

Mitigation of Vessel-Strike Risk to North Atlantic Right Whales in Canadian Waters: Historical Perspectives and Updated Risk Analyses

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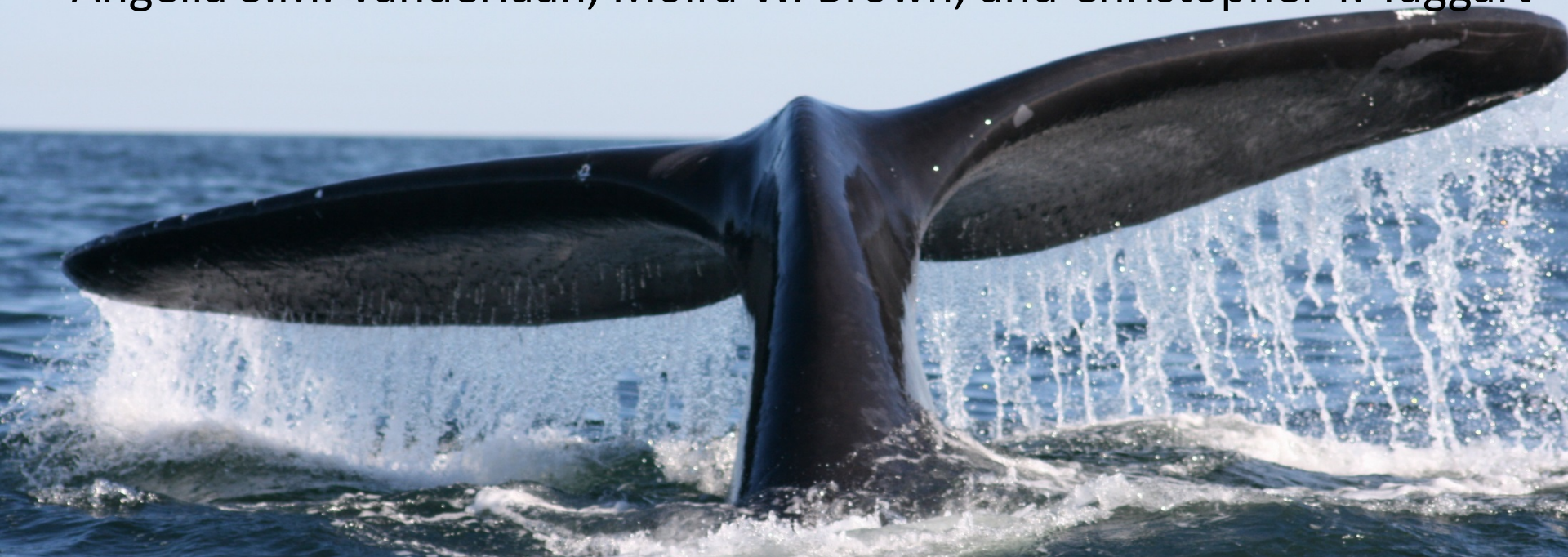
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Lethal vessel strikes hamper the recovery of endangered North Atlantic right whales (*Eubalaena glacialis*). We summarize Canadian policies implemented to reduce vessel-strike risk to right whales between 1992 and 2017. When mariner-awareness programs proved ineffective, probability analyses resulted in area-specific, vessel-traffic schemes adopted by the International Maritime Organization and Canada, to reduce likelihood of a vessel striking a right whale. The first was an amendment to the traffic separation scheme (TSS) in the Bay of Fundy and the second a recommendatory (i.e., voluntary) area to be avoided (ATBA) in the Roseway Basin, Scotian Shelf. The Marine Stewardship Recognition Program has since been used to communicate with vessel operators navigating the Roseway region and to evaluate the effectiveness of the ATBA. Annual weekly compliance estimates stabilized at an average of $80\% \pm 4\%$ over 2009 through 2014. New estimates for 2015 and 2016 will be presented for comparison. Updated risk analyses for enhanced conservation in the Bay of Fundy given increased vessel traffic that may result from the proposed Energy East Pipeline show that additional speed restrictions in the TSS could reduce the existing risk by ~42% if all vessels complied with a 10 knot speed restriction. Preliminary analyses show that compliance with a voluntary 10 knot speed restriction zone in the Gulf of St. Lawrence in summer 2017 was low. However, following the implementation of a mandatory 10 knot restriction zone, average vessel speeds within the zone averaged 9.0 knots (± 2.4 SD). We conclude that although not all conservation initiatives have been successful, and vessel strikes still continue in Canadian waters, the initiatives implemented around known critical habitats have reduced lethal-strike risks and similar initiatives could be extended to other risk-prone areas.

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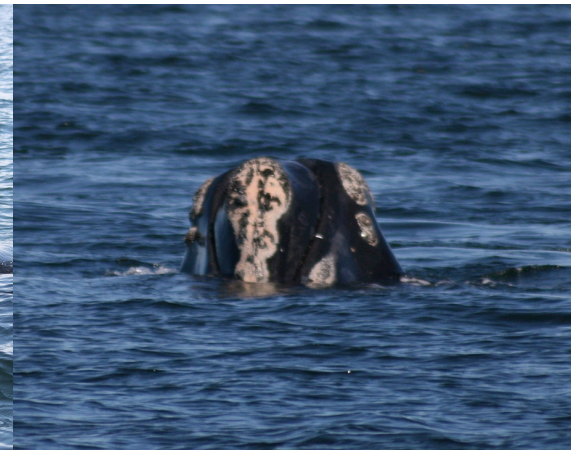


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Canada

North Atlantic right whales and vessel strikes

- ✦ Vessel strikes documented throughout right whale range
(Kraus and Rolland 2007, van der Hoop et al. 2014).
- ✦ Substantial conservation initiatives implemented to reduce the risk of vessel strikes
- ✦ Right whale vessel strike mortalities have significantly declined from 2.0 (2000-2006) to 0.33 per year (2007-2012) (van der Hoop et al. 2014)



Mariner Awareness Program

Four goals over the period 1993-1999:

- ✦ right whale Conservation Areas designated in each of the Grand Manan Basin (Bay of Fundy) and Roseway Basin (SW Scotian Shelf)
- ✦ publication of information on right whales, the Conservation Areas, and precautionary guidelines for vessel operations
- ✦ DFO publication of a species-specific pamphlet entitled 'Caution Mariners: Please Avoid Collisions with Right Whales'
- ✦ right-whale 'information box' with the location of the Right Whale Conservation Areas printed on the back of two nautical charts

The Effectiveness of the Mariner Awareness Program

- ✦ Increased mariner awareness
- ✦ Education alone was not solving the vessel-strike problem
- ✦ Effectiveness in reducing vessel strikes appeared limited due:
 - ✦ to visibility constraints
 - ✦ ability and(or) willingness of marines to follow precautionary advice (IMO 1990)
- ✦ No indication of mariners avoiding right whale conservation areas or decreasing speed as they transit (Vanderlaan et al. 2008, Vanderlaan and Taggart 2009).

Estimating Risk of Lethal Vessel Strikes

- Use the “set of triplets” proposed by Kaplan & Gerricks (1981)

Set of triplets for Risk:

1. What can happen or what can go wrong?
2. How likely is it that it will happen?
3. If it does happen, what are the consequences?

Estimating Risk of Lethal Vessel Strikes

- Use the “set of triplets” proposed by Kaplan & Gerricks (1981)

Set of triplets for Risk:

1. What can happen or what can go wrong?

✈ Vessel can strike a right whale



Estimating Risk of Lethal Vessel Strikes

Set of triplets for Risk:

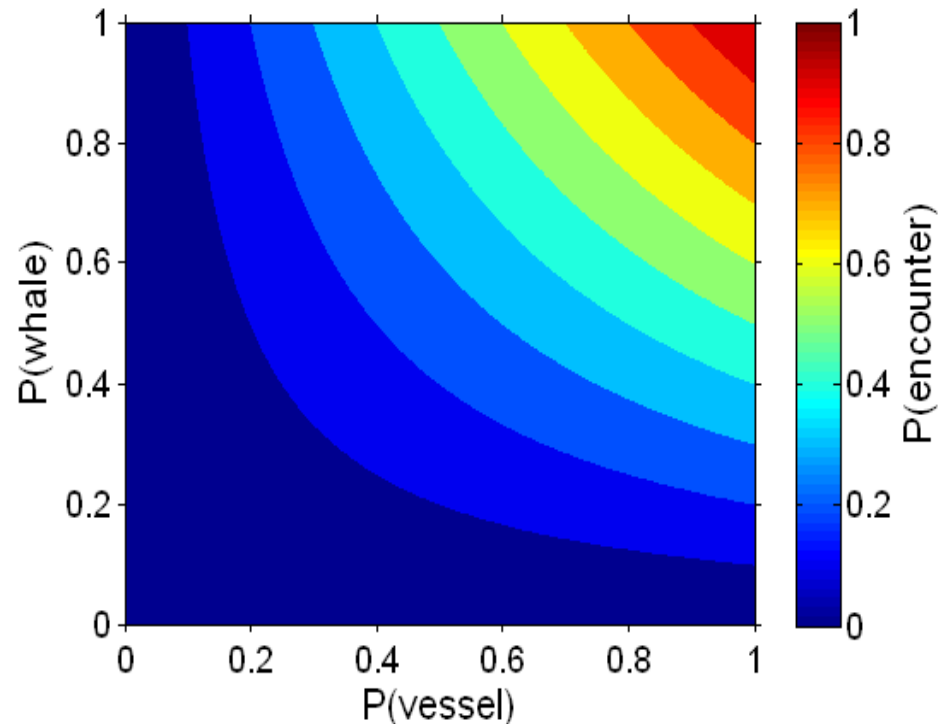
1. What can happen or what can go wrong?
2. How likely is it that it will happen?

Spatiotemporal-Encounter Probabilities

Depends on:

🐋 probability of a vessel present at point x,y

🐋 probability a whale present at point x,y



Estimating Risk of Lethal Vessel Strikes

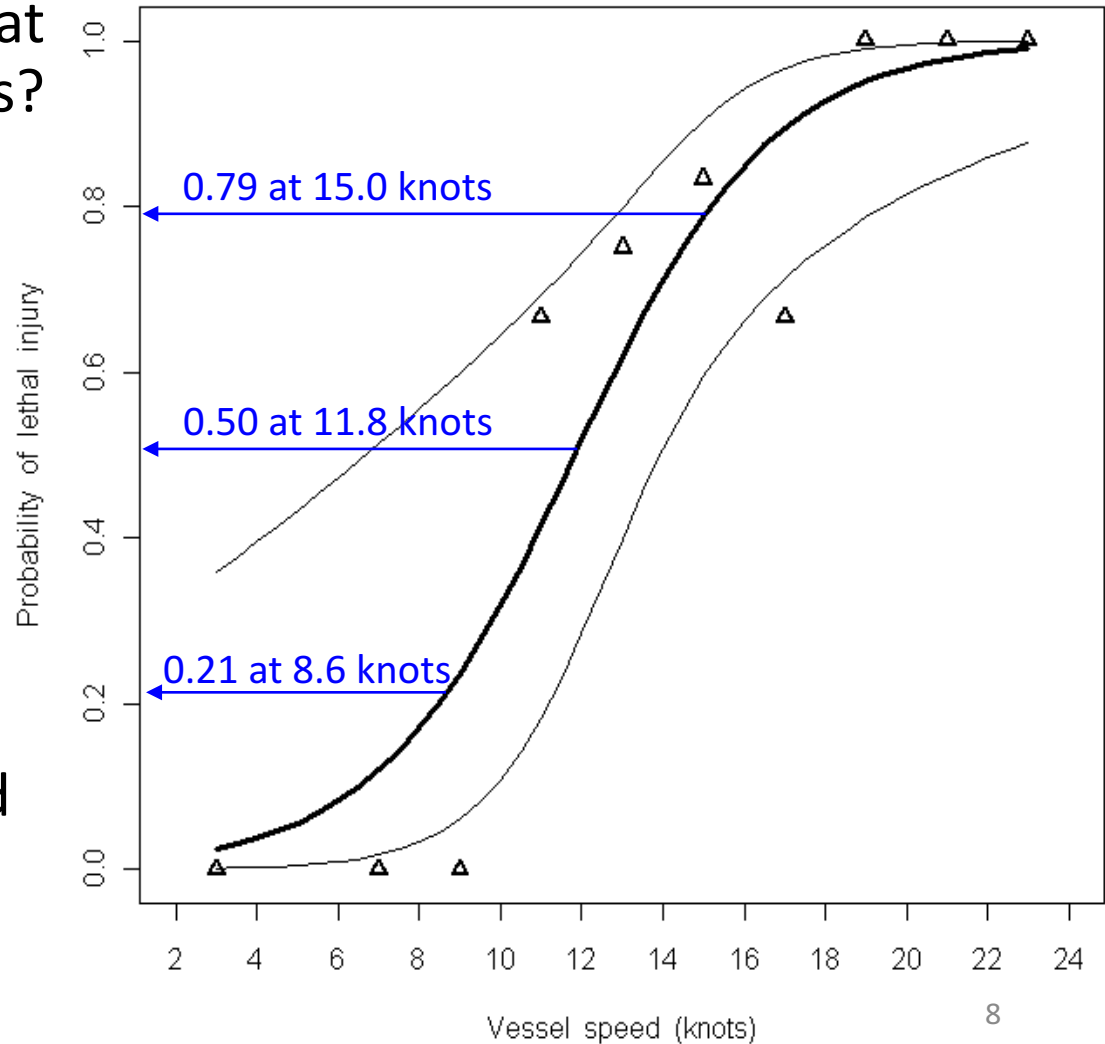
Set of triplets for Risk:

