

Entanglement trends and impacts



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Right whale "Churchill"

Three approaches

- Frequency and severity of entanglements by year
- Injured whale monitoring
- Impacts on health, reproduction, and survival

Scar coding

Moderate



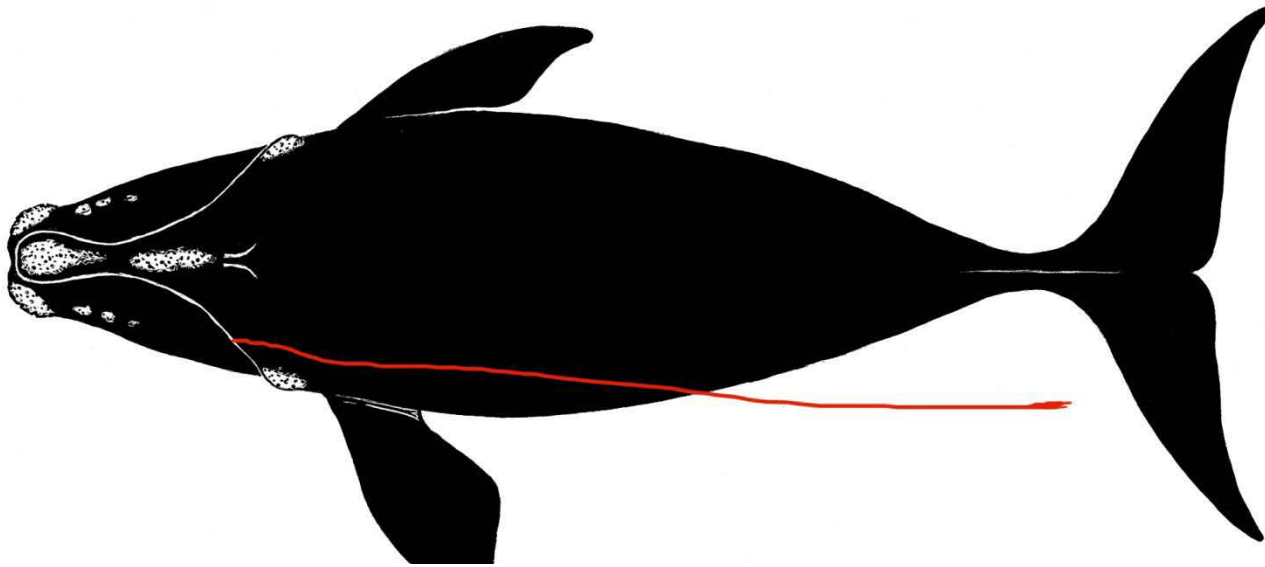
Minor



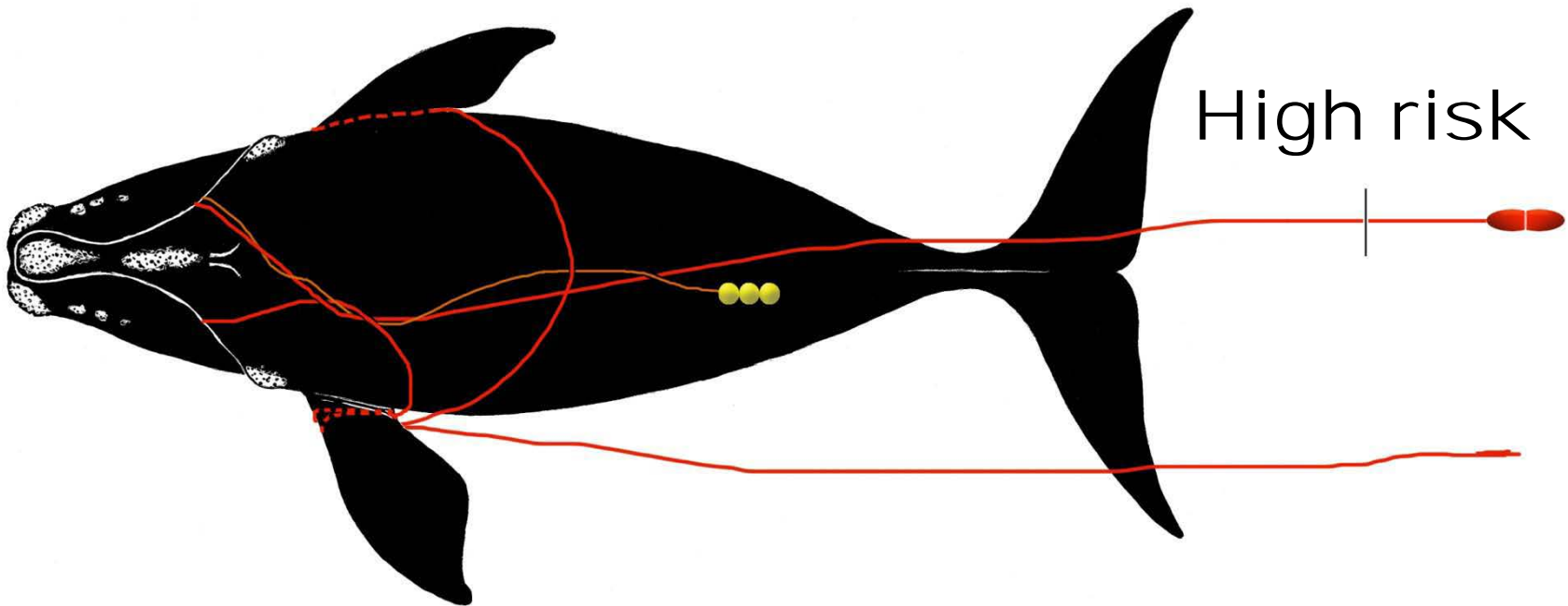
Severe

Entanglement injury
3 injury severity levels
(based on extensiveness and depth of wounds)

