Assessing suspended oyster (*Crassostrea virginica*) aquaculture impacts to eelgrass (*Zostera marina*)

-Marc Skinner & Simon Courtenay-

UNB

Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Rivers Institute

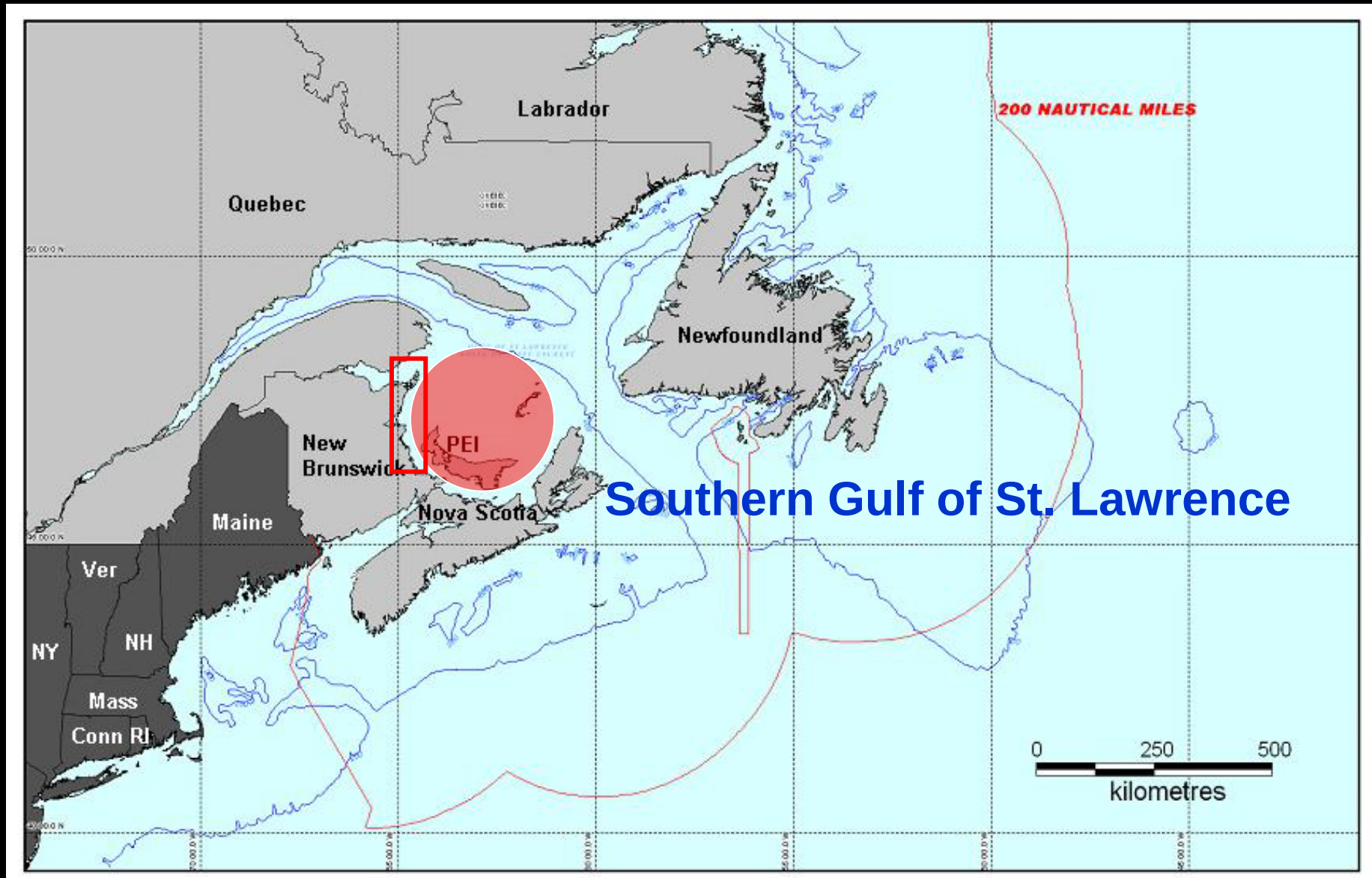
Assessing the relative habitat value of suspended oyster aquaculture to coastal and estuarine epibenthic fauna

-Marc Skinner & Simon Courtenay-

UNB

Fisheries and Oceans Canada | Pêches et Océans Canada

Canadian Rivers Institute


Labrador
200 NAUTICAL MILES
Quebec
Newfoundland
New Brunswick
PEI
Nova Scotia
Maine
Ver
NH
NY
Mass
Conn RI
Southern Gulf of St. Lawrence
0
250
500
kilometres

