Bayesian modeling of Atlantic salmon smolt inter-stage survival from Canadian rivers

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OCEAN TRACKING NETWORK

MACQUARIE UNIVERSITY

The Issue

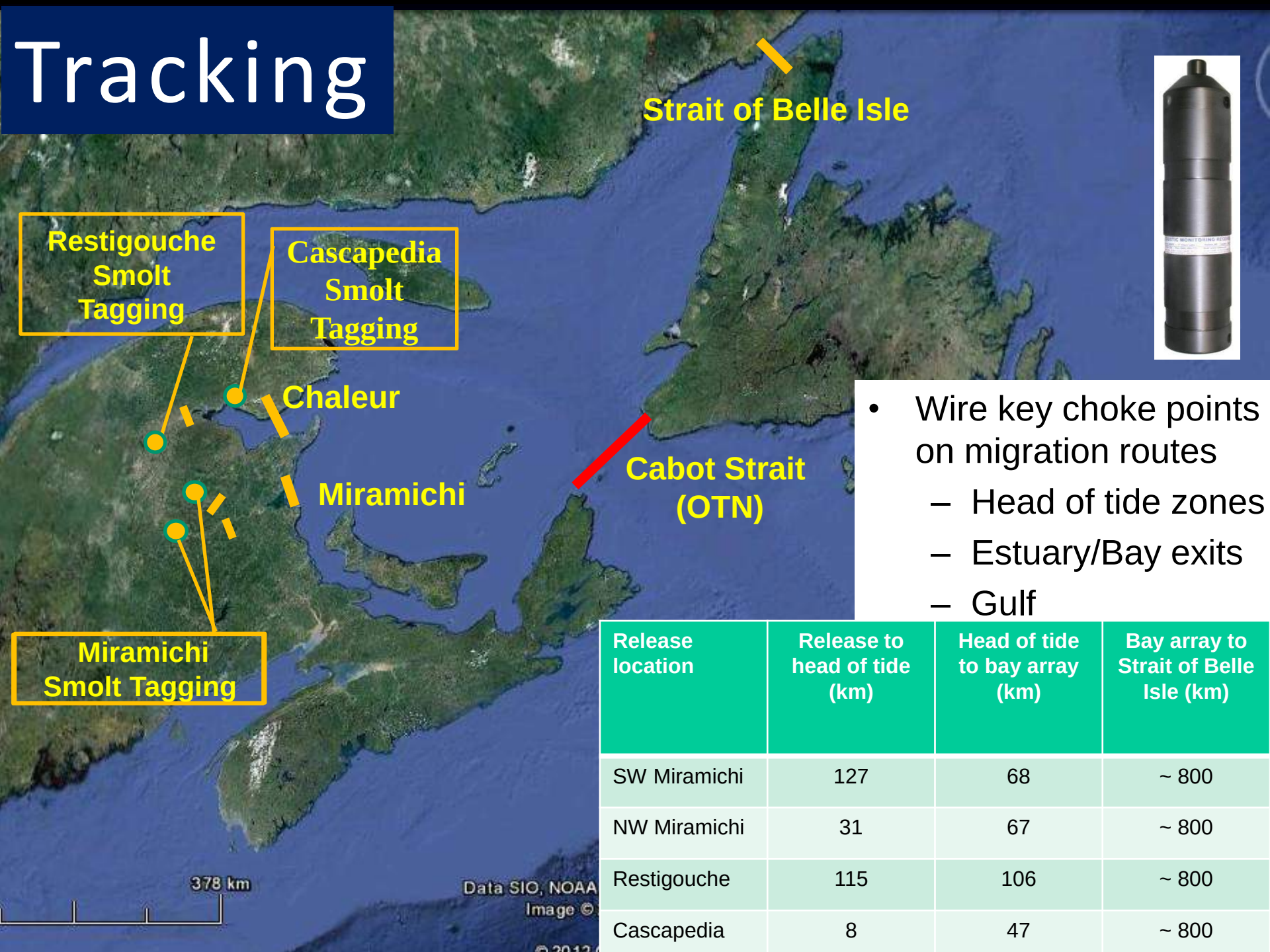
- North American salmon abundance stuck at historic low levels.
- Hypotheses re. freshwater, estuary, sea.
- High juvenile densities in key rivers.
- Points to an unknown problem in ocean.
- Follow the problem.

