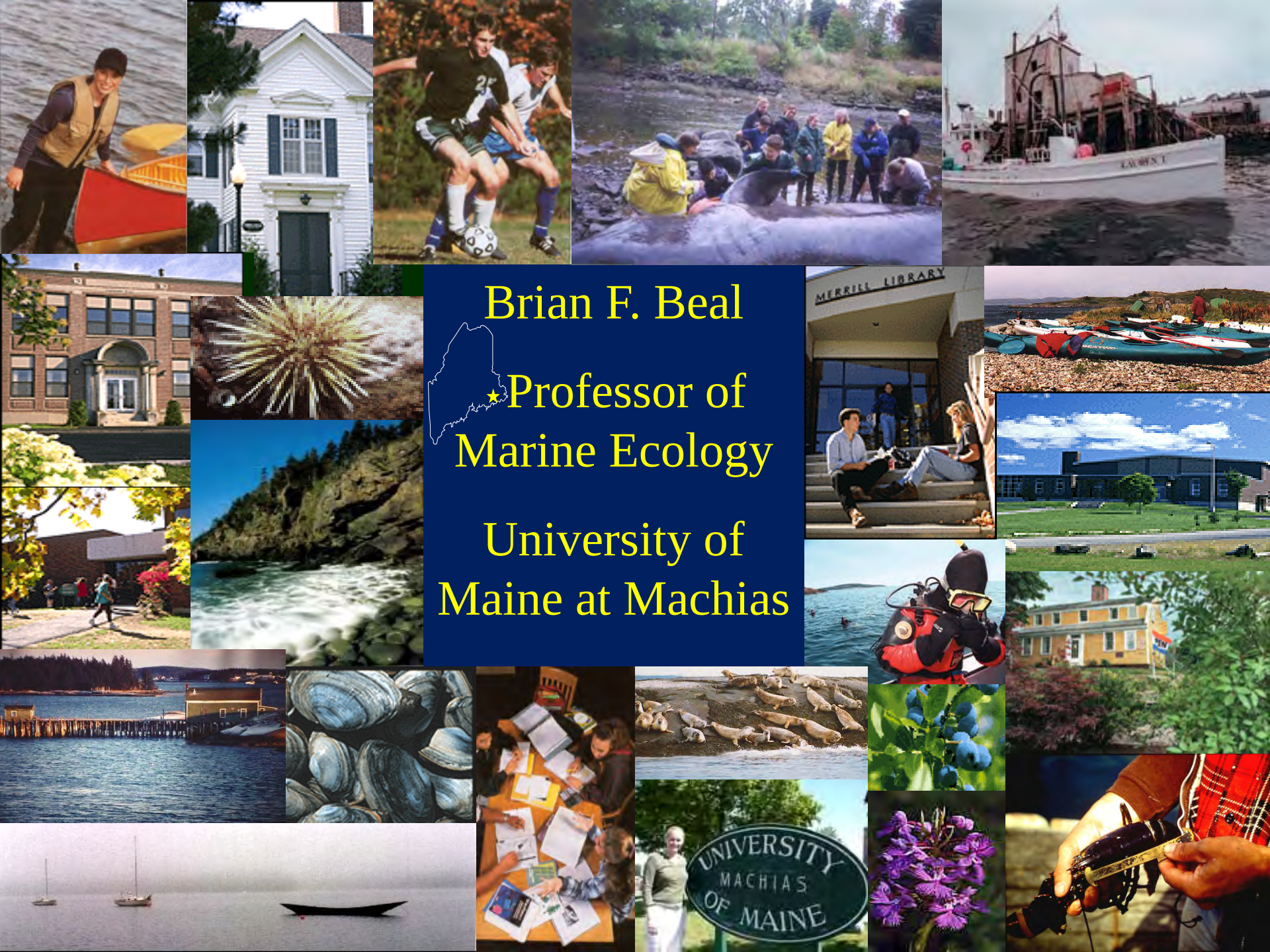
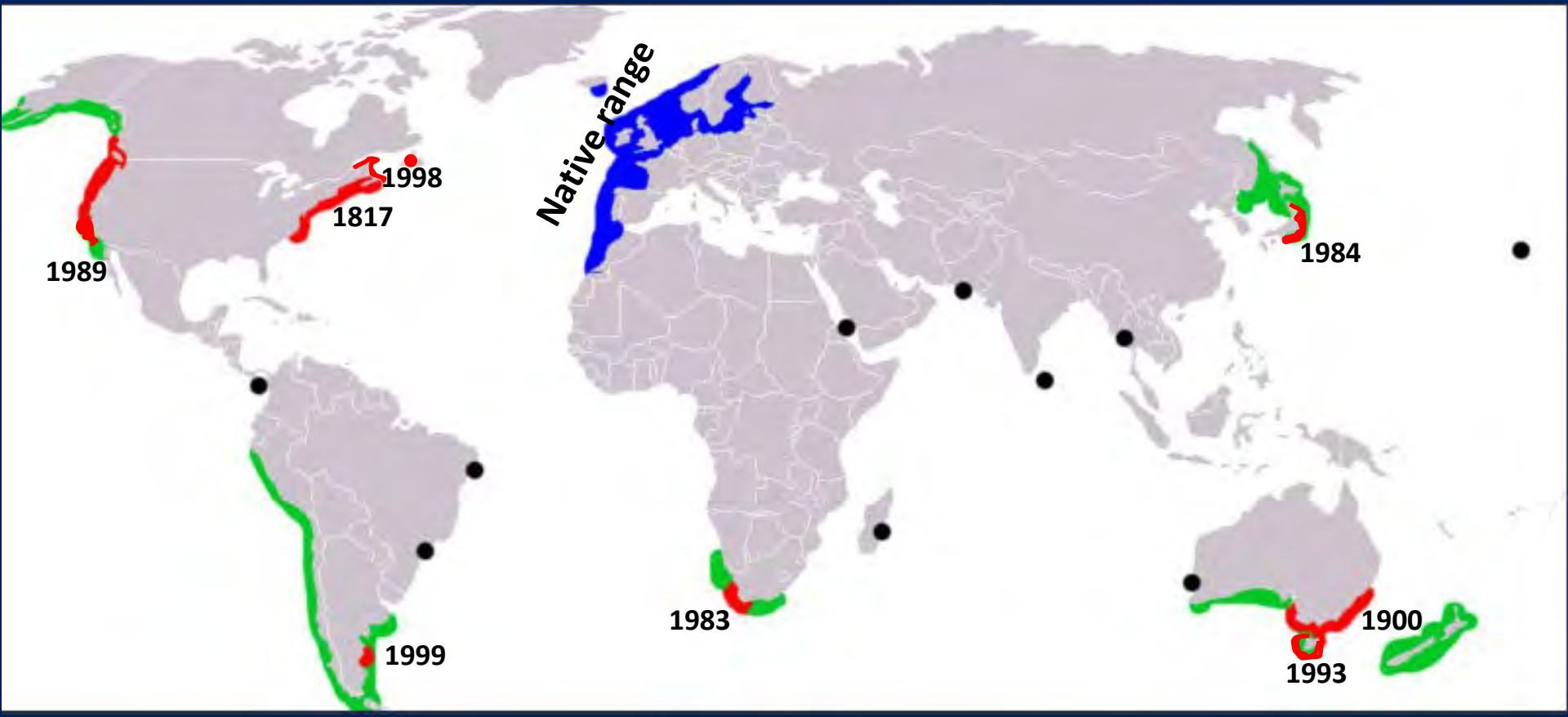

Brian F. Beal
Professor of
Marine Ecology
University of
Maine at Machias
MERRILL LIBRARY
UNIVERSITY
MACHIAS
OF MAINE

Green Crabs: Ecology, and Their Effects on Soft-shell Clams





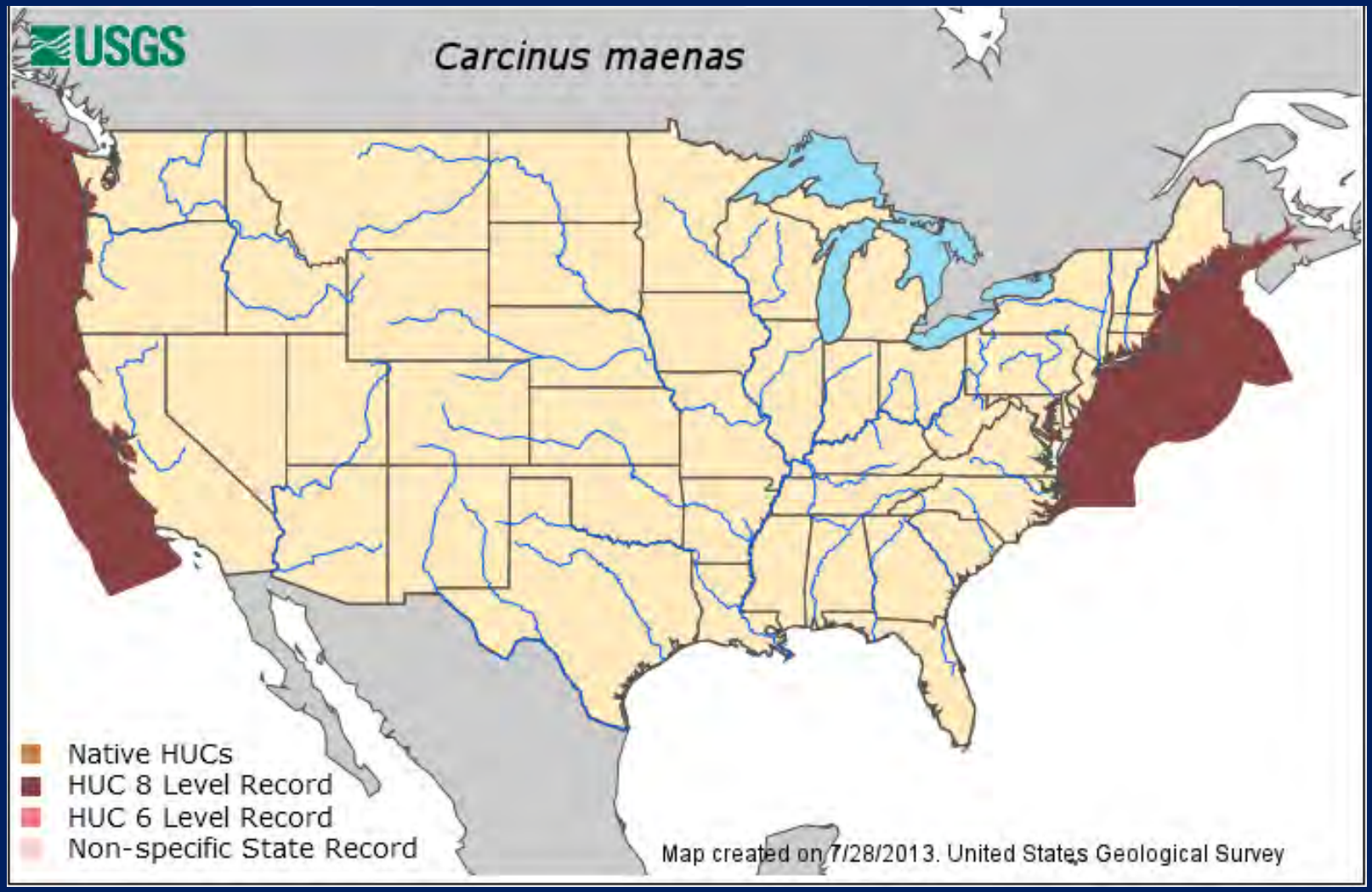

GEOGRAPHIC DISTRIBUTION



Carlton and Cohen (2003)

http://carnivoraforum.com

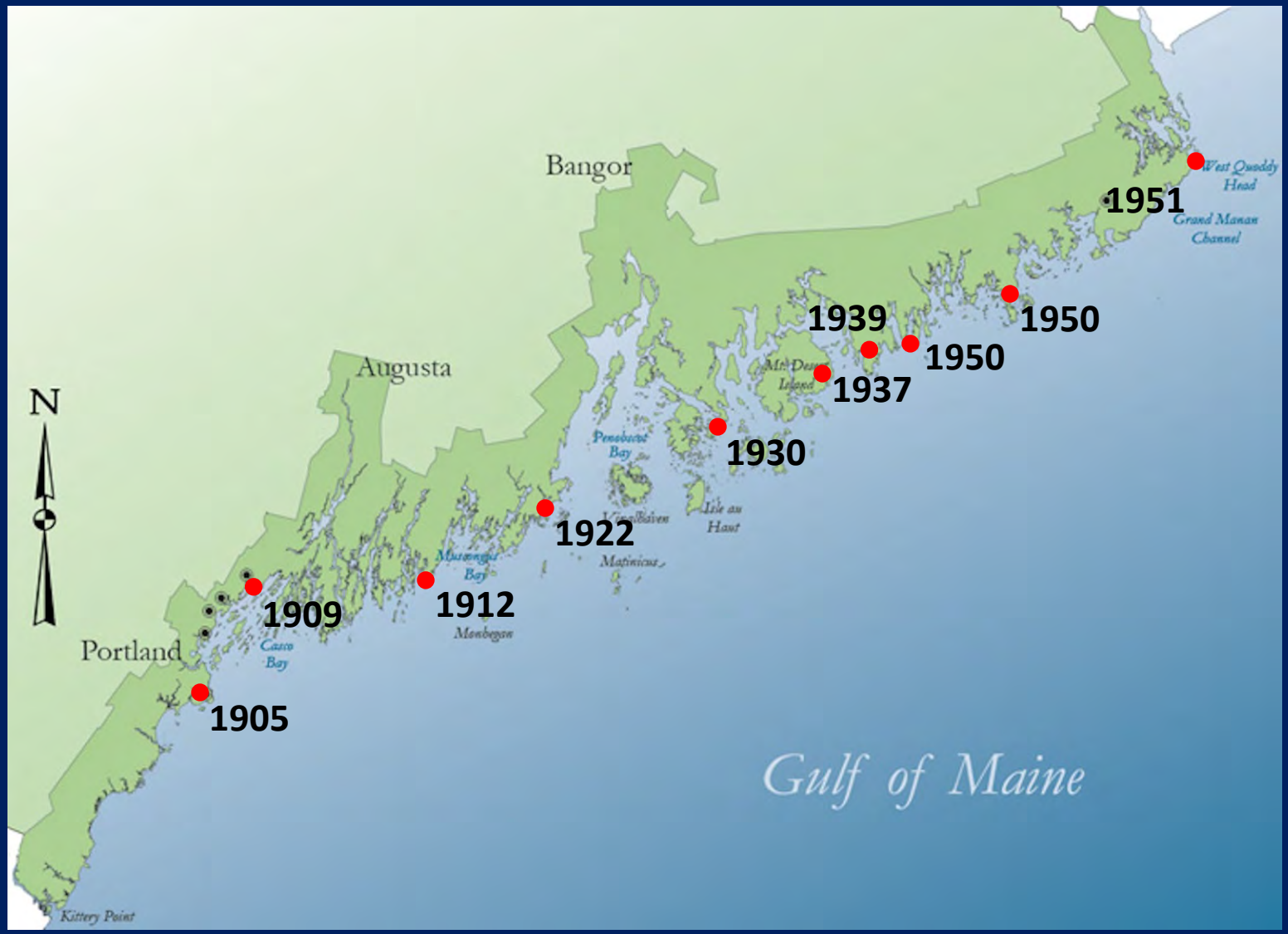
Hidalgo et al. 2007



http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=190

http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=190

Green crab range extensions along the Maine coast (1905 – 1951)