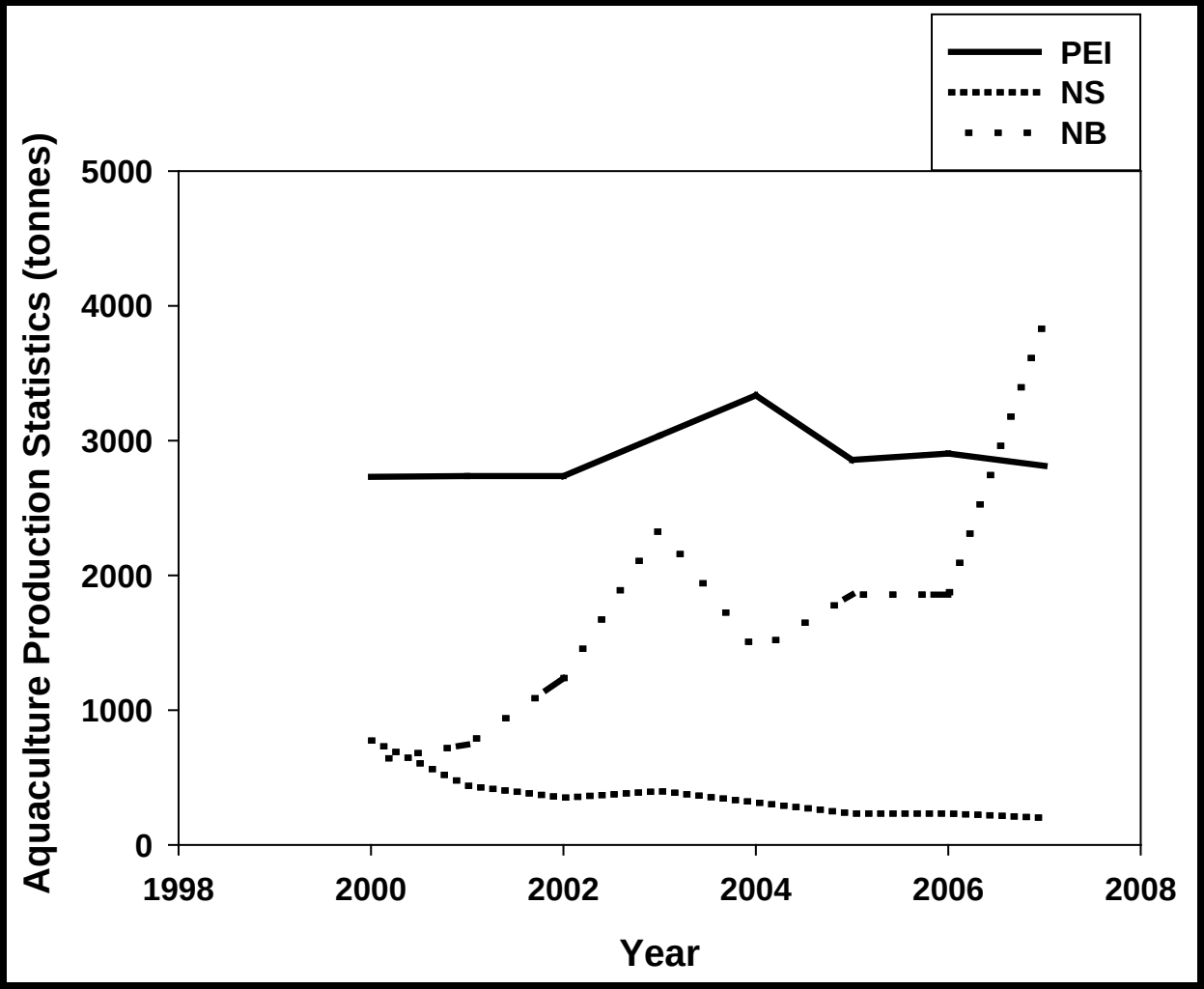
introduction

Atlantic Canadian shellfish aquaculture industry has greatly increased production in recent years.

Blue mussel (*Mytilus edulis*) and American oyster (*Crassostrea virginica*) aquaculture production have combined value $41.1 million in 2007

CANADIAN RIVERS INSTITUTE

American oyster aquaculture production in NB has increased >6-fold since 2000



http://www.dfo-mpo.gc.ca/communic/statistics/aqua/index_e.htm

introduction

Two culture methods used:

- Bottom/off-bottom
- Suspension

In PEI and NS, 80% of leases are off-bottom

In eastern NB 86% are suspension (as of 2002)

- Almost all grown out in Vexar™ (plastic mesh) bags in shallow subtidal zone

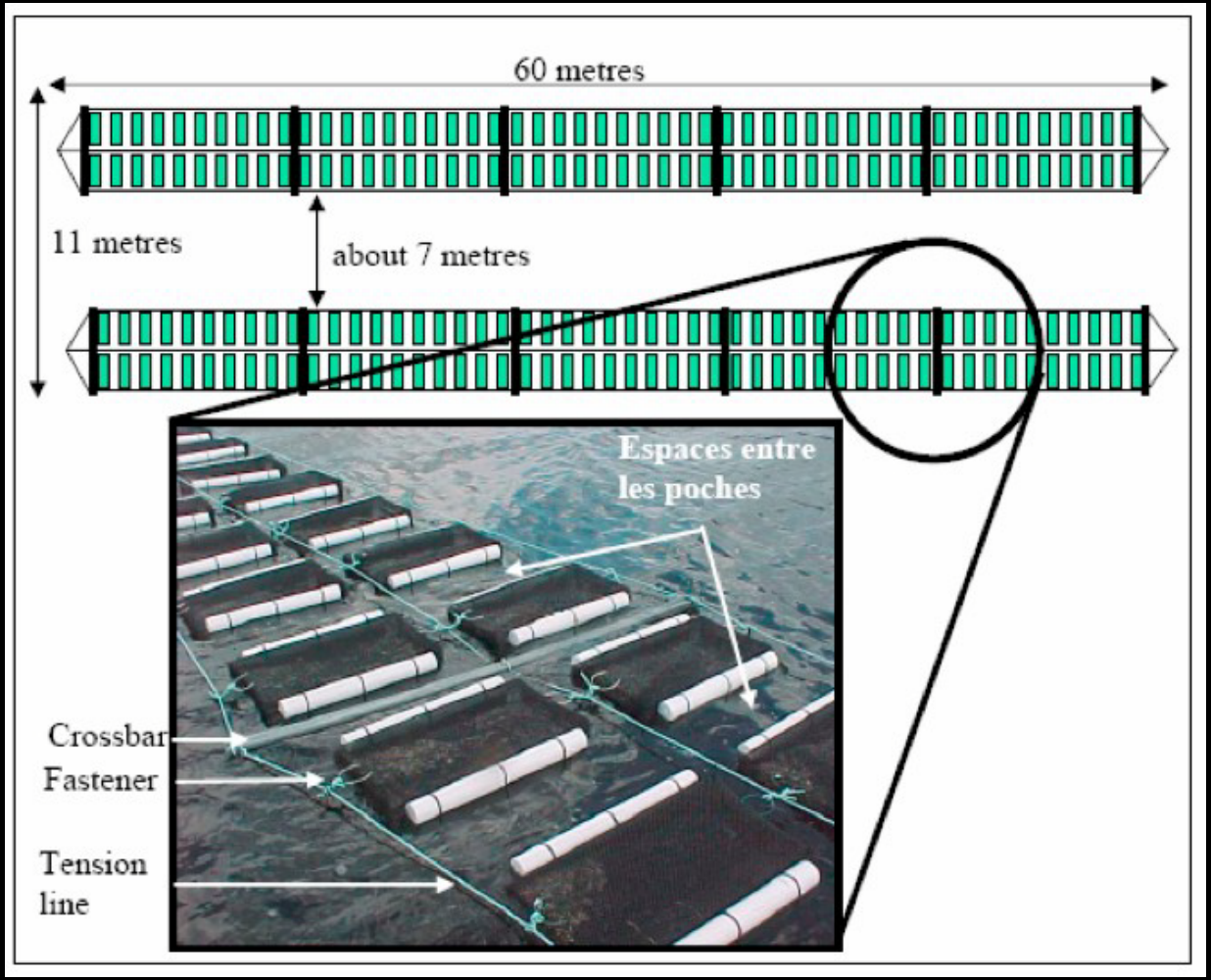
Source: http://www.glf.dfo-mpo.gc.ca/pe-pe/es-se/oyst-huit/oyster-huitre-e.html#note_2

introduction

Stocking density range from 3000-12000 kg·hectare^{-1}

- 200-1500 oysters·bag^{-1}
- 15-20 lines·hectare^{-1}

- Total leased area NB = 2513 ha
- Mean lease area NB = 4.03 ha (no var)



Bastien-Daigle *et al.* (2001)

Introduction – DFO Bay Management

Fisheries and Oceans Canada | Pêches et Océans Canada

Fisheries and Oceans Canada (DFO)

- *Sect 35 Fisheries Act,* CEAA, NWPA
- EA conducted site by site for potential impacts (cumbersome)

1999 – DFO & TC move to RCSR*

- *applicable if low risk
- single report synth of sci lit on env effects (Qual Risk Assess)
- ID measures known to mitigate potential (-) effects (BMP)
- Reassess 5 yr cycle or if new info

RCSR compatible with Bay Management Plan (NBSAECC)

- Predefine suitable aquaculture areas while integrating conservation and regulatory concerns (GIS-based)

Bastien-Daigle, S., M. Hardy and G. Robichaud. 2007. Habitat Management Qualitative Risk Assessment: Water Column Oyster Aquaculture in New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 2728 : vii + 72p.

