Seasonality of fouling organisms in view of climate change and bioinvasion

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June 4-8, 2018

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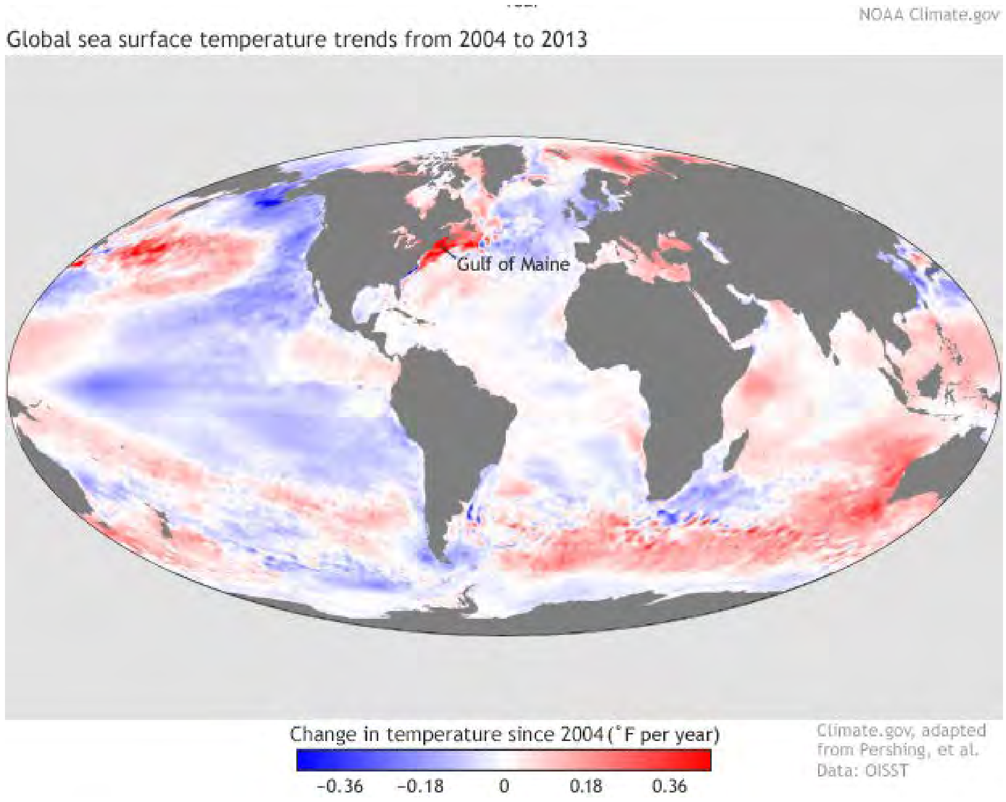
4th Int Symp on The Effects of Climate Change on the World's Oceans- ECCWO

Climate is changing differently across the globe

Warming rates are among the highest in the Gulf of Maine (Pershing et al. 2015)