Entanglement configuration risk

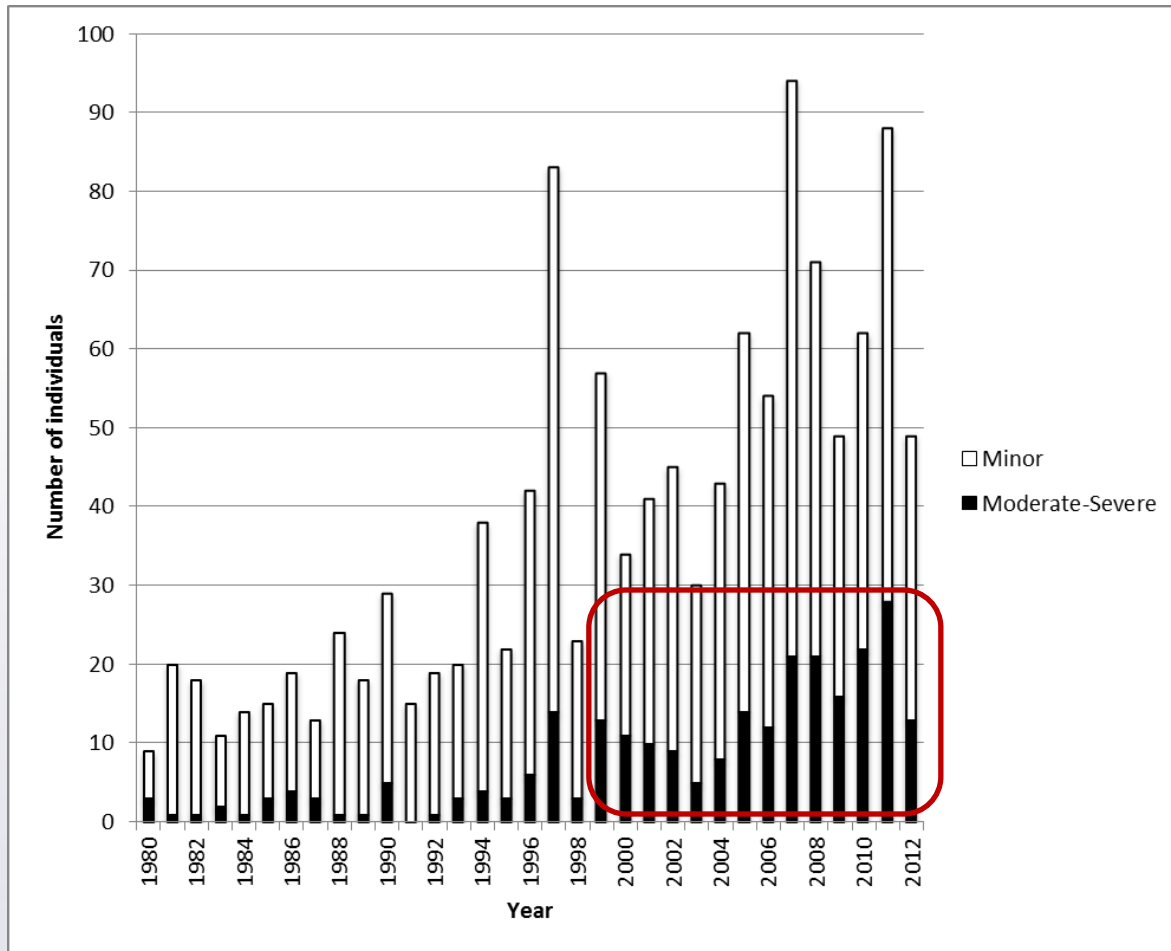


Low risk



High risk

Entanglement injuries



From Knowlton et al. (2012) Monitoring North Atlantic right whale *Eubalaena glacialis* entanglement rates: a 30 year retrospective. Marine Ecology Progress Series 466:293-302

1,269 entanglement interactions between 1980-2012

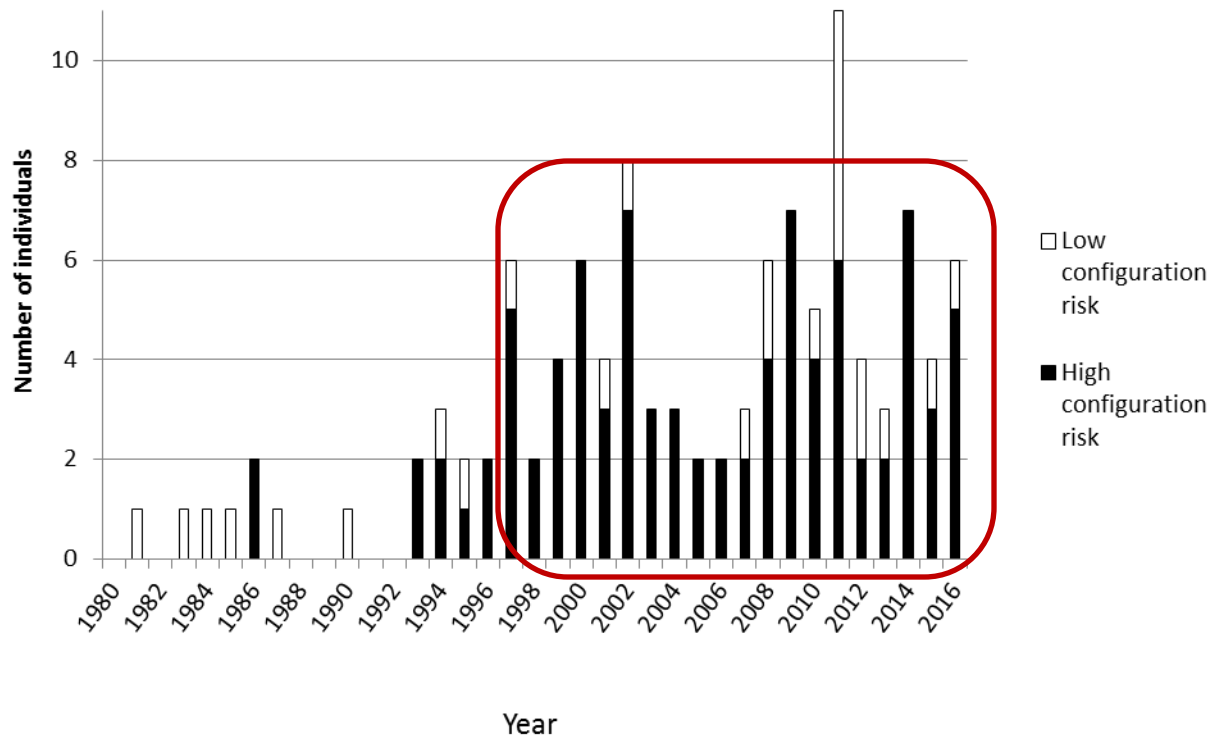
Assessment of data through 2009 showed 83% of the population has experienced one or more entanglement events

