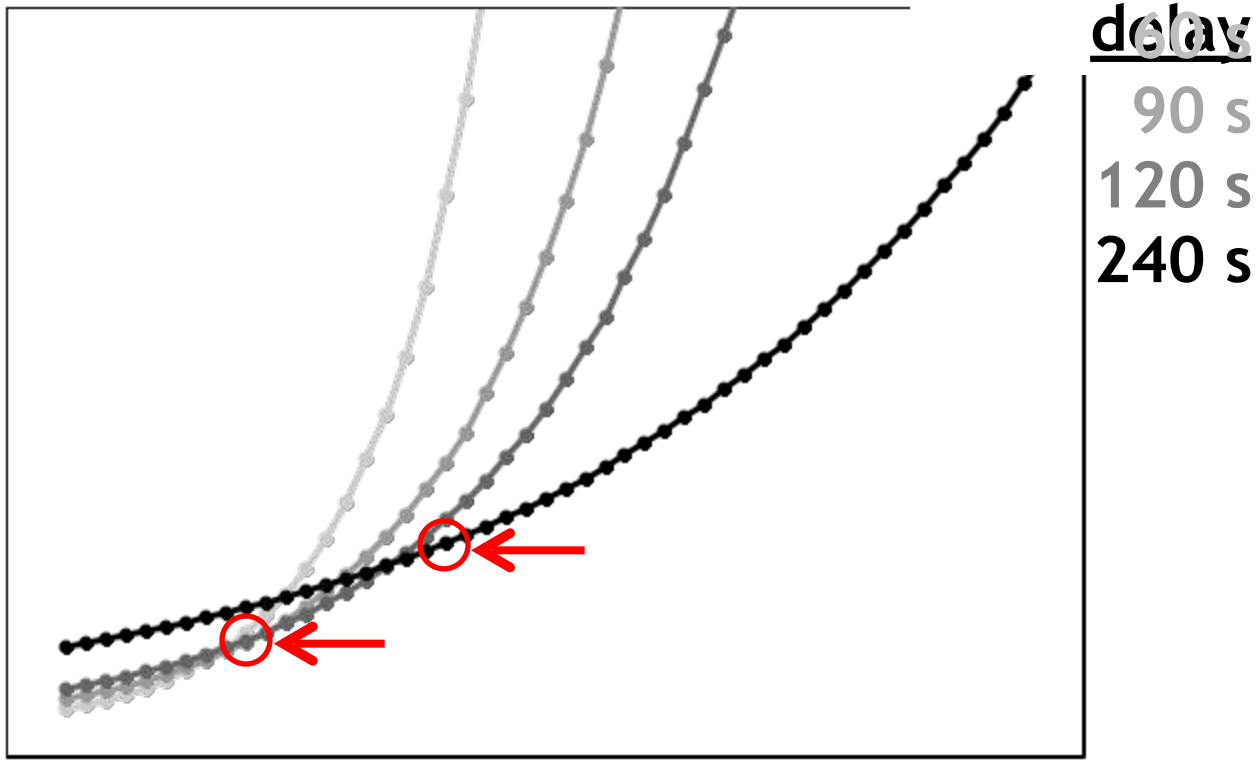
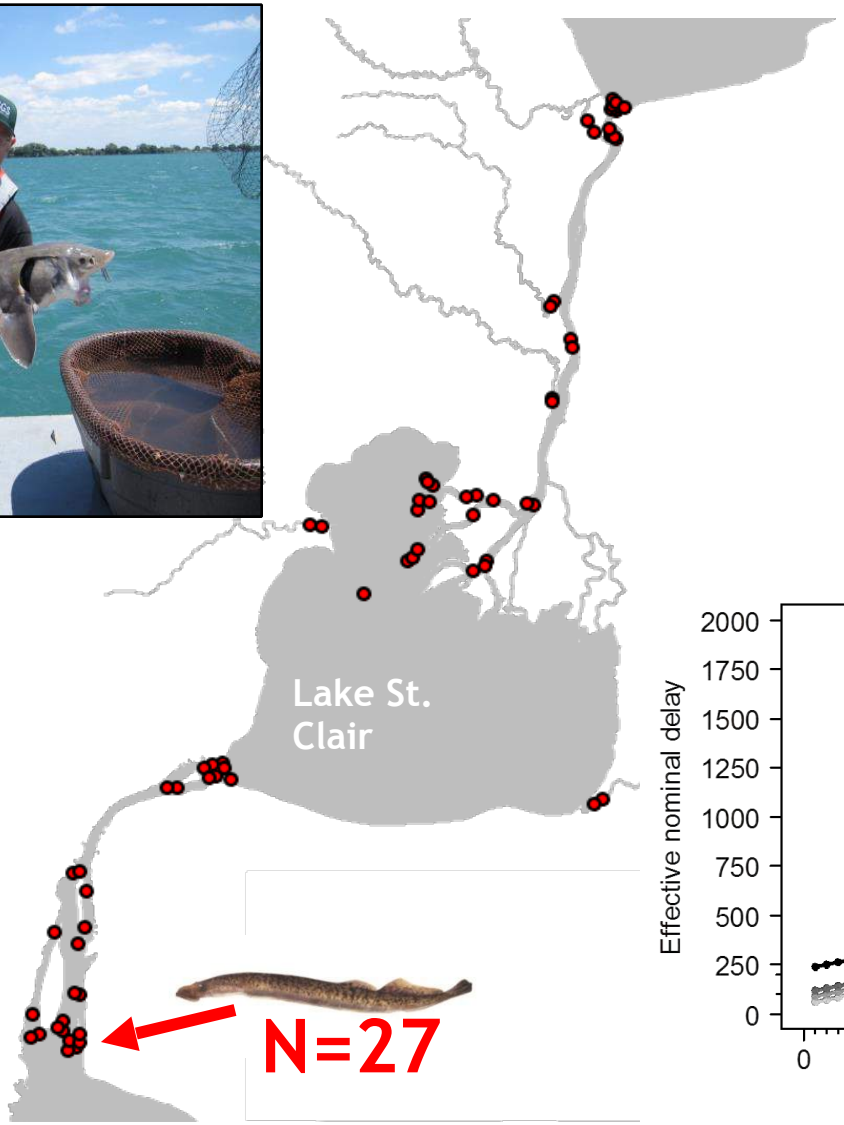
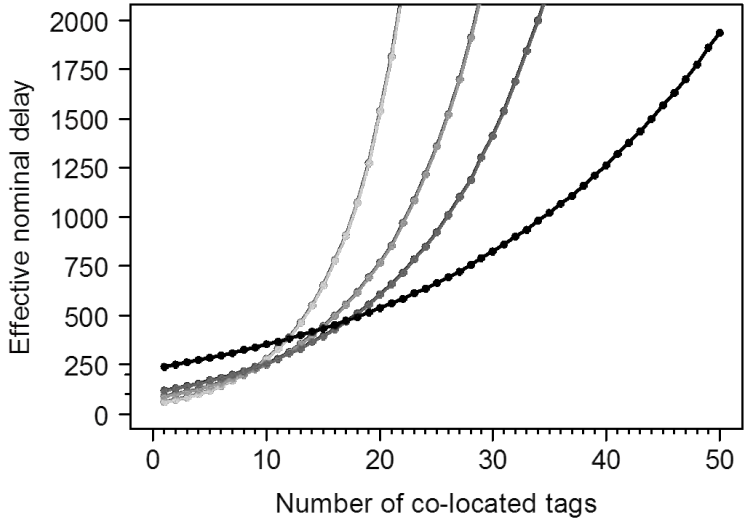