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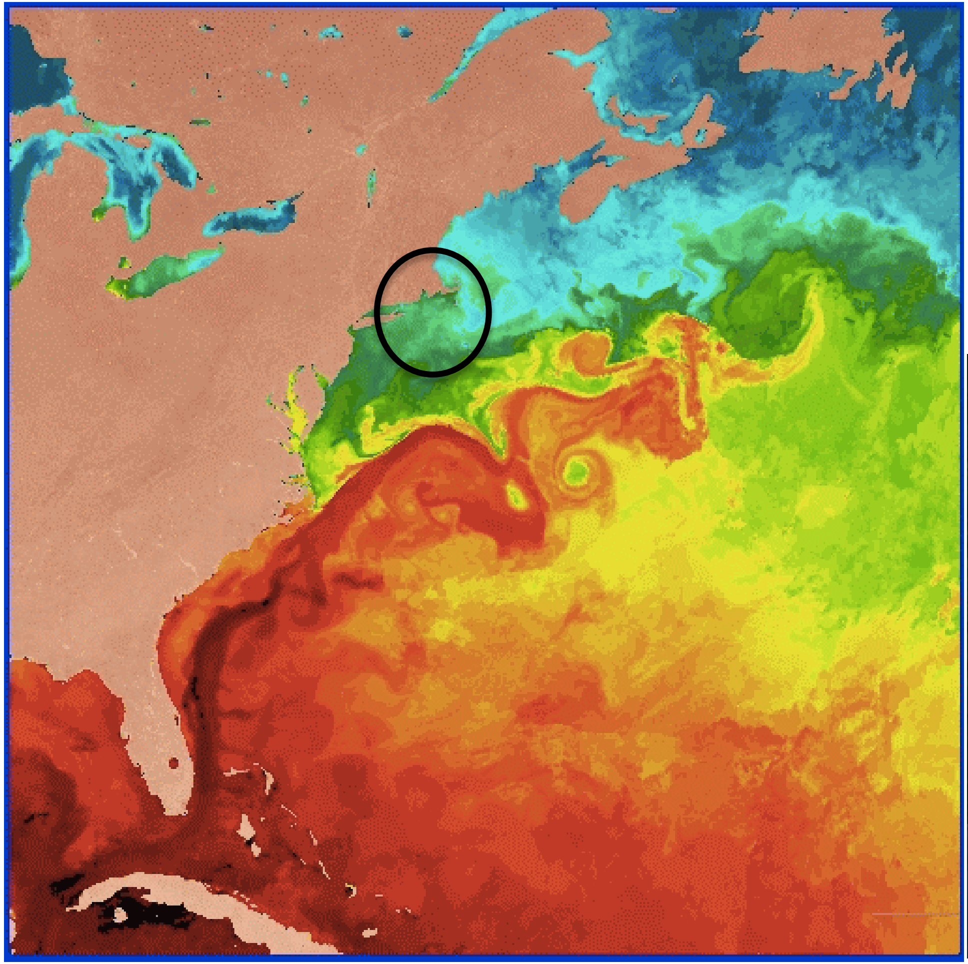
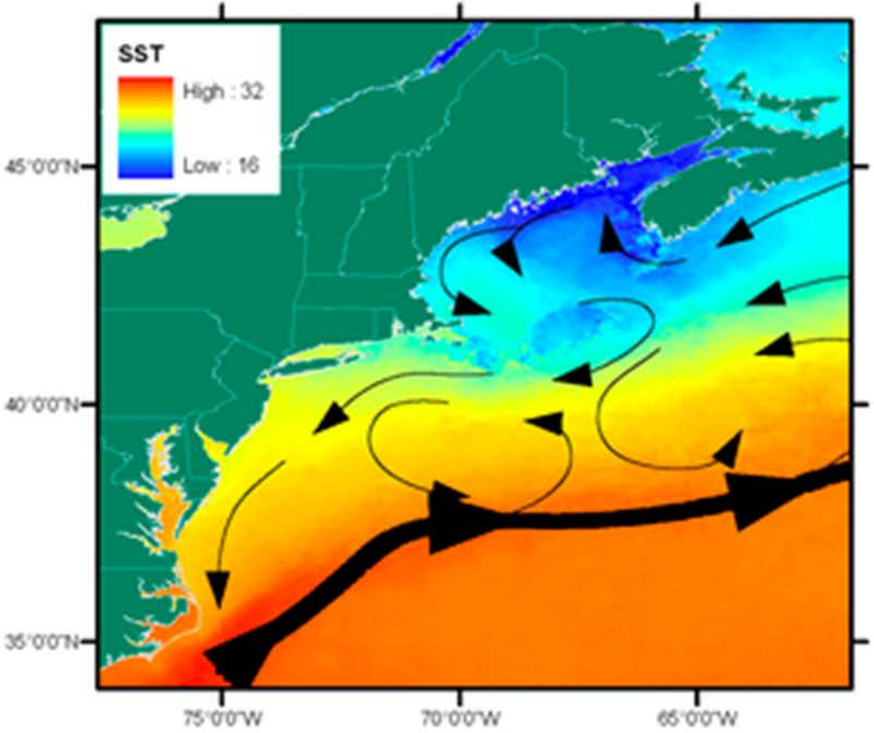
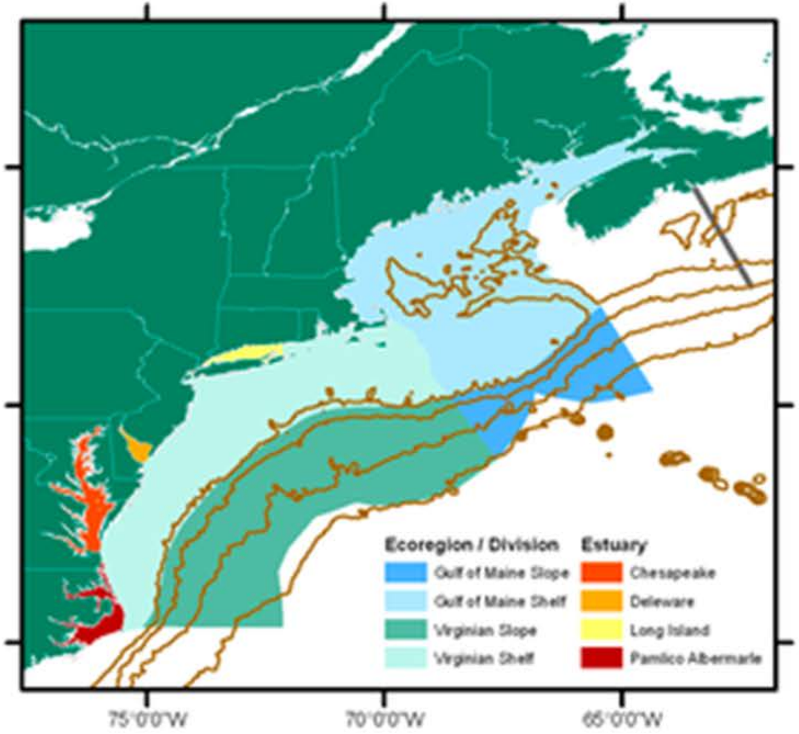