Zostera marina (eelgrass) decline:

Hypothesized decline of *Z. marina* in areas of SBOA leases

methods – 2006

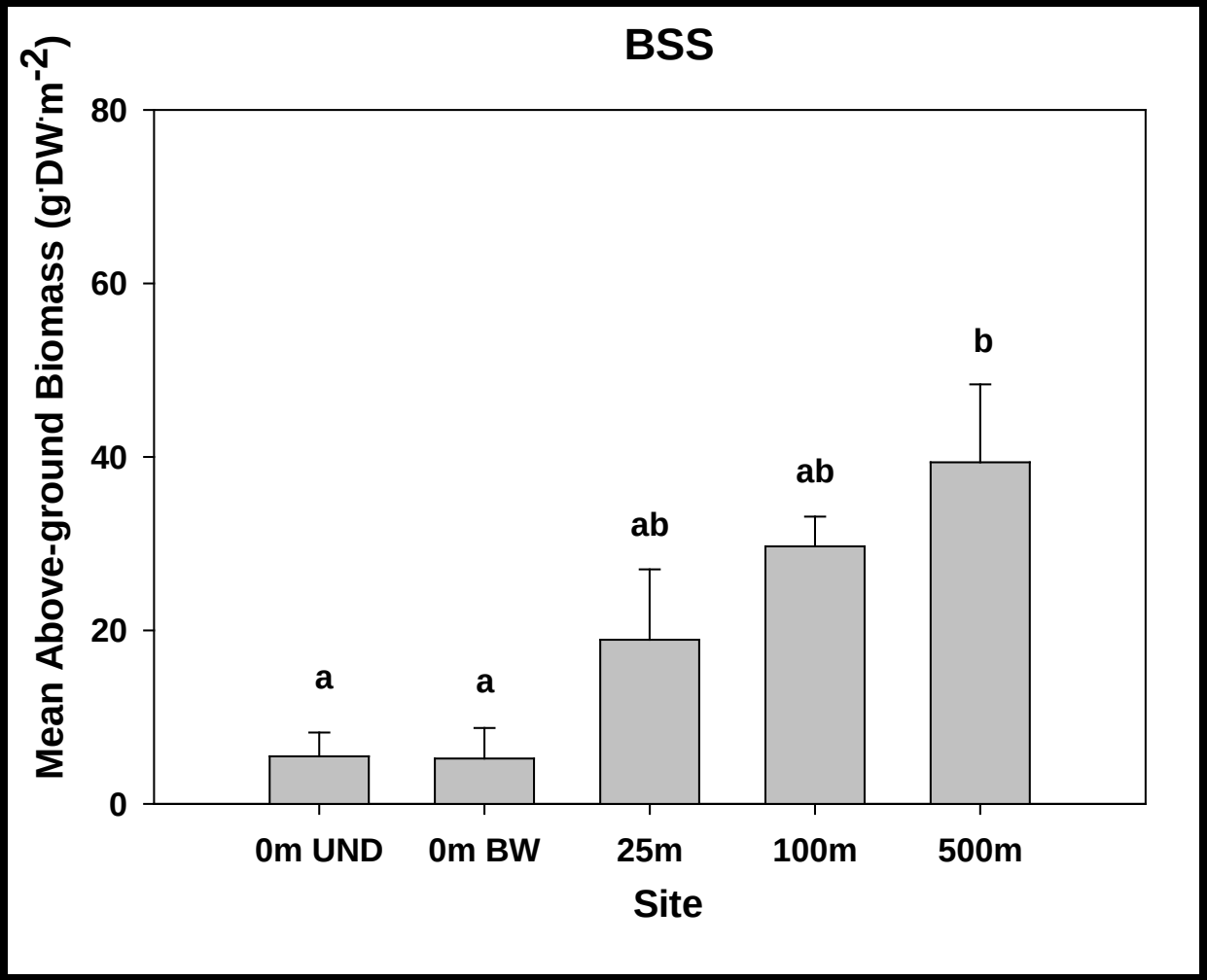
0.25 m^2 quadrat samples (n=6) taken by SCUBA at 1 lease in each of 3 waterbodies from:

- lease between lines
- lease under lines
- 25m, 100m, 500m from lease edge

CANADIAN RIVERS INSTITUTE

PRELIMINARY DATA – DO NOT CITE

Lowest *Z. marina* above-ground biomass ($g \cdot DW \cdot m^{-2}$) found at SBOA leases