Managing Collisions



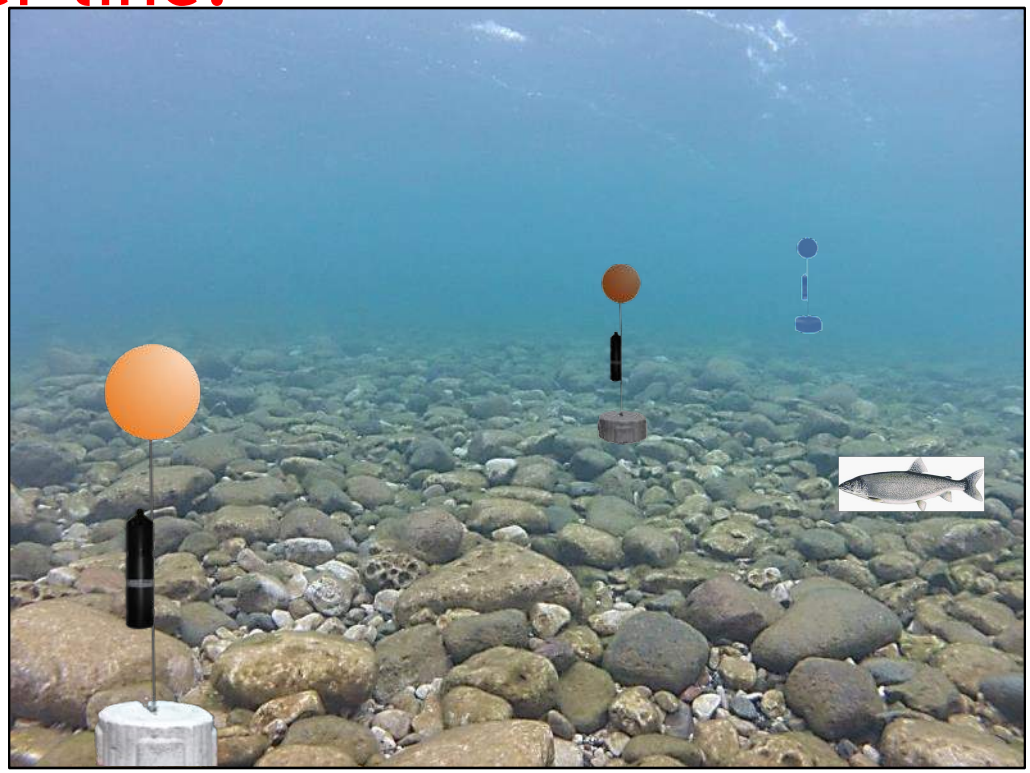


Telemetry System Performance

2. Receiver spacing (detection range)

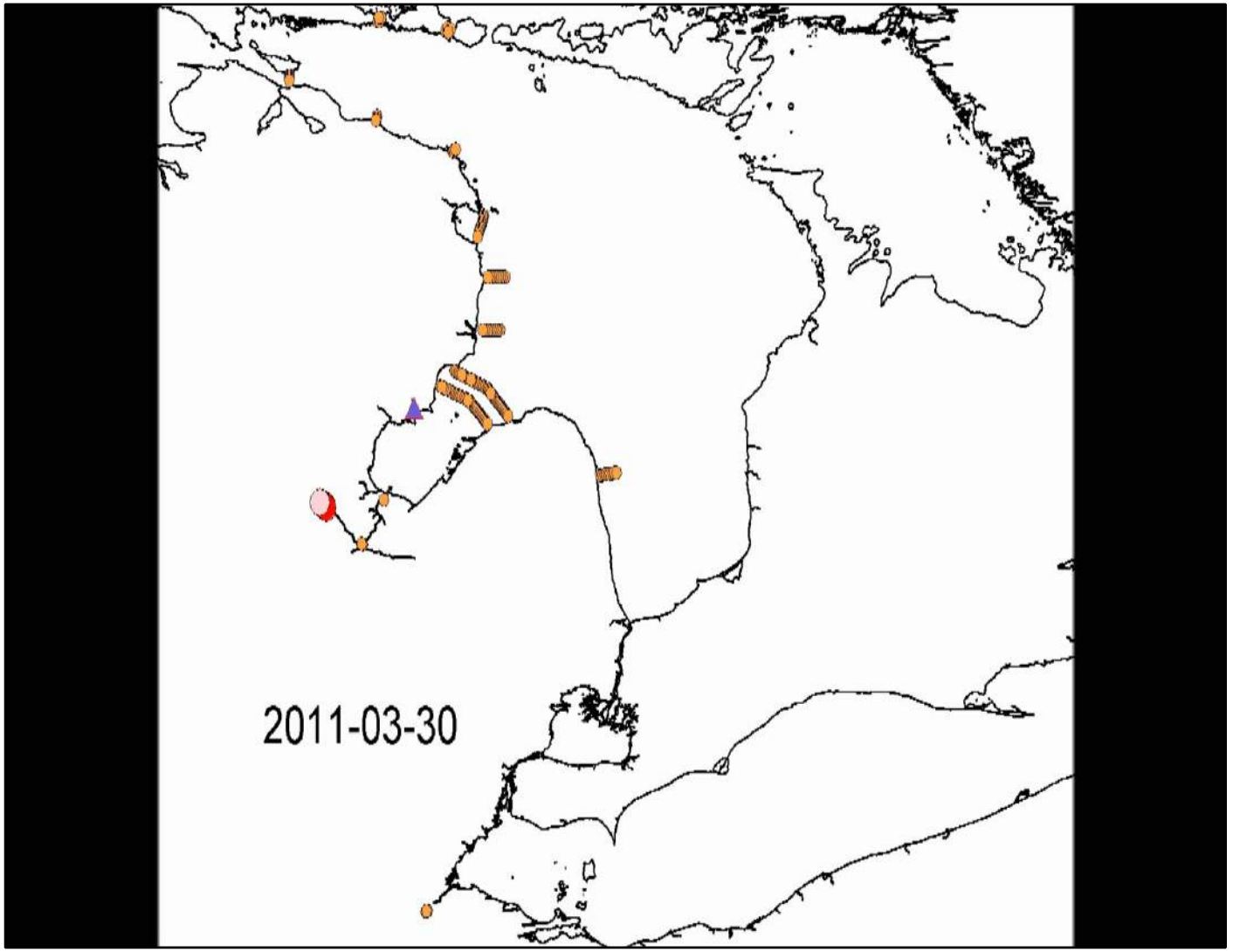
Objective:

Determine max. receiver spacing to detect all fish passing a receiver line.



Detection Range

Detection Range



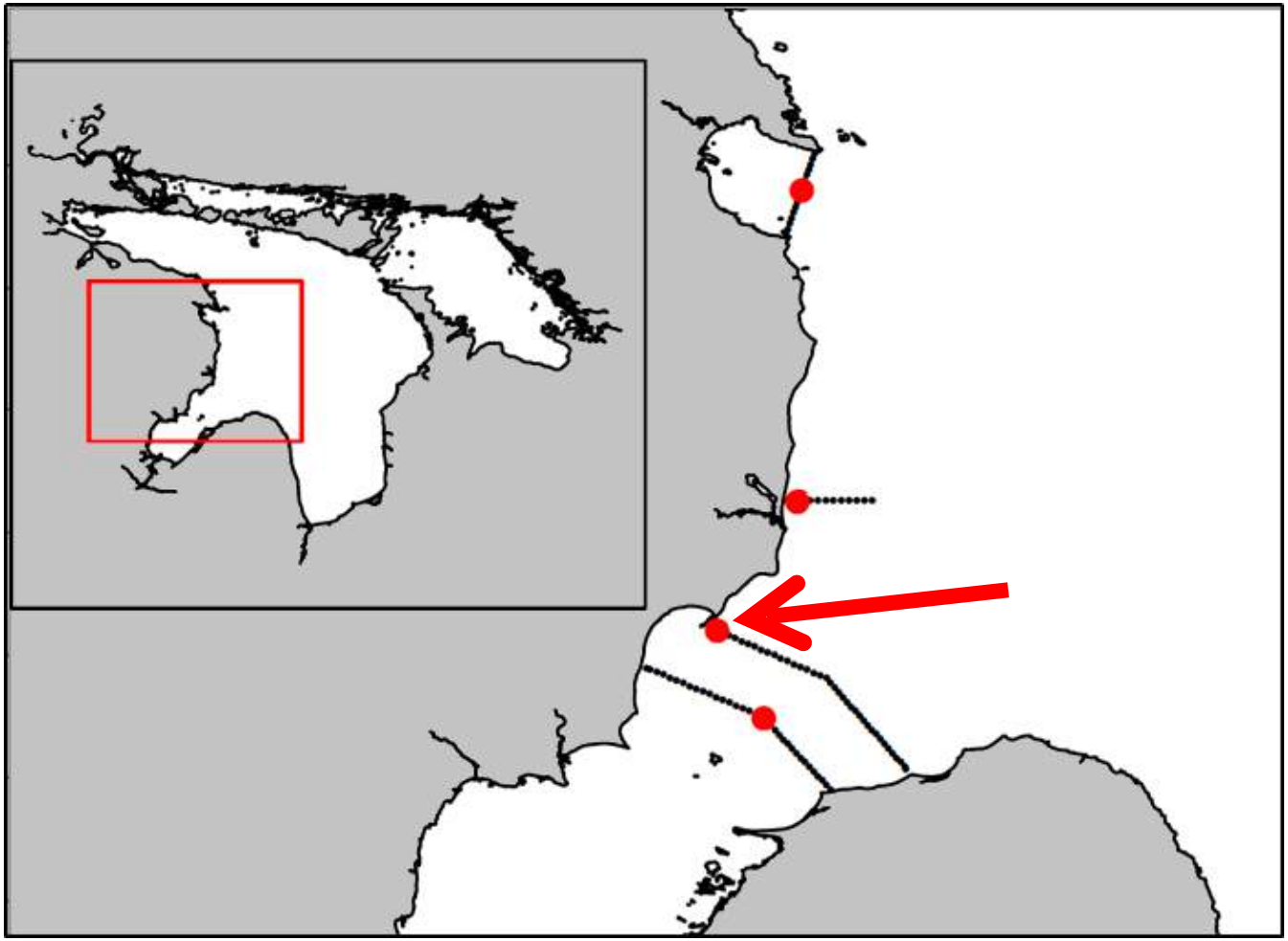
Detection Range

Approach:

1. **Describe detection range curve – in situ test**
2. **Simulate fish passing receiver line**
   - estimate line detection probability