Tagging

Sonic tag smolt from rivers in Gulf of St Lawrence, starting:

- 2003 NW & SW Miramichi
- 2004 Restigouche
- 2006 Cascapédia
- **More than 2300 smolt tagged**

Tracking



- Wire key choke points on migration routes
  - Head of tide zones
  - Estuary/Bay exits
  - Gulf

Release location	Release to head of tide (km)	Head of tide to bay array (km)	Bay array to Strait of Belle Isle (km)
SW Miramichi	127	68	~ 800
NW Miramichi	31	67	~ 800
Restigouche	115	106	~ 800
Cascapedia	8	47	~ 800

RECEIVER ARRAYS

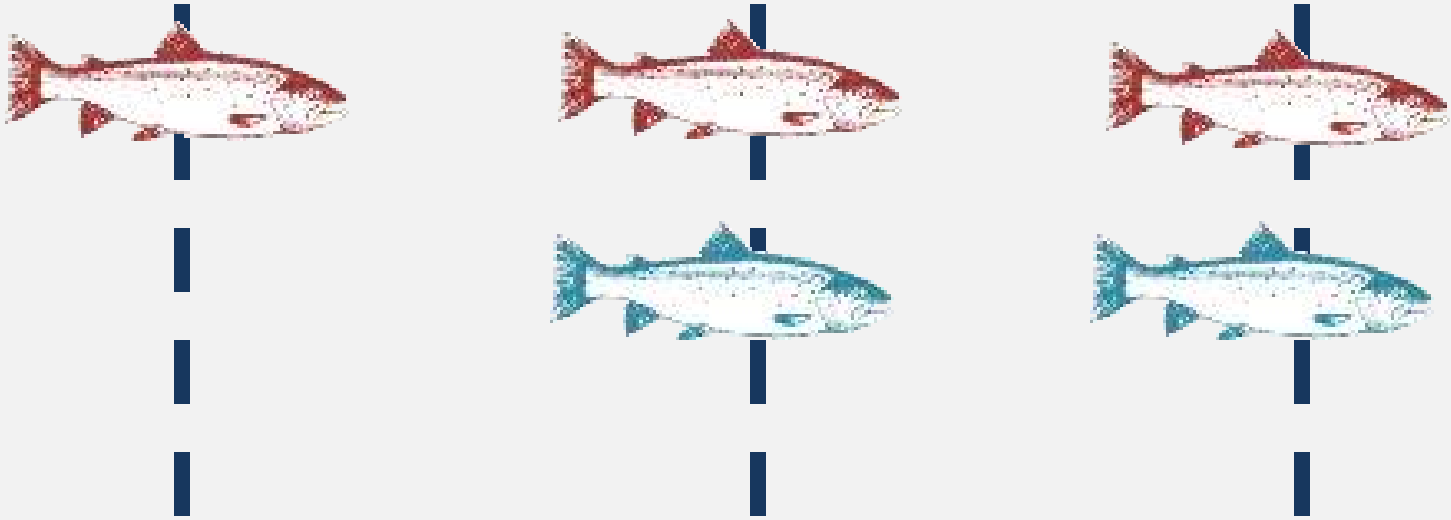
Strait of Belle Isle
2007-14

Outer Bay
2003-14

Head of Tide
2003-14

Cabot Strait
OTN
2012-14

Hierarchical Modelling of Inter-Stage Survival Rates



HoT
2003-2014

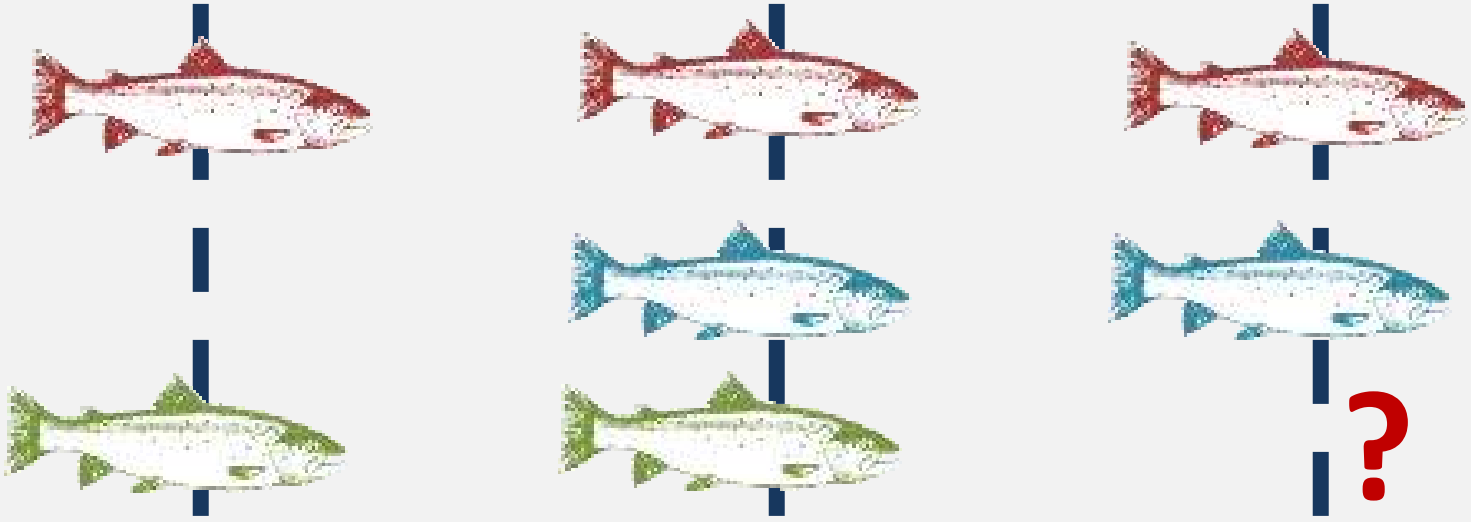