Higher proportion of moderate-severe injuries since late 1990's

Pattern persists through 2012 analysis

Scar coding is now being done for 2013-2015 data

Entanglement configuration risk



113 cases with attached gear

Majority of entanglements are high configuration risk since mid 1990's

Rate of entangled whales has increased significantly over 30 year period

Injured whale monitoring: a near real-time assessment

- As of December 2016, there are 63 whales with severe injuries acquired between March 2004 to December 2016 (majority from 2010 to present) that are being monitored
- 84% entanglement, 14% vessel strike
- 43% in declining health
- 43% could not be assessed because they either disappeared or images too poor but could be in declining health

	Entanglement		Vessel Strike	Other	Total
	Gear Present	No Gear Present			
Decline in Condition	10	14	2	1	27
Inconclusive	11	11	5	0	27
No Decline in Condition	0	4	1	0	6
Extended Monitor	1	2	1	0	4
Total	22	31	9	1	63

Impact of anthropogenic injury on health by injury type for North Atlantic right whales on the active injury monitoring list.

Assessing impacts of entanglement

- Use Hierarchical Bayesian modeling to compare health of right whales impacted by entanglement to un-impacted whales
- Evaluate potential effect of entanglement on reproductive capacity and survival
- Use different categories of entanglement severity to compare the degree of lethal and sublethal health impacts



Minor



Moderate



Severe

Entanglement levels
3 injury severity levels
(based on extensiveness
and depth of wounds)
+
With or without
attached gear
=
6 IMPACT LEVELS

Methods

- Determine monthly health score and anomaly for each individual over their lifetime
- Categorize 1,195 entanglement events documented from 1980-2011 into 6 entanglement impact categories

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- Categorize 1,195 entanglement events documented from 1980-2011 into 6 entanglement categories
- Determine timeframe within which entanglement occurred and duration if gear was attached