Detection Range

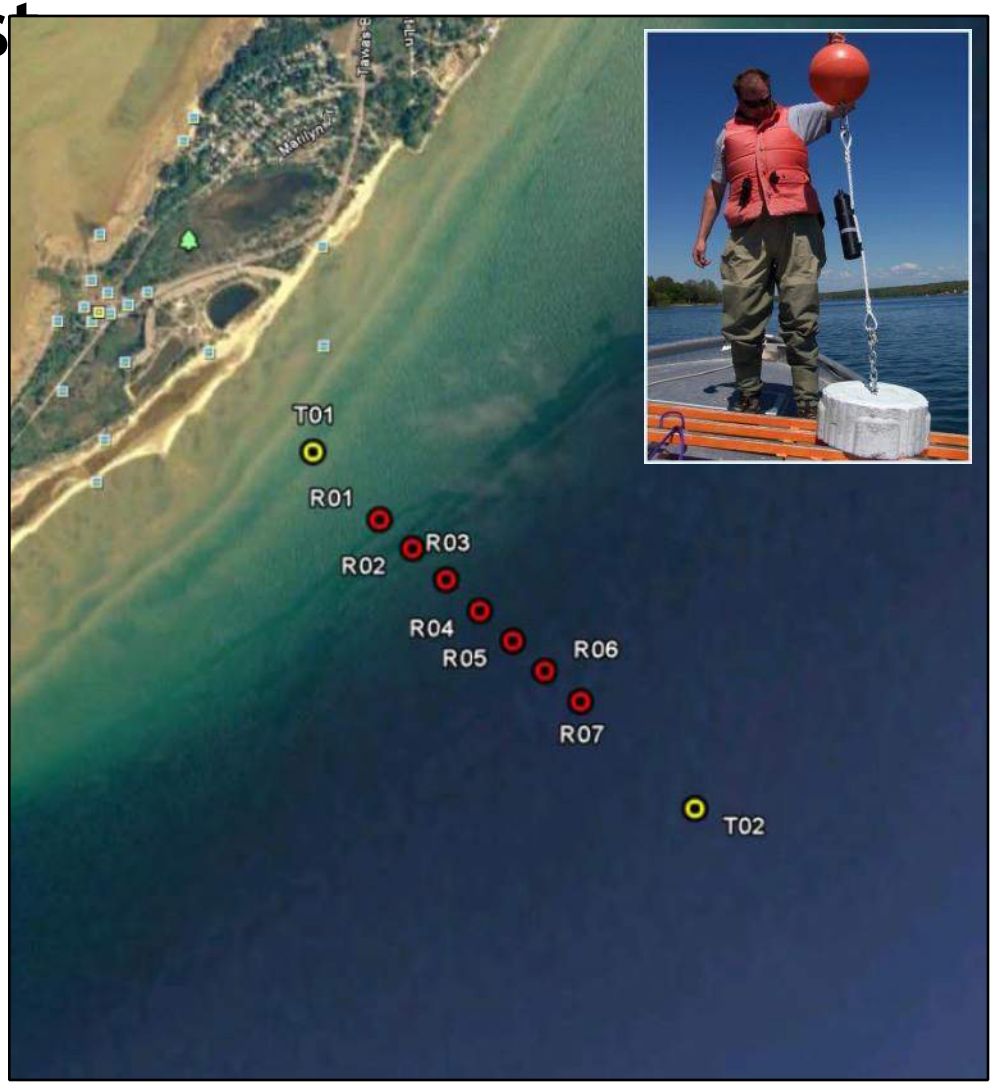
10-day static range test



Detection Range

10-day static range test

- **7 receivers** (VR2W)
- **2 sentinel tags**
  - V16-4H (25 s)



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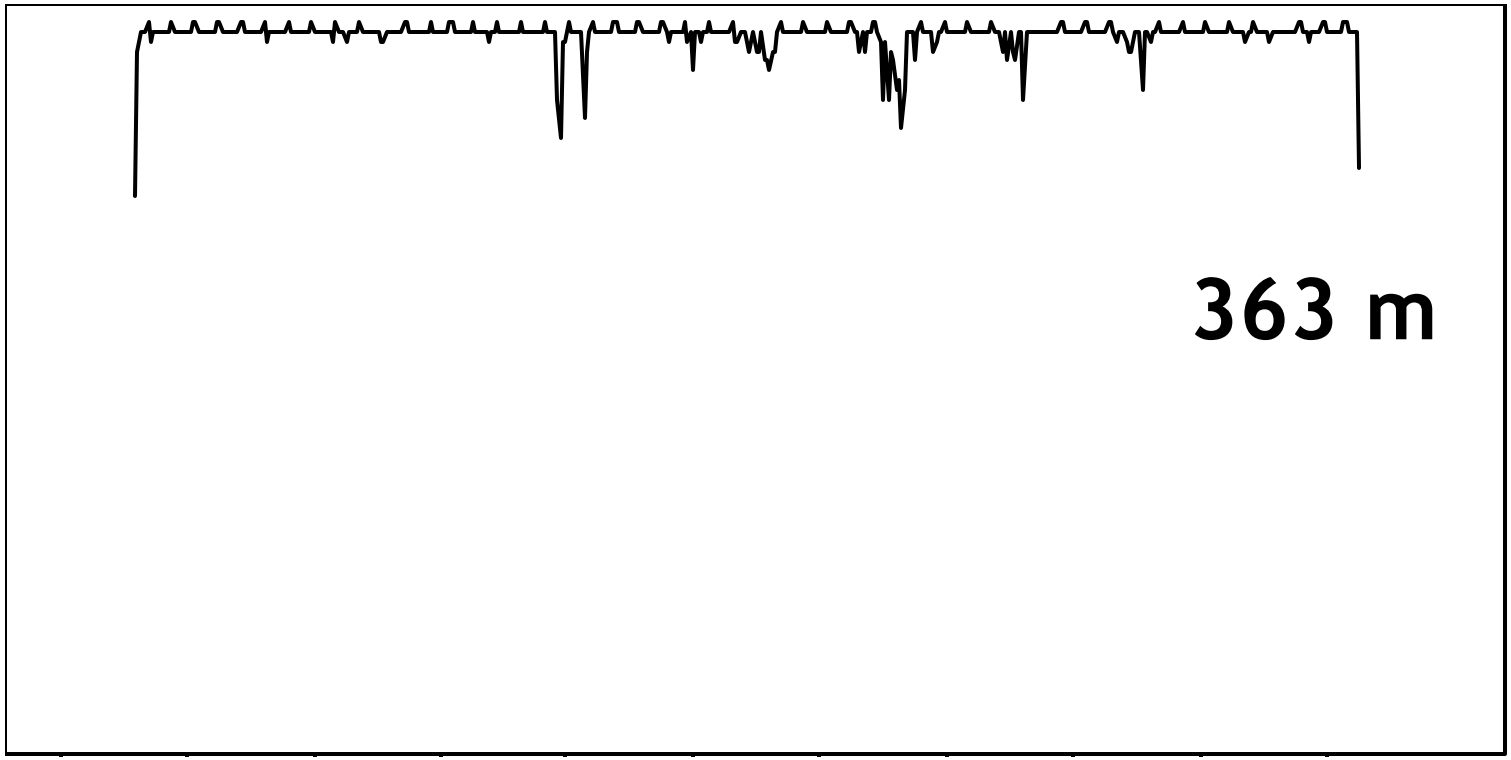

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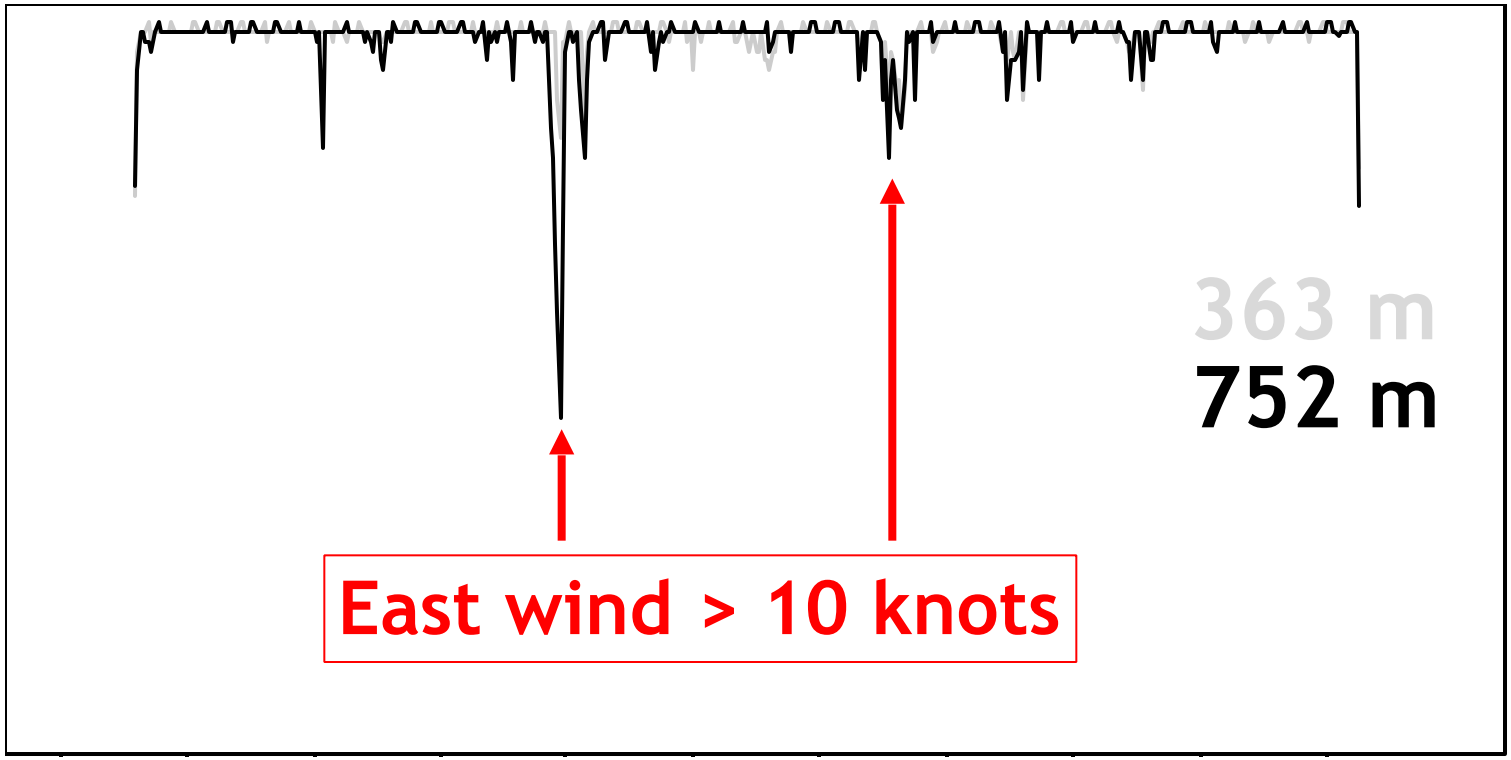