3. If it does happen, what are the consequences?

Measure of consequence based on historical records

- Probability of a lethal injury:
 - function of vessel speed at the time of collision (all large whales)

Vanderlaan and Taggart 2007

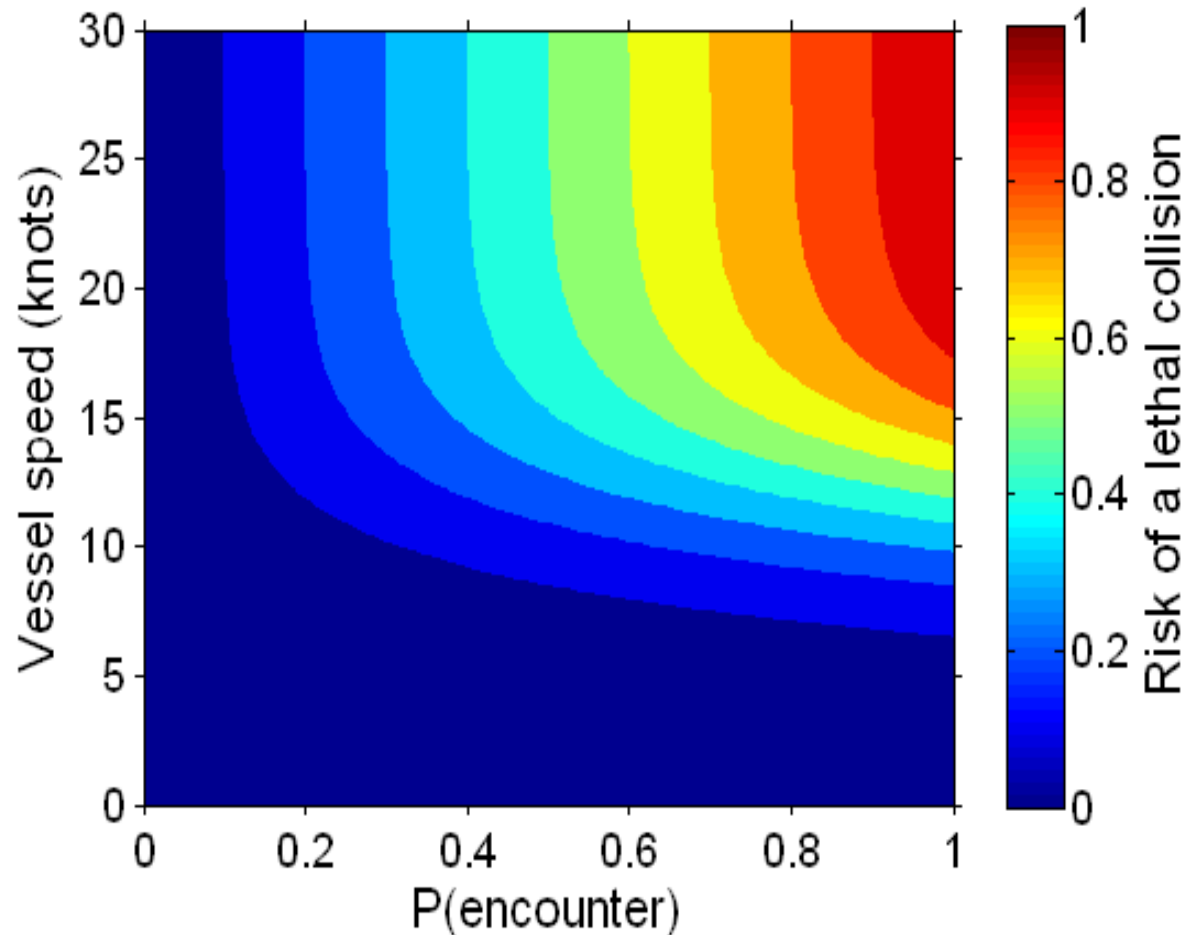


Risk of Lethal Vessel Strikes

Two ways to reduce the risk of lethal vessel strikes:

✎ vessel rerouting

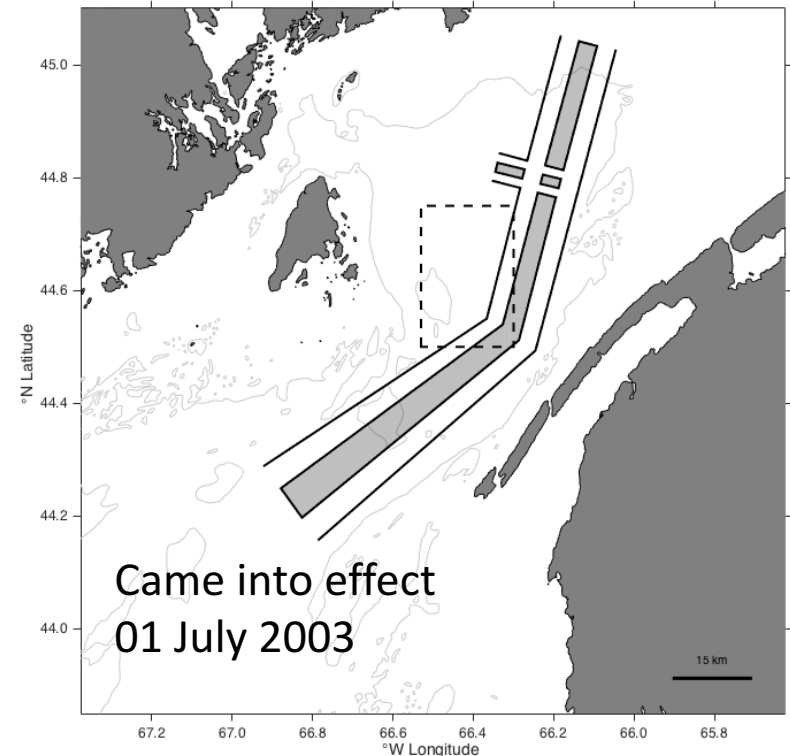
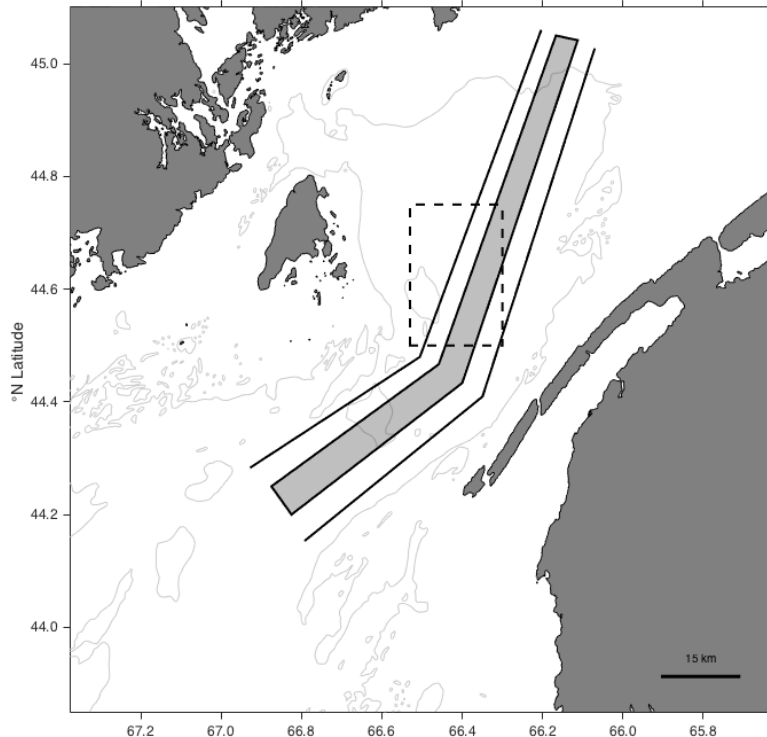
✎ vessel speed reductions



Science-based Conservation in the Bay of Fundy

Three studies undertaken in the Bay of Fundy

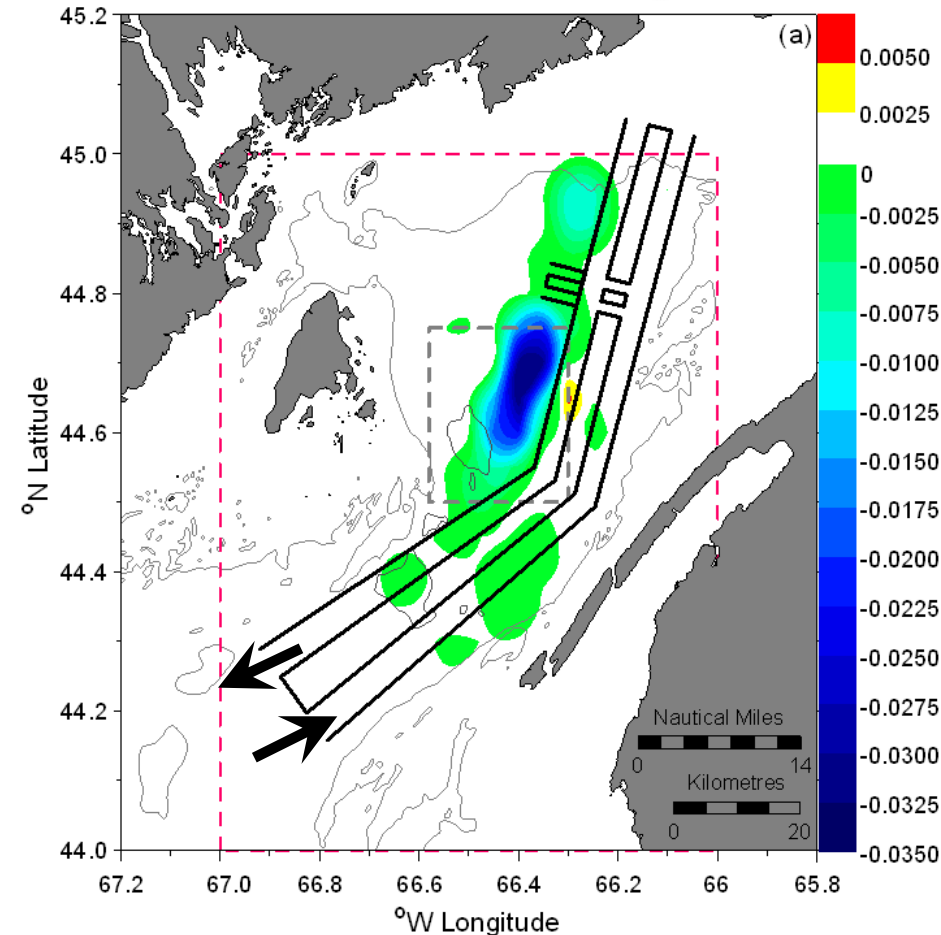
- 3rd estimated the relative probability of a vessel encountering a right whale (Vanderlaan et al. 2008)
 - Provided quantitative rationale for amending the Fundy TSS.