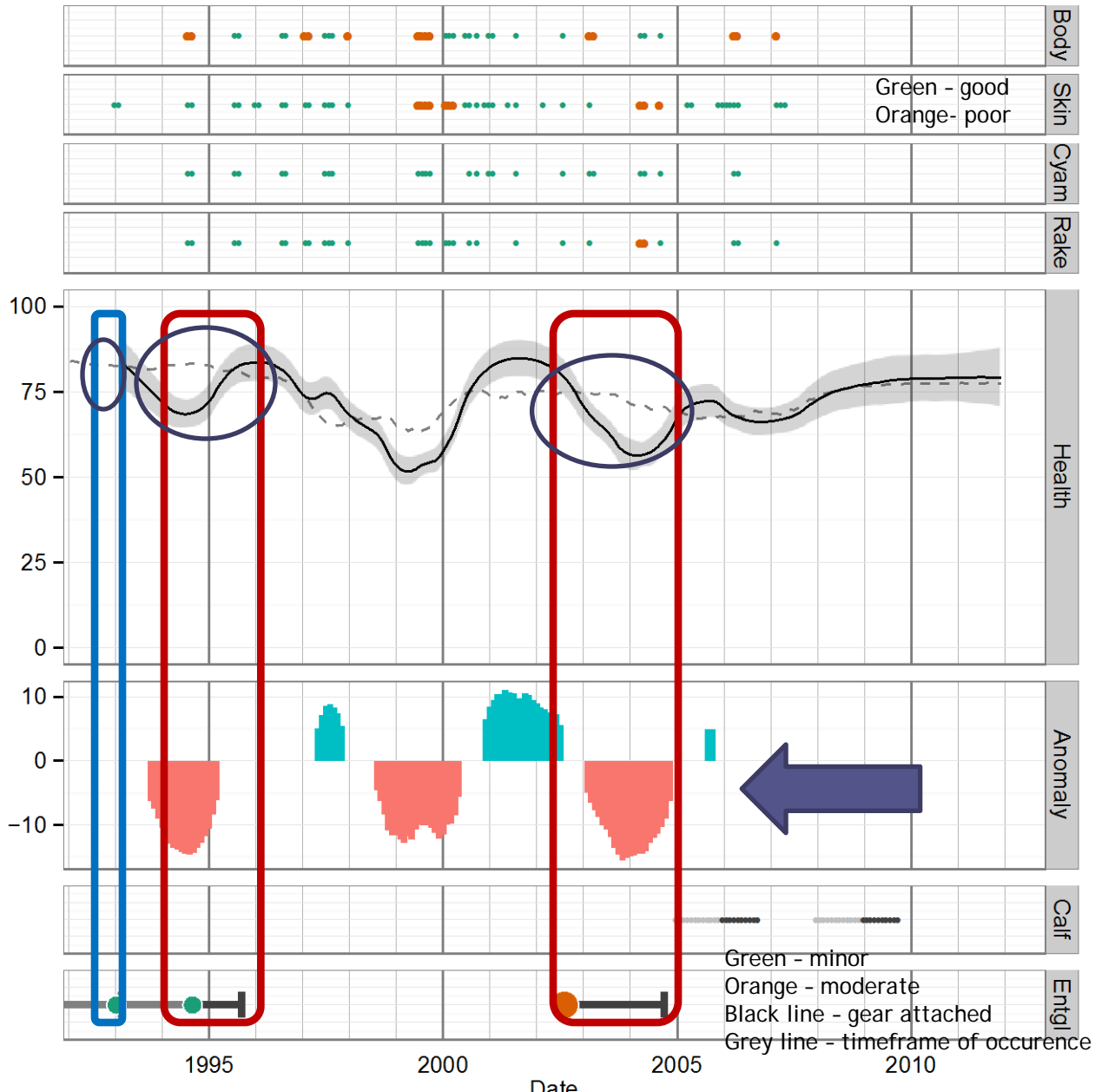
Methods

- Determine monthly health score and anomaly for each individual over their lifetime
- Categorize 1,195 entanglement events documented from 1980-2011 into 6 entanglement categories
- Determine timeframe within which entanglement occurred and duration if gear was attached
- Carried out 4 independent analyses

ANALYSIS 1 - Mean health anomaly of impacted vs. unimpacted

- Create “entanglement health windows”

EGNo = 2320



Entanglement health windows

With gear (red box):
Up to 3 months prior to first sighting with gear to 3 months after last sighting with gear

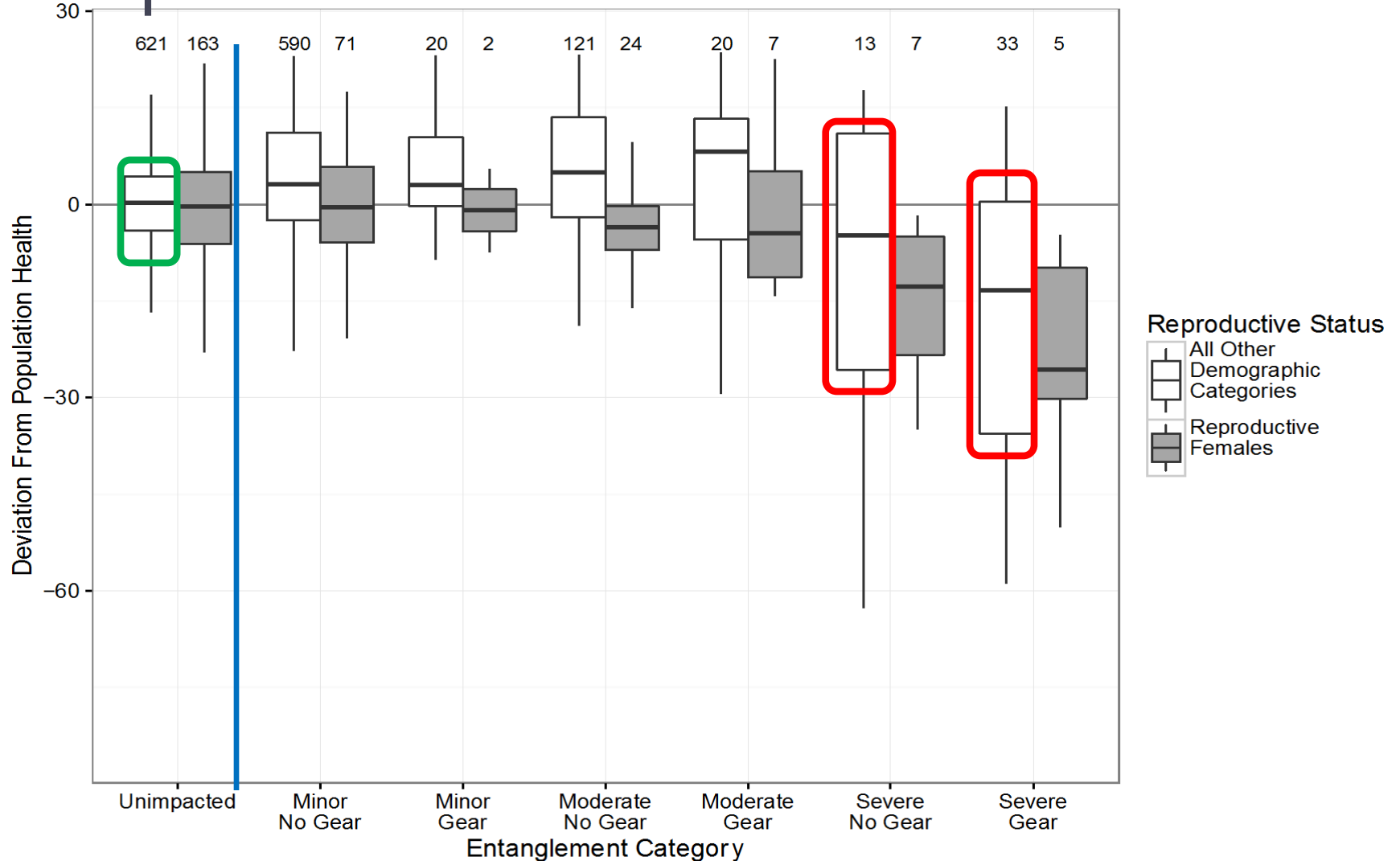
Scars only (blue box):
Up to 3 months prior to first detection with scars