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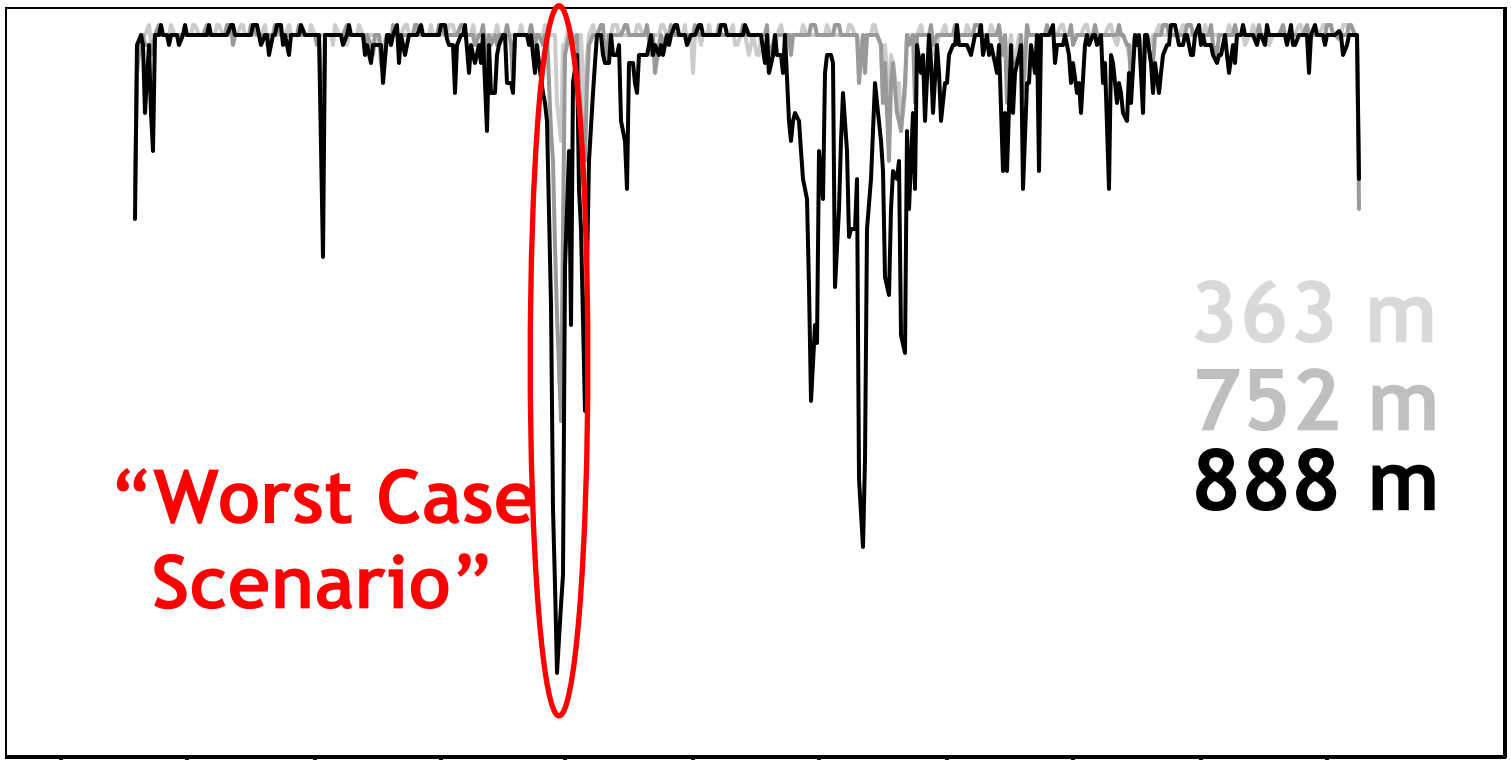

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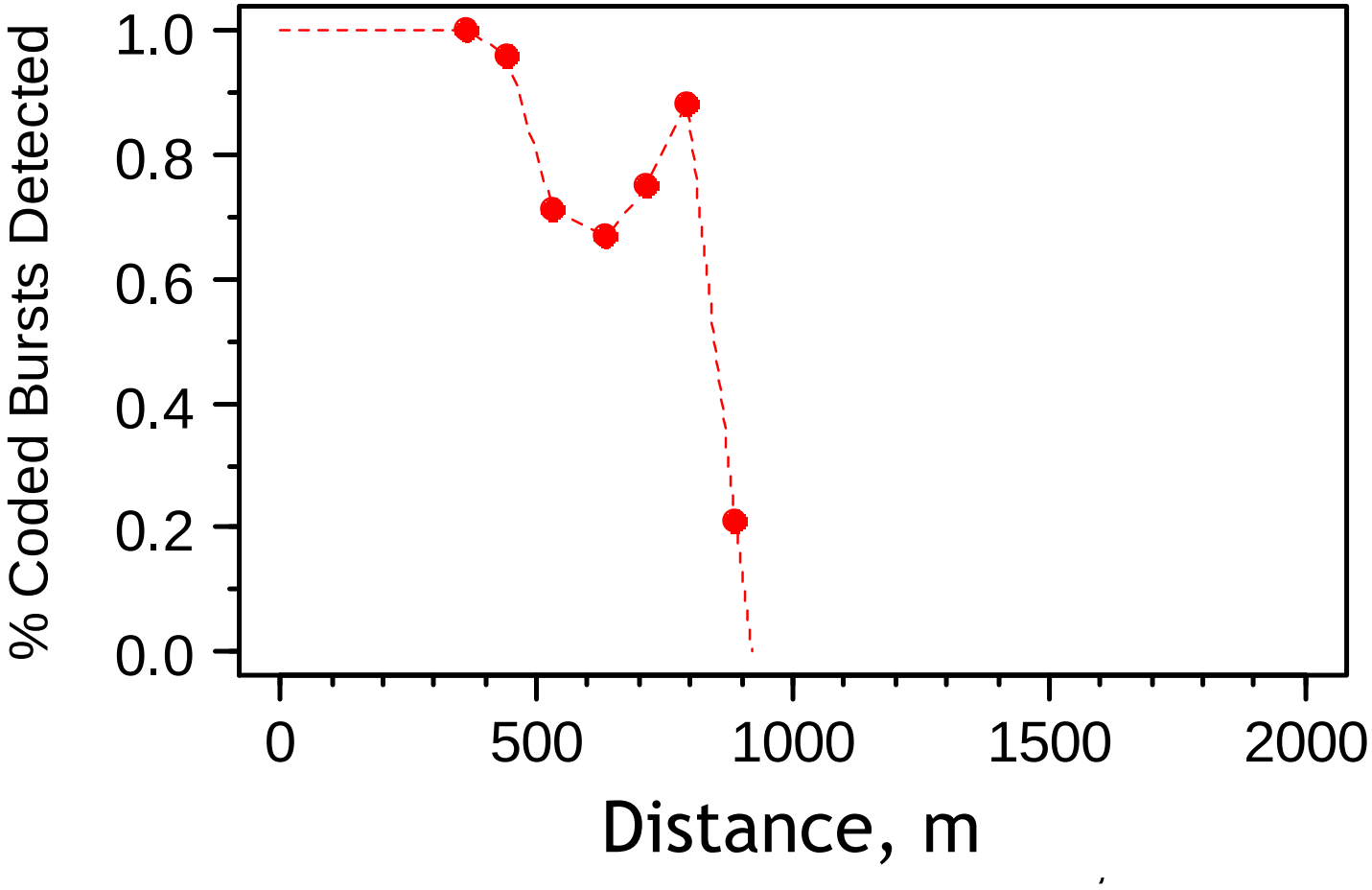