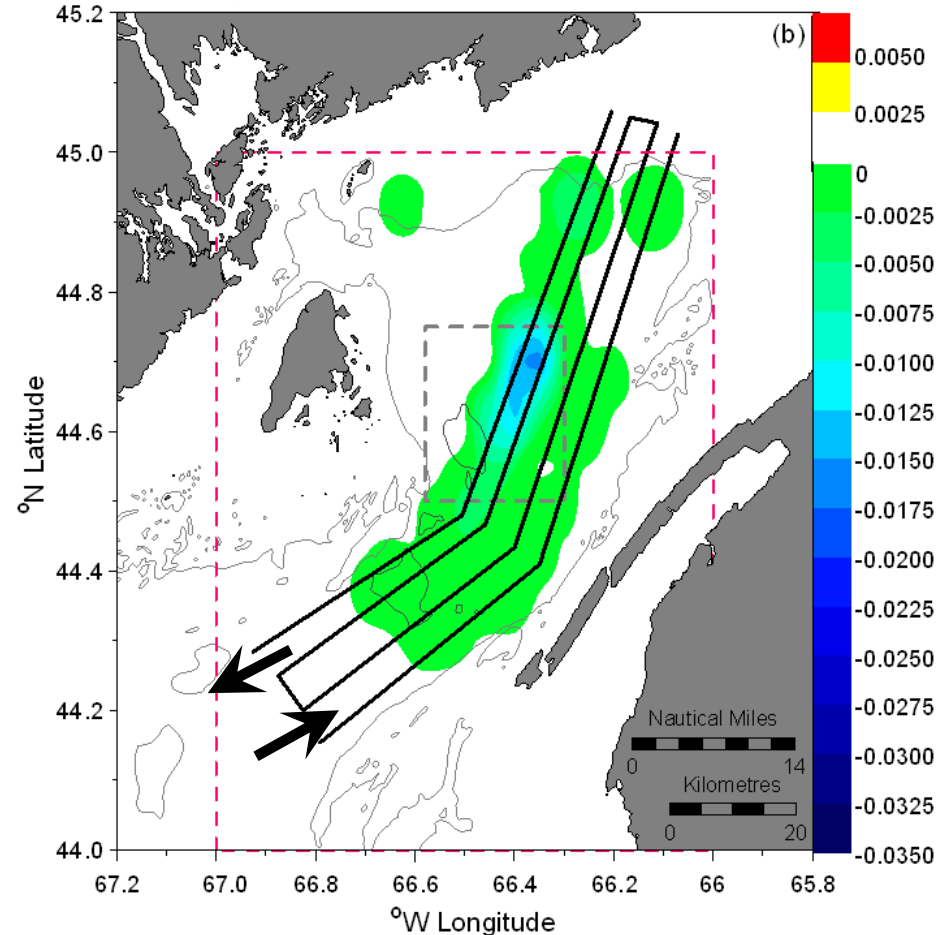
Alternative risk reduction

Re-routing

or Speed reduction



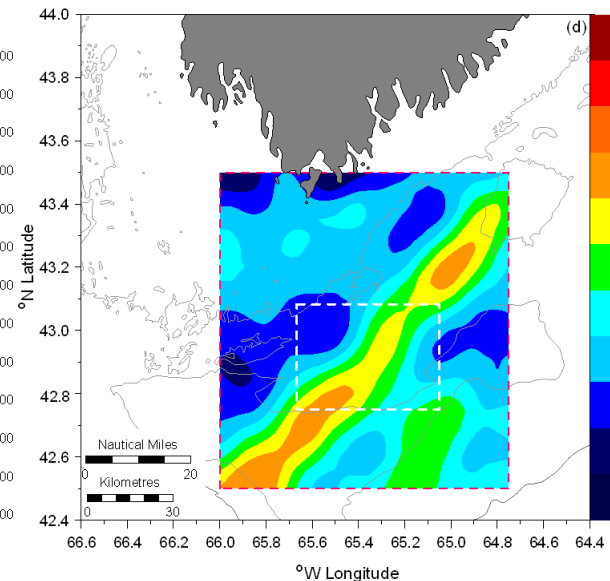
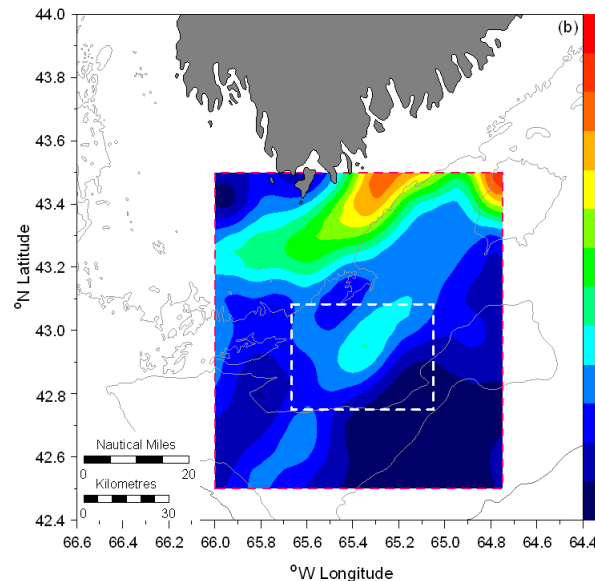
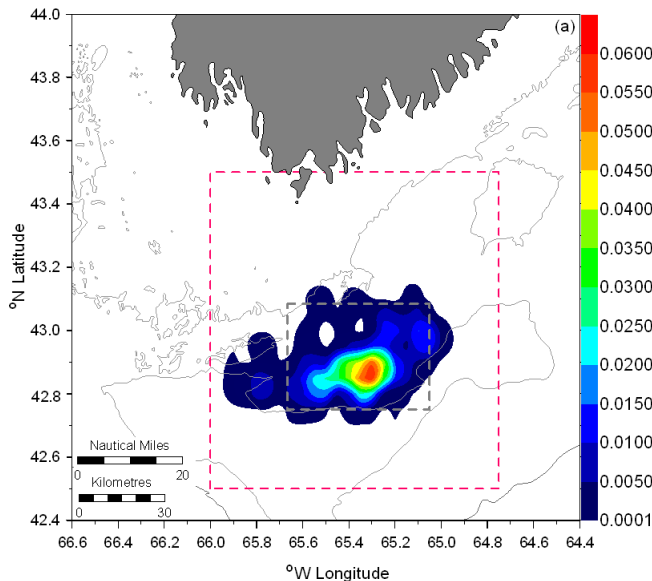
- **62%** reduction in overall risk
- Transit time in outbound lane increases by **~1.4%**



- **52%** reduction in overall risk
- Transit time in outbound lane increases by **~20%**

Science-based Conservation: Area To Be Avoided on Roseway Basin

- Two right whale deaths attributable to vessel strikes in the Roseway Basin Region
- Two further studies undertaken



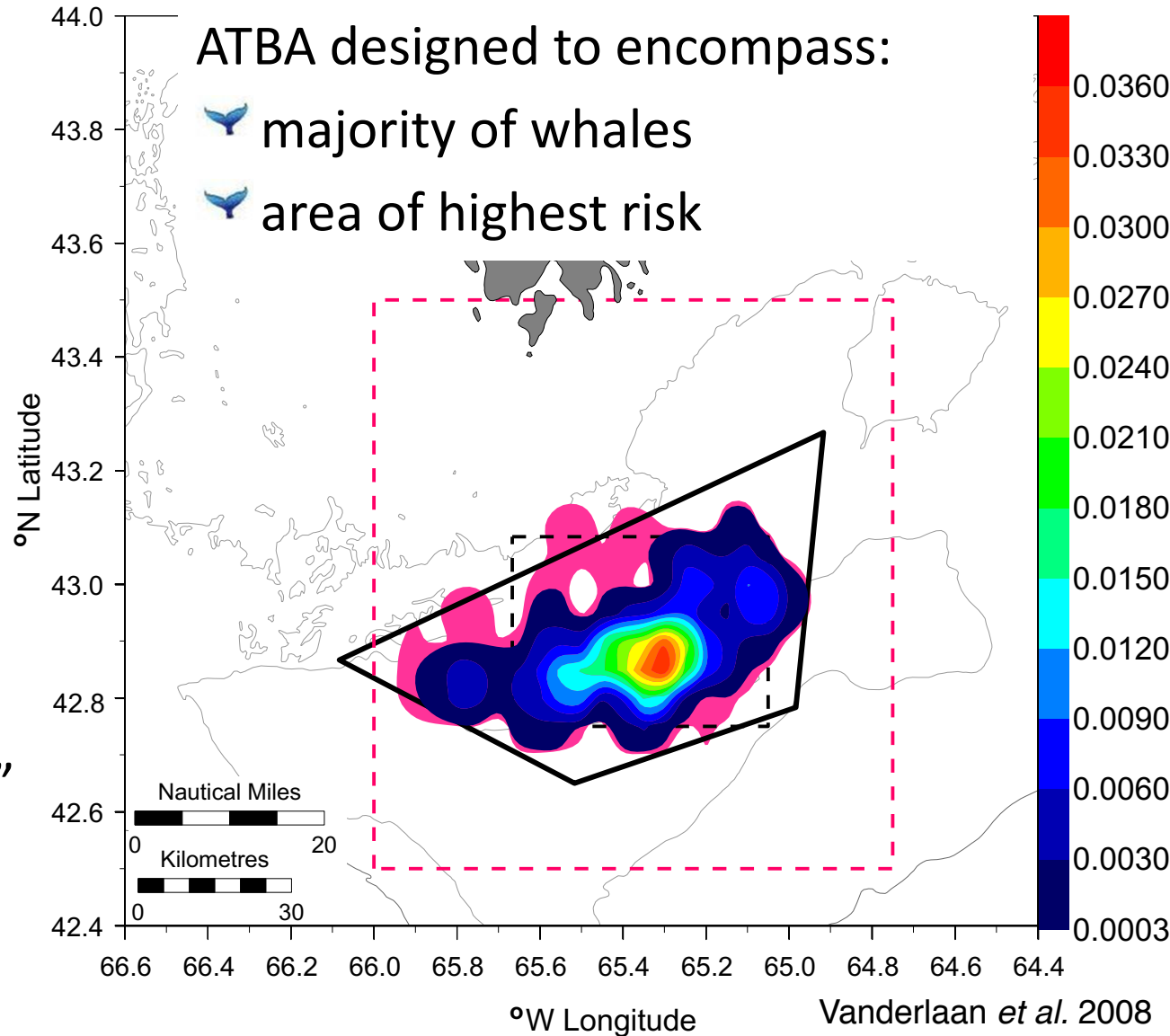
Science-based Conservation: Area To Be Avoided on Roseway Basin

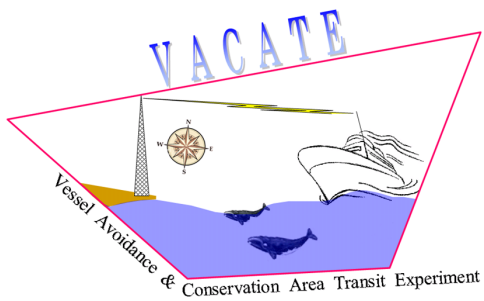
Highest risk within Conservation Area:

- ~68X higher on average, in Conservation Area than outside

Due to

- aggregated whales
- diagonal traffic “lane”
- higher vessel speed

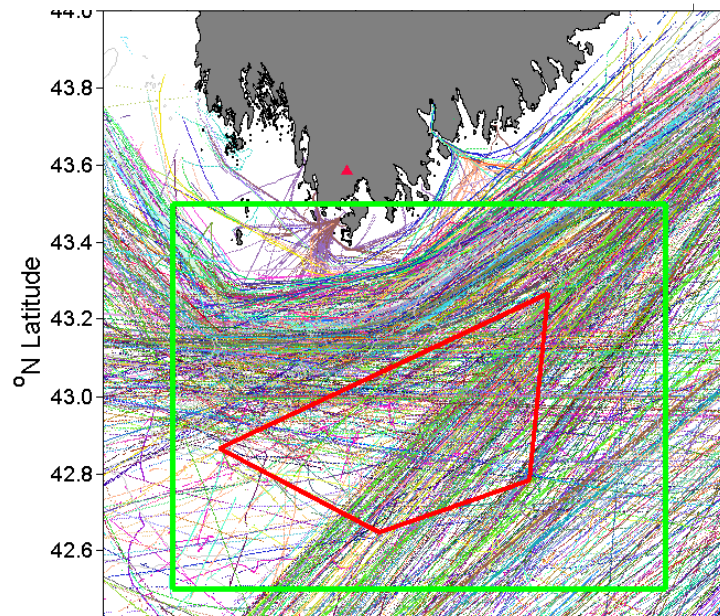




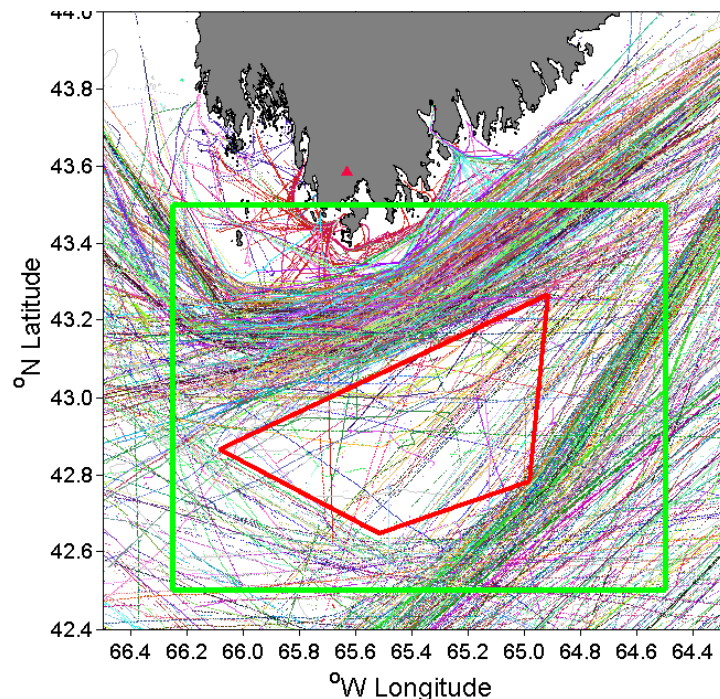
VACATE and the Marine Stewardship Recognition Program

- ✦ Vessel Avoidance and Conservation Area Transit Experiment (VACATE) was initiated to monitor vessels and measure vessel-operator compliance
- ✦ Marine Stewardship Recognition Program to increase compliance through a letter writing campaign
 - ✦ Direct communication with shipping industry
 - ✦ Congratulate vessel operator that avoided the ATBA
 - ✦ Increases the awareness of vessels continuing to transit the ATBA
 - ✦ Goal of achieving 100% compliance

Jun – Oct 2007 before implementation



Jun – Oct 2008 1st year post implementation



First year of implementation
compliance stabilised at:

71% ($\pm 11\%$)