Calculated average health anomaly score of all months in window

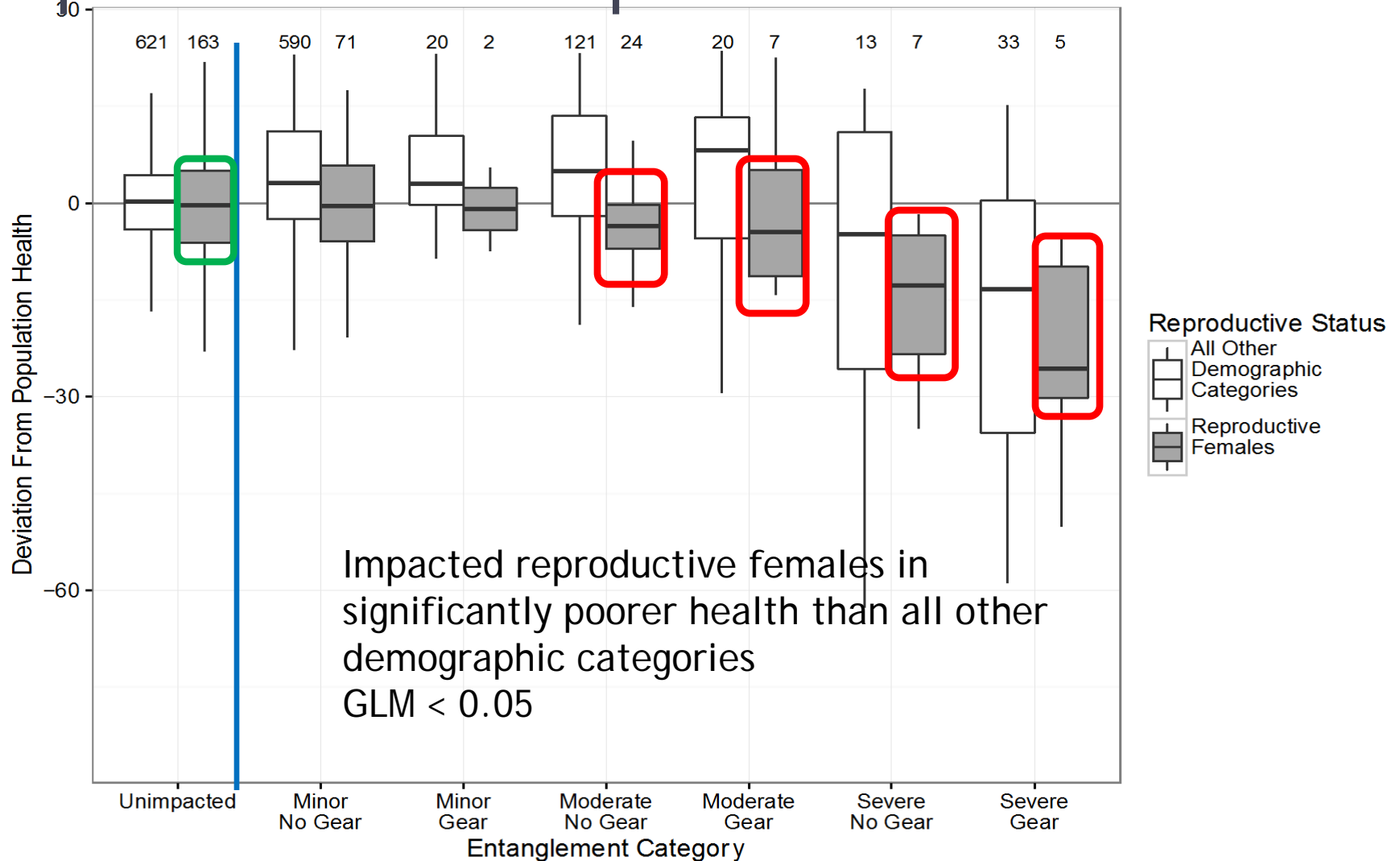
ANALYSIS 1 - Mean health impacted vs. unimpacted

- Create “entanglement health windows”
- Compare average monthly anomalies
 - 6 entanglement categories vs. unimpacted (never experienced an entanglement)
 - reproductive females vs. all other demographic groups