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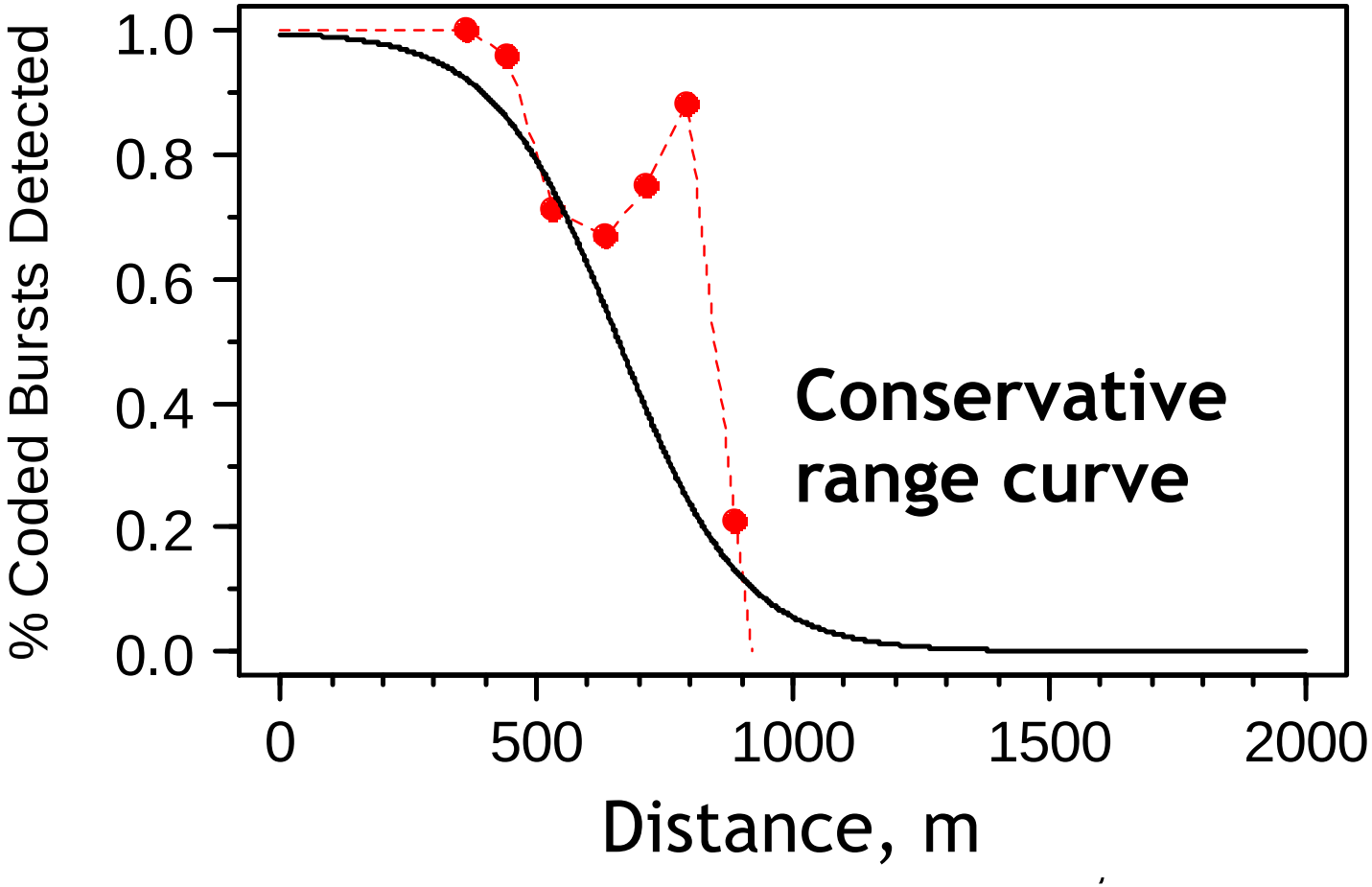


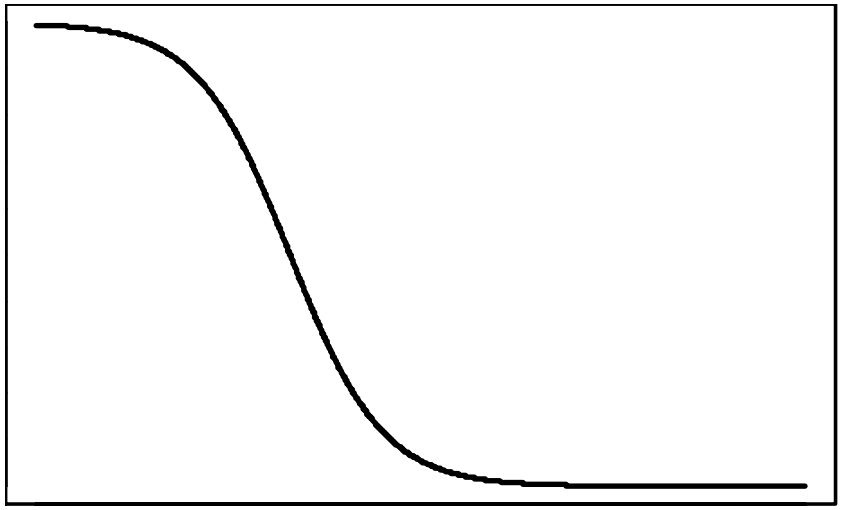
Receiver Spacing

Simulate fish passing receiver line (R function)

Inspired by Pincock (2009) http://www.vemco.com/pdf/line_performance.pdf

Input parameters

– Detection prob. curve



Receiver Spacing

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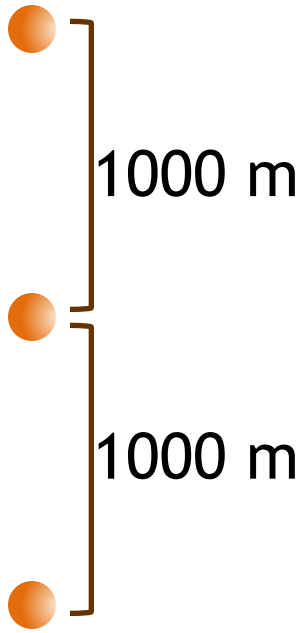
Input parameters

- Detection prob. curve
- Receiver spacing (m)



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Input parameters

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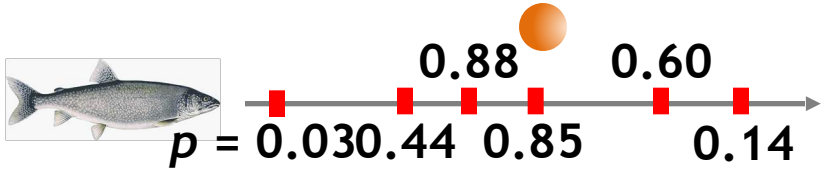
- Fish velocity (m/s)
- Tag delay range (s)
- Burst duration (s)



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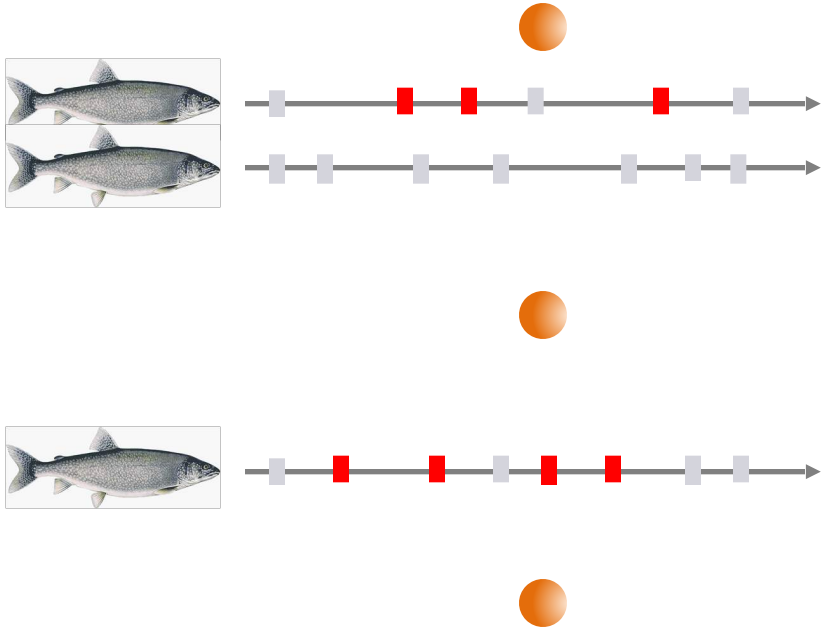

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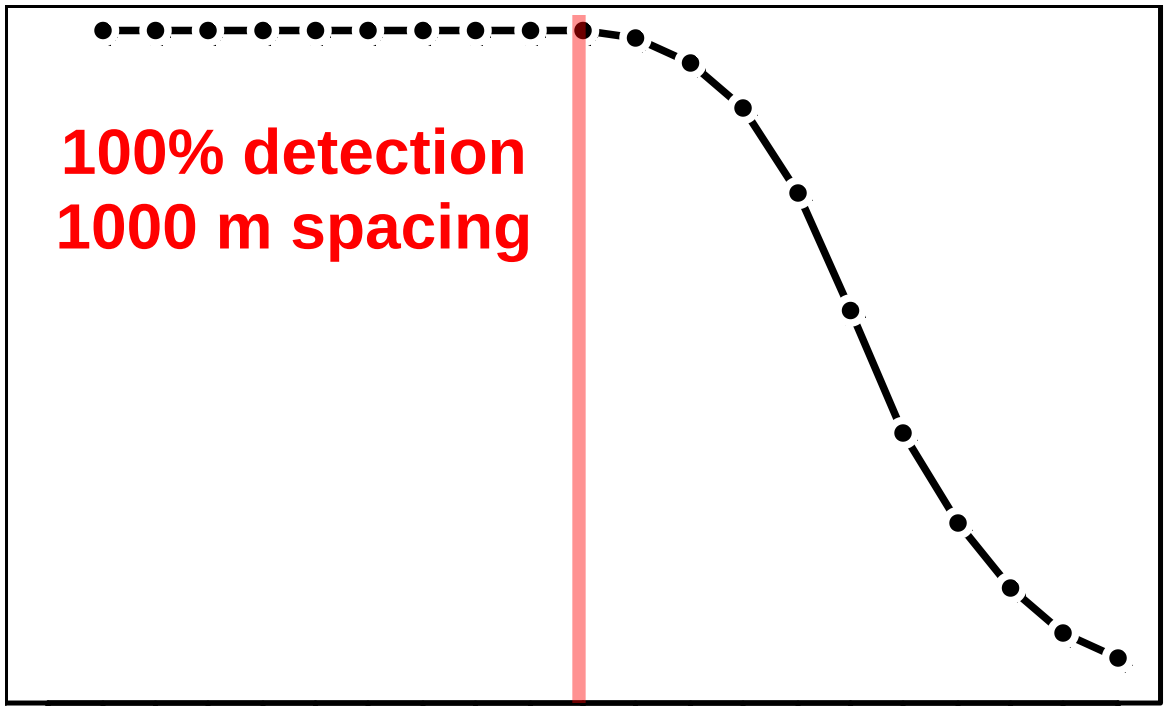