✦ Voluntary reduction in risk of 82%

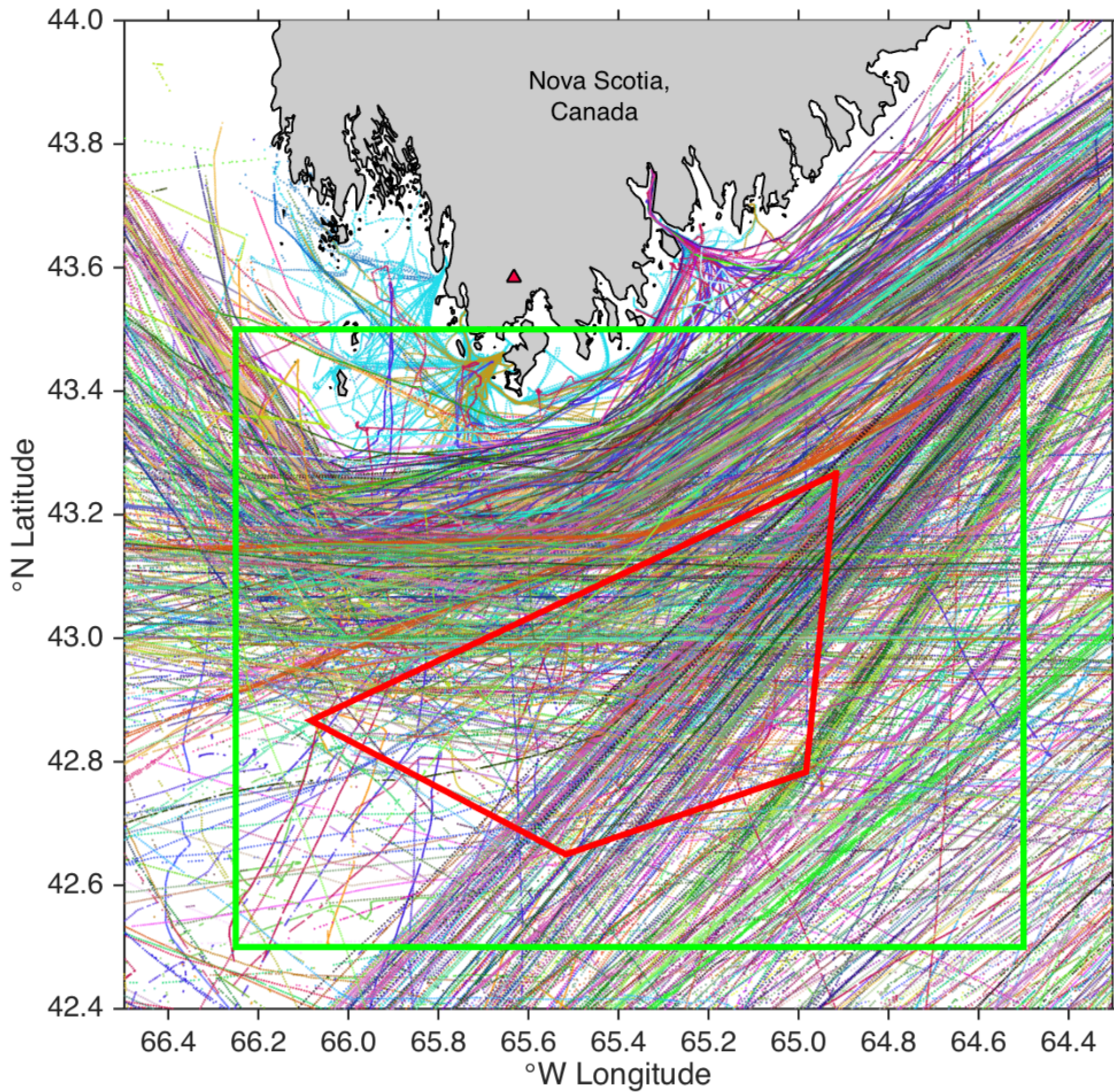
✦ Significant change in the distribution of vessels ($P=0.0001$)

✦ Shipping industry able and willing to voluntarily alter course

2007

VACATE: Compliance

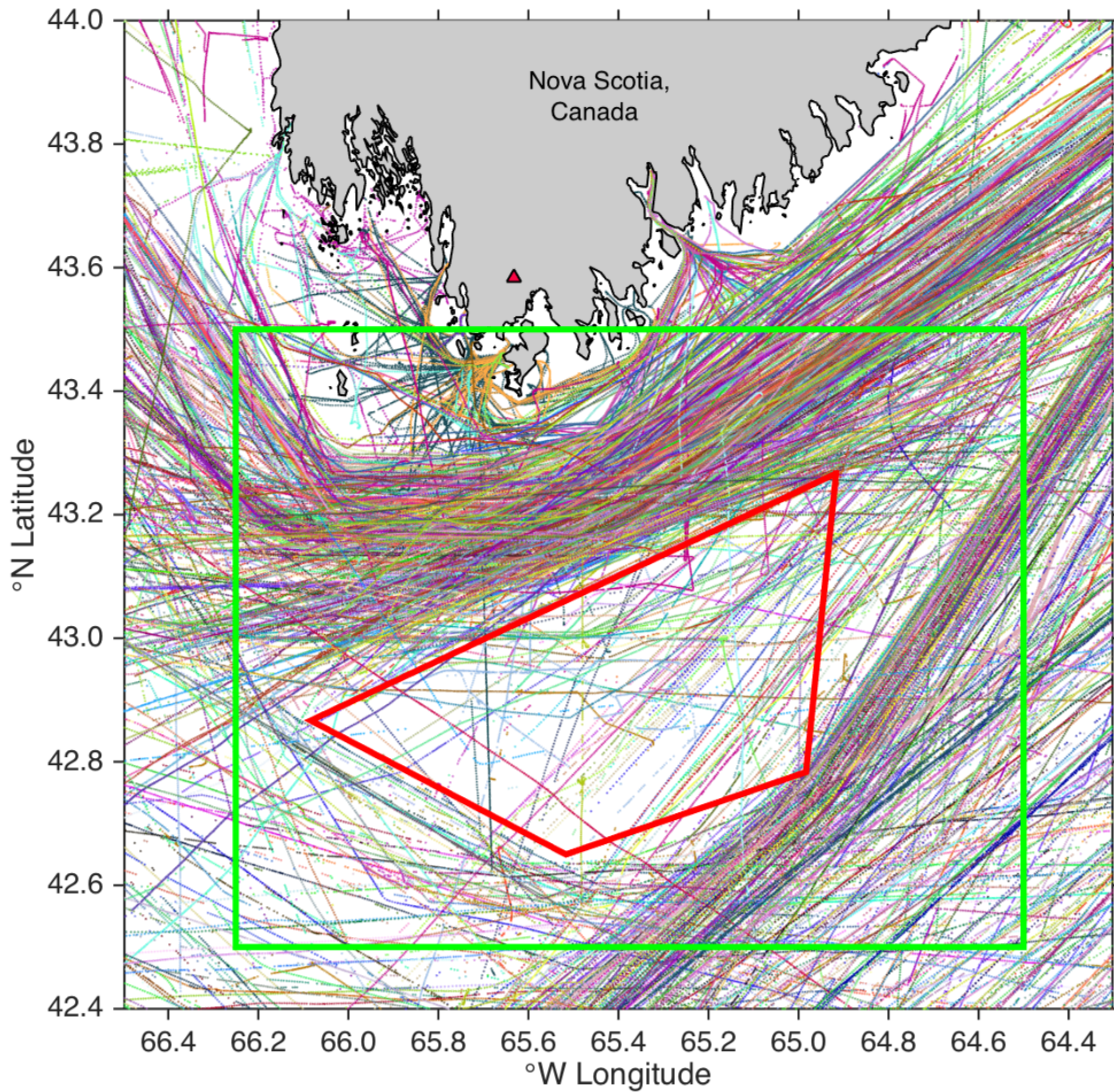
Vanderlaan
and Taggart,
unpublished
data



2008

VACATE: Compliance

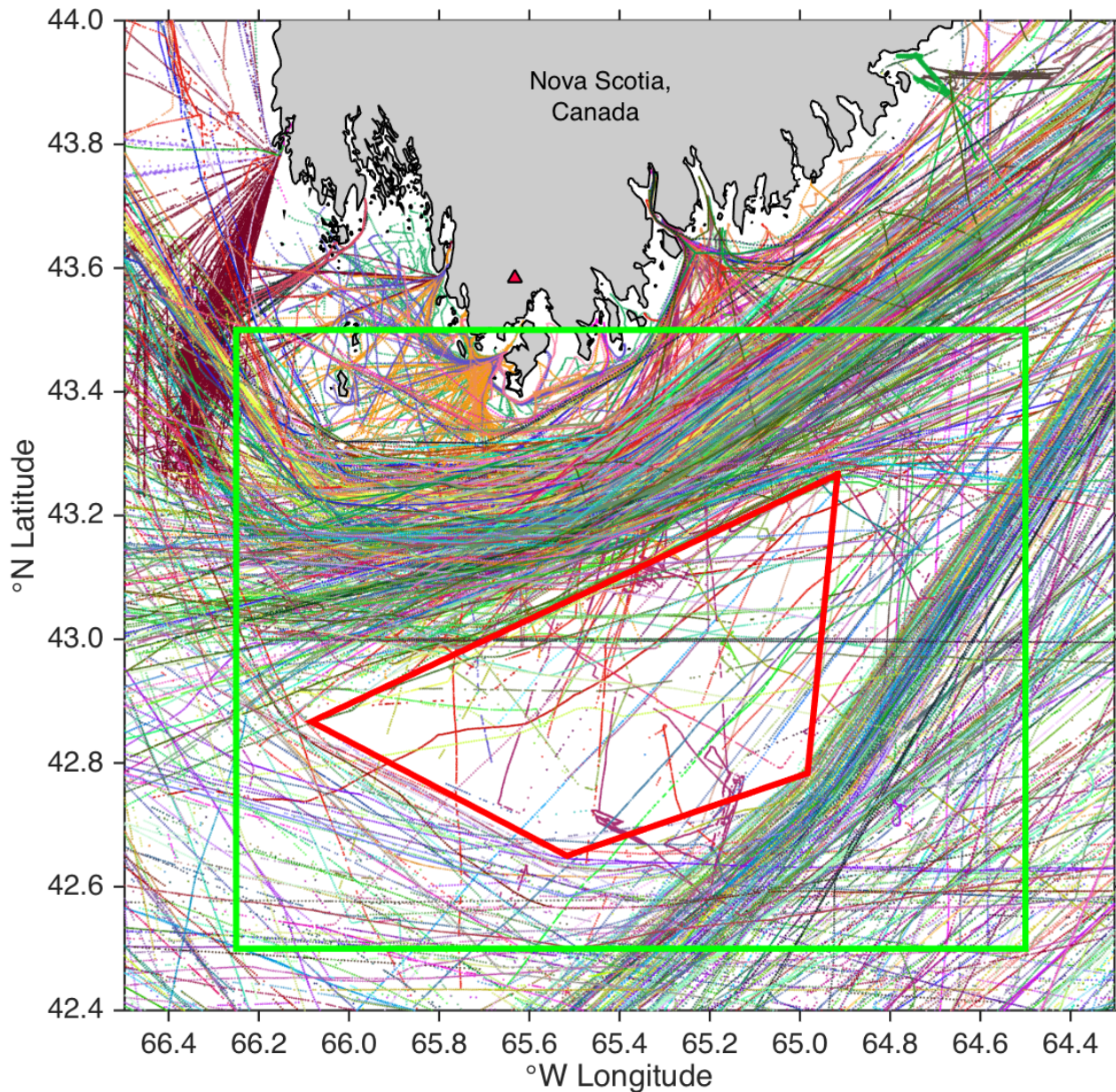
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2009