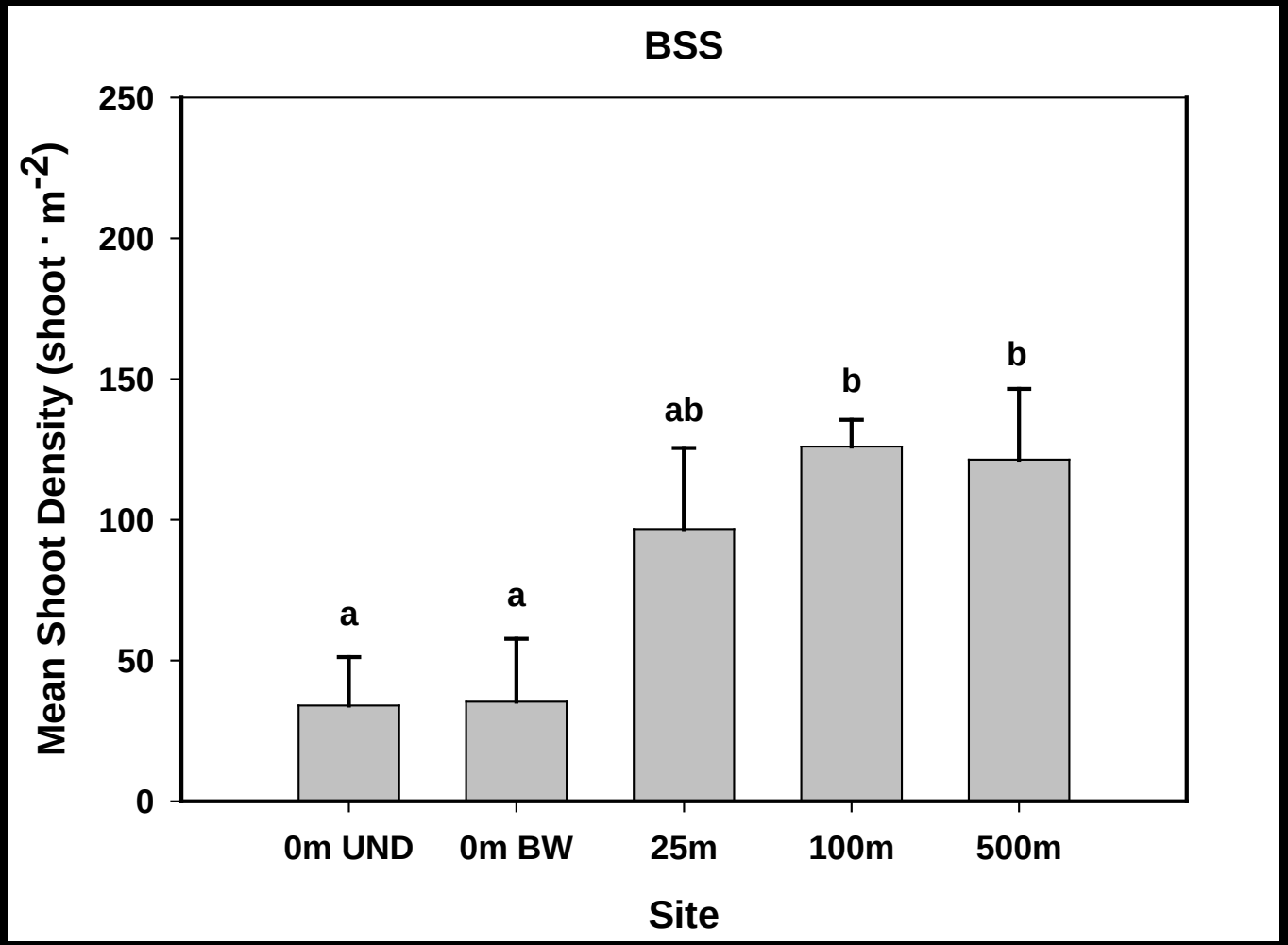


$F_{4,25} = 6.295$; $p<0.001$

n = 6; α=0.05; ± SE

PRELIMINARY DATA – DO NOT CITE

Lowest *Z. marina* shoot density (shoot · m^{-2}) found at SBOA leases

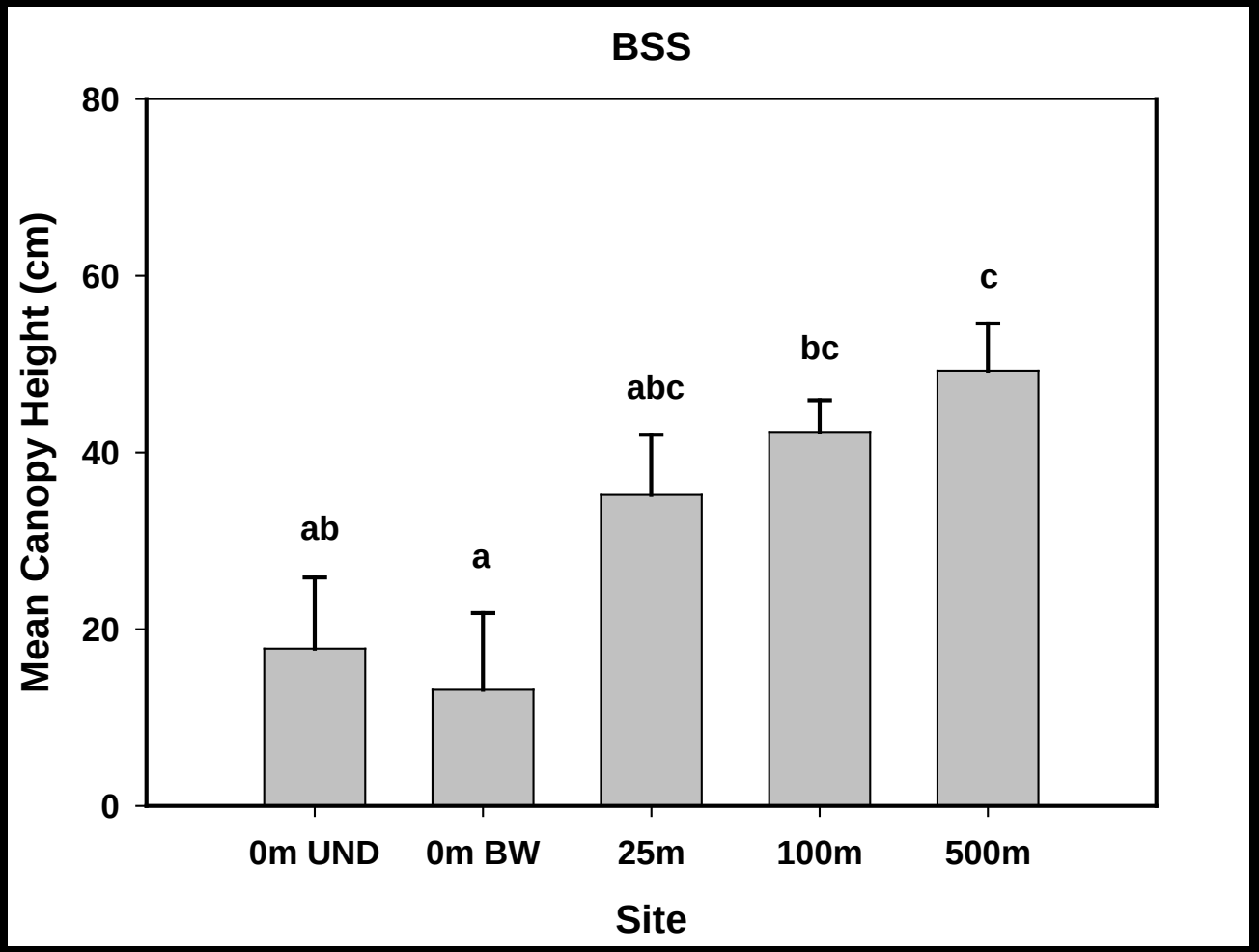


$F_{4,25} = 5.245$; $p = 0.003$

n = 6; α=0.05; ± SE

PRELIMINARY DATA – DO NOT CITE

Lowest *Z. marina* canopy height (cm) found at SBOA leases



$F_{4,25} = 5.331$; $p = 0.003$

$n = 6$; $\alpha = 0.05$; $\pm$ SE

Canadian Rivers Institute

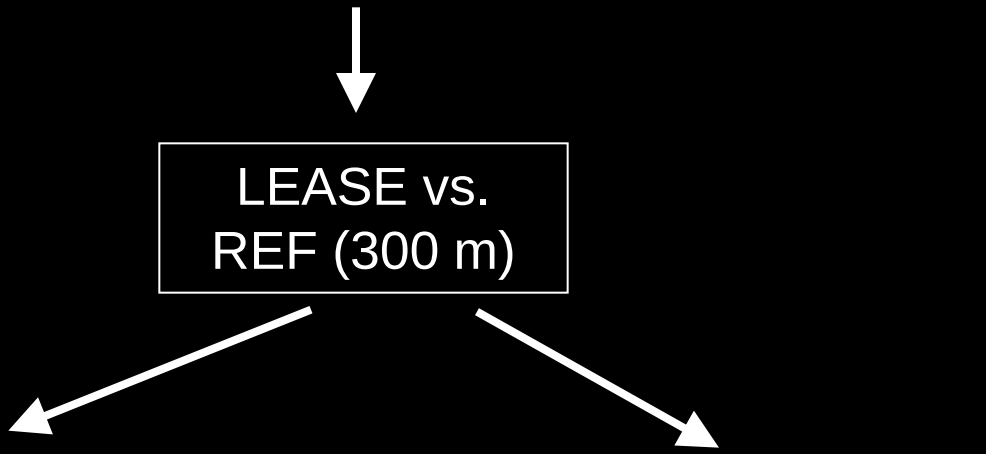
introduction

Lease

500 m

introduction

• **decreased above ground biomass, shoot density, canopy height @ Lease vs. non-Lease sites (n=3)**



•**Generality of trend?**

•**Above-ground biomass, shoot density, canopy ht.**

•**Epiphyte biomass**

• **leaf marking**

CANADIAN RIVERS INSTITUTE

methods – *Z. marina* leaf growth

Study design:

- 8 Leases and 8 reference sites sampled in 4 bays over 125 km distance in July 2007.
- All shoots within a 0.25 m^2 quadrat marked by punching a hole through the leaf sheath with a syringe.
- Plants harvested 3 weeks later and growth determined using the plastechrone method developed for *Z. marina* (Short and Duarte, 2001).
- Above-ground biomass also recorded

CANADIAN RIVERS INSTITUTE

preliminary results – *Z. marina* leaf growth

PRELIMINARY DATA – DO NOT CITE

Leaf Growth:

- Overall, mean leaf growth **21.7% lower @ LEASE vs REF** across all bays
  - **$Mean_{LEASE}$** = 4.90 $mg \cdot shoot^{-1} \cdot day^{-1}$ ± 0.313 SE
  - **$Mean_{REF}$** = 6.25 $mg \cdot shoot^{-1} \cdot day^{-1}$ ± 0.358 SE

Two-way ANOVA (TMT & BAY)

Significant interaction $F_{3,168} = 6.403$; $p<0.001$

Simple Effects

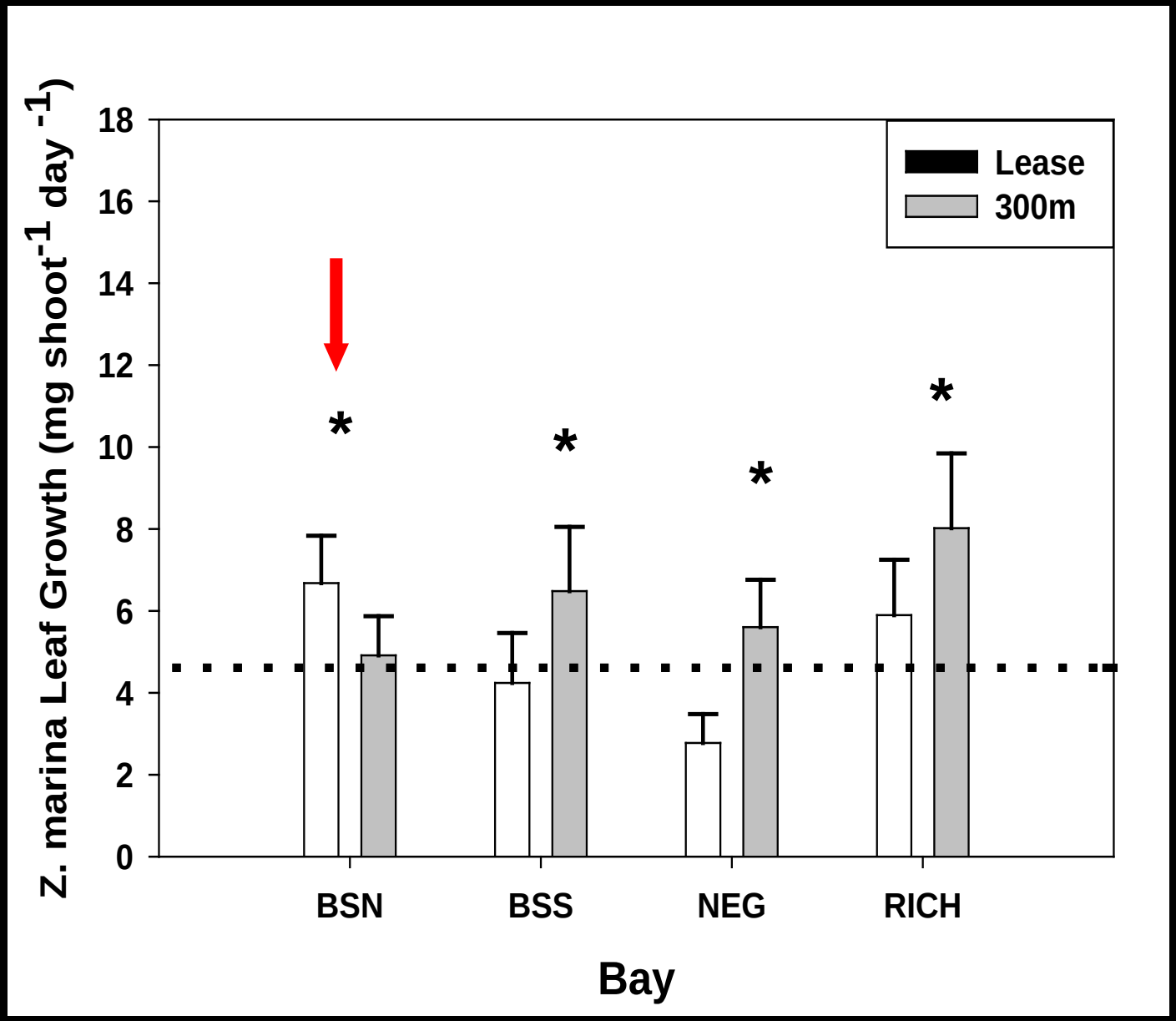
Bay	F-ratio (df=1,42)	p	% difference
BSN	5.935	0.019	+28
BSS	7.678	0.008	-14
NEG	17.858	<0.001	-41
RICH	18.737	<0.001	-26

Canadian Rivers Institute

preliminary results – *Z. marina* leaf growth

PRELIMINARY DATA – DO NOT CITE

Gaekle & Short (2001)