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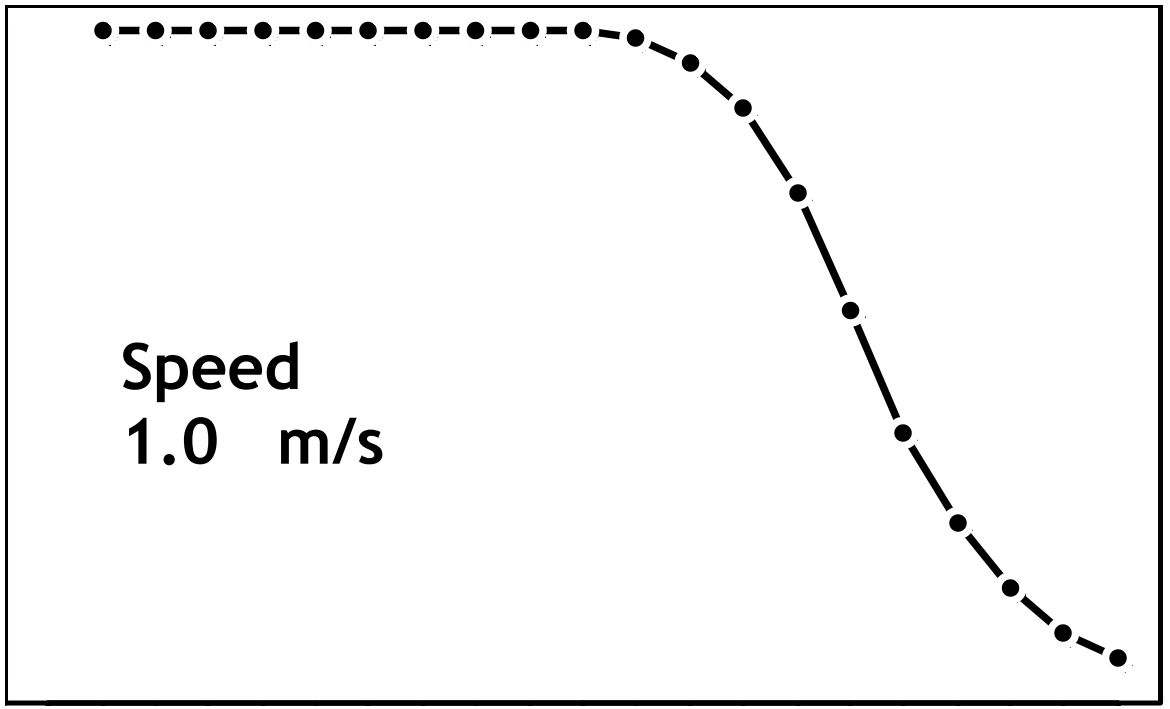

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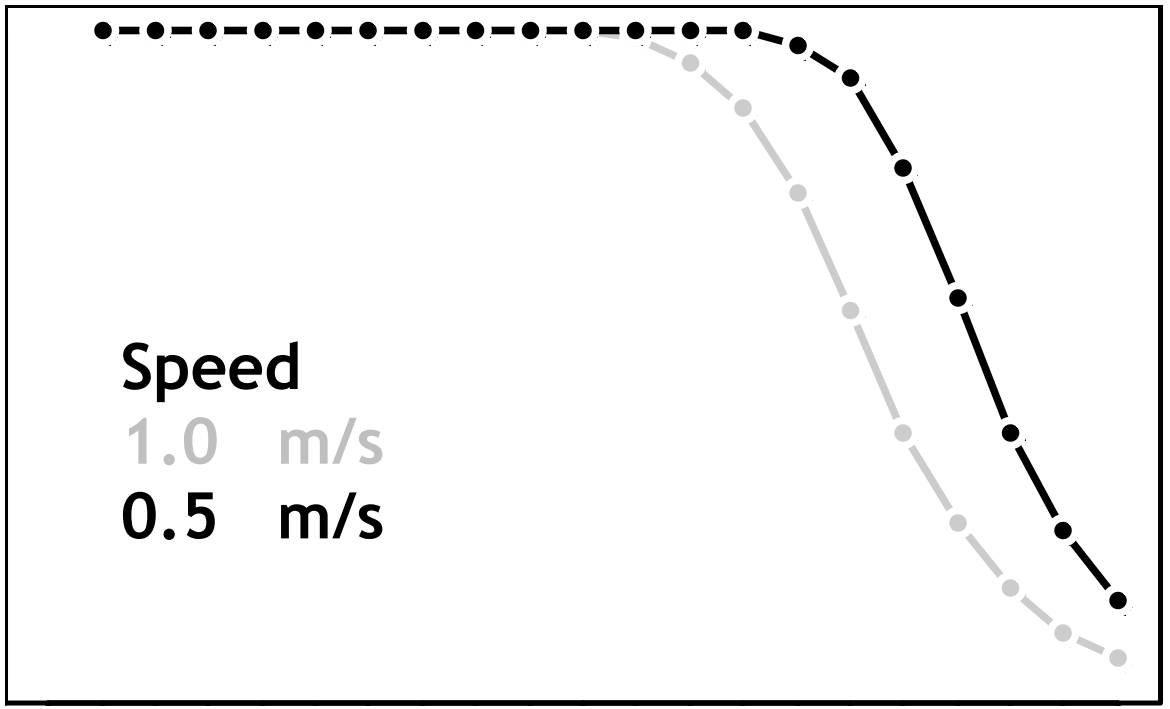

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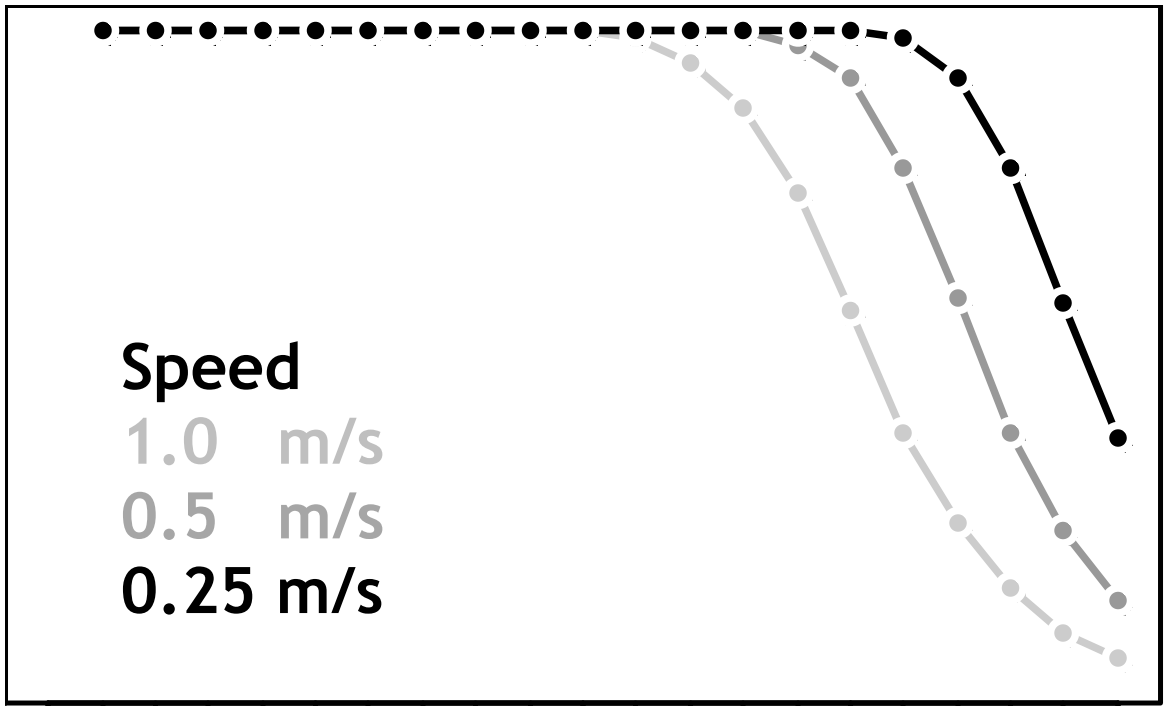
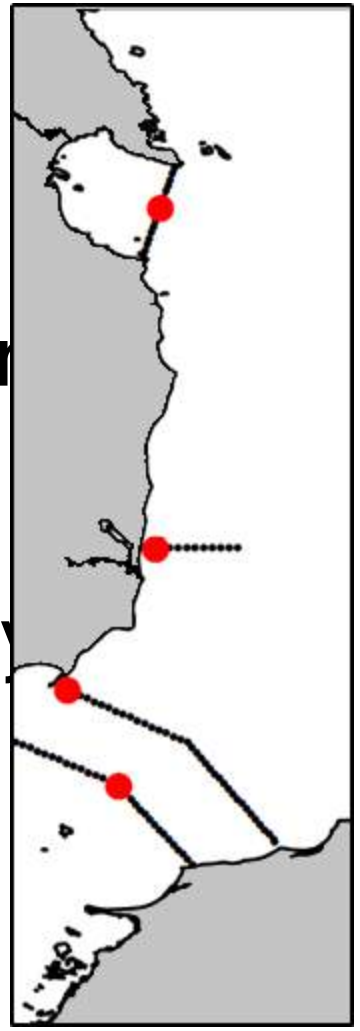