ANALYSIS 1 - Mean health impacted vs. unimpacted

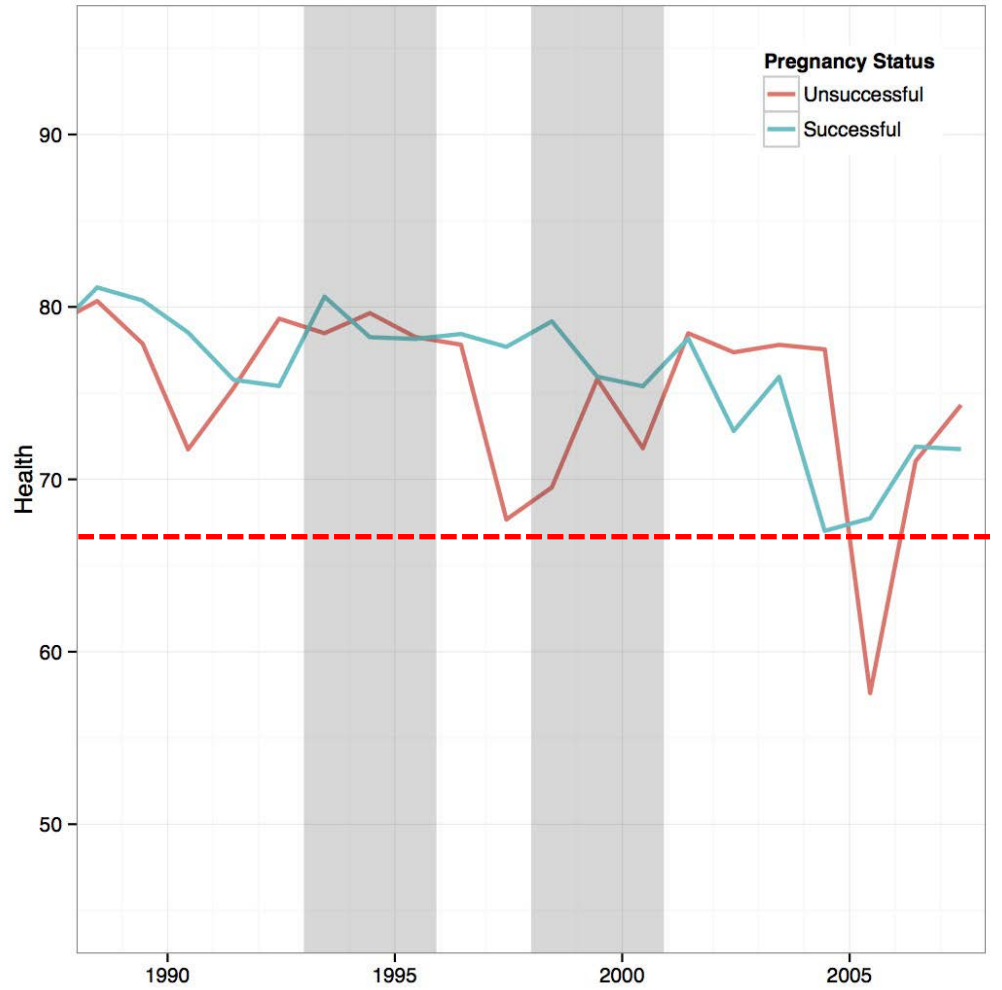


ANALYSIS 1 - Mean health anomaly of impacted vs. unimpacted



ANALYSIS 2 - Impact on calving threshold

HEALTH IN CALVING VS. NON-CALVING FEMALES



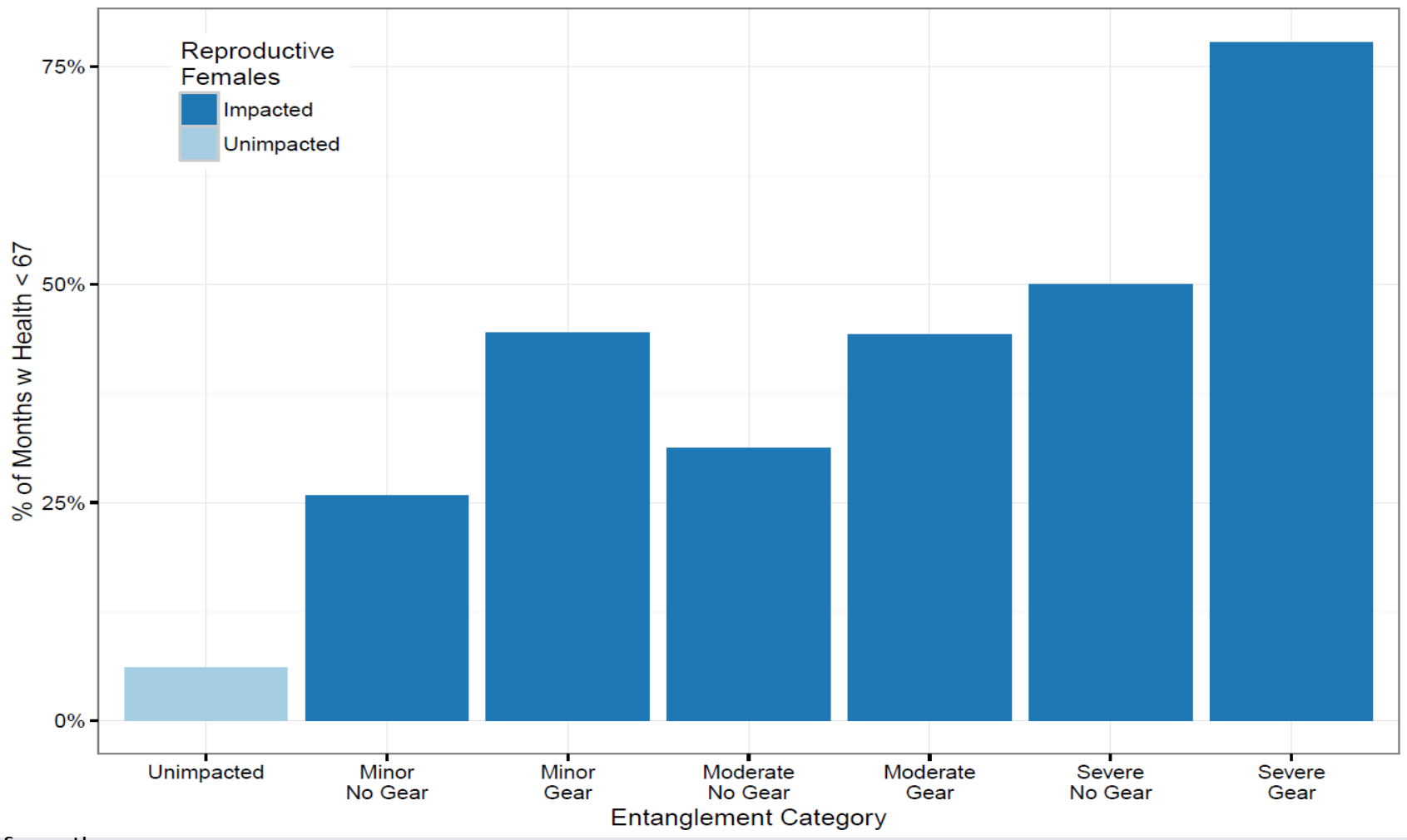
‘Successful’ =
resting/available
females that became
pregnant the following
year and calved