n = 2; 95% CI; α=0.05

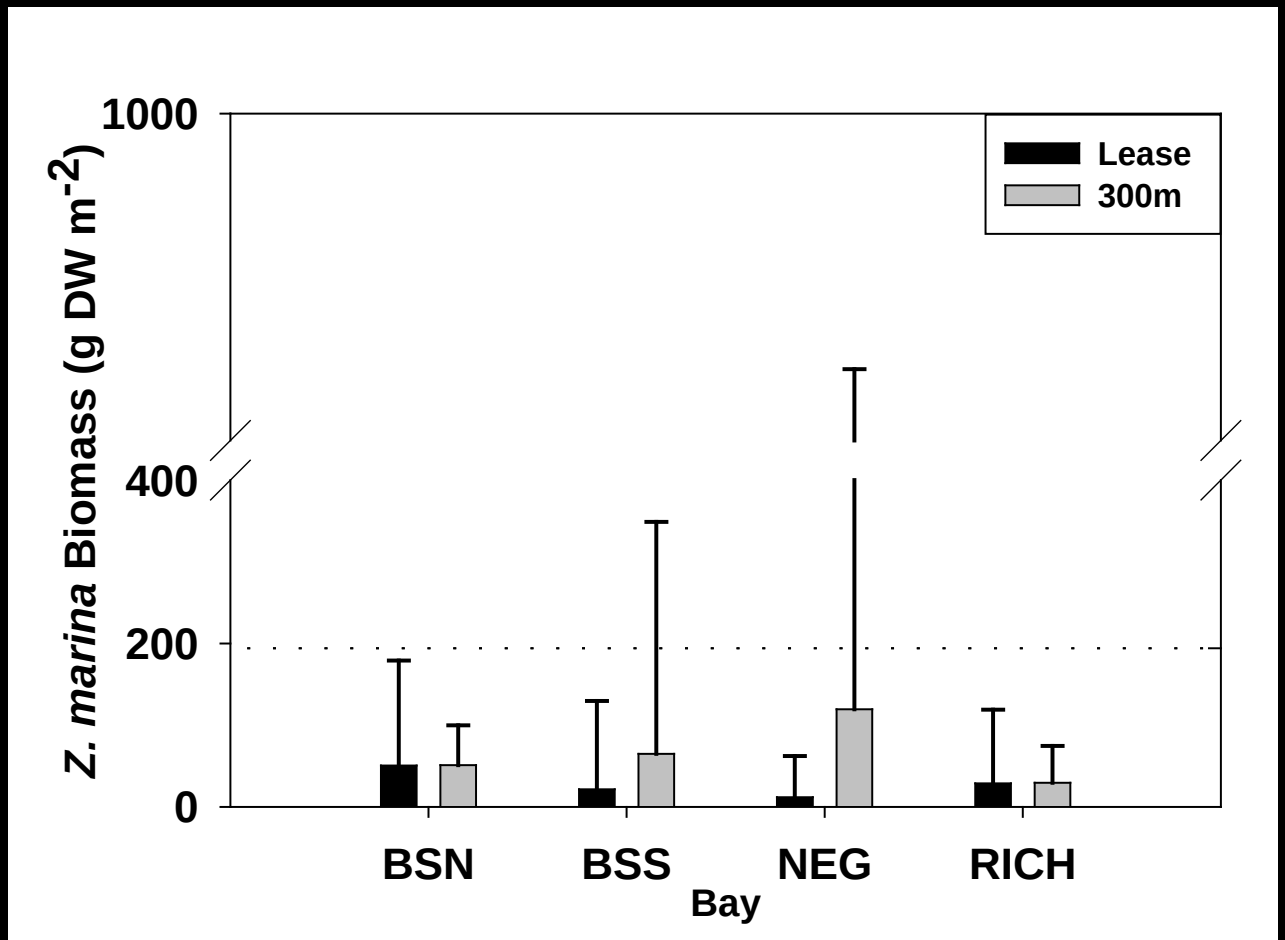
Canadian Rivers Institute

preliminary results – *Z. marina* above-ground biomass

- **57.7% lower @ LEASE vs REF** with no effect of bay or interaction
  - **Mean$_{LEASE}$** = 28.1 g DW·m^{-2} ± 6.236 SE
  - **Mean$_{REF}$** = 66.2 g DW·m^{-2} ± 18.374 SE

Two-way ANOVA (TMT & BAY) - TMT $F_{3,8} = 7.572$; p=0.025

PRELIMINARY DATA – DO NOT CITE



n = 2; 95% CI; α=0.05

Patriquin & Butler (1976)

CANADIAN RIVERS INSTITUTE

methods – 2007 *Z. marina* morphometrics

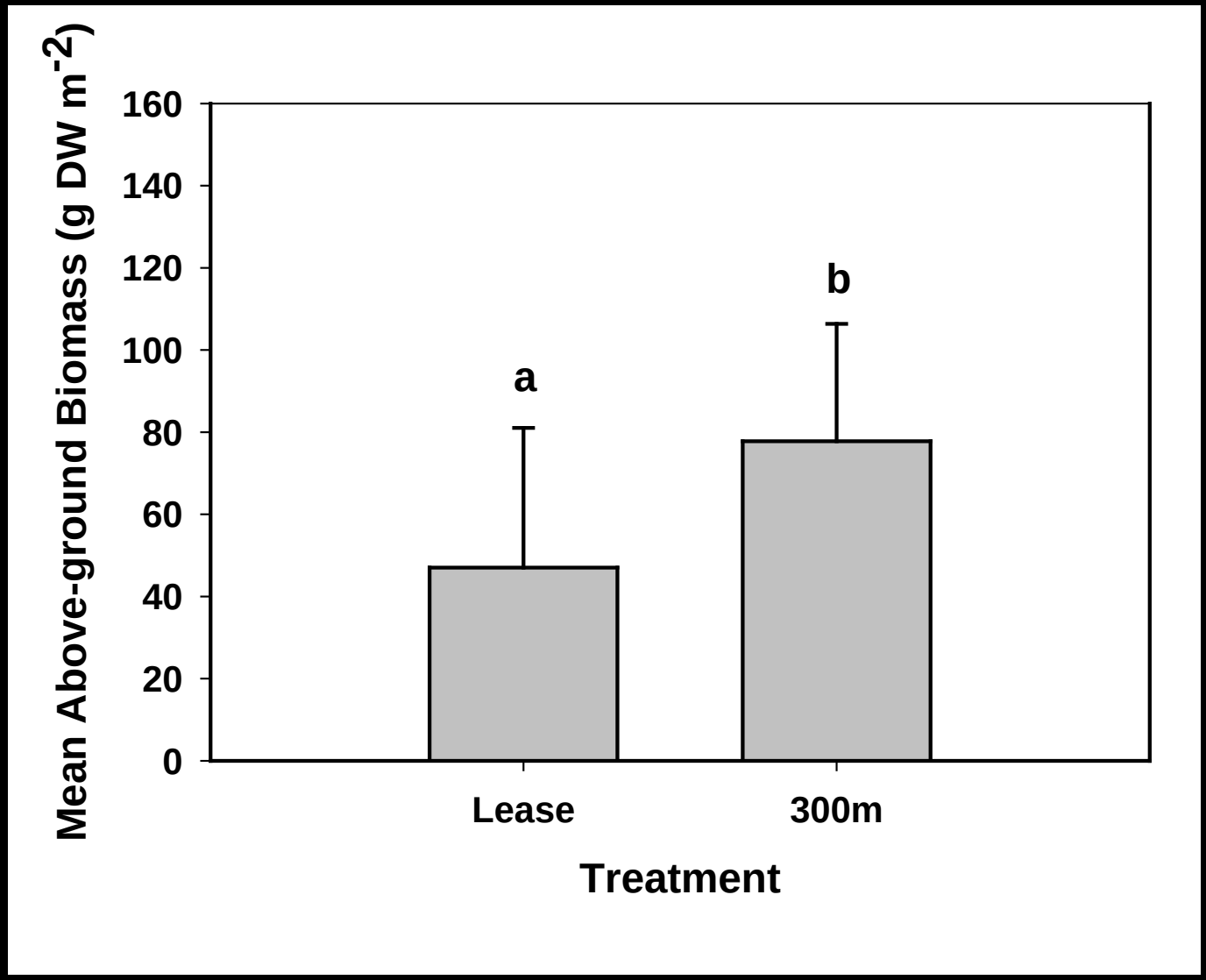
Study design:

- 9 Leases and 9 reference sites sampled in one bay in August 2007.
- All shoots within a 0.0625 m^2 quadrat harvested
- Above-ground biomass, shoot density, canopy height, shoot surface area, N/C content, and epiphyte biomass determined
- Data intended for use as correlates for epifaunal community samples