Receiver Spacing

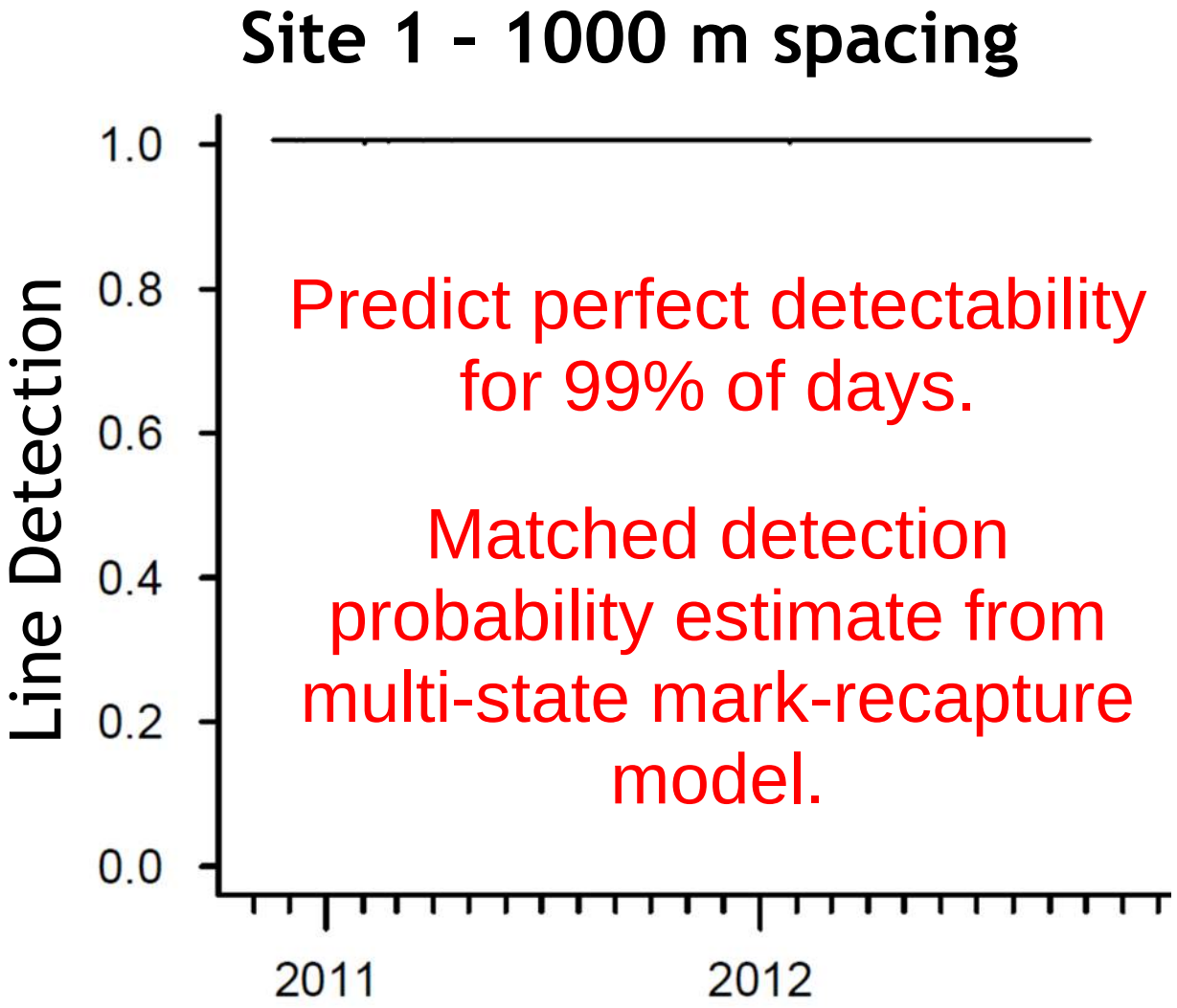
At four locations over two years:

- Estimated daily detection range cur
  - 2 sentinel tags at each site

- Estimated line detection probabilit
  - simulation



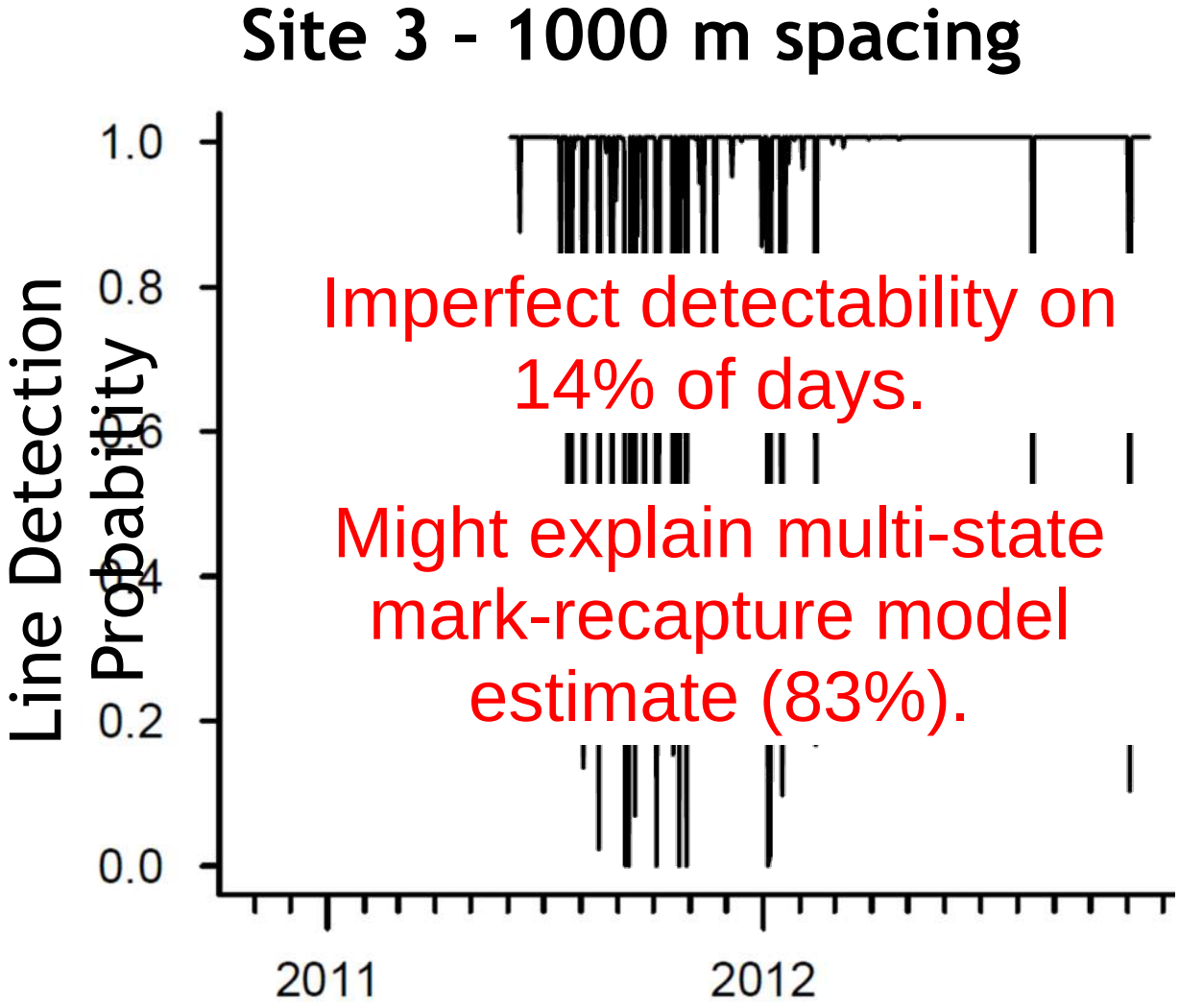
Receiver Spacing



Predict perfect detectability for 99% of days.

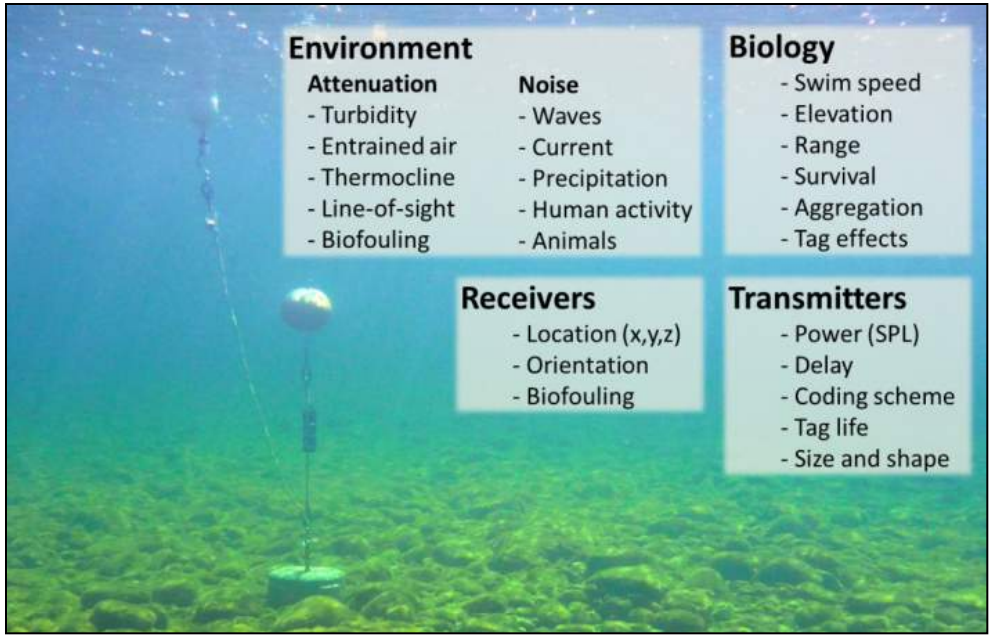
Matched detection probability estimate from multi-state mark-recapture model.