**VACATE:
Compliance**

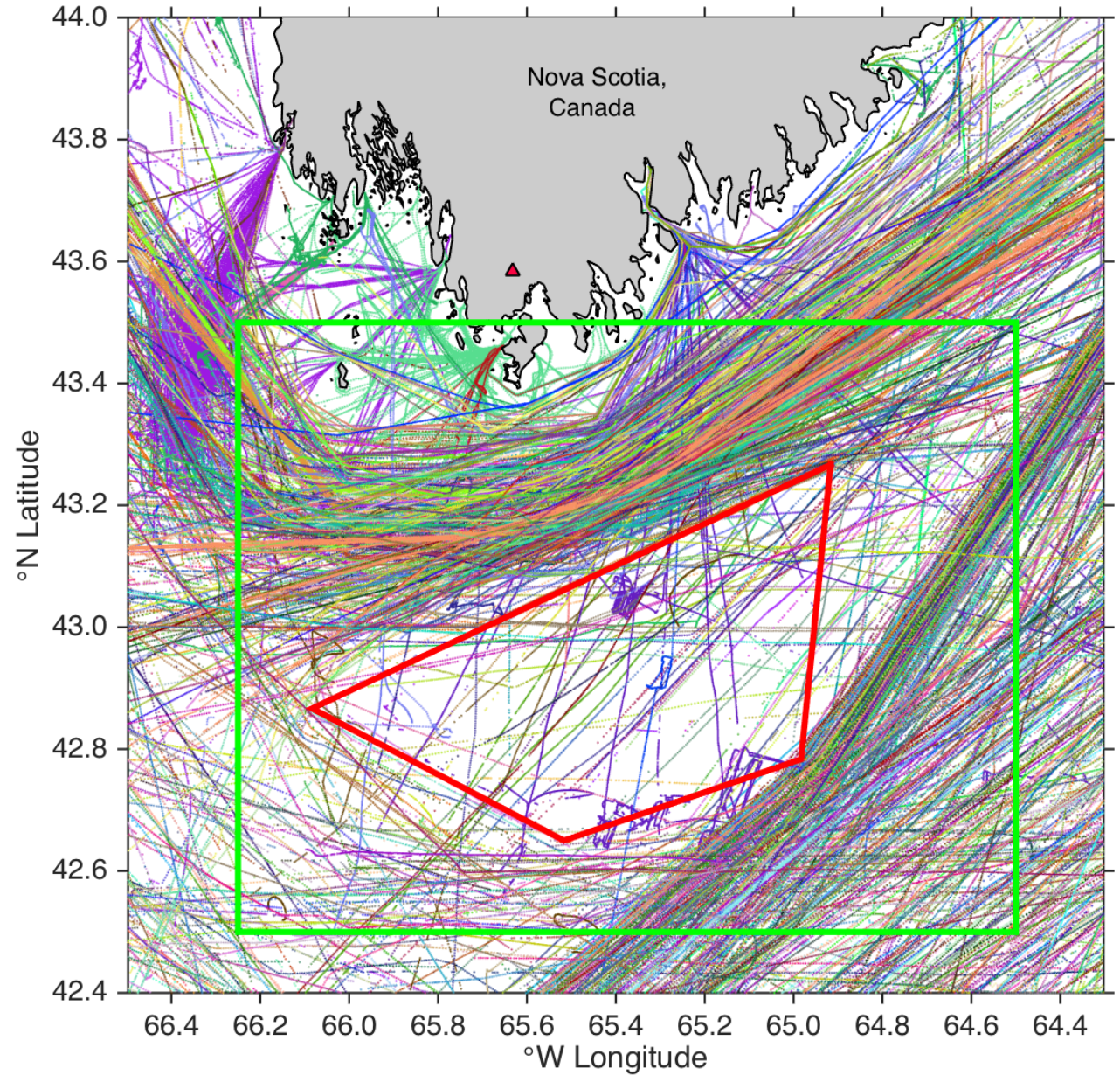
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2010

**VACATE:
Compliance**

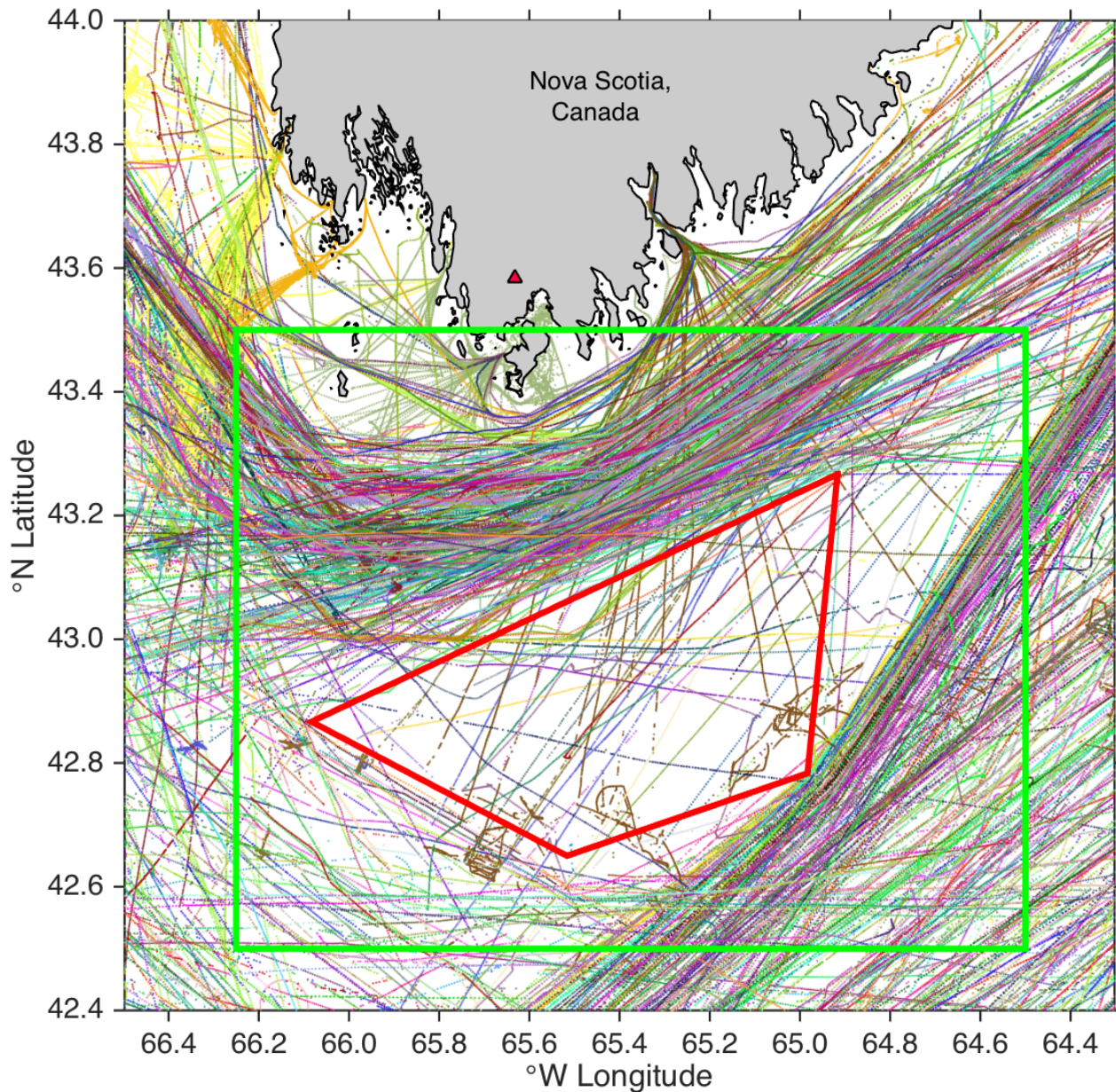
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2011

VACATE: Compliance

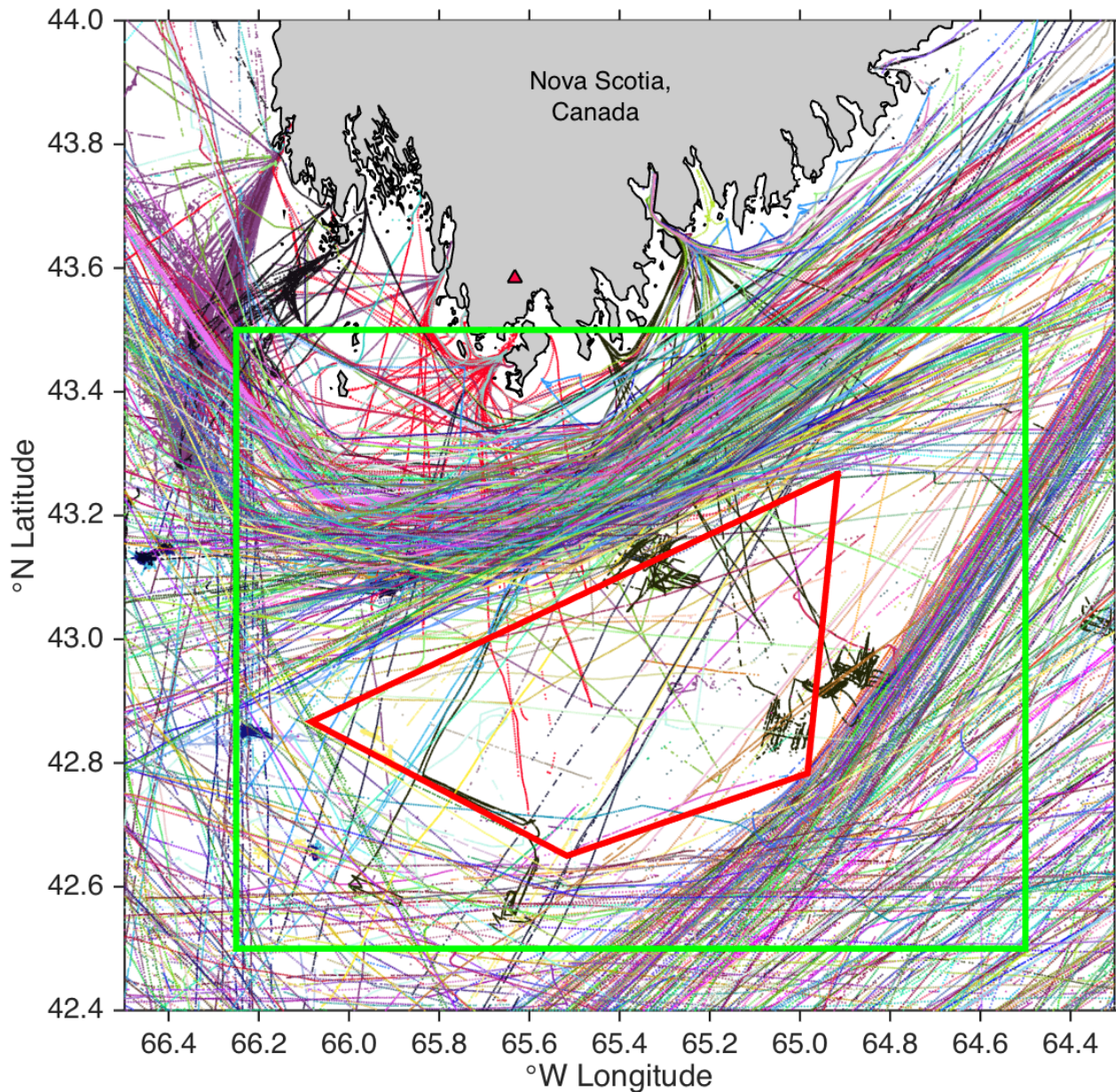
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2012

VACATE: Compliance

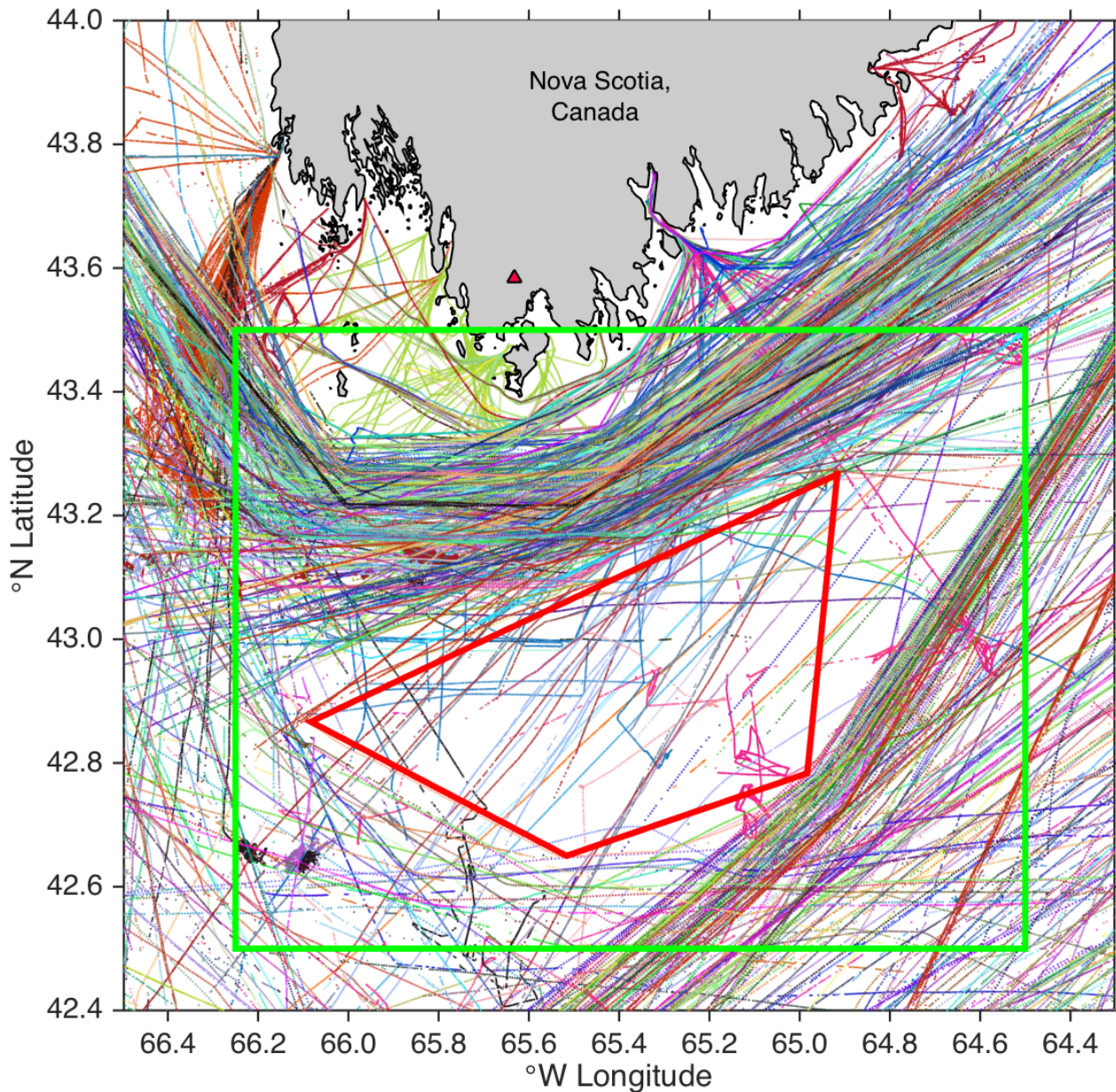
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2013