← Threshold for calving =
67

ANALYSIS 2 - Impact on calving threshold

- For reproductive females, assess the % of months within the entanglement windows that fell below health score of 67 for 6 entanglement levels
- Compare to unimpacted reproductive females

ANALYSIS 2 - Percentage of Months during Entanglement Windows with Estimated Health < 67



# of months Assessed =	2,329	275	20	89	118	16	50
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Analysis 3

Impact on calving frequency

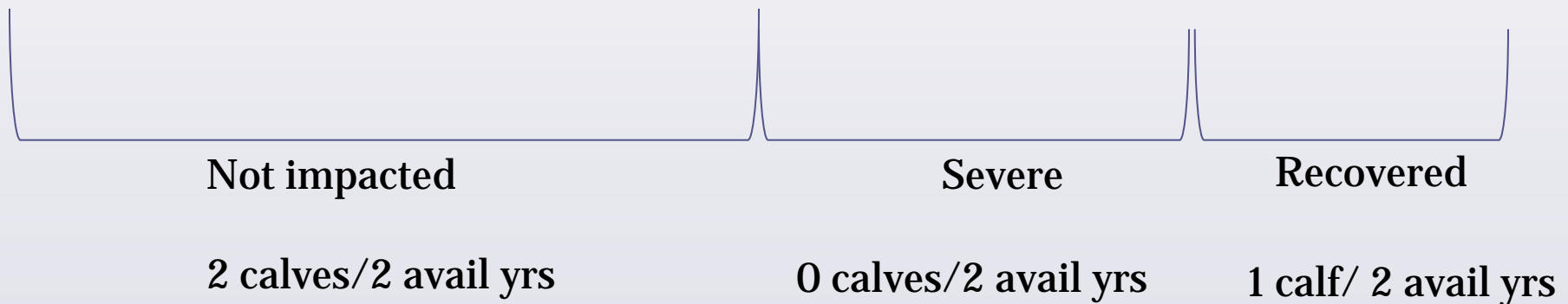
- Female considered “available” to give birth 3 years after last calf and until and including next calf
- If female experienced an entanglement she was placed in that entanglement severity category for 3 years and then shifted to recovered status (assumption is if there is no negative impact, she would still calve at 3 years)

Analysis 3

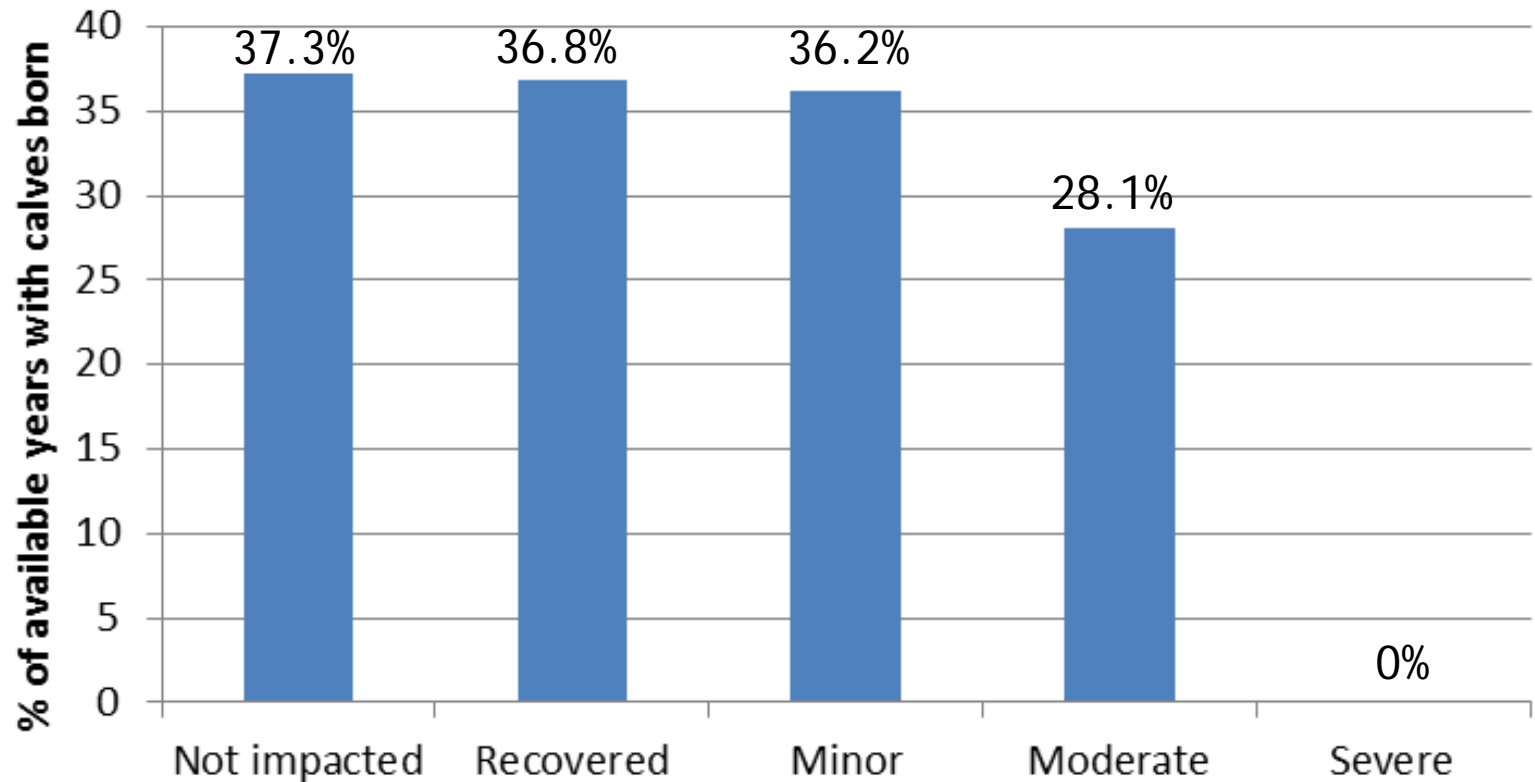
Impact on calving frequency

Example of Female X: green = years available to calve

2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
CALF			CALF		Severe	Severe	Severe		CALF