CANADIAN RIVERS INSTITUTE

results – 2007 *Z. marina* biomass

PRELIMINARY DATA – DO NOT CITE

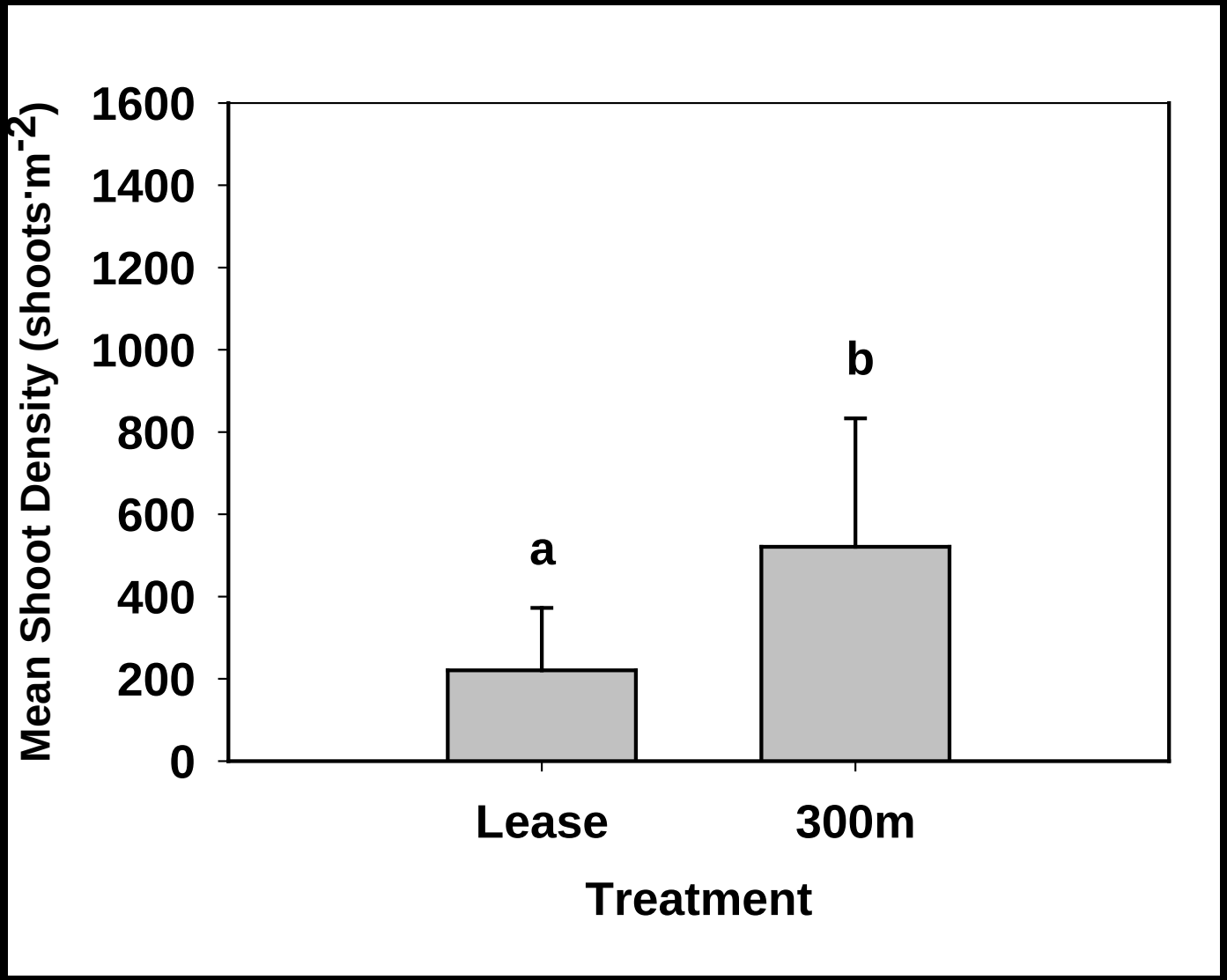


Paired $t_{0.05(1),8} = -2.058$; $p = 0.037$ n = 9; 95% CI; α=0.05

CANADIAN RIVERS INSTITUTE

results – 2007 *Z. marina* shoot density

PRELIMINARY DATA – DO NOT CITE

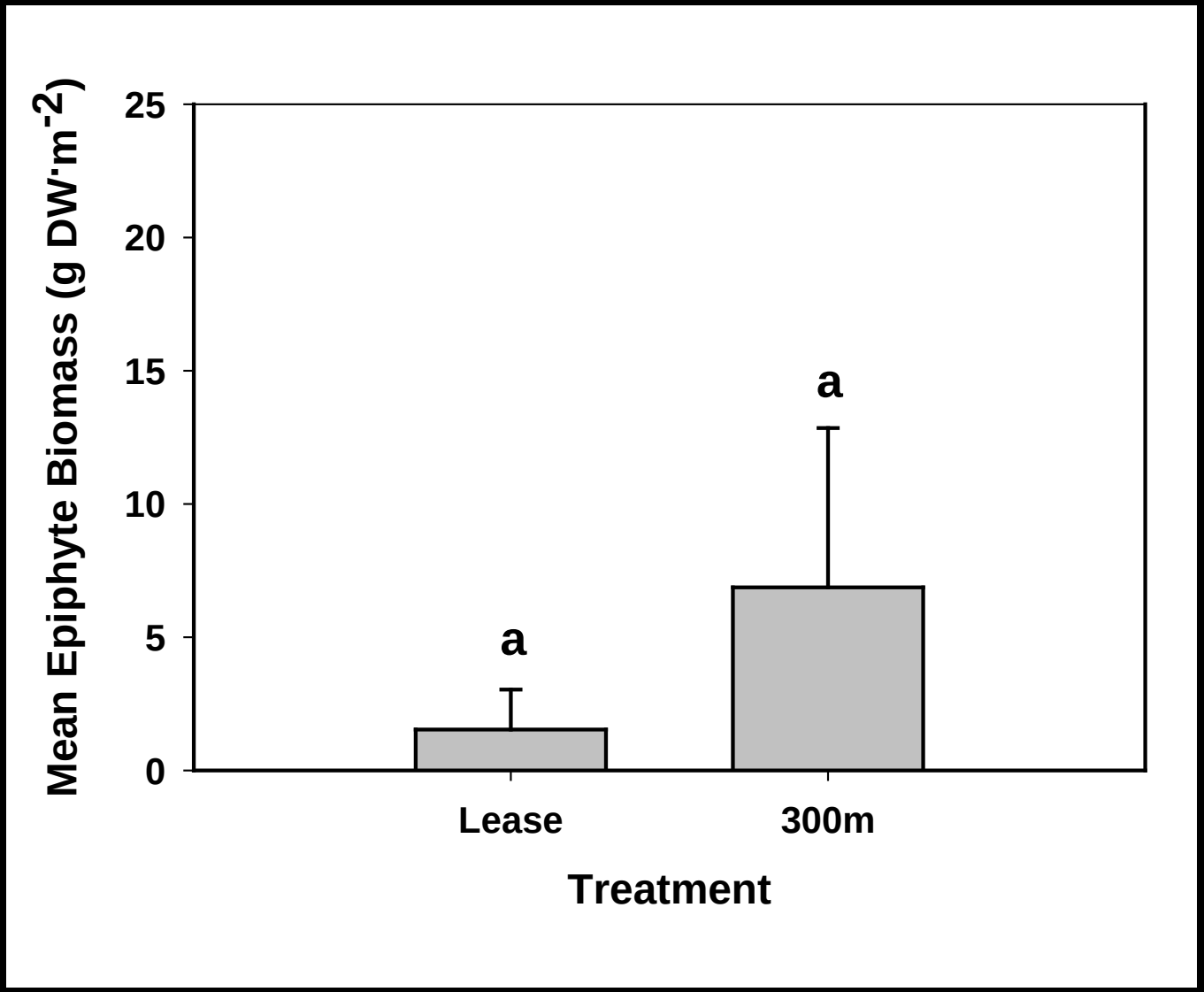


Paired $t_{0.05(1),8} = -2.502$; $p = 0.018$ n = 9; 95% CI; α=0.05

Canadian Rivers Institute

results – 2007 *Z. marina* epiphyte biomass

PRELIMINARY DATA – DO NOT CITE

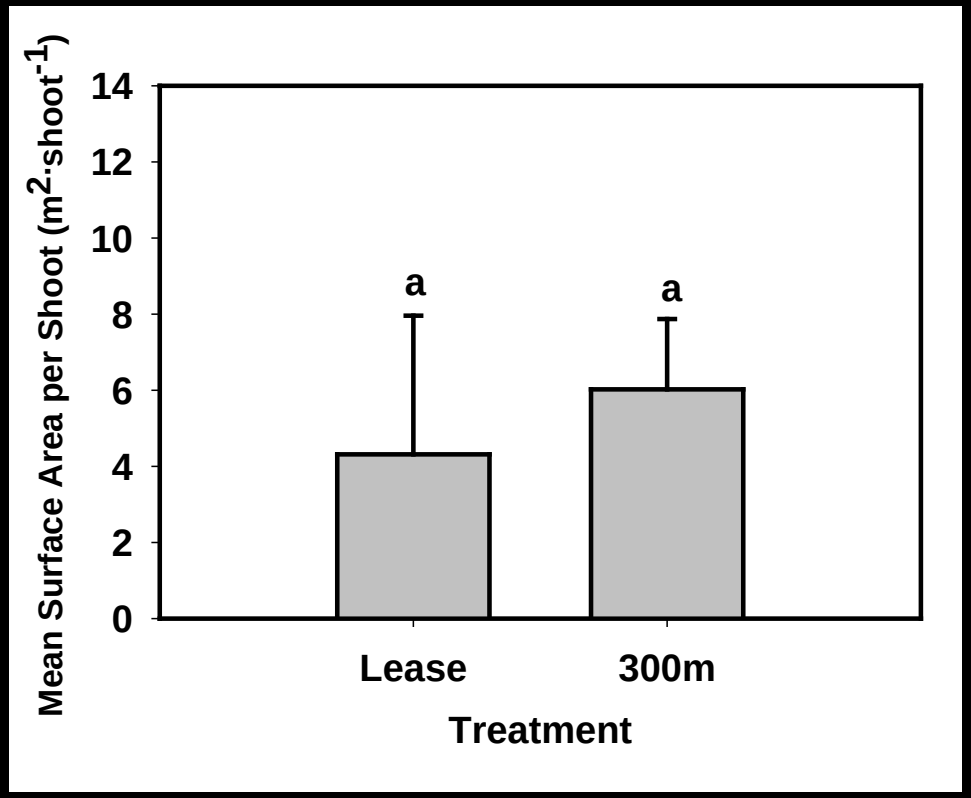


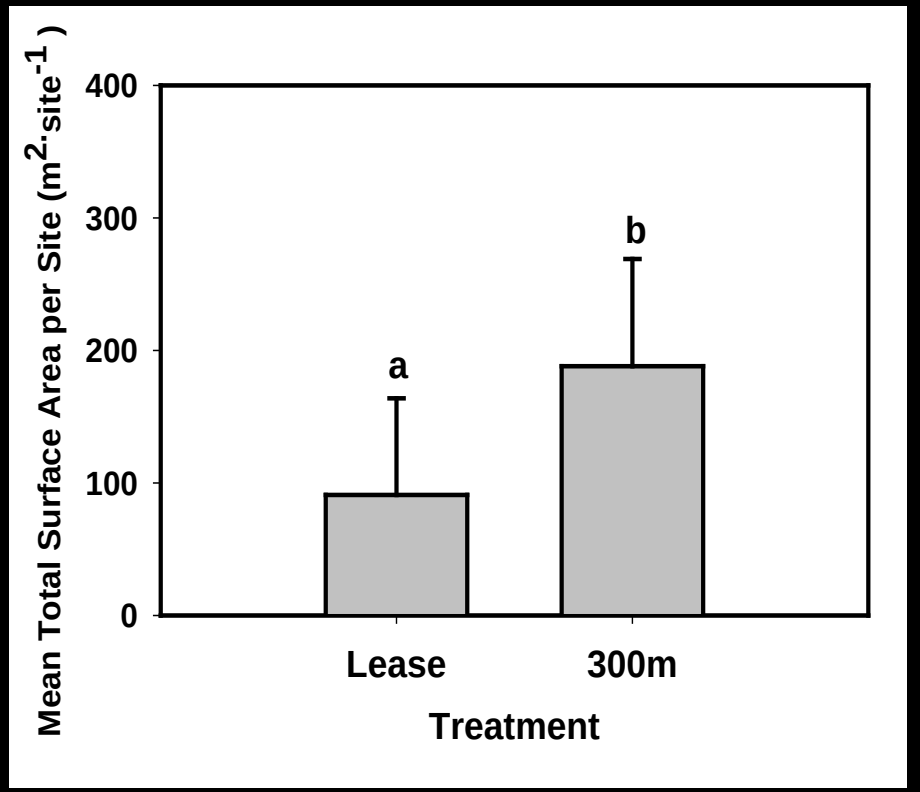
Paired $t_{0.05(1),8} = -1.667$; $p = 0.067$ n = 9; 95% CI; α=0.05

CANADIAN RIVERS INSTITUTE

results – 2007 *Z. marina* surface area

PRELIMINARY DATA – DO NOT CITE





Paired $t_{0.05(1),8} = -1.598$; $p = 0.077$

n = 9; 95% CI; α=0.05

Paired $t_{0.05(1),8} = -2.270$; $p = 0.029$

n = 9; 95% CI; α=0.05

CANADIAN RIVERS INSTITUTE

synthesis

1. General trend in **decrease** in *Z. marina* biomass, SD, CH, TSA across sGSL Lease sites
2. **Clear reduction** in leaf growth @ Lease sites
3. Observed local **reductions may not be due solely to physical disturbance** of benthos
   - **Light penetration?**
   - **Nutrients?**

In perspective:

- Local scale – effects within 300m (or less)
- Up to 5-fold increase in mean abundance of fish and epibenthic inverts at Lease vs 300m