VACATE: Compliance

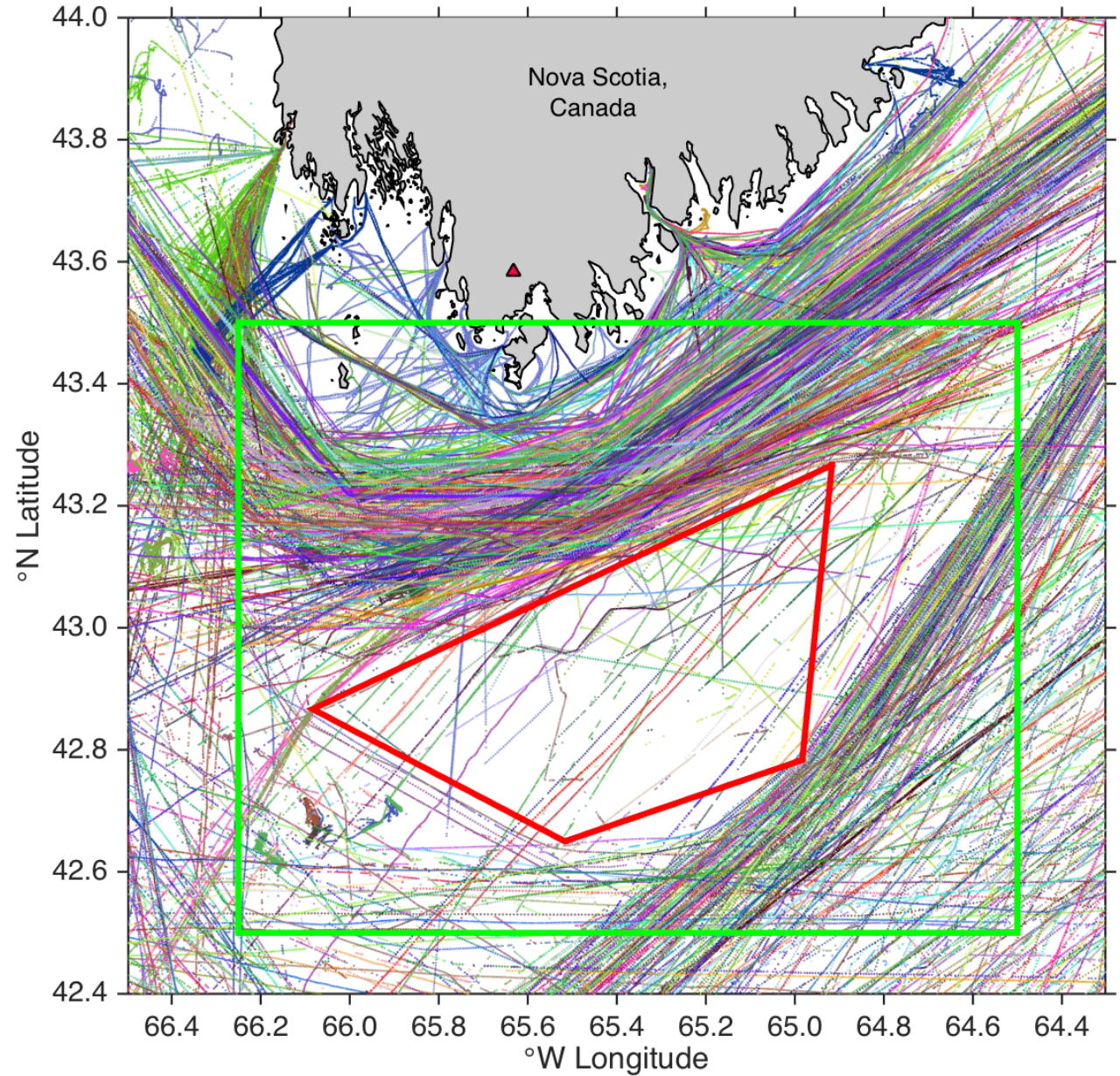
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2014

**VACATE:
Compliance**

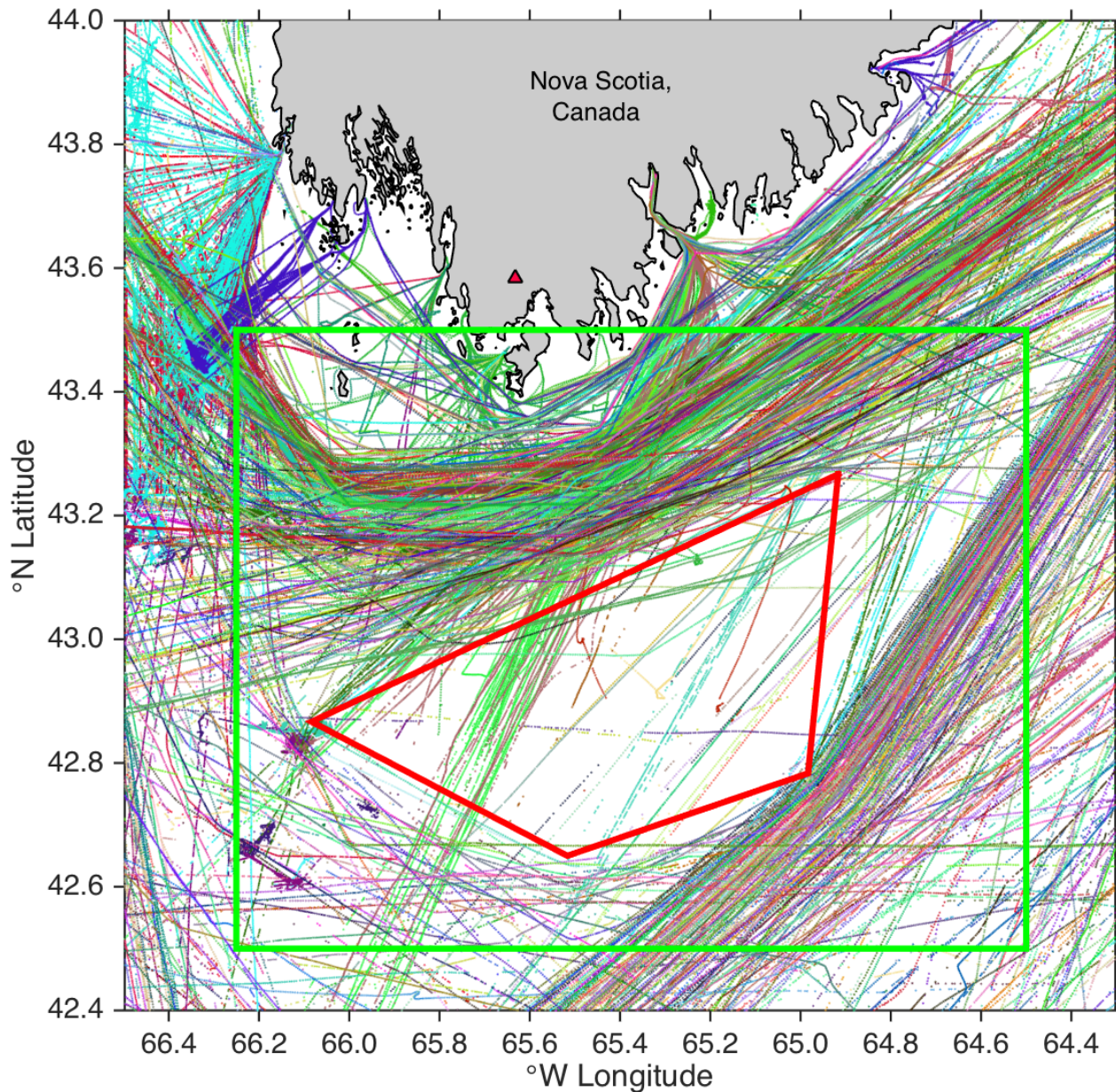
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2015

**VACATE:
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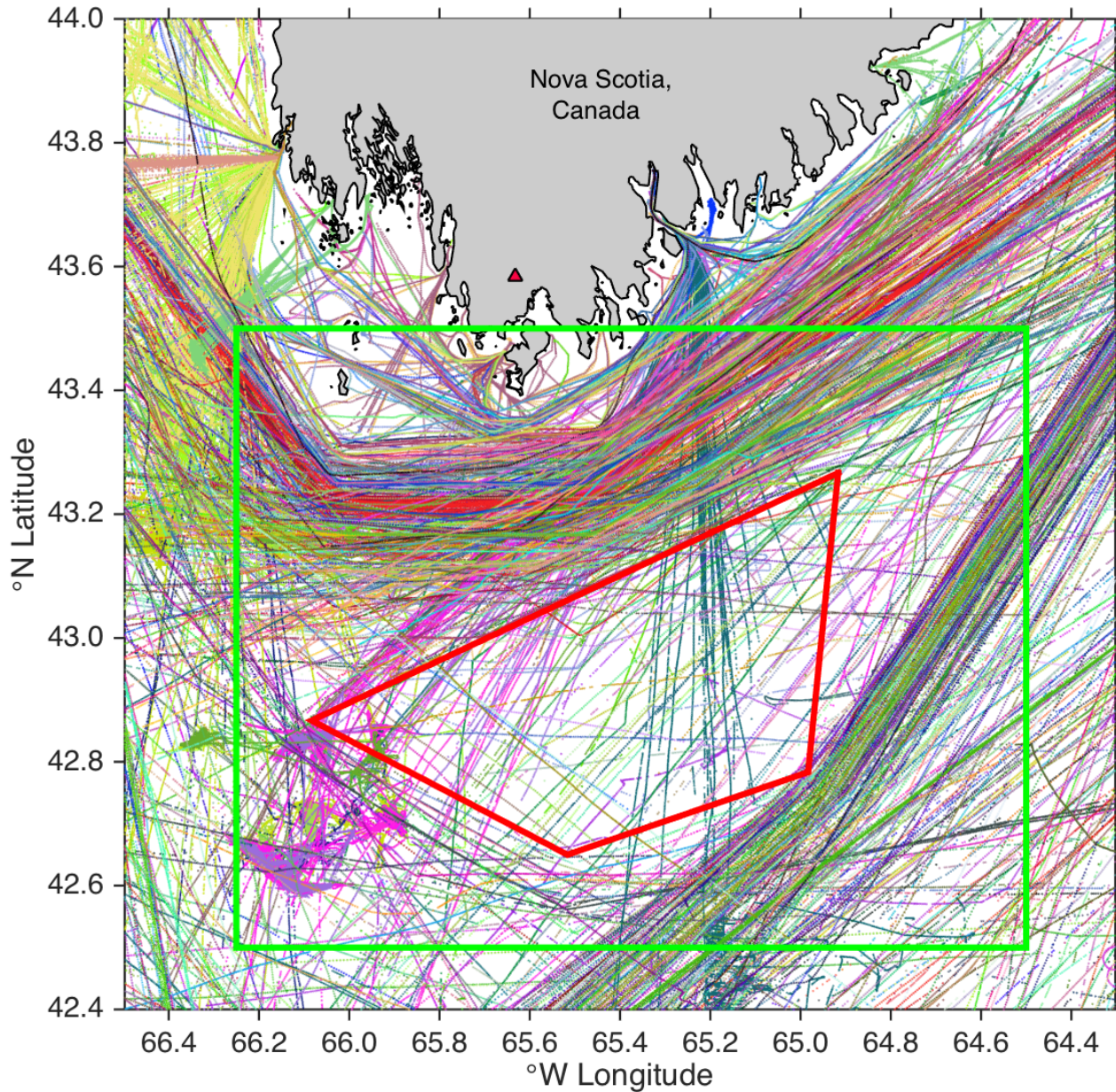
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2016