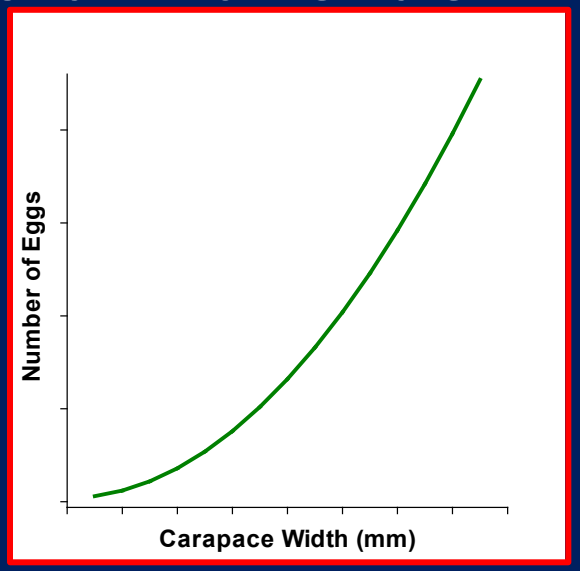


Map from: http://outdooradventurers.blogspot.com

Data from Glude (1955)

The green crab is the consummate invader of new ecosystems

- Highly fecund (maximum clutch size for a 2-inch female = 165,000 eggs)
- Planktonic (wide) dispersal
- Larvae have relatively wide thermal (8-25^{O}C; 15^{O}C is optimal) and salinity (10-30 ppt; 25ppt is optimal) tolerances



- Adults have even wider tolerances for temperature (0-33^{O}C) and salinity (4-54 ppt), starvation for up to 3 months

Bravo et al. 2007
Griffen 2013
Hines 2004
Nagaraj 1993

The green crab is the consummate invader of new ecosystems

- **Adults can withstand seemingly improbable conditions out of water (air exposure) for > 10 days at summer temperatures**
- **Inhabits a variety of marine habitats (mud, sand, rock, eelgrass, *Spartina*)**
- **Has a diverse diet (omnivorous; but, prefers to prey on animals) with the most important sources being blue mussels and soft-shell clams. (Plants such as eelgrass and salt marsh grass are found in 30% of adults and up to 60% of juveniles.)**
- **Gregarious behavior enhances sexual encounter rates**

Ropes 1968
Elner 1981

Life-history traits for green crabs in Maine and northern waters

Copulation:	Peaks in August
Egg masses appear:	July to November
Eggs carried:	May to June
Larvae in plankton:	50-82 days
Larvae settle:	Peaks in Aug-Oct.
Size (first winter):	3-10 mm CW
Size (second winter):	13-30 mm CW
Maximum size:	86 mm ♂; 80 mm ♀
Size at first mating:	35-45 mm CW
Age at first mating:	2-3 yrs
Life span:	5-6 yrs

Berrill 1982
Klassen and Locke 2007
http://www.arkive.org

Larvae hatching

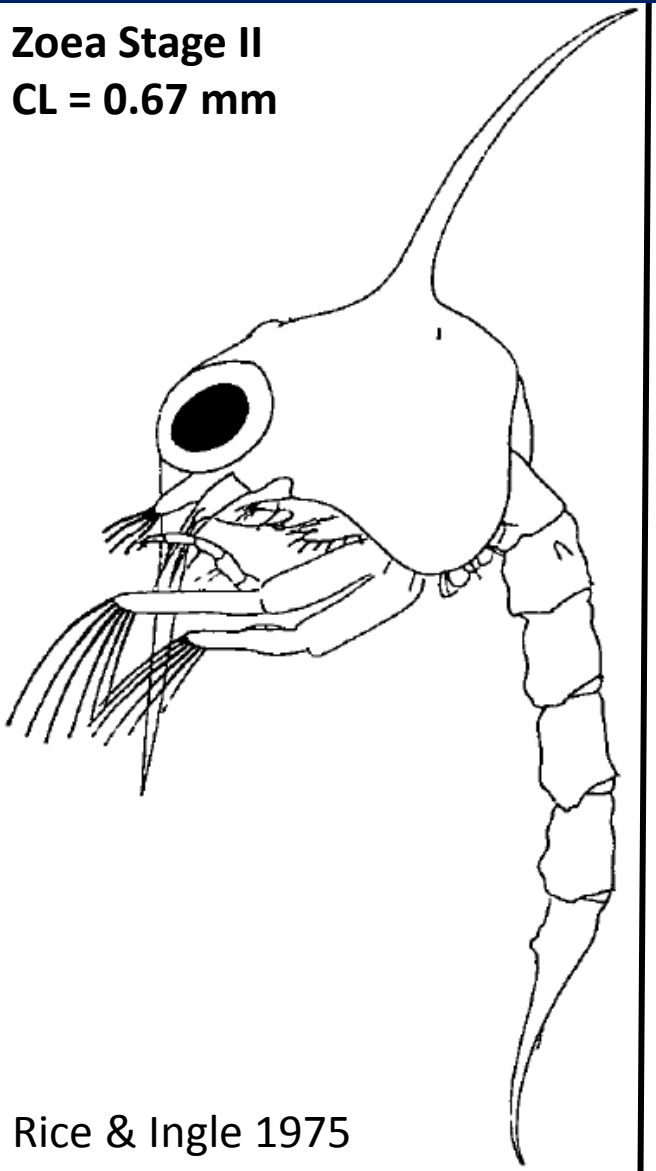
http://ziranzhi.com/2576.html

Zoea Stage I

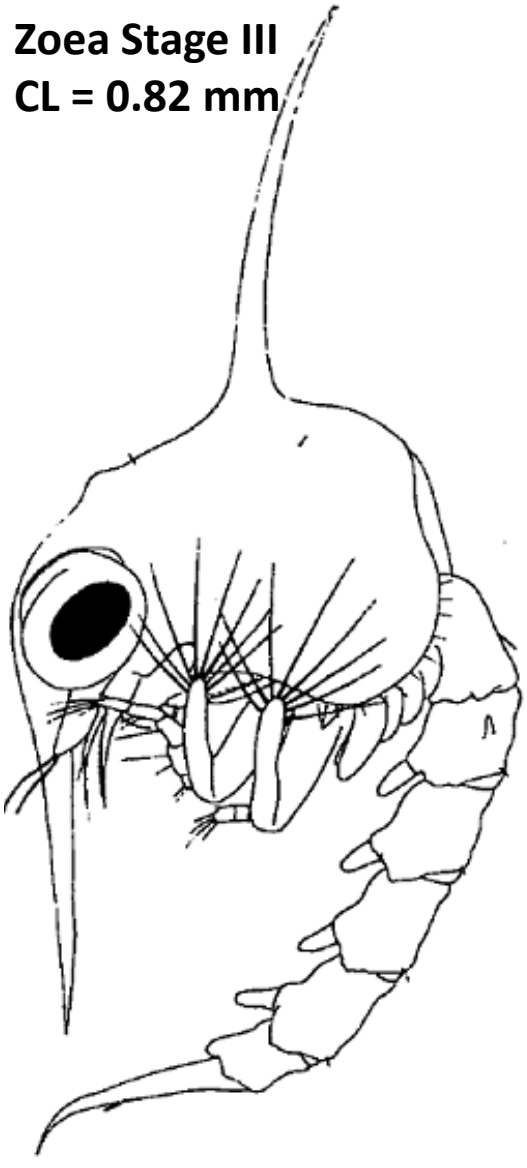
http://www.corbisimages.com

Zoeal Stages I - IV

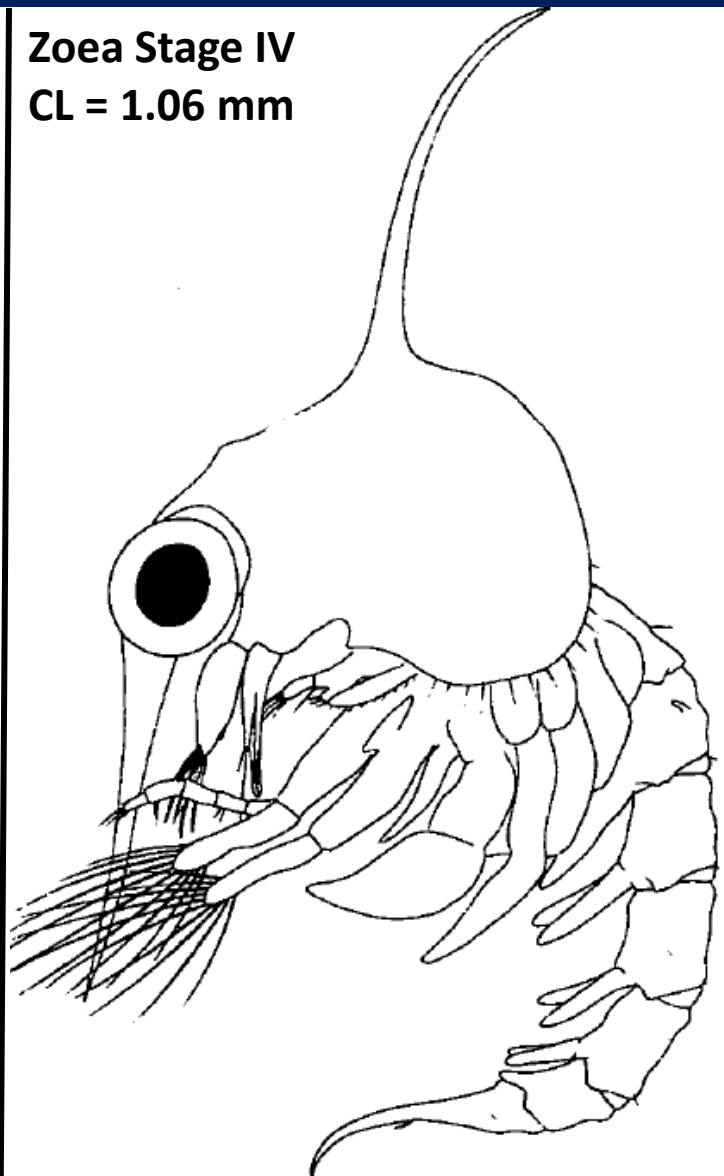
Zoea Stage II
CL = 0.67 mm



Zoea Stage III
CL = 0.82 mm

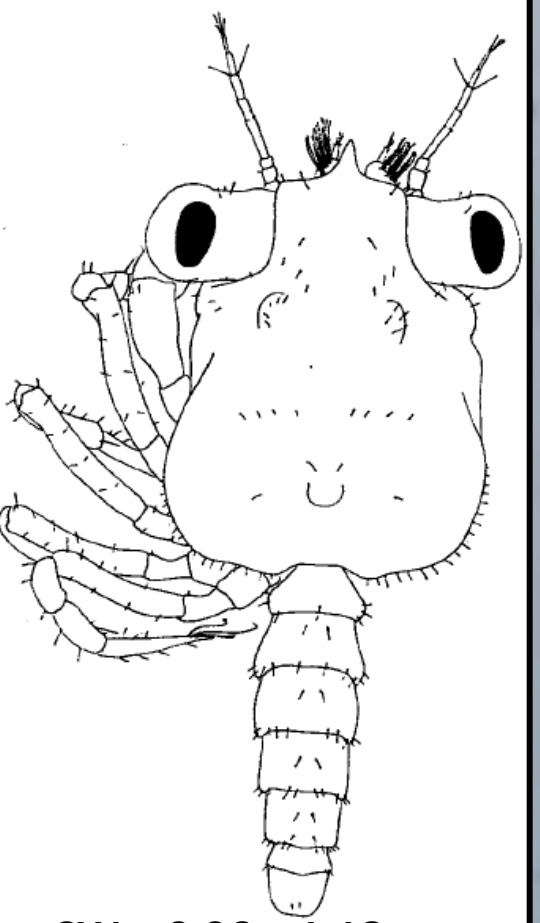


Zoea Stage IV
CL = 1.06 mm

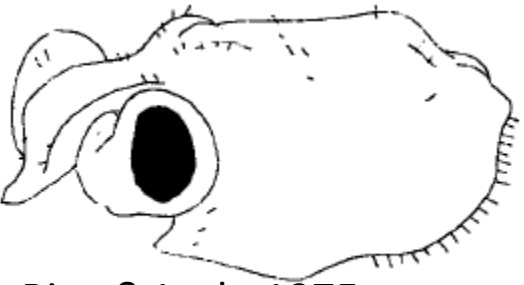


Rice & Ingle 1975

MEGALOPA



CW = 0.96 – 1.18 mm



Rice & Ingle 1975

Bravo 2011

http://www.marinespecies.org/photogallery.php?album=717&pic=38419


5 mm

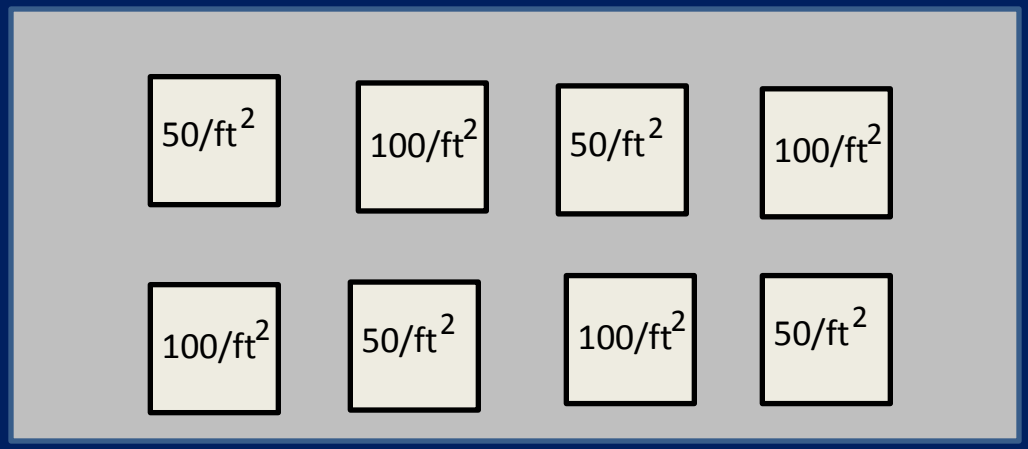
A LOOK BACK

Green crabs in Maine - 1950's

THIRD ANNUAL CONFERENCE ON CLAM RESEARCH

Boothbay Harbor, Maine (January 15-17, 1952)

Results of Experimental Clam Farming in Maine, 1951



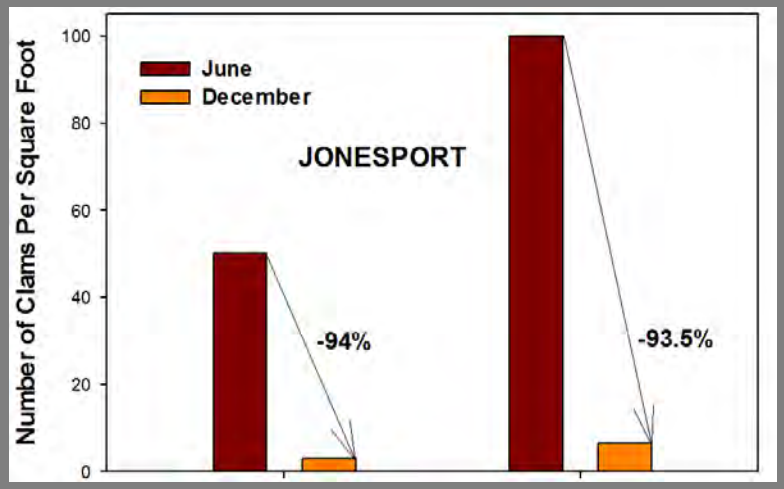
Jonesport (Cumming's Beach)
Southport (Love's Cove)
Georgetown (Sagadahoc Bay)
Wells (Pope Creek)