Outer Bay
2003-2014

SoBI
2007-2014

Cormac-Jolly-Seber ***mark and recapture model***

- disentangle the imperfect detection (*p*) of tagged smolts on the sonic arrays from apparent survival.

Hierarchical Modelling of Inter-Stage Survival Rates



HoT
2003-2014

Outer Bay
2003-2014

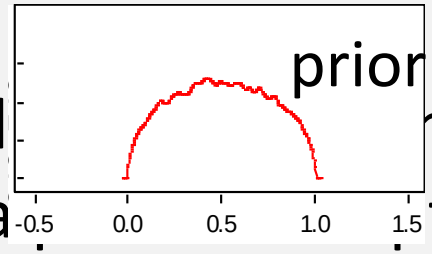
SoBI
2007-2014

Sentinel tags

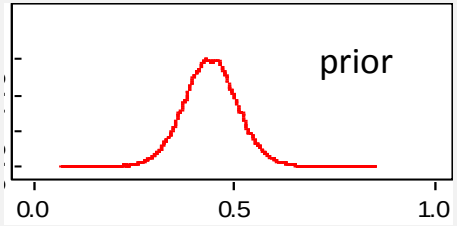
Hierarchical Modelling Assumptions

Survival and detection probabilities assumed exchangeable & conditional on:

- **HoT arrays (4):** exchangeable among years for each river.
- **Bay arrays (2):** exchangeable among years and rivers which shared a common bay.
- **SoBI array:** probabilities of d nd survival (ϕ) can only be estimated with a tion for p at this array.