Region is also a major biogeographic boundary

Warm Gulf Stream vs
Nova Scotia and Labrador current

Virginian vs Gulf of Maine bioregions





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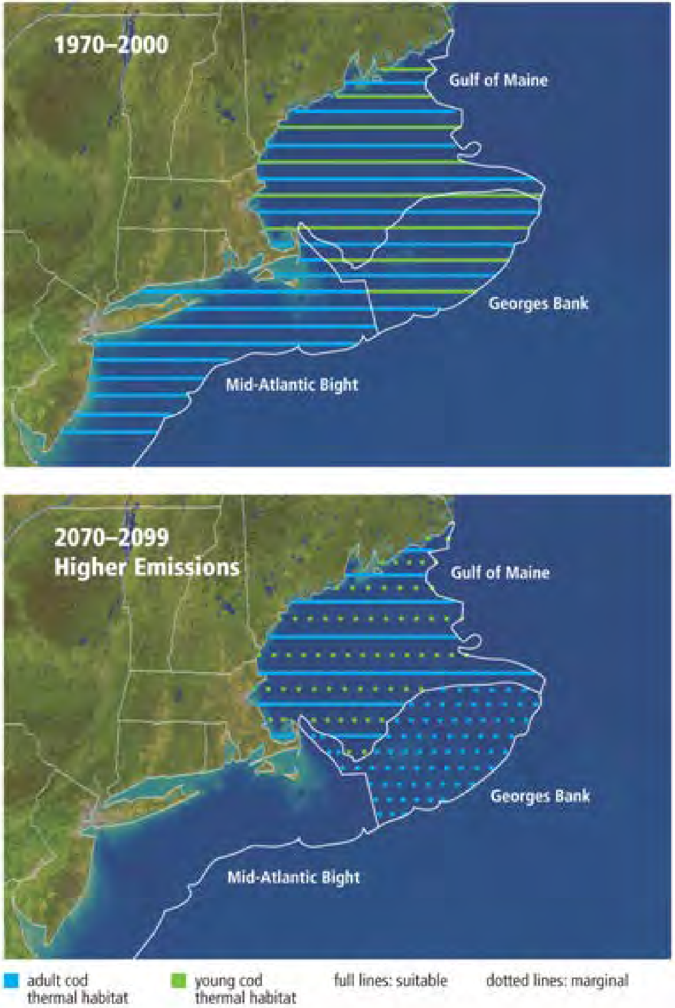
Fautin et al 2010 PlosOne

Species Distribution Shifts

- Fish and phytoplankton populations moving 45 miles/decade - higher latitudes, deeper waters (Molinos et al. 2015)
- Invertebrates species in the North Sea shifting at 3.8 – 7.3 km/y (Hiddink et al. 2015)
- Impacts to human economy and food supply (e.g., cod and lobster)



Frumhoff et al 2007 Report Union of Concerned Scientists

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