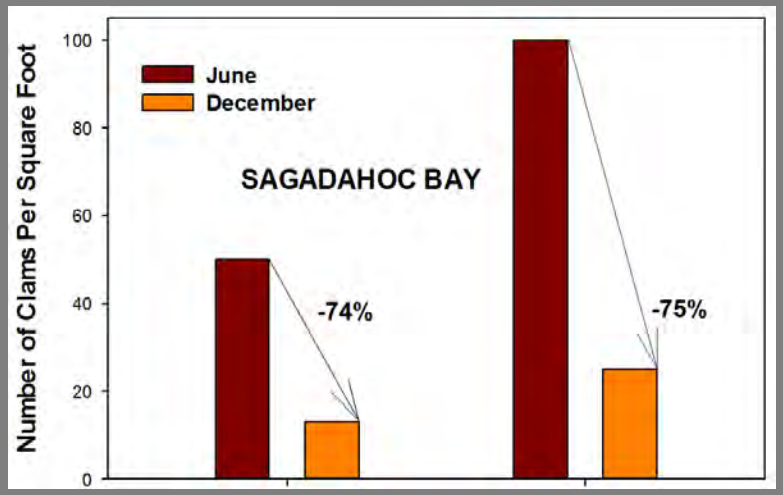
Seed clams obtained from Western Beach, Scarborough

1 bu. clams would cover one 50/ft2 plot

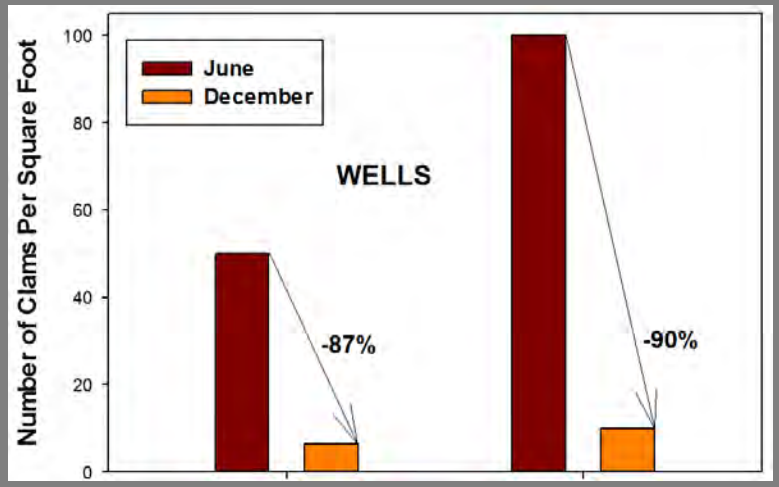
THIRD ANNUAL CONFERENCE ON CLAM RESEARCH

Boothbay Harbor, Maine (January 15-17, 1952)





"At the Southport Farm, nearly all clams were eaten by green crabs within two months of planting."



THIRD ANNUAL CONFERENCE ON CLAM RESEARCH

Boothbay Harbor, Maine (January 15-17, 1952)

"Green crab studies, which started at Boothbay Harbor, Maine in 1951, were stimulated by the destruction of a clam farm at Love's Cove within one month after planting. "

a) **During winter 1951-1952, 100 square-foot plots of seed clams planted;**

b) **An intensive trapping program during fall of 1952 to determine if it is possible to deplete an area of green crabs by continued trapping;**

1) **Traps with ¼-inch mesh screening,**
2) **Three strings at 1, 5, and 9-ft depths in the cove,**
3) **Fished/baited daily for 35-days.**

THIRD ANNUAL CONFERENCE ON CLAM RESEARCH

Boothbay Harbor, Maine (January 15-17, 1952)

Results of the Love's Cove studies

a) **"Plantings for October and November were destroyed immediately while plantings for December, January, February and March survived until April 15. At that time, green crabs had invaded the tidal flats, and within a short time had destroyed all of the seed clam plantings."**

b) **"Although the total average catch was nearly 1,000 green crabs a day, 1,400 were caught on the last day of trapping. This increase might be explained by a sudden migration into the area. Intensive green crab trapping does not appear to be a satisfactory method of green crab control."**

FOURTH ANNUAL CONFERENCE ON CLAM RESEARCH

Boothbay Harbor, Maine (March 17-19, 1953)

Area II (Cutler to Schoodic Point)

This has been the most productive area in Maine with approximately 65% of the State's total production coming from this region in 1950 and 1951. There has been a definite backlog of clams built up here. The general belief that clams should not be dug during the spawning season has probably been stronger here than elsewhere in the state.

Area VI (Small Point, Phippsburg to Portland)

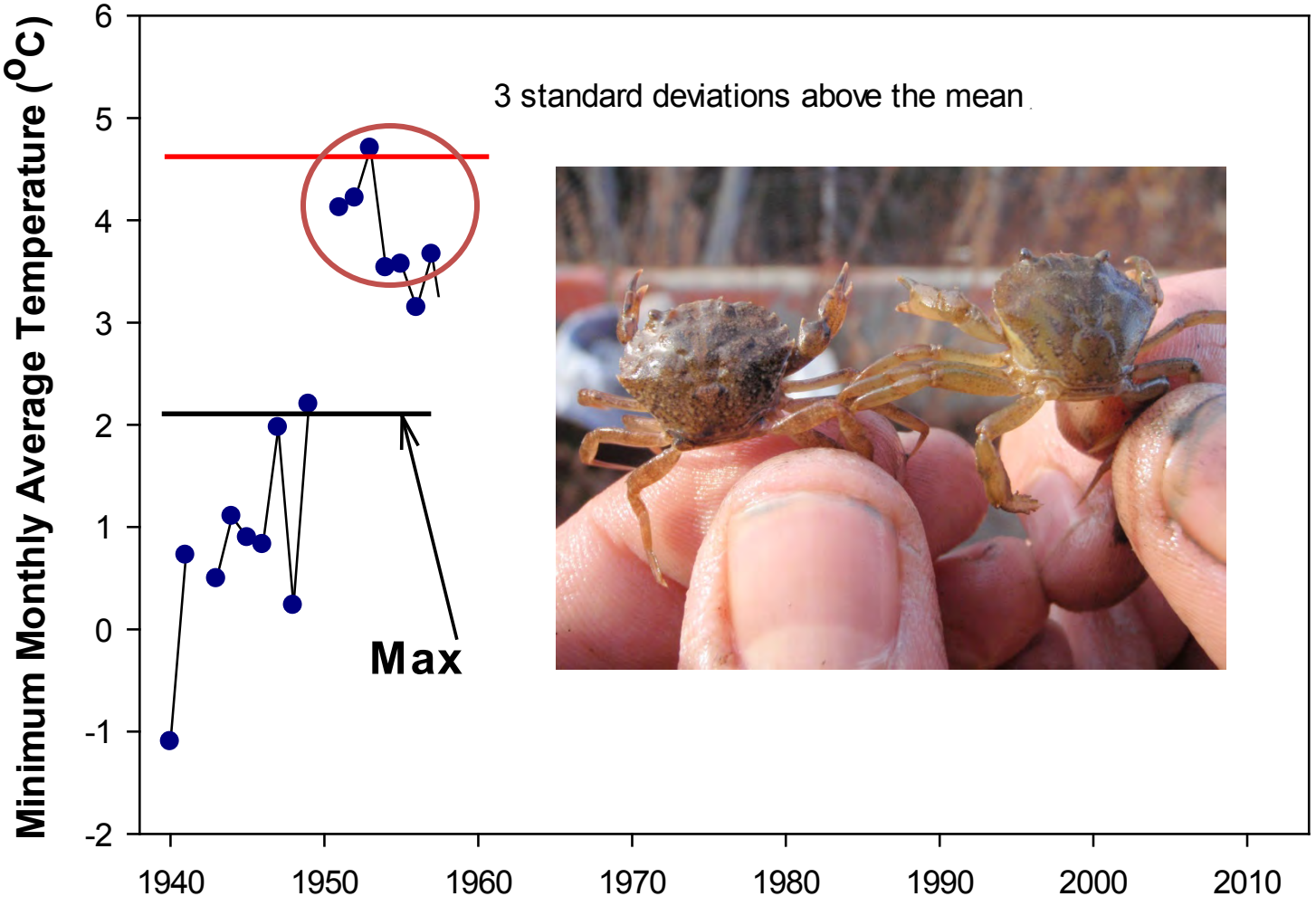
As far as clam production is concerned, the entire Casco Bay area has nearly gone out of commercial production of *Mya*. Quahogs have replaced soft-shell clams in West Bath, Brunswick, Freeport, and Harpswell. This last year (1952) there has been limited *Mya* production.

Experimental Clam Farm (Newbury, Massacchusetts – 1953)

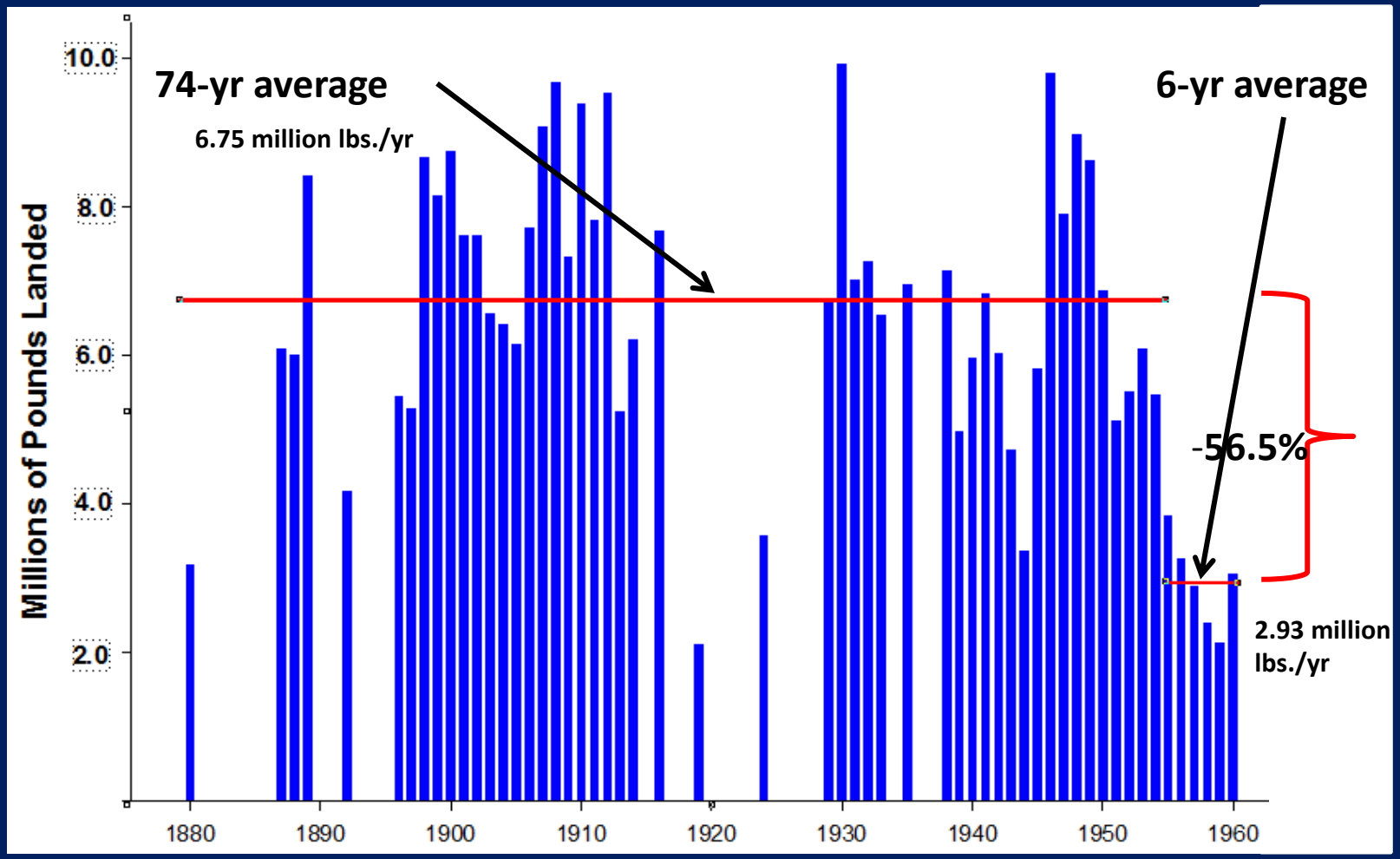
Fig. 5 - Fence built in Plum Island Sound, Newbury, Mass., June 3, 1953, to protect clams from horseshoe and green crabs. The photograph was taken about three weeks after the fence was built. Note that entire flat outside fence is covered with excavations of predators, while the soil inside is still smooth.

Smith et al. (1955)

Boothbay Harbor Coldest Monthly Average Temperature (1940-1957)