  - **Dissertation explores this paradox**

CANADIAN RIVERS INSTITUTE

synthesis

Next steps in 2009:

- Nutrient analyses on these samples for %C & %N
- Diving PAM survey of leases and ref areas

- Experimental manipulations
  - Dependent vars – leaf growth, biomass, shoot density, surface area
  - Independent vars - shading, physical disturbance, oyster density

acknowledgements

Simon Courtenay
PhD Supervisory Committee
Sarah Khan
Celine Godin
Brad Firth
Robert Dupuis
Gisele Richard
Lynne Post
Doris Daigle
Fred Page
Andre Mallet
Claire Carver
Gilles Miron
Gerhard Pohle
Bob Clarke
Roger Newell
Jeff Barrell
Lin Liu
Patrick Nussey

Chris McKindsey
Philippe Archambault
Olivier D'Amours
Lise Ouellette
Peter Cranford
Wayne Fairchild
Mark Hanson
Hélène Dupuis
Toby Balch
Mark TeKamp
Sylvio Doiron
Peter Strain
Peter Jarvis
Monica Boudreau
Marie-Helene Theriault
Daniel Bourque
Roy Parker
Elise Mayrand
Marcia Chiasson

Alex Levi
Maurice Daigle
Sophie Bastien-Daigle
Andrew Boghen
Yrois Robichaud
Lisa Robichaud
Paul Robichaud
Denise Méthé
Guy Robichaud
Marc Ouellette
Kevin Leblanc
Luc Comeau
Matthew Hardy
Thomas Landry
Gilles Olivier
Jon Grant
Myriam Barbeau
John Kershaw
Jason Hallett
Noel Swain

Songez à la Viabilité
Think Sustainability

NSERC
CRSNG

Canadian Rivers Institute

Fisheries and Oceans Canada
Pêches et Océans Canada

UNB