Receiver Spacing



Summary

-Pilot data invaluable ("Plan for the worst…") but need to capture real variation in performance across space and time.

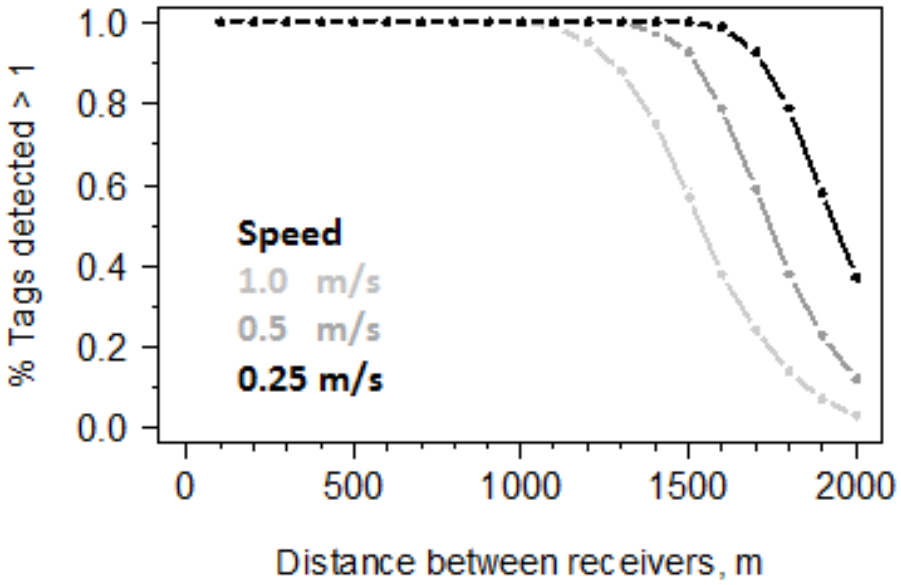


Summary

-Pilot data invaluable ("Plan for the worst…") but need to capture real variation in performance across space and time.

-Can predict perform
during, and after a s

-Accessibility will be
key to broader use c
simulation tools.

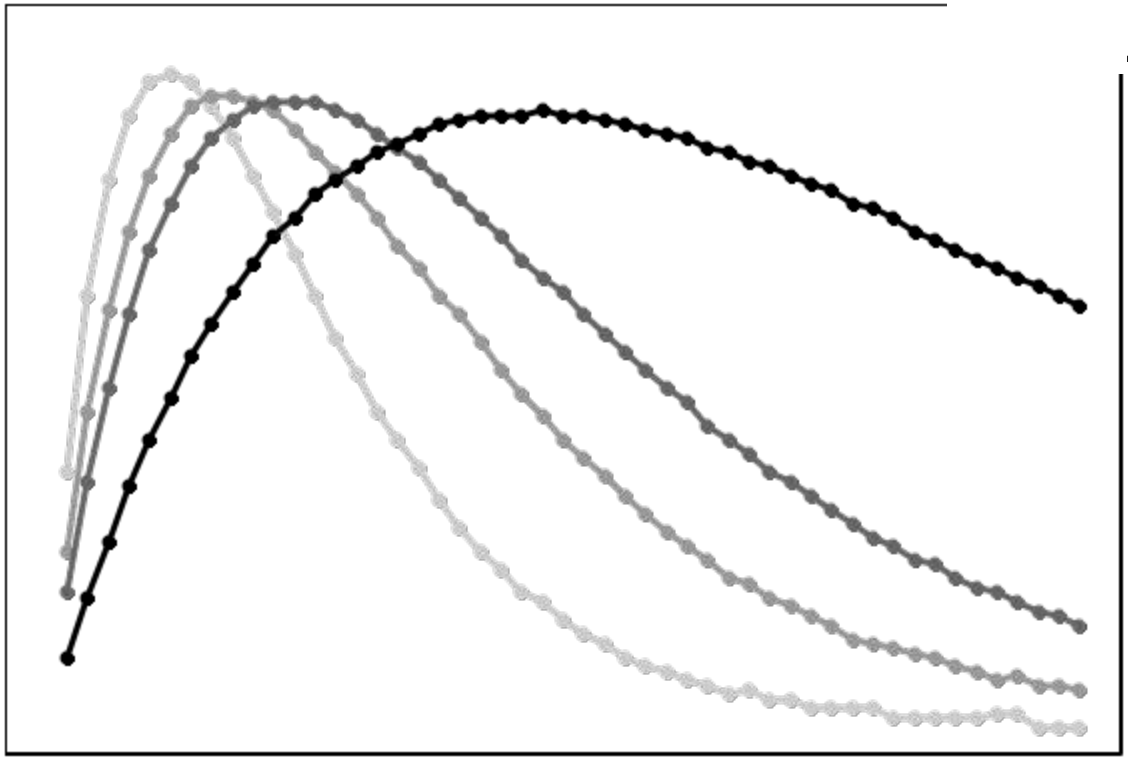


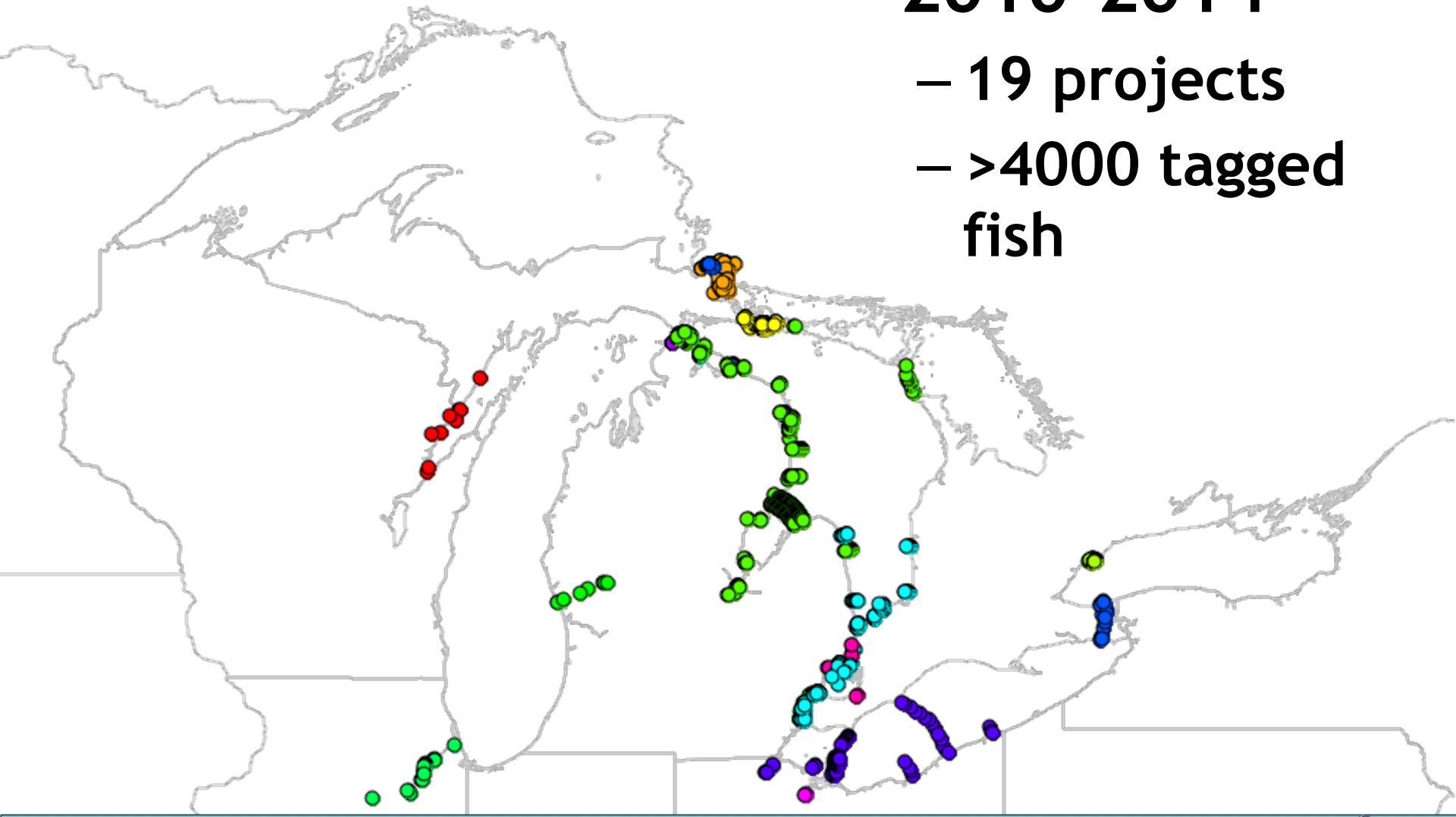
Questions?

USGS Hammond Bay Biological Station

Managing Collisions

Tool #1: Collision Probability Simulator



GLATOS Network

- 2010-2014
  - 19 projects
  - >4000 tagged fish