MAINE CLAM LANDINGS – 1880 TO 1960

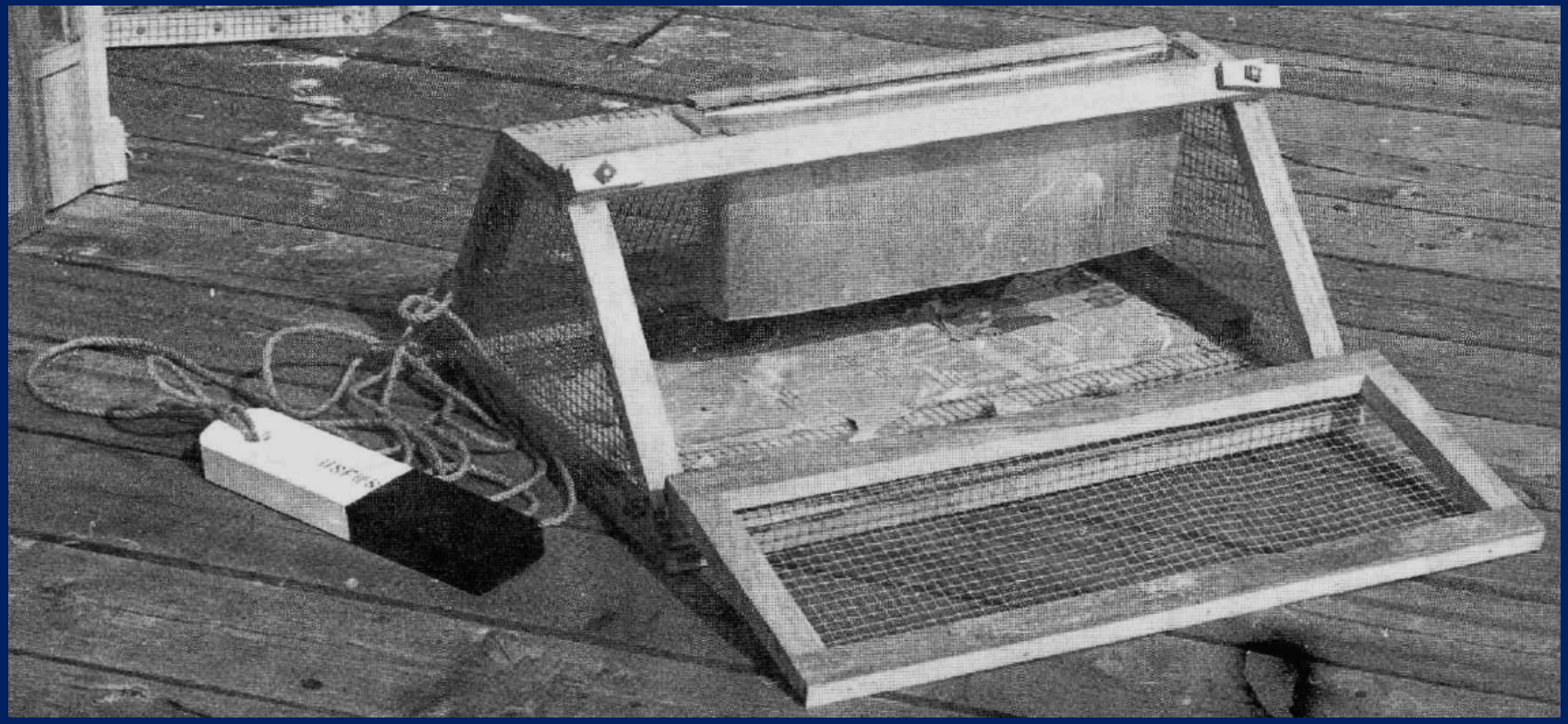


FIFTH ANNUAL CONFERENCE ON CLAM RESEARCH

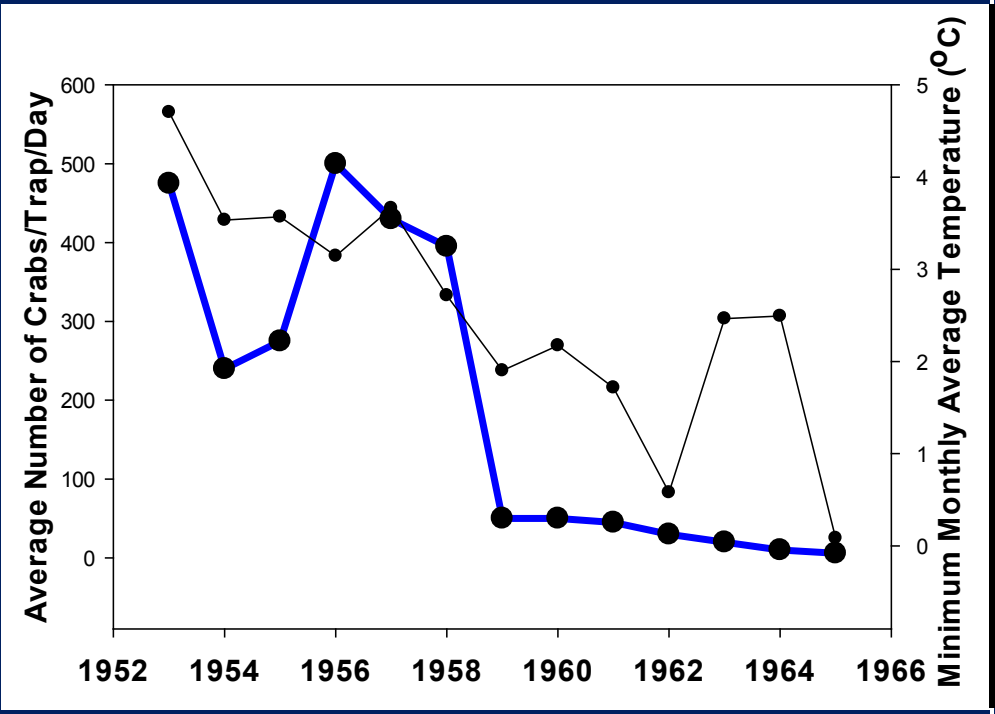
Boothbay Harbor, Maine (March 1-3, 1955)

“Standard” green crab trap

Fished for 24-hrs on two consecutive days during the first week of each month from late spring to late fall

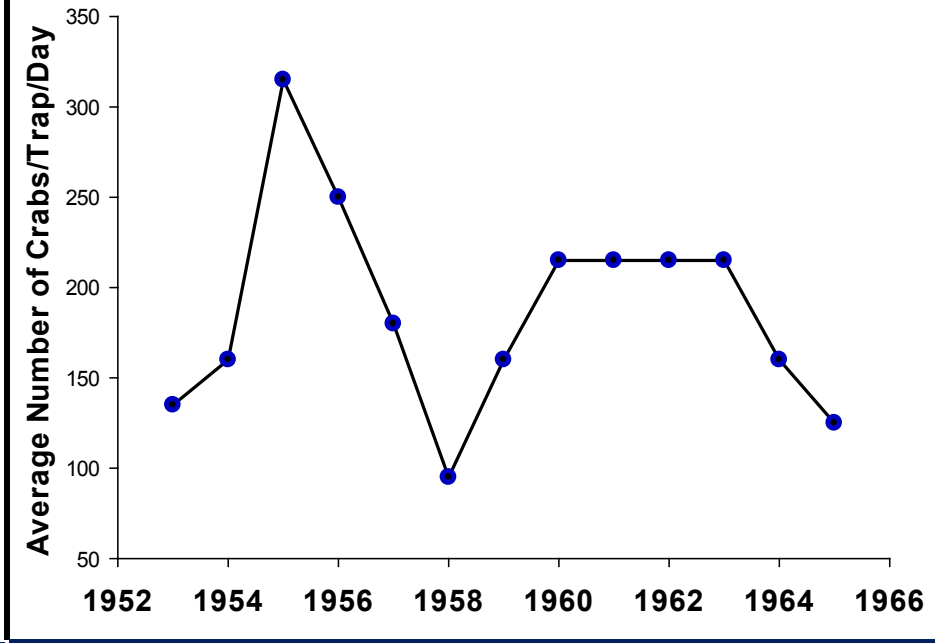


Jonesport (Cumming's Beach)
(1953 to 1965)



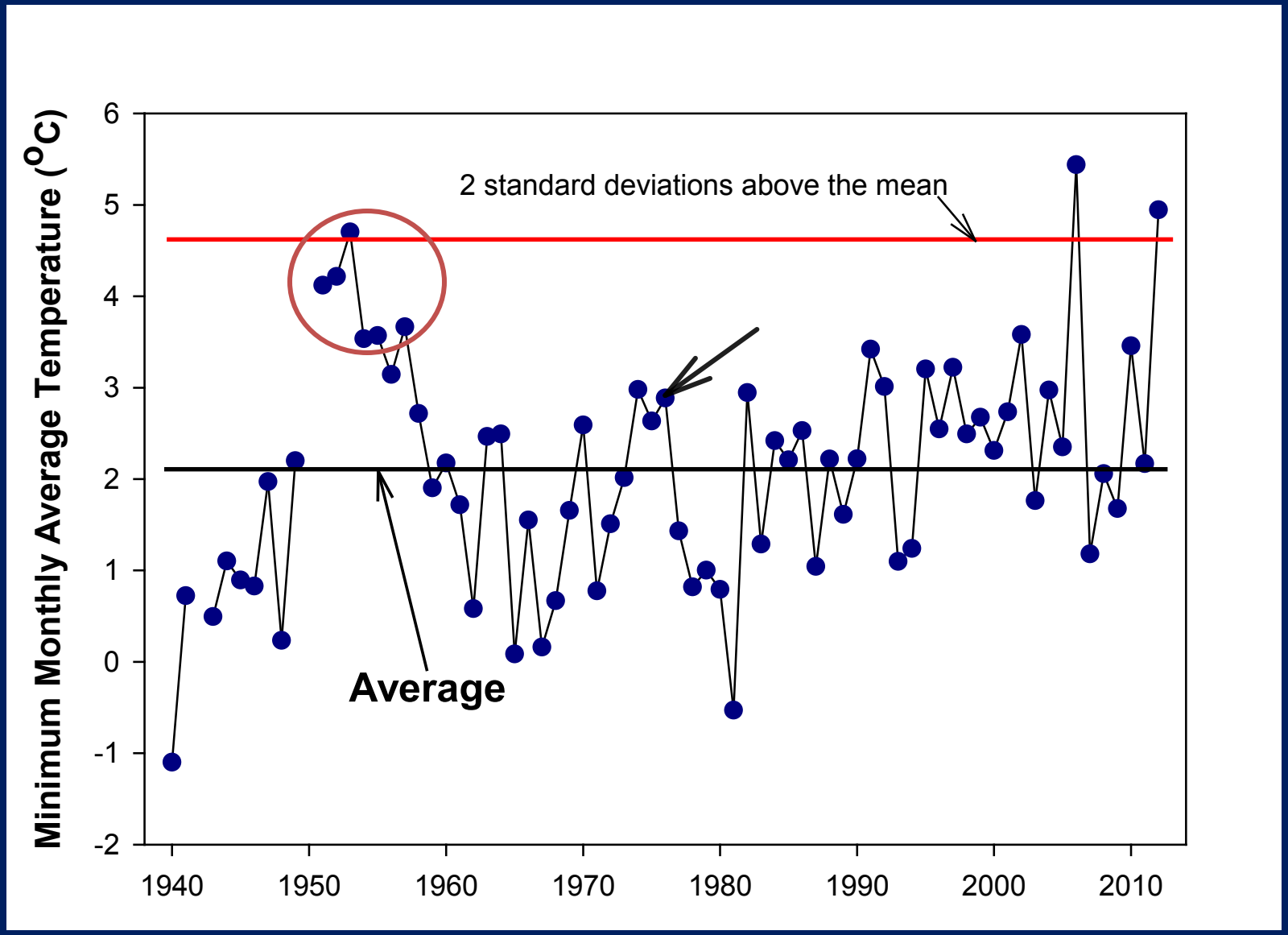
Crab number and temperature are linearly correlated (r = 0.76; P = 0.003)

Southport (Love's Cove)
(1953 to 1965)

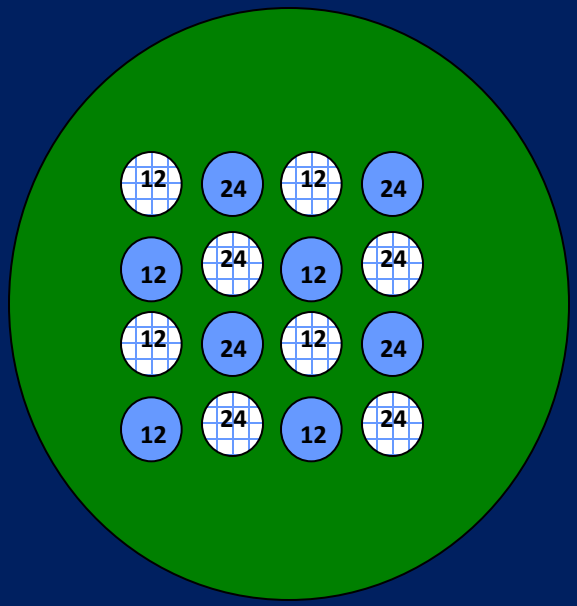


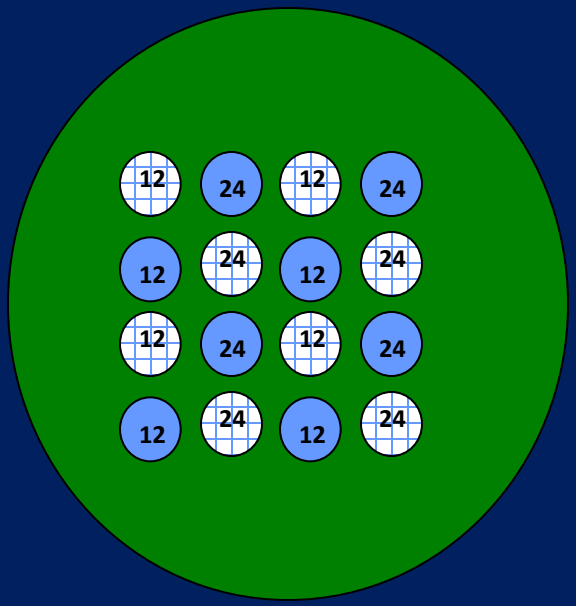
In 1953, daily catches ranged from 110 to 670 green crabs. Average population estimate from tagging = 10,000 crabs per acre.

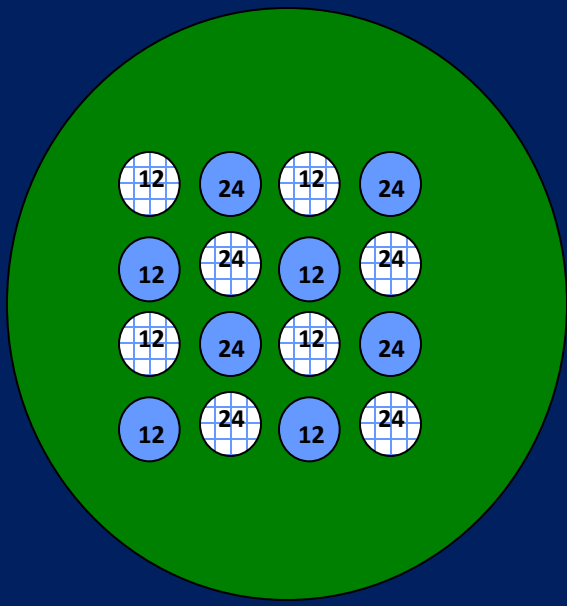
Boothbay Harbor Coldest Monthly Average Temperature (1940-2012)

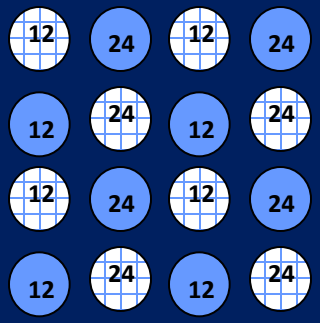


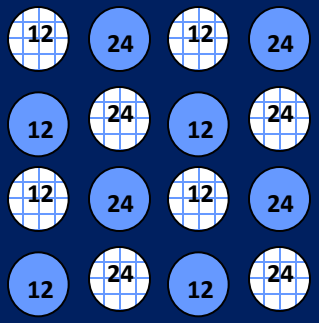
1999: 15 July to 28 October
UMM and Orono marine ecology classes

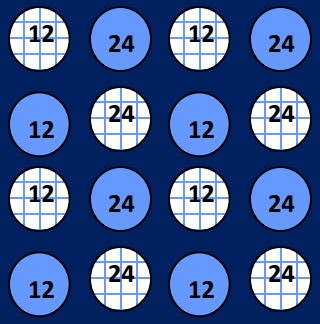


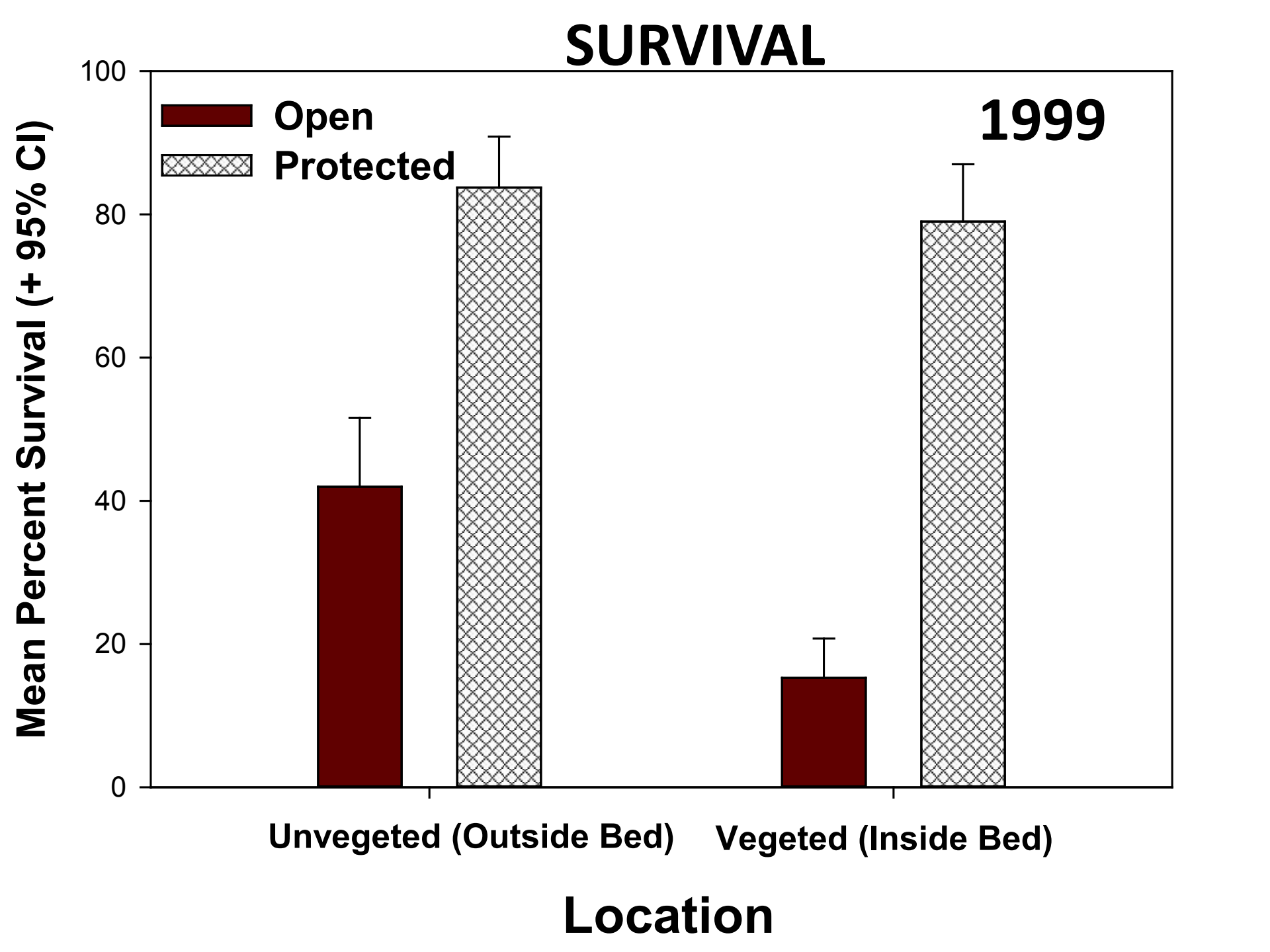


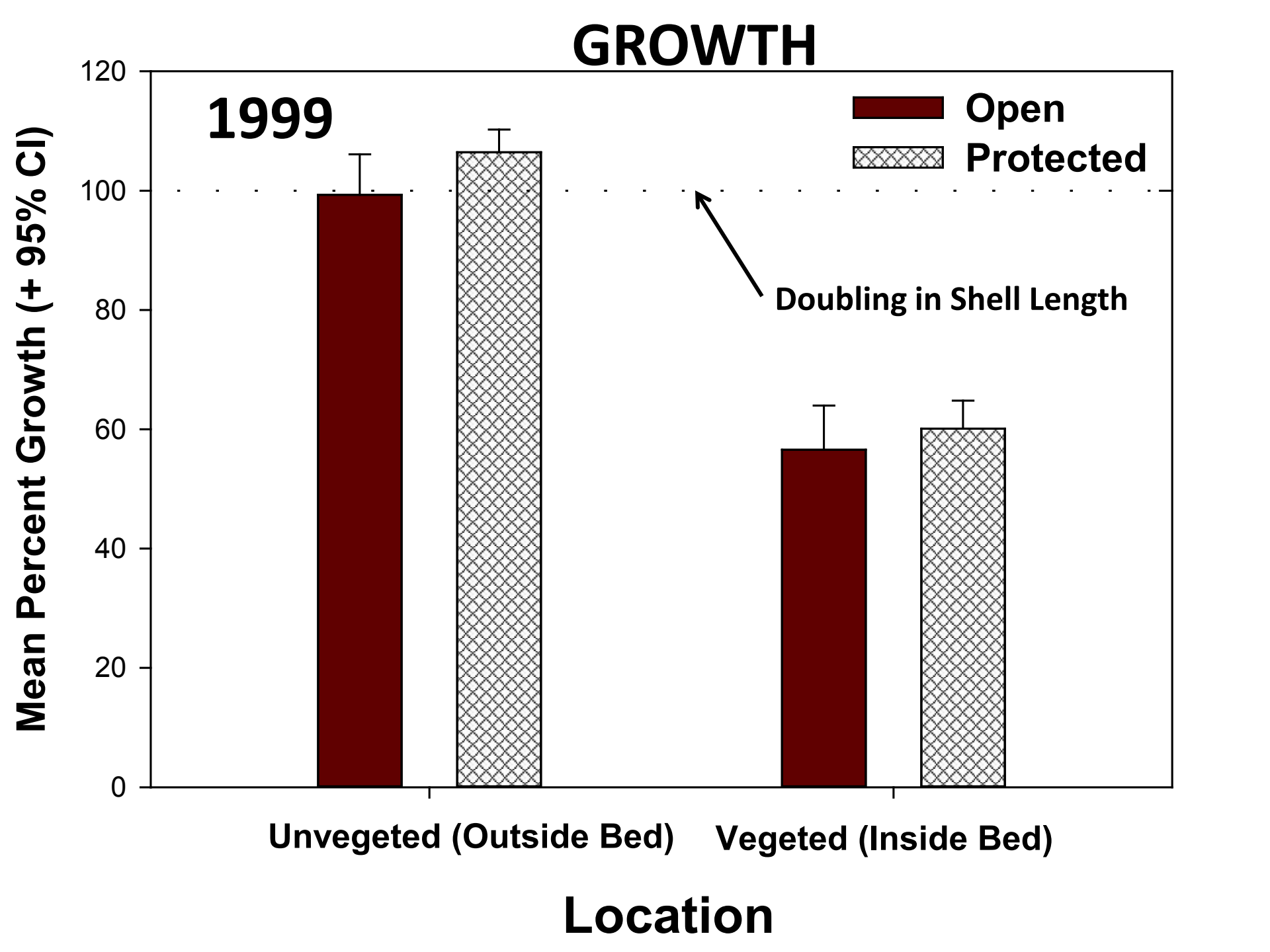




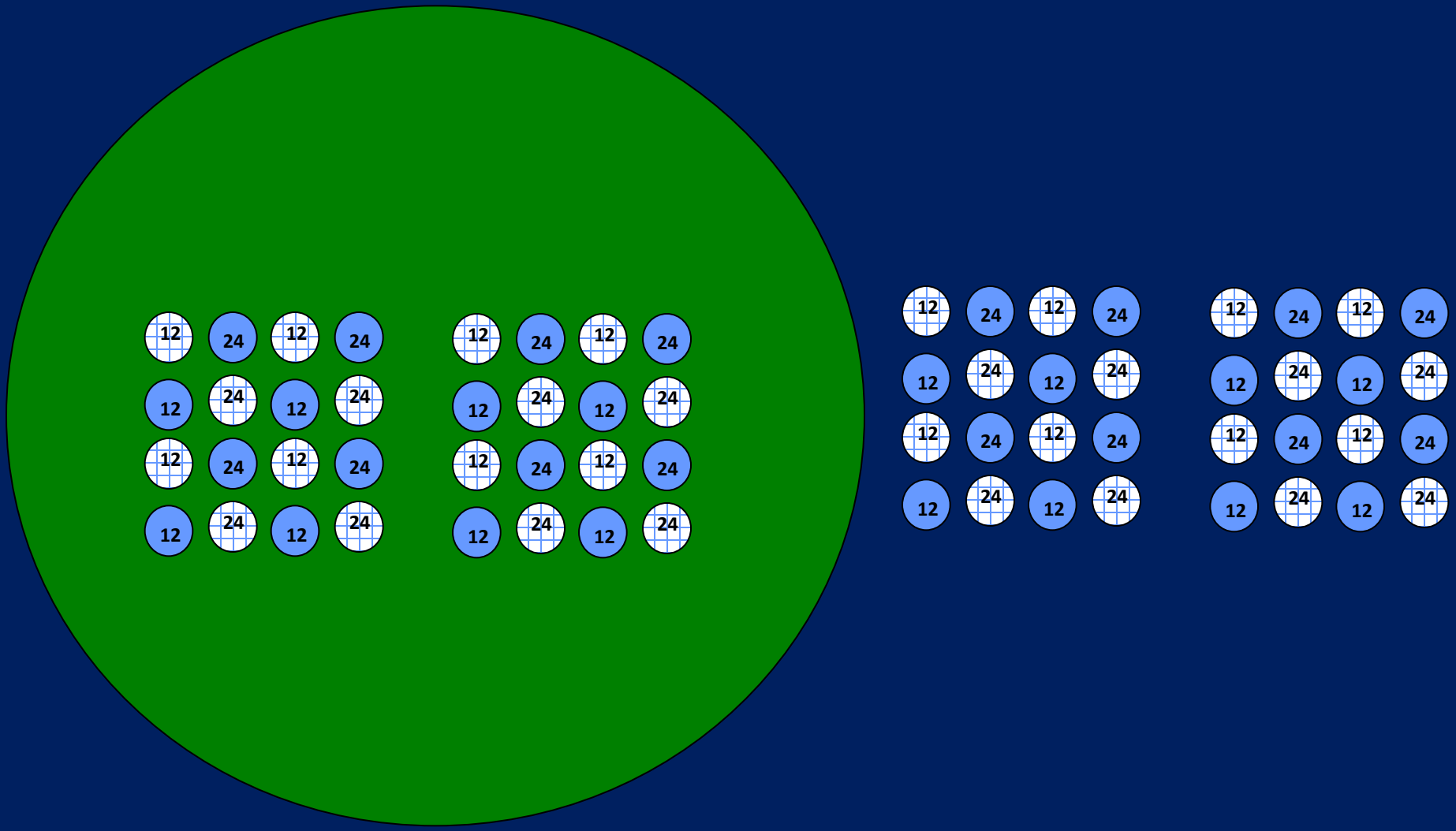


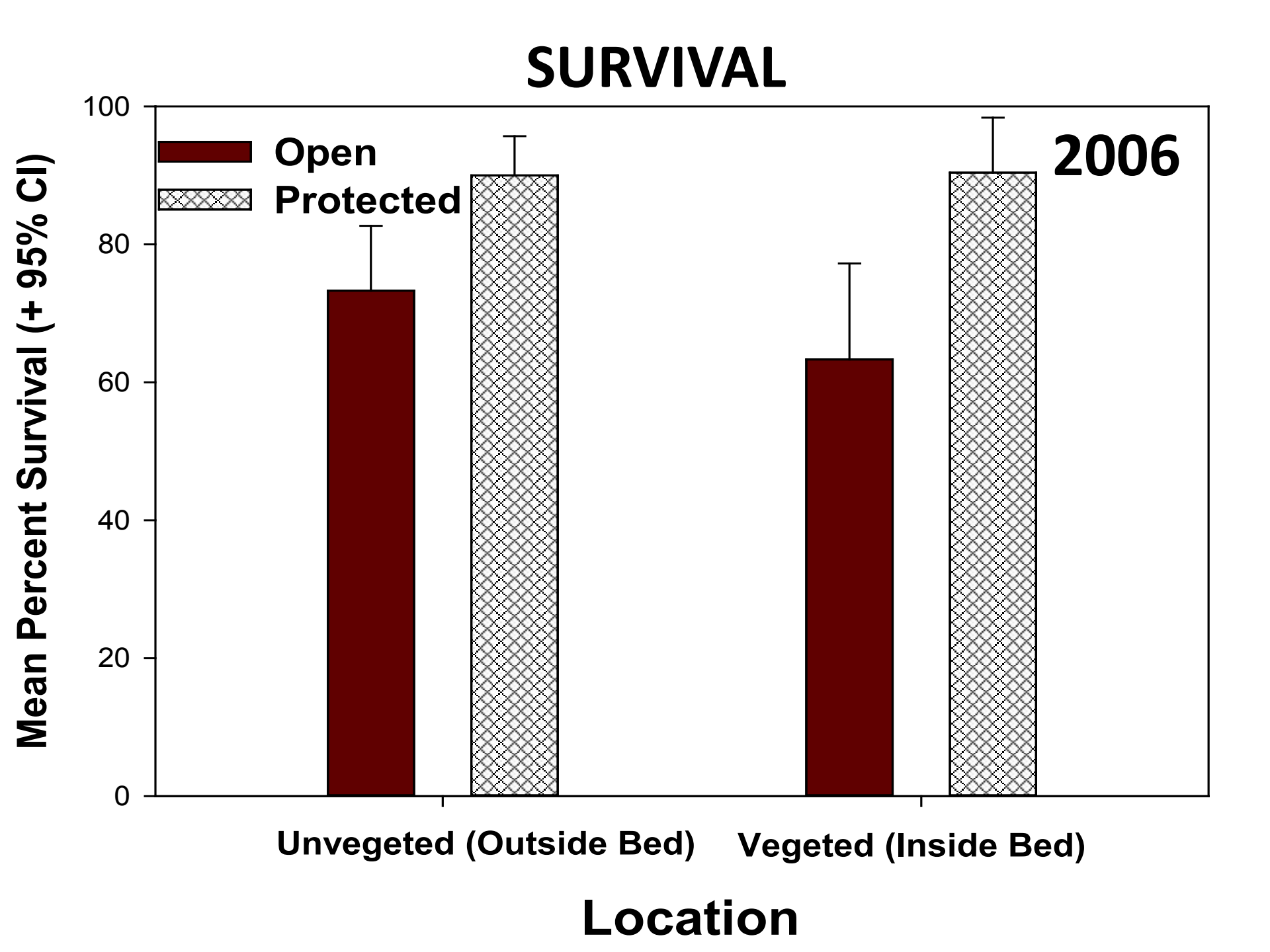


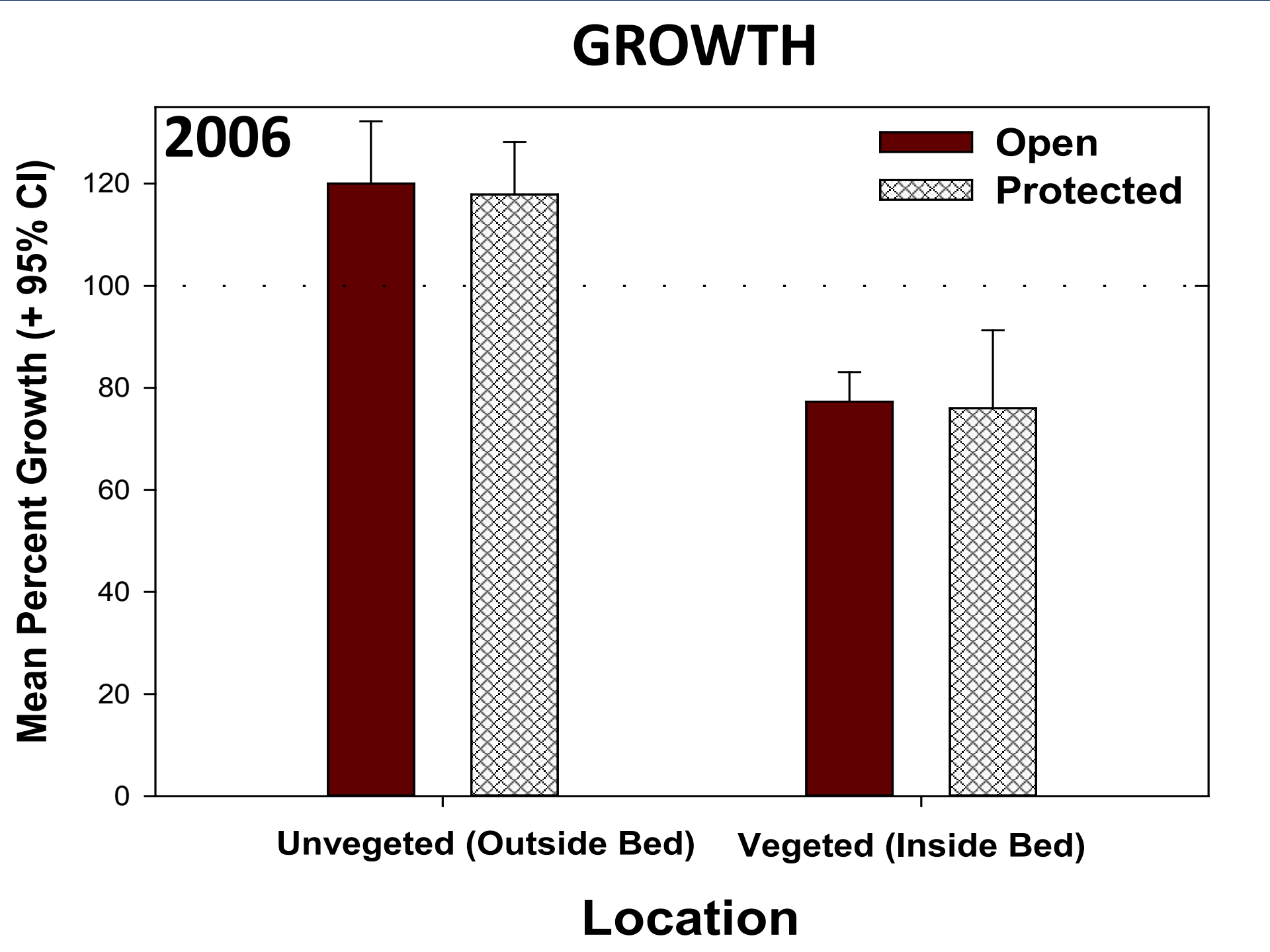

SURVIVAL
1999
Open
Protected
Mean Percent Survival (+ 95% CI)
100
80
60
40
20
0
Unvegeted (Outside Bed)
Vegeted (Inside Bed)
Location


GROWTH
1999
Open
Protected
Doubling in Shell Length
Mean Percent Growth (+ 95% CI)
120
100
80
60
40
20
0
Unvegeted (Outside Bed)
Vegeted (Inside Bed)
Location

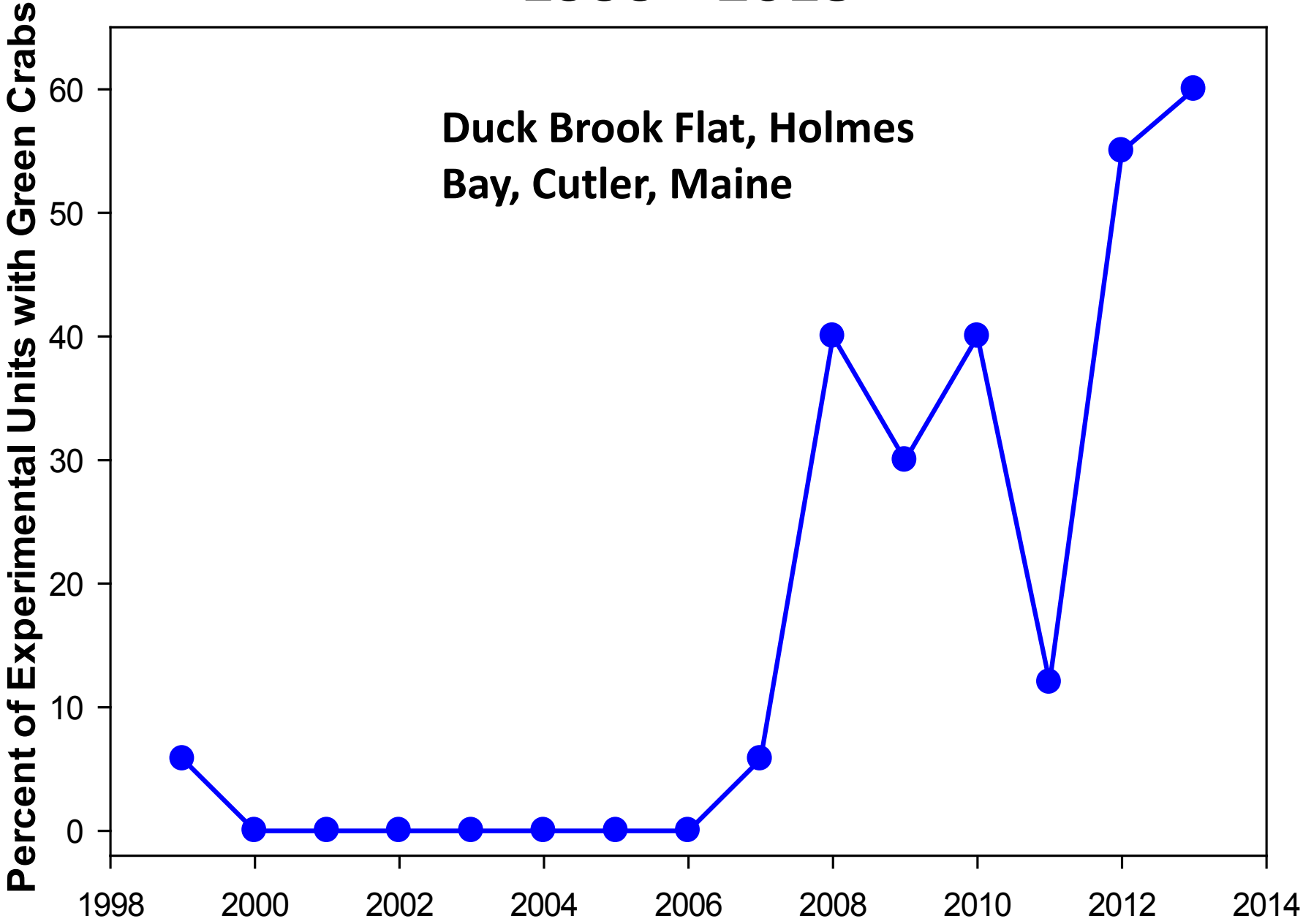
2006: 14 July to 7 November
UMM marine ecology classes

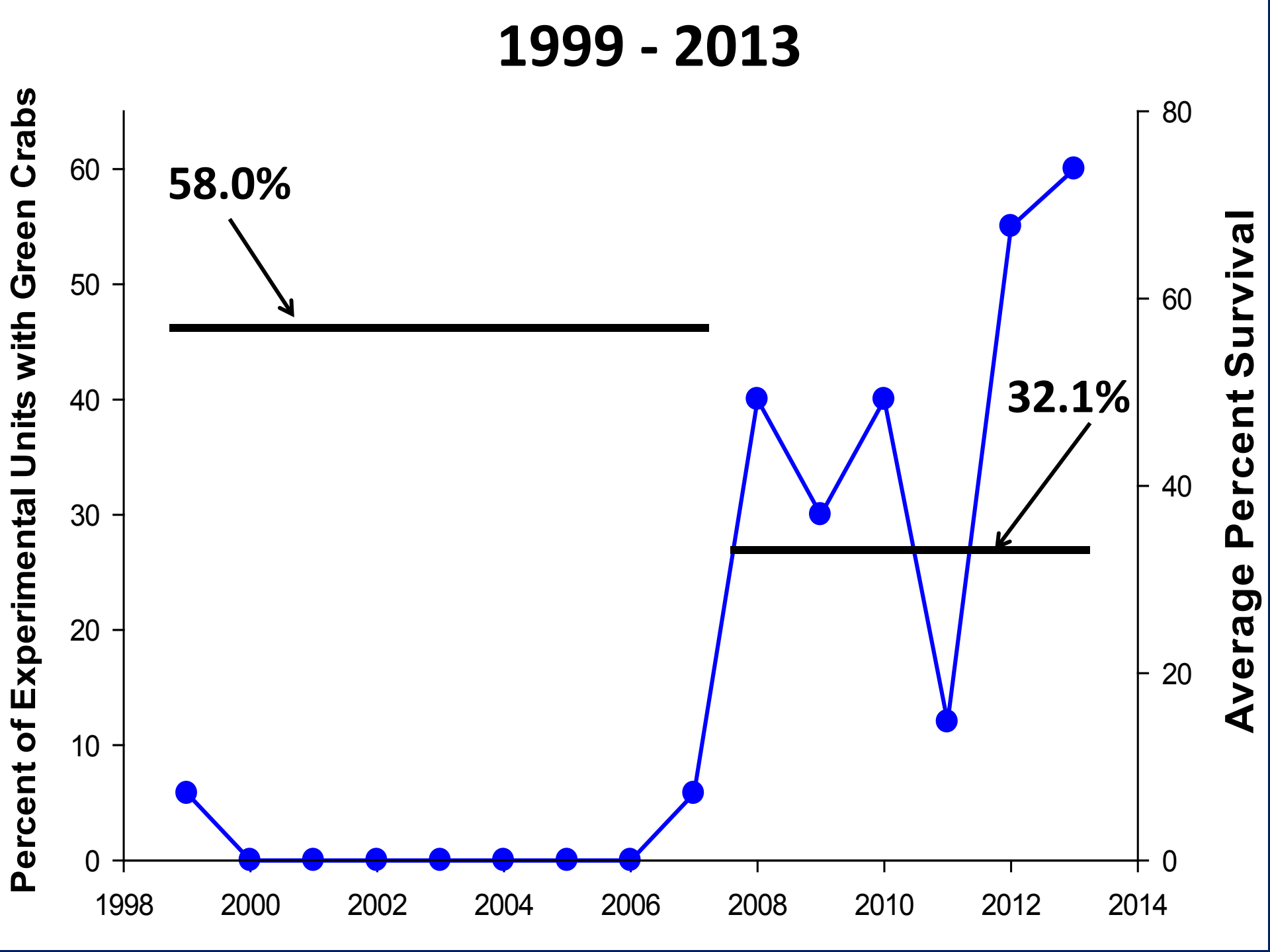



SURVIVAL
100
80
60
40
20
0
Open
Protected
2006
Mean Percent Survival (+ 95% CI)
Unvegeted (Outside Bed)
Vegeted (Inside Bed)
Location

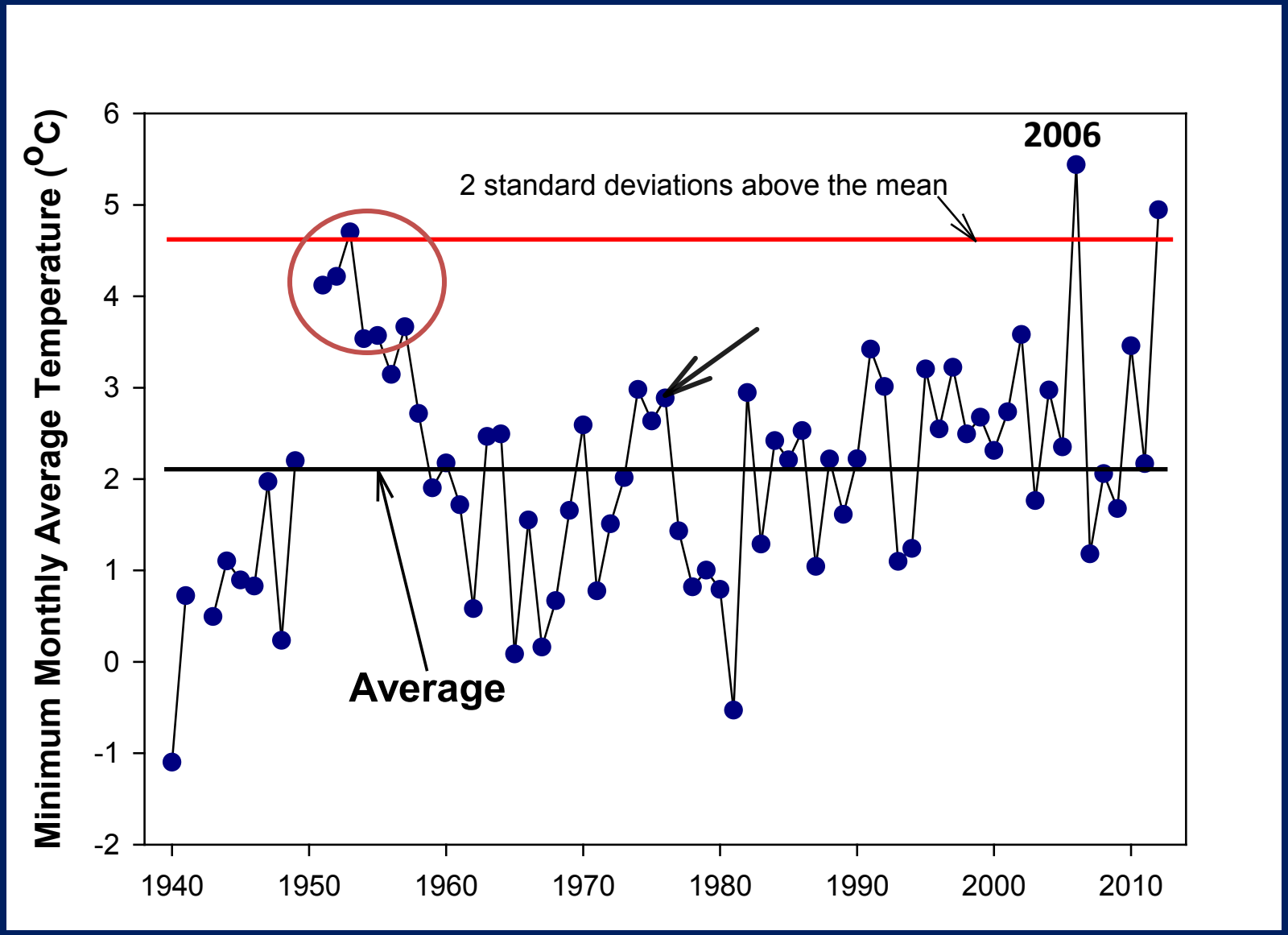

GROWTH
2006
Open
Protected
Mean Percent Growth (+ 95% CI)
120
100
80
60
40
20
0
Unvegeted (Outside Bed)
Vegeted (Inside Bed)
Location

1999 - 2013

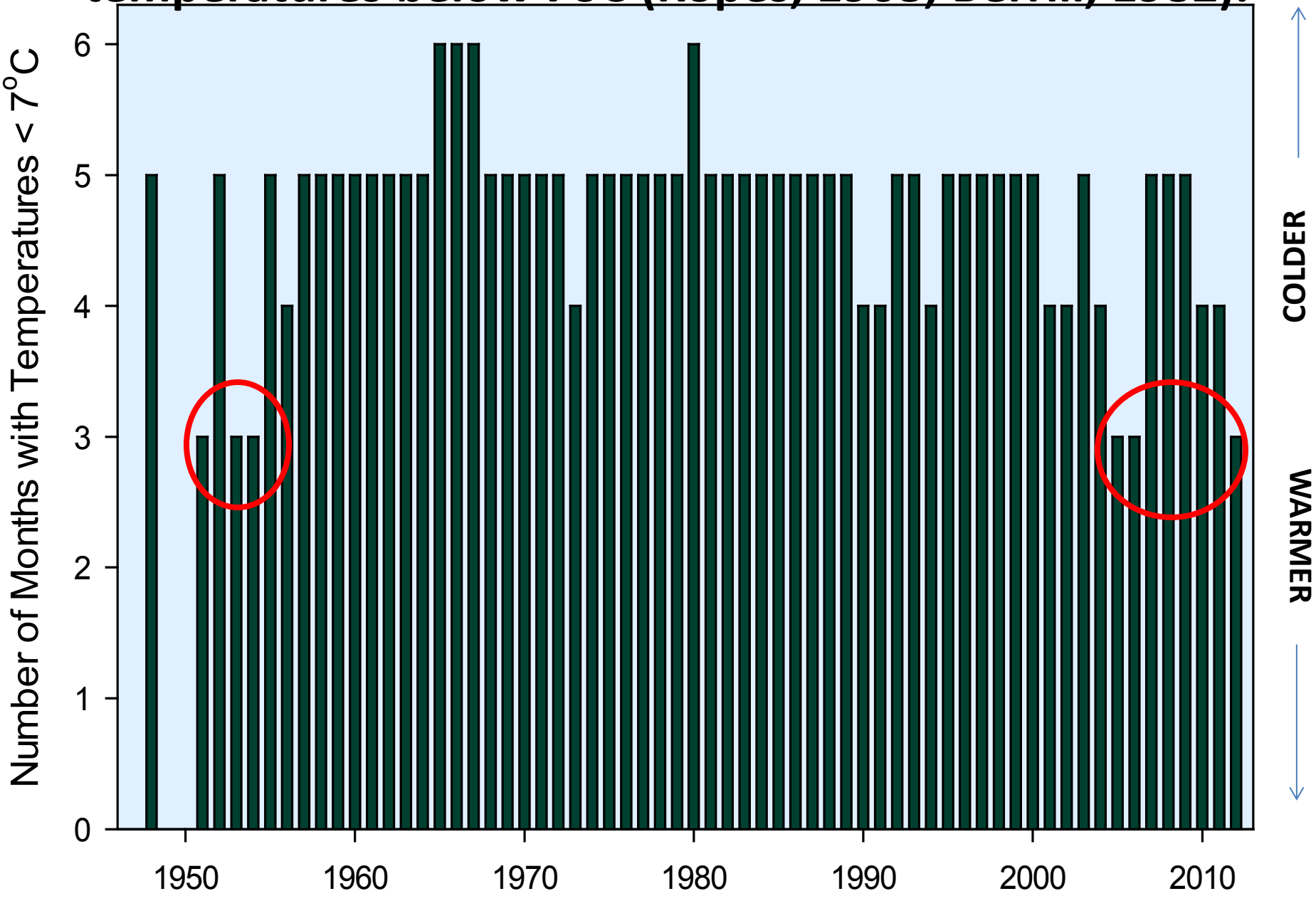

Duck Brook Flat, Holmes Bay, Cutler, Maine
Percent of Experimental Units with Green Crabs
0
10
20
30
40
50
60
1998
2000
2002
2004
2006
2008
2010
2012
2014


1999 - 2013
Percent of Experimental Units with Green Crabs
Average Percent Survival
58.0%
32.1%
0
10
20
30
40
50
60
0
20
40
60
80
1998
2000
2002
2004
2006
2008
2010
2012
2014

Boothbay Harbor Coldest Monthly Average Temperature (1940-2012)



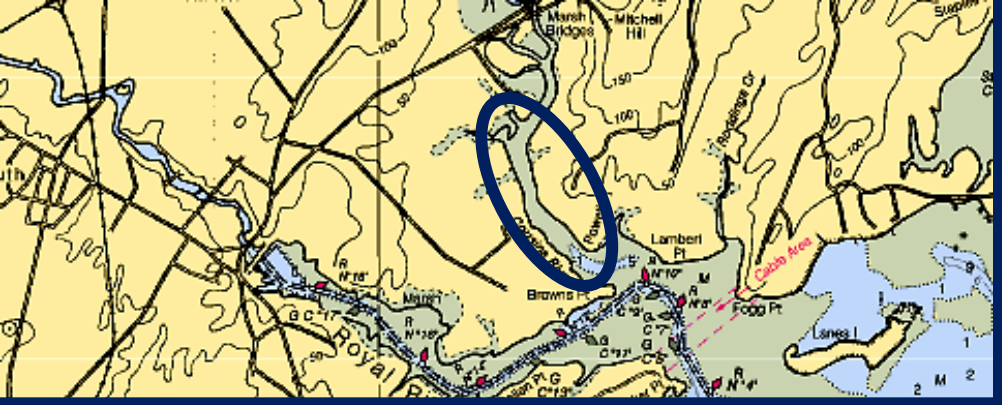
“Feeding by green crabs appears to be suppressed by temperatures below 7oC (Ropes, 1968; Berrill, 1982).”



2013

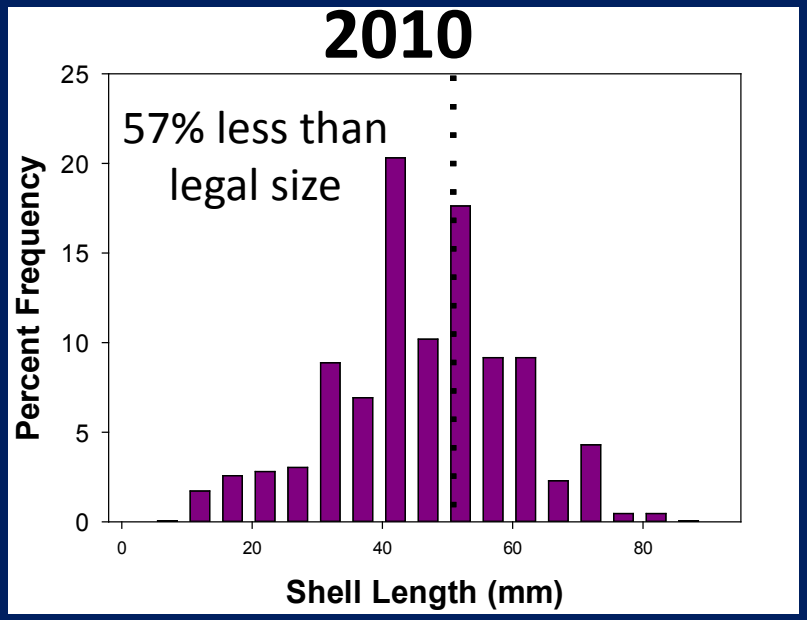
"The Maine shellfish industry is in deep trouble. We think that we're only maybe two years away from really no commercial viability in the state on soft-shell clams, which has been, historically and traditionally, one of the most important and economically valuable resources on the coast of Maine."

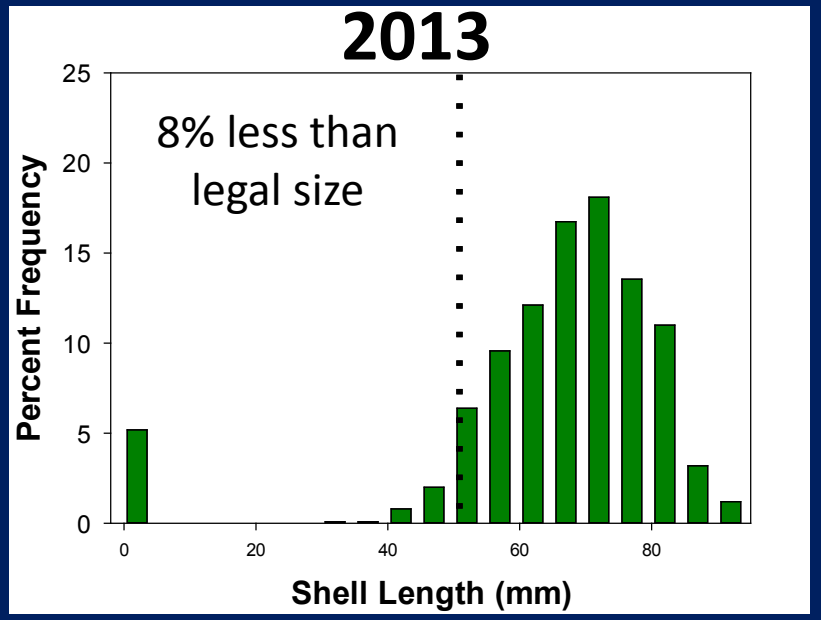
C. Coffin
MPBN Radio
http://www.mpbn.net/Home/tabid/36/ctl/ViewItem/mid/5347/ItemId/29698/Default.aspx



Cousins River – Yarmouth
MER Assessment Corporation

312 bushels/acre



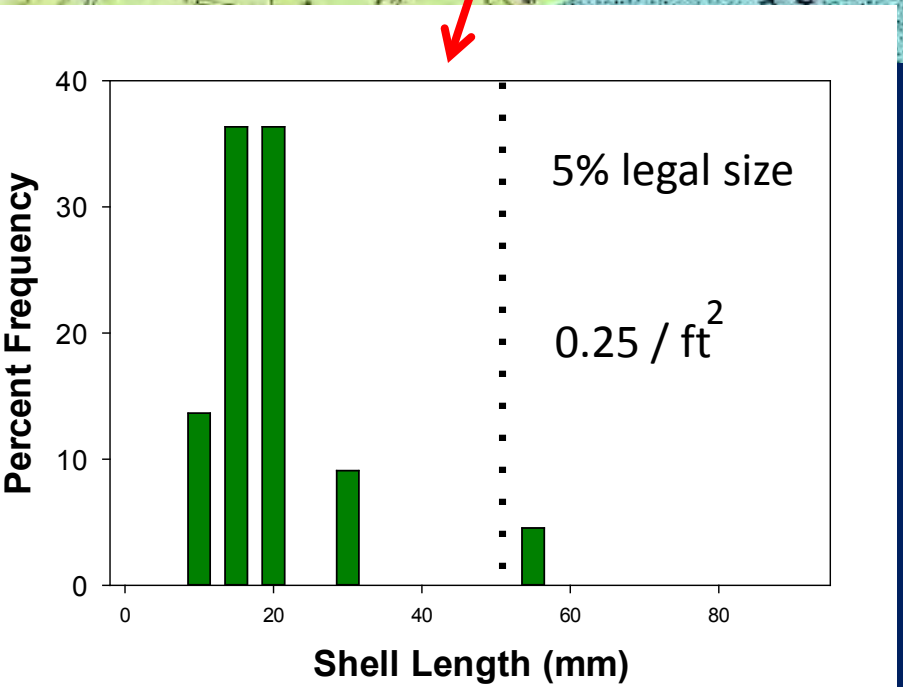


Heinig 2013
http://www.yarmouth.me.us/vertical/sites/%7B13958773-A779-4444-B6CF-0925DFE46122%7D/uploads/Yarmouth_2013_Clam_Survey_Report_100713_Final.pdf

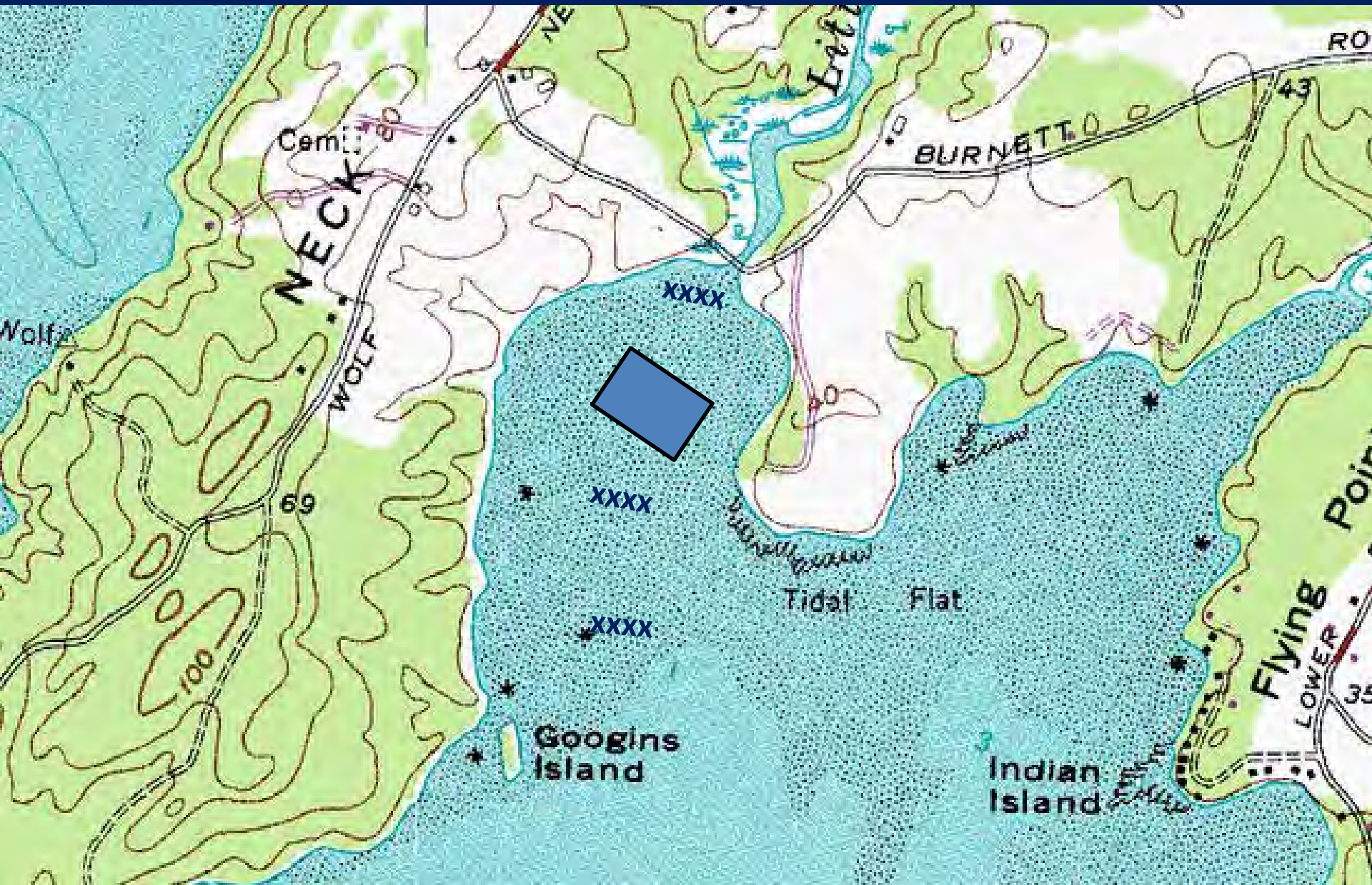
Spar Cove – Freeporpt Harraseeket River June 2013

Zero clams in 20 core samples

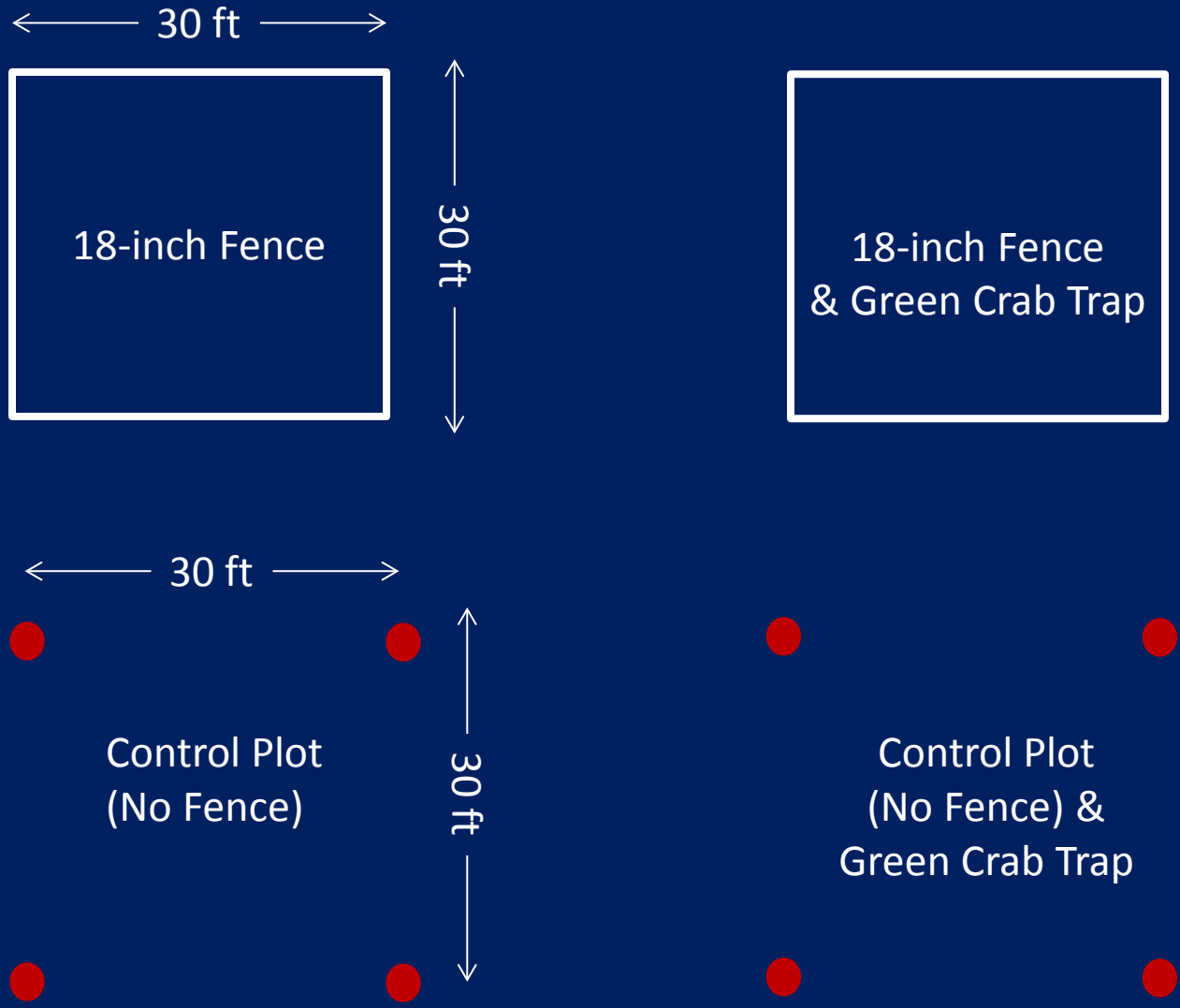
Zero clams in 20 core samples



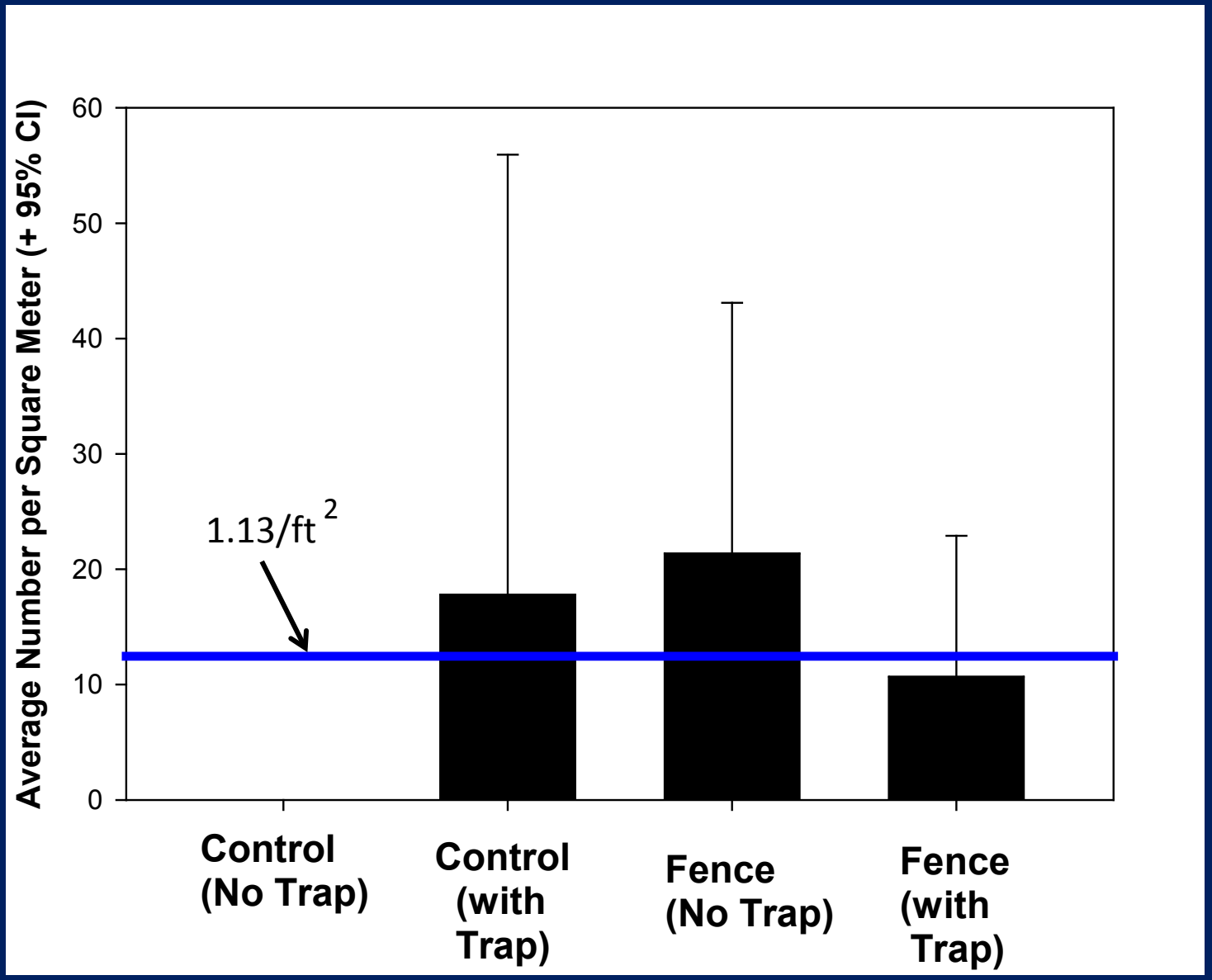
Freeport – Little River

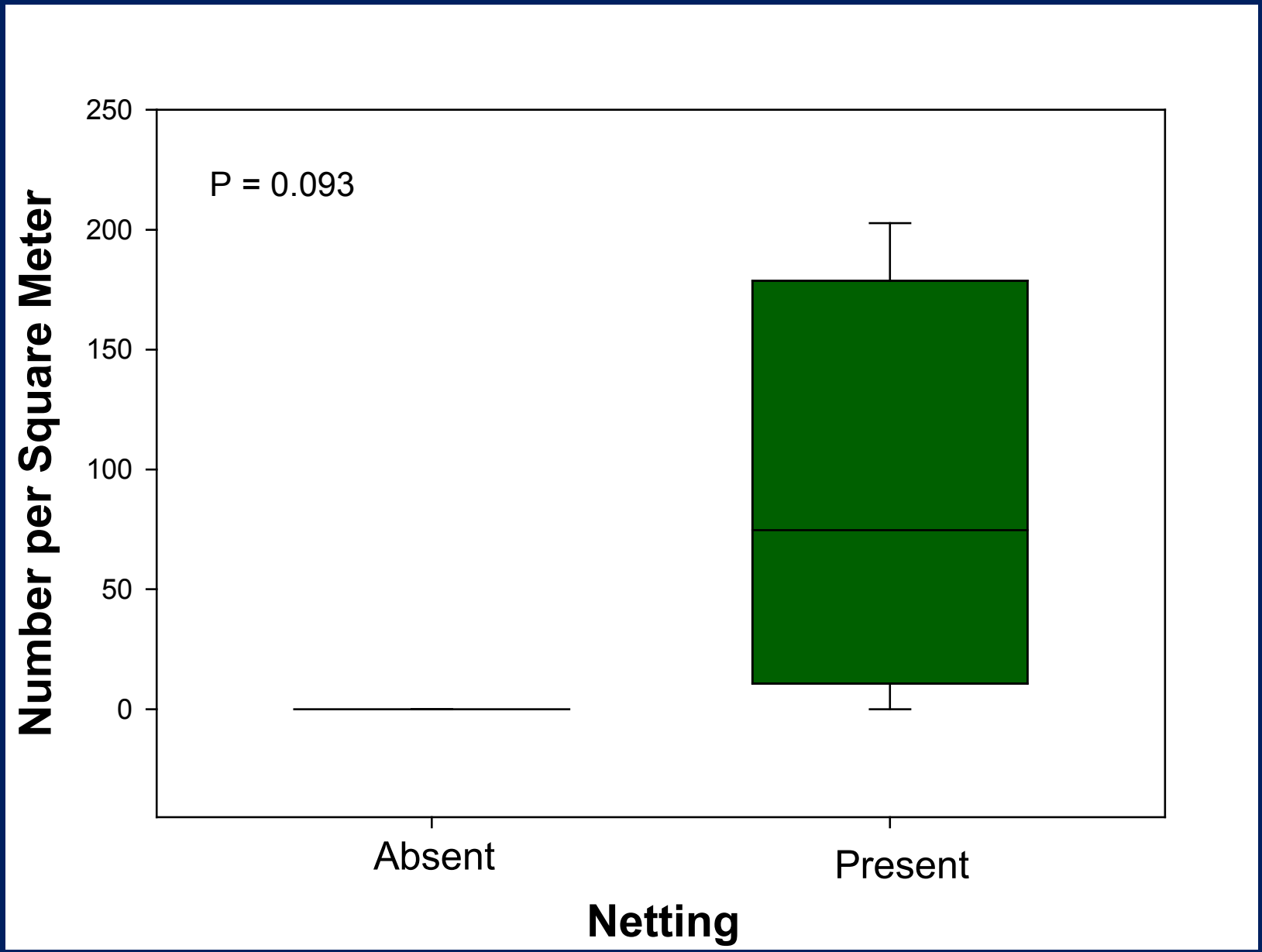


27-28 July
to
16 November
(111 days)



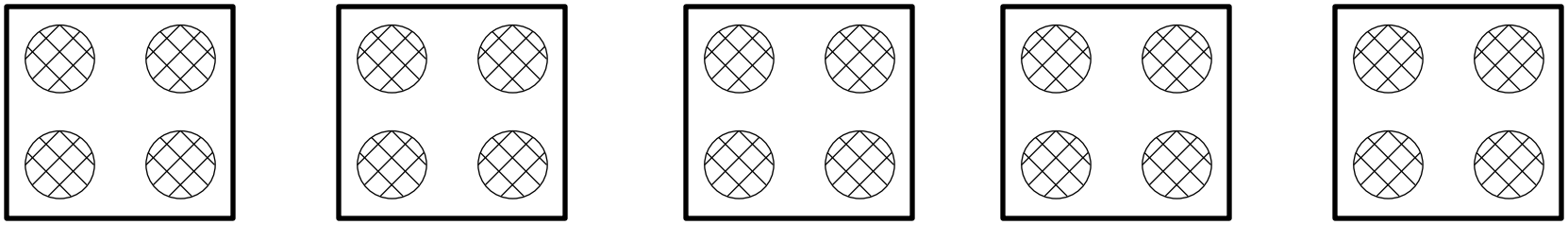
3 replicate plots/treatment
5 replicate cores per plot (0.02 m^2)


Average Number per Square Meter (+ 95% CI)
60
50
40
30
20
10
0
1.13/ft 2
Control (No Trap)
Control (with Trap)
Fence (No Trap)
Fence (with Trap)

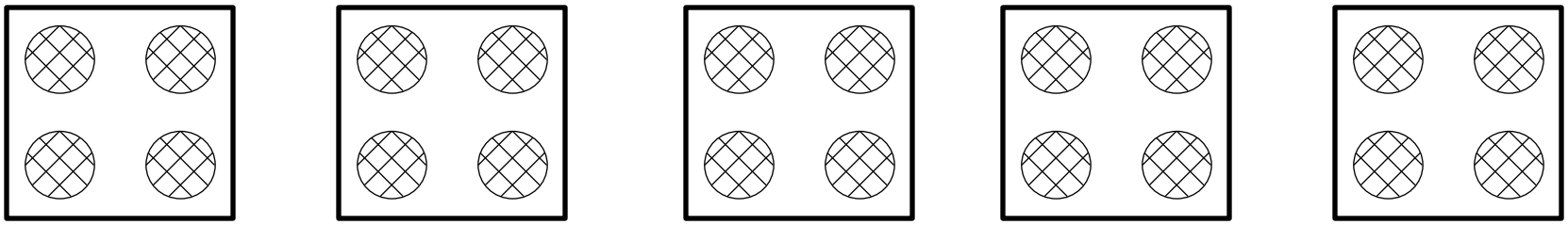

P = 0.093
Number per Square Meter
250
200
150
100
50
0
Absent
Present
Netting

Maine SEA GRANT – Effects of Tidal Height on Soft-shell Clam Growth

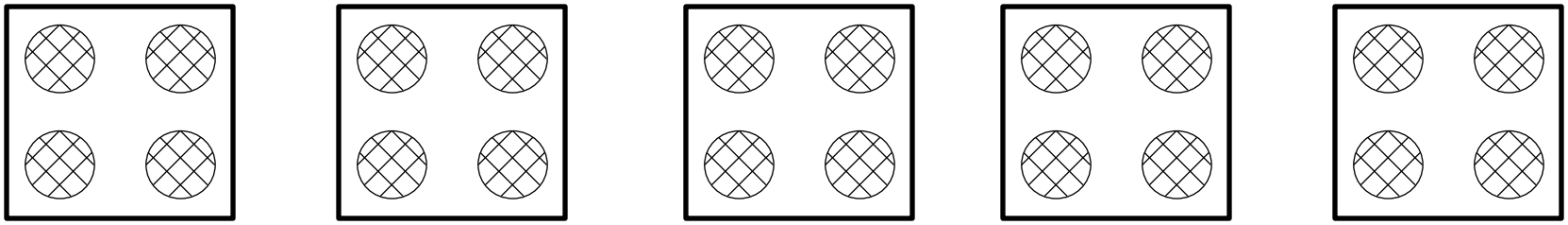
William,Ambrose, Jr. (Bates College)
Brian Beal (Univ. Me. Machias)



UPPER



MID



LOW

674 wild clam spat in the pot = 3,344/square foot

THE SYSTEM HAS TREMENDOUS BOUNCE-BACK POTENTIAL . . . WE JUST NEED TO BE VIGILENT AND ATTENTIVE IN OUR RESPONSE

160 wild clam spat in the pot = 793/square foot

Long live the Maine clammer . . . Especially the Next Generation

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Maine Sea Grant
Town of Freeport

Fondly remembered for all of his work on clams and green crabs on behalf of Maine clammers

Photo and other credits:

http://www.flickr.com/photos/gwylan/2171282773/in/photostream/ (older green crab with eggs)

http://www.arkive.org/common-shore-crab/carcinus-maenas/image-A21527.html (crab embryos)

http://ziranzhi.com/2576.html (Larvae hatching)

http://www.corbisimages.com (Zoea stage I)

http://www.marinespecies.org/photogallery.php?album=717&pic=38419 (Megalopa)

http://carnivoraforum.com/search/94/?c=3&mid=3323712&month=1&year=2012 (range)

http://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=190 (U.S. map)

http://outdooradventurers.blogspot.com (Maine map)

http://www.mpbn.net/Home/tabid/36/ctl/ViewItem/mid/5347/ItemId/29698/Default.aspx (C. Coffin interview on MPBN radio – 8/28/13)

Kyle Pepperman (Downeast Institute) – Sea Grant clam photos

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