VACATE: Compliance

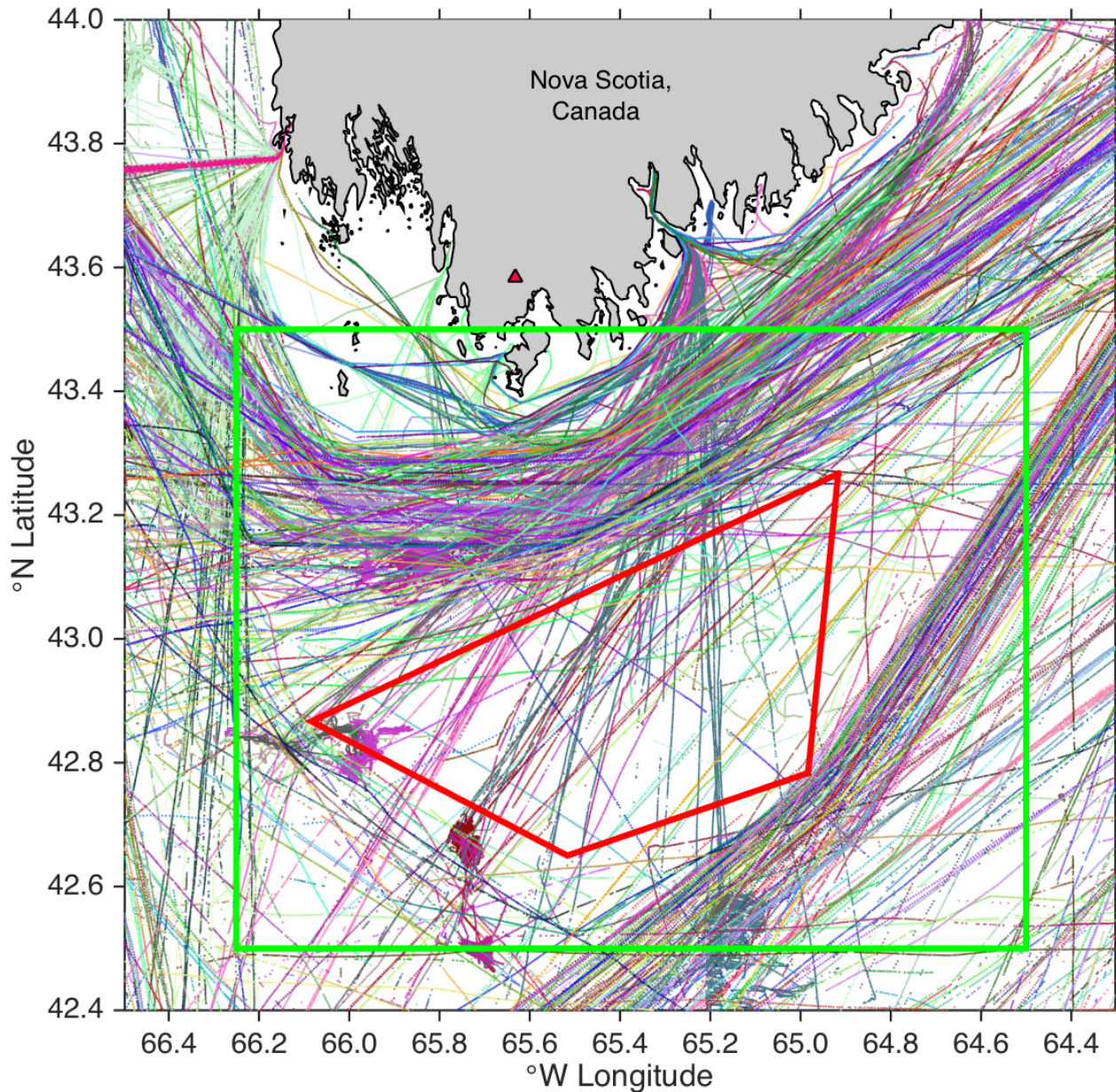
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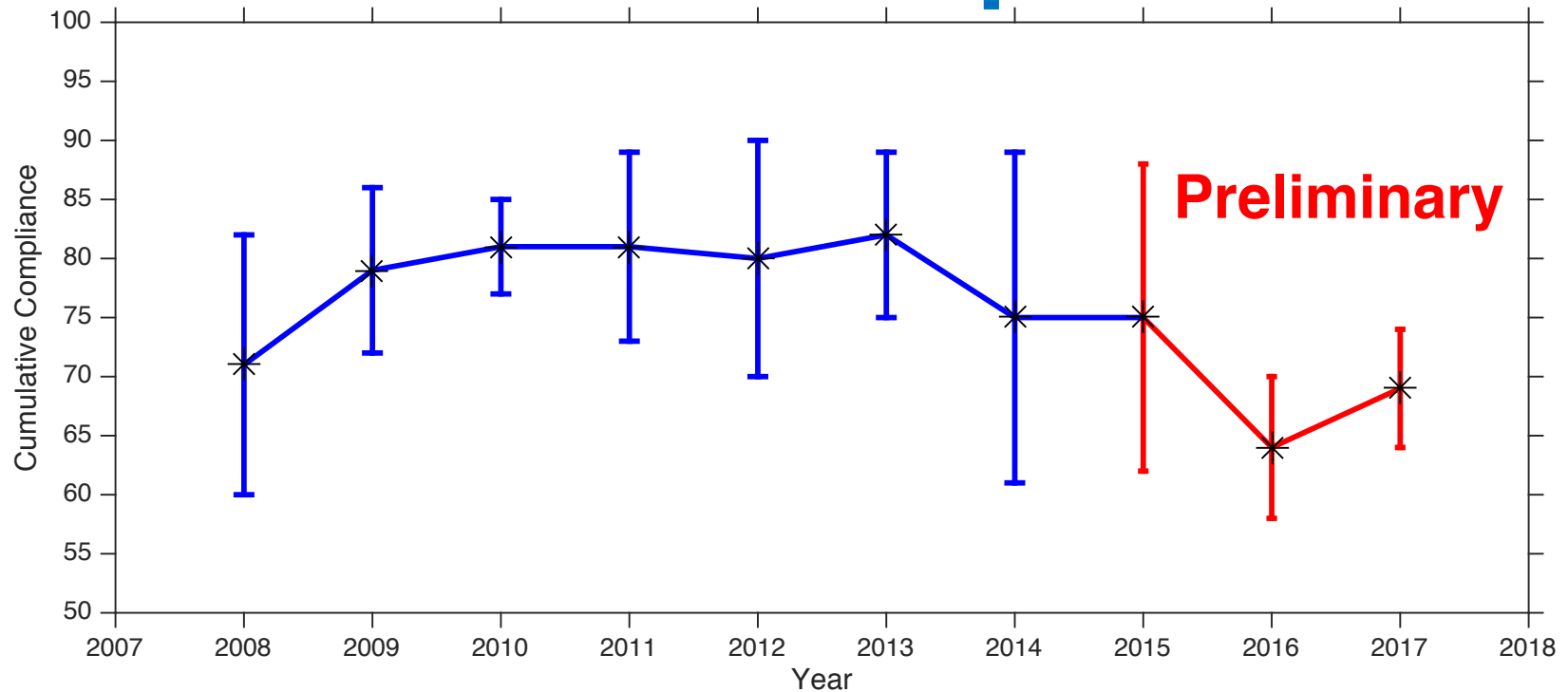
2017

**VACATE:
Compliance**

**Vanderlaan
and Taggart,
unpublished
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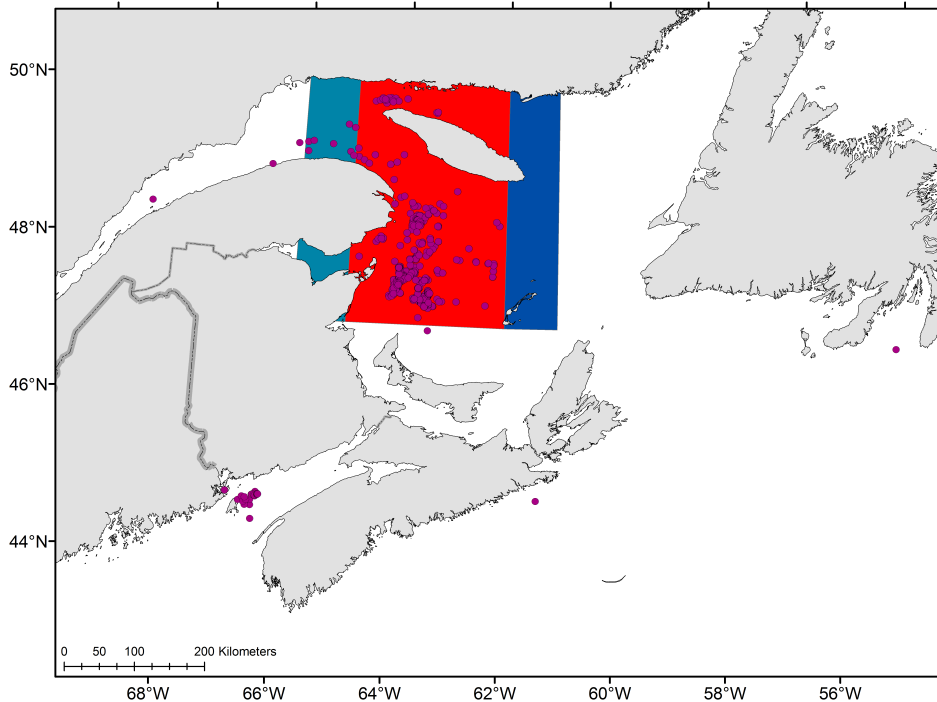


VACATE: Compliance



- Weekly compliance estimates ranged from:
14%(± 43%) to 100%(± 0%)
- Annual cumulative compliance estimates stabilized between:
64% and 82%

Speed Restriction Compliance



Voluntary speed restriction (10 knots) recommend on 22 July 2017

Mandatory speed restriction implemented on 13 Aug 2017

$P(\text{lethal injury} \mid \text{collision at 10 knots}) = 0.31$



MEOPAR



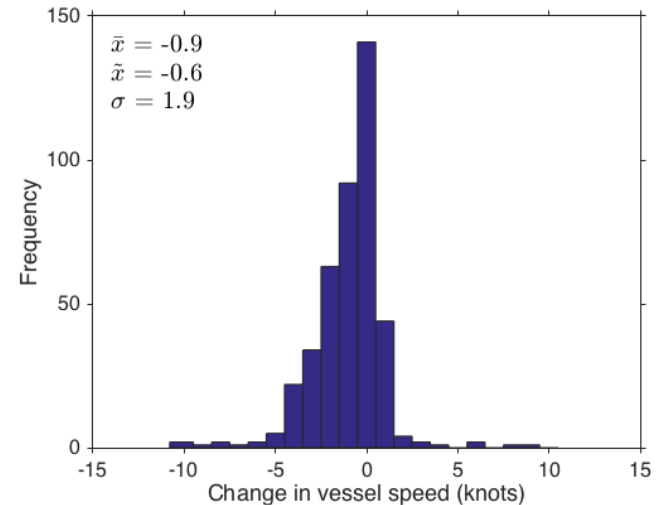
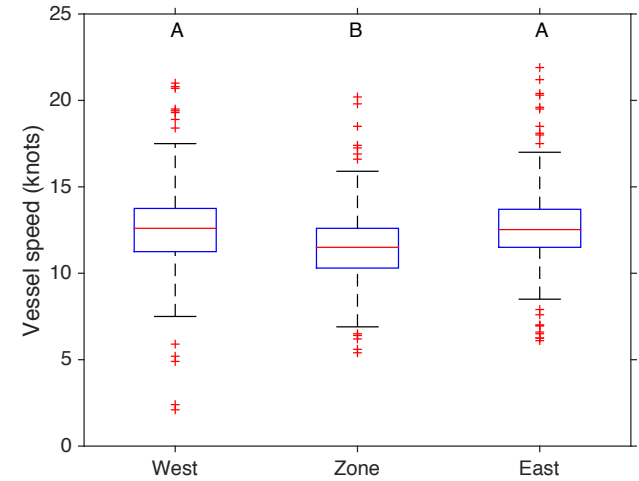
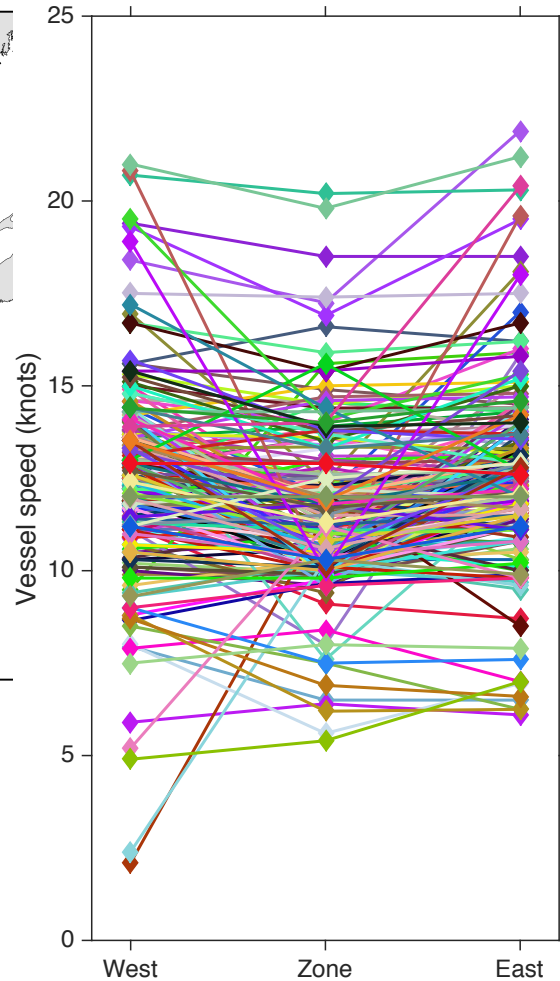
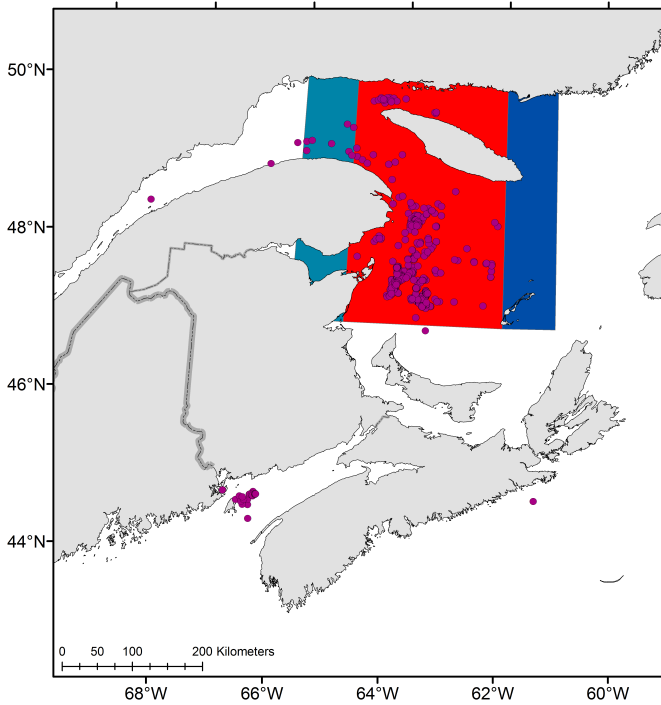
WHALE

exactEarth®

Speed Restriction Compliance:

Vanderlaan and Taggart, unpublished data

3 weeks of voluntary slow down



MEOPAR WHaLE

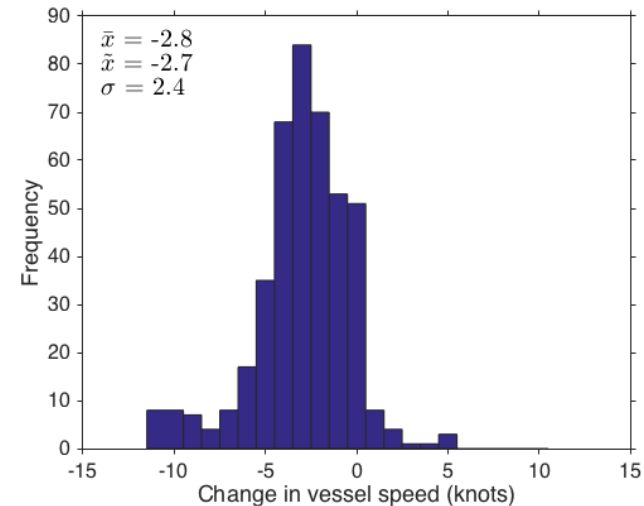
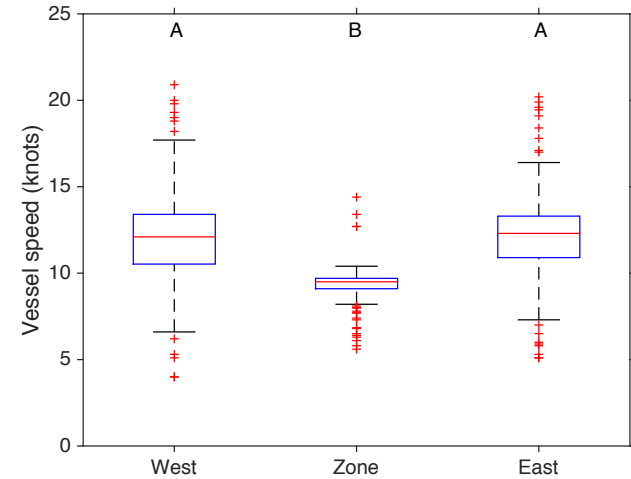
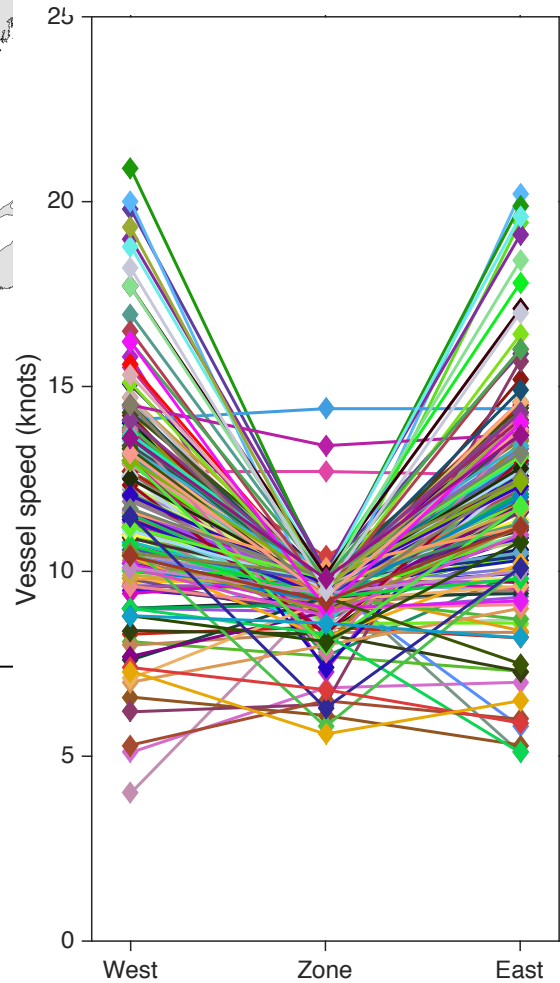
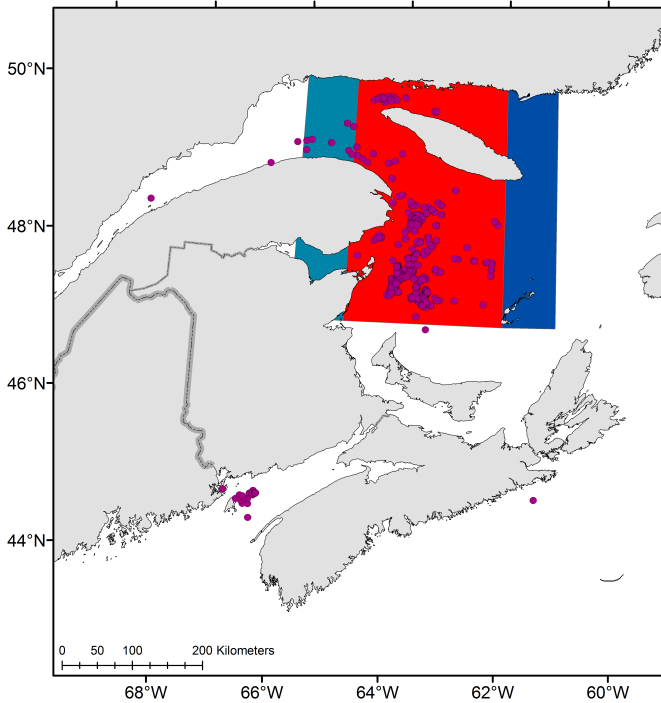
exactEarth®

~42% compliance

Speed Restriction Compliance:

Vanderlaan and Taggart, unpublished data

3 weeks of mandatory slow down



~98% compliance

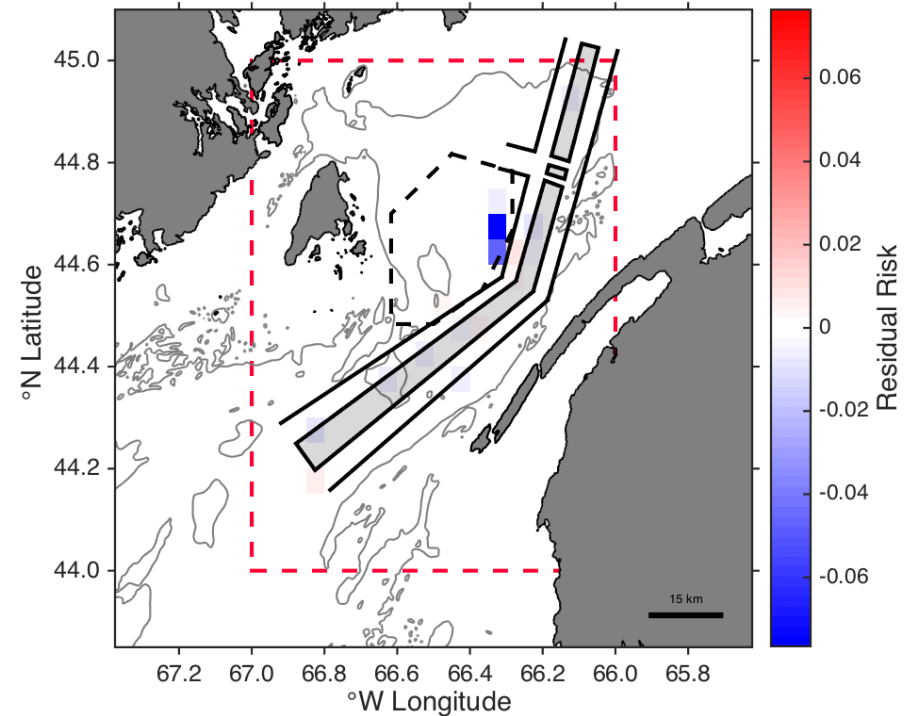
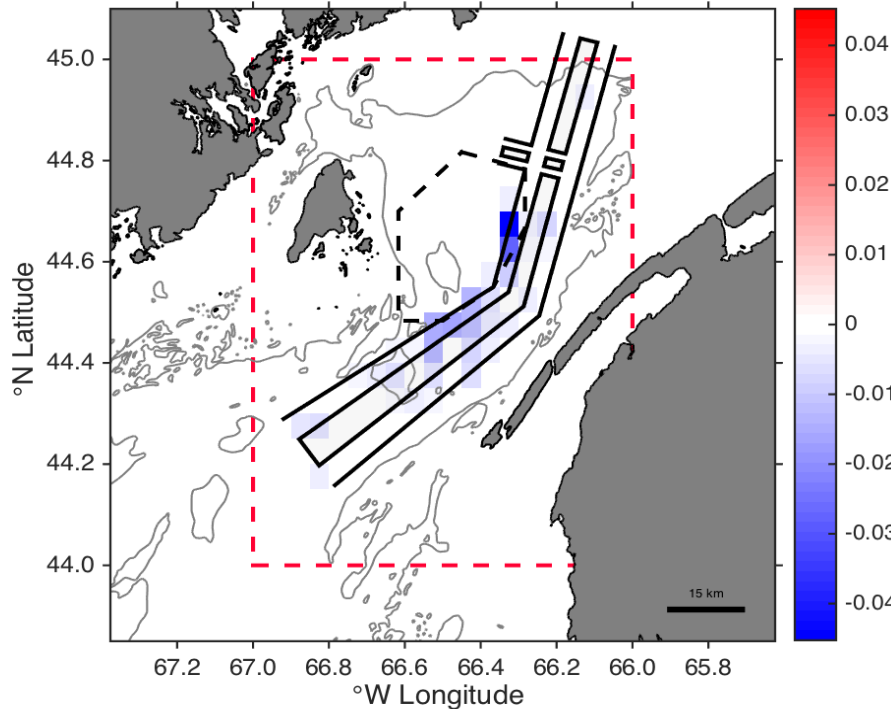
Updated risk analyses for the Bay of Fundy

- ✦ Examined various scenarios that would change the risk of lethal vessel strikes including:
 - ✦ Speed restrictions with varying levels of compliance
 - ✦ Modifying the traffic separation scheme to ensure vessels transit outside right whale critical habitat
 - ✦ Increased traffic due to the proposed Energy East Pipeline

Speed restriction versus re-routing vessels

- 10 knot speed restriction in the TSS
- 42.7% reduction in overall risk
- Increase in transit time by ~42%

- TSS no longer intersects the critical habitat
- 26.2% reduction in overall risk
- Increase in transit time by ~5.6%



Vanderlaan, A.S.M, and M.W. Brown. 2017. Risk assessment and vessel strike mitigation measures for endangered North Atlantic right whales in the Bay of Fundy, Canada. Final Project Report for Irving Oil.

Increased Traffic in the Bay of Fundy

- ✦ Energy East Pipeline or other projects could bring increased traffic into the Bay of Fundy
- ✦ Using representative tanker transit we simulated 100, 200, and 300 extra trips

Changes in risk:

Extra Trips	Current TSS	Speed Restriction in current TSS	Proposed Lanes
100	+7.0%	-42.4%	+3.6%
200	+11.0%	-42.0%	+6.3%
300	+13.8%	-41.7%	+8.4%

Vanderlaan, A.S.M, and M.W. Brown. 2017. Risk assessment and vessel strike mitigation measures for endangered North Atlantic right whales in the Bay of Fundy, Canada. Final Project Report for Irving Oil.

Conclusions

- ✦ Conservation initiatives implemented will not eliminate vessels strikes
- ✦ Reductions in risk have been achieved in Bay of Fundy, Roseway Basin with minimal effects on industry
- ✦ Simulation studies can be conducted to examine the effects of conservation initiatives:
 - ✦ changes in whale distribution
 - ✦ changes in vessel traffic

Acknowledgements

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- ✓ Fisheries & Oceans Canada
- ✓ Natural Sciences and Engineering Research Council of Canada
- ✓ Irving Oil



Fisheries and Oceans,
Environment Canada



Sea-web™



Questions ???