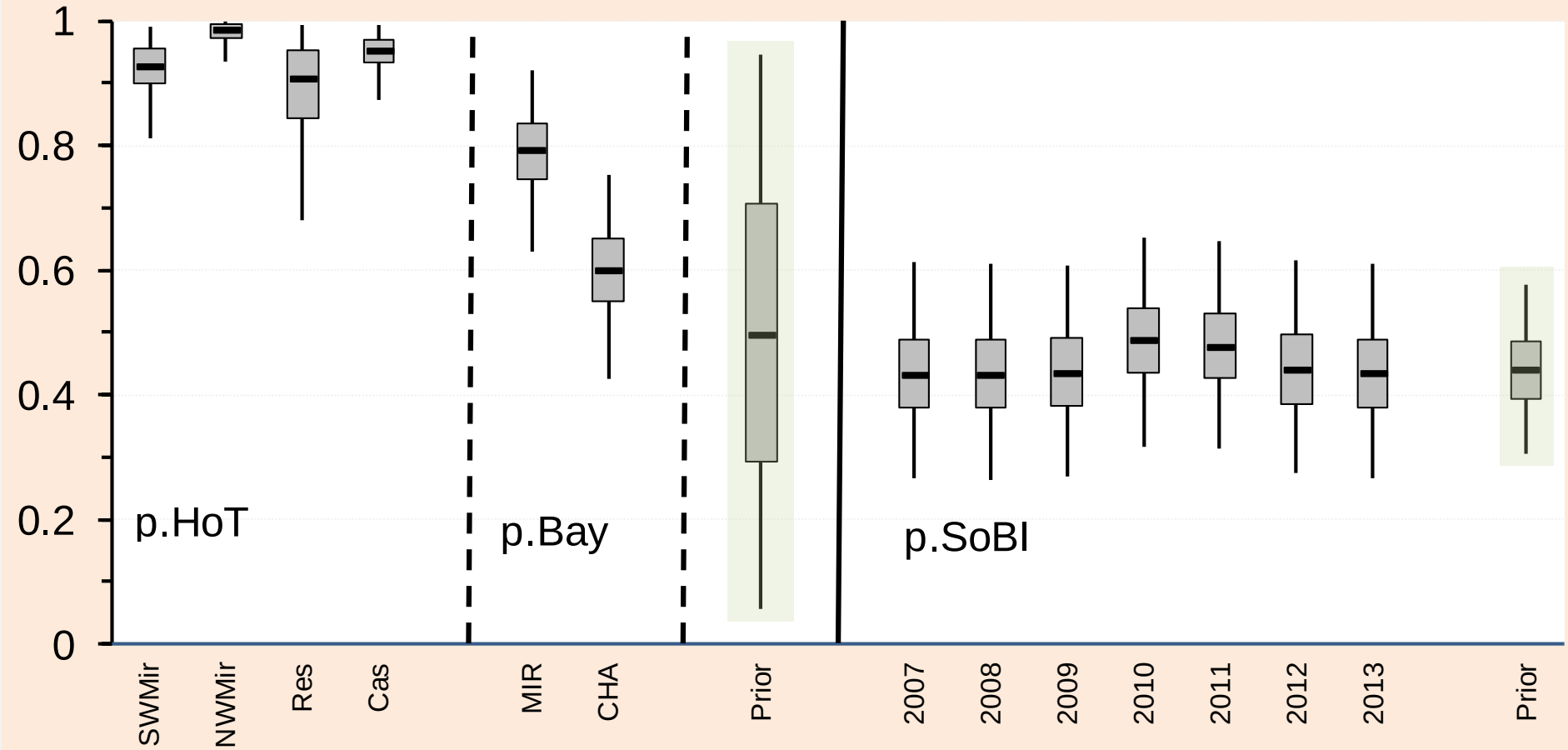


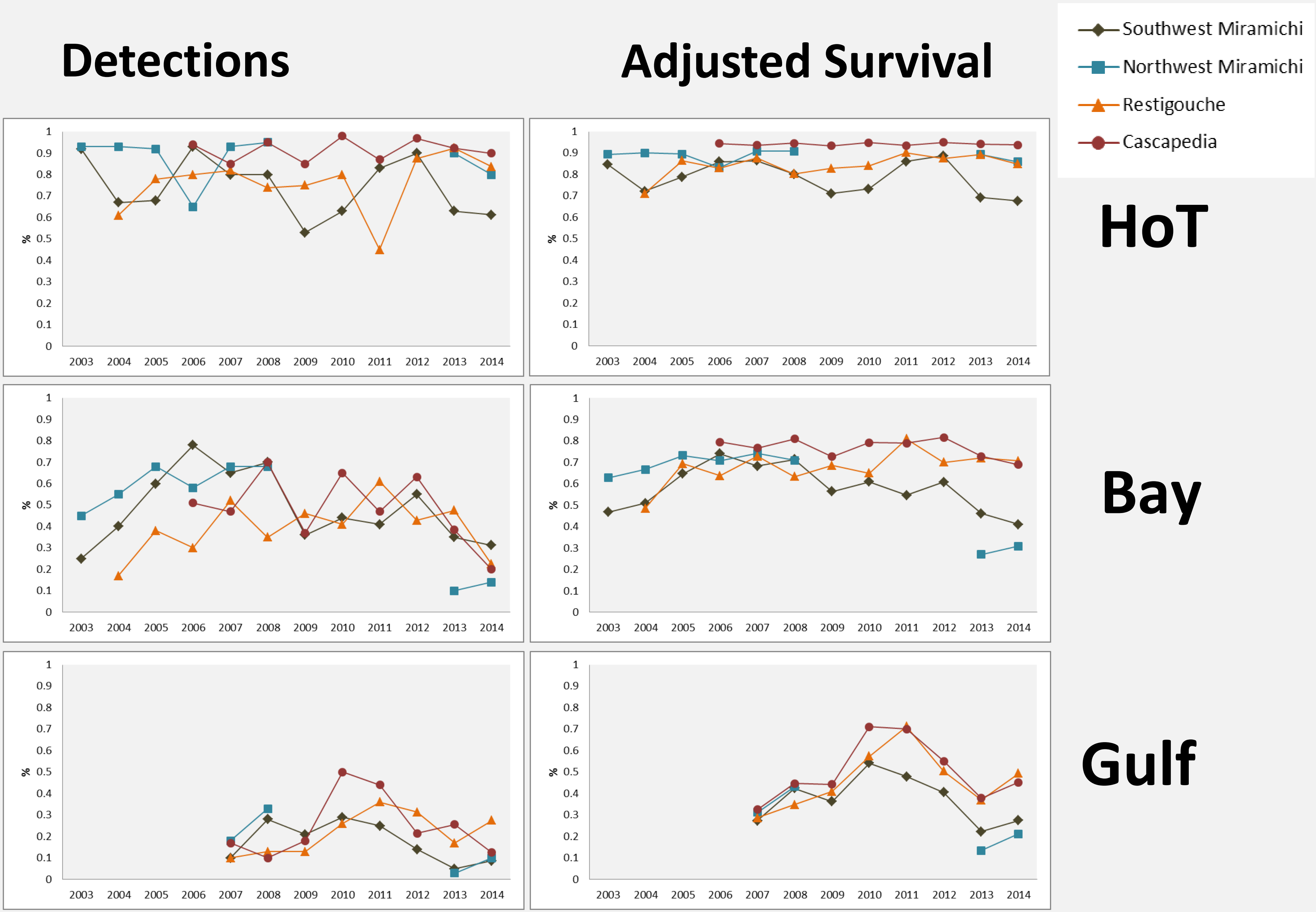
  - prior for p was derived using sentinel tags placed at three distances near two receivers.
  - mean p from logistic model of detection vs distance was 0.44



Probability of Detection Relative to Priors

- Head of tide (HoT) array: high probability of detection.
- Bay arrays: Miramichi line is more efficient than Chaleur array.
- Strait of Belle Isle (SoBI) array: p distributions dominated by prior.





Detections
Adjusted Survival
Southwest Miramichi
Northwest Miramichi
Restigouche
Cascapedia
HoT
Bay
Gulf
%
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014

What have we learned?