% of available years with calves born



n = calves/
total available years

76/204

302/823

34/94

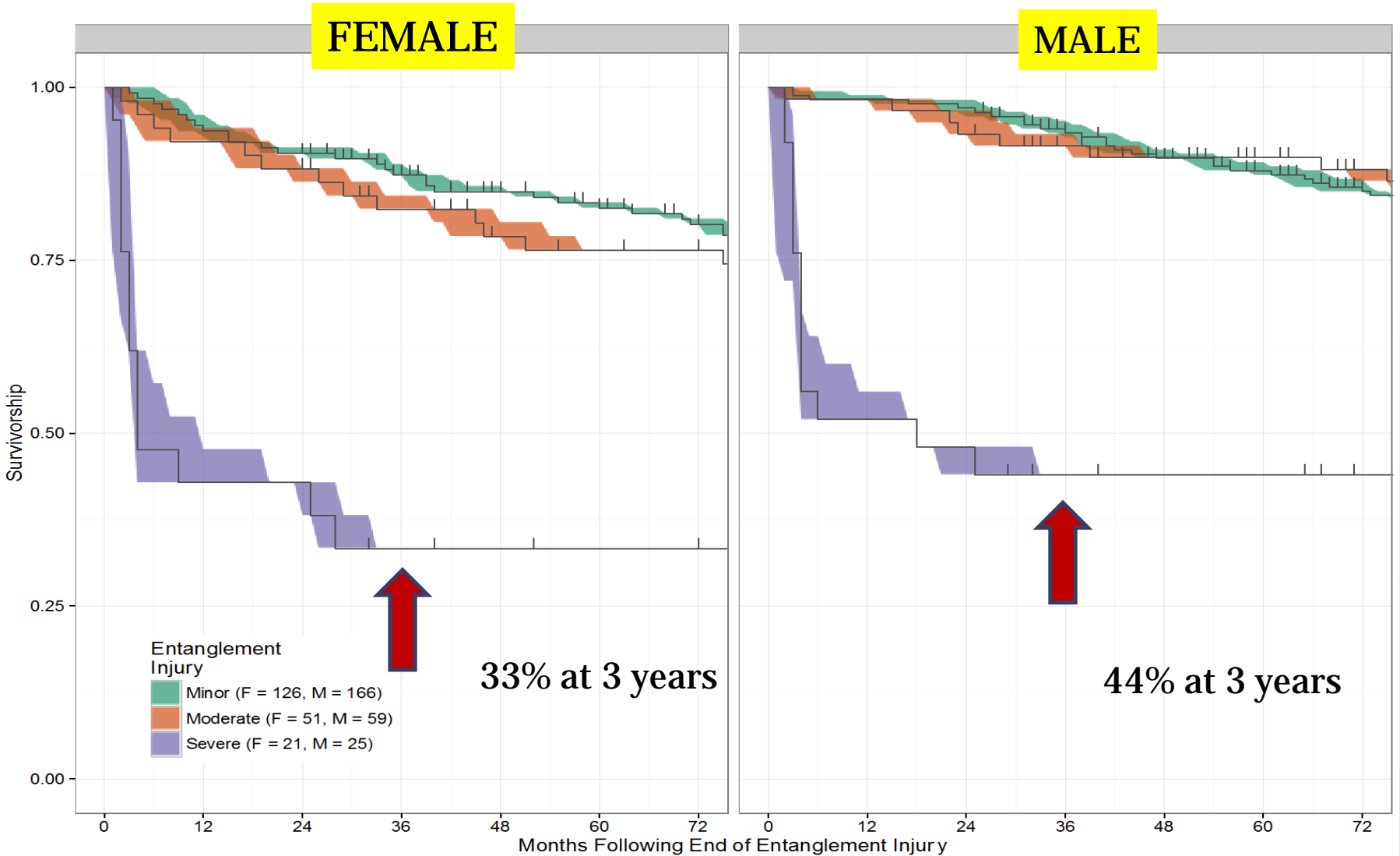
10/33

0/8

ANALYSIS 4 - Survival of impacted whales by gender

- Create Kaplan-Meyer survival curves by 3 injury categories
- Evaluate survival after first sighting with scars or last sighting with attached gear for an individual's last entanglement event
- Compare males and females

ANALYSIS 4 - Survival by Gender



Summary

- Frequency of high risk gear configurations and moderate to severe injuries from entanglement are increasing
- Health of right whales is impacted by entanglement depending on severity
- Reproductive female health is more negatively impacted than other demographic groups
- The sublethal impacts on reproductive females is reducing their ability to get pregnant
- Survival after a severe entanglement drops dramatically for both females and males


Future work

- Continue efforts to monitor injuries and health in near real-time to identify emerging issues
- Maintain catalog, scar coding, and visual health assessment programs to monitor changes as management actions are put in place
- Coordinate with NMFS to review all severe injury cases and consider revisions to the serious injury criteria with these new findings in hand

Acknowledgements

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A large whale tail fluke is shown emerging from the ocean, silhouetted against a sunset sky with soft, golden light. The tail is dark and tapers to a point. Water droplets are visible around the base of the tail where it meets the sea. The ocean surface is calm with gentle ripples.

North Atlantic Right Whale Consortium

PCAD working group

The right whales