- **Survival rates in the freshwater are high (80 to 95%).**

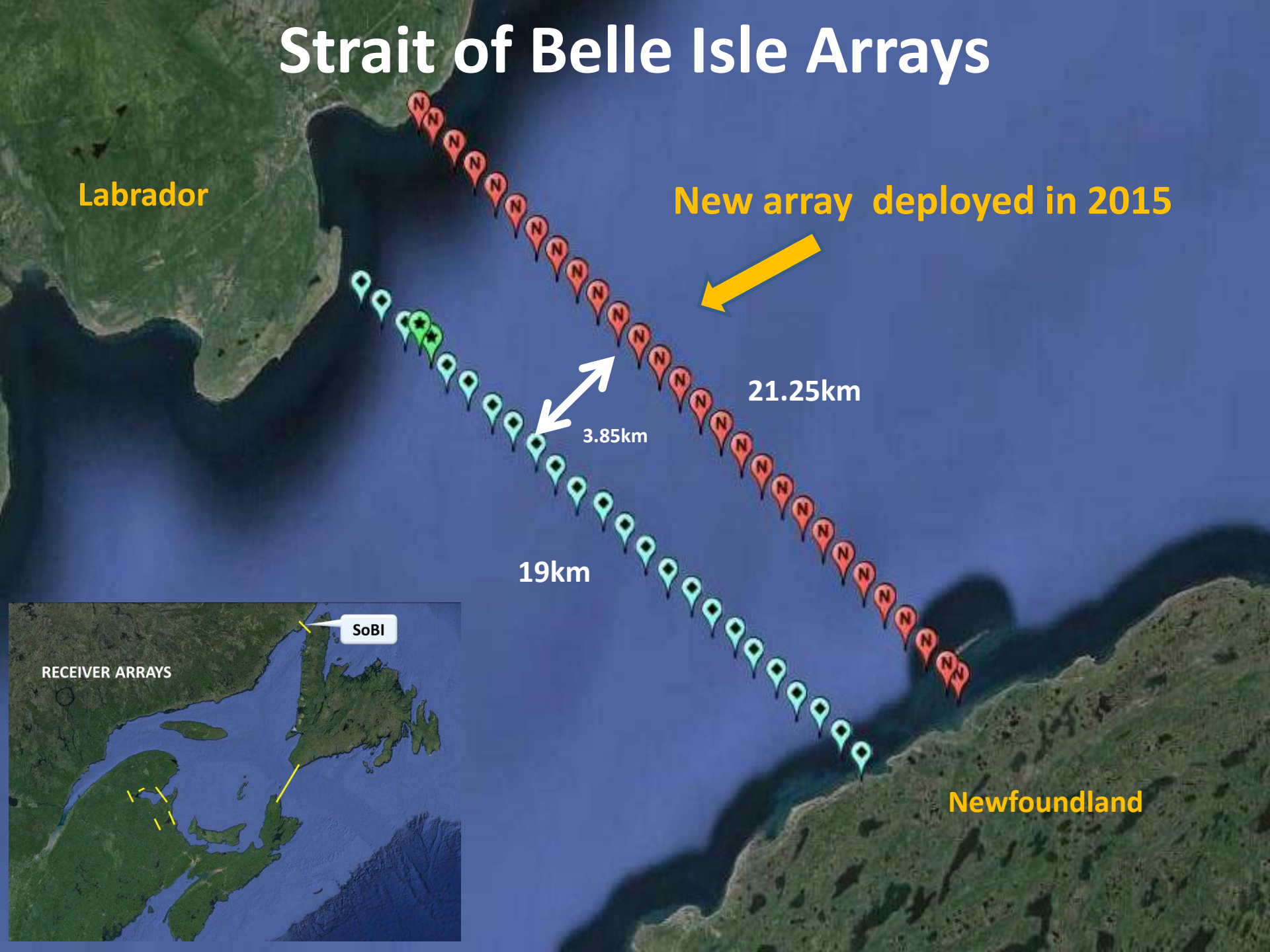
- **Survival rates through the bay are variable.**
  - Chaleur Bay: Restigouche: 68%, Cascapédia: 76%.
  - Troublesome results for smolt passing Miramichi Bay.
    - NW survival only 28% last 2 years (2013, 2014).
    - SW survival only 43% last 2 years (2013, 2014).

- **Survival through the Gulf of St. Lawrence highly variable.**

What's next?

1. **Need a better estimate of survival through Gulf of St. Lawrence.**
    - Second Strait of Belle Isle Array

Strait of Belle Isle Arrays



What's next?

1. **Need a better estimate of survival through Gulf of St. Lawrence.**
   - Second SoBI array
2. **More adjustments needed to get a clear picture of survival estimates.**
   - Tag loss
   - Predation Events

Acknowledgements

- Countless volunteers
- *Adopt a Smolt and Kelt* Donors
- Field and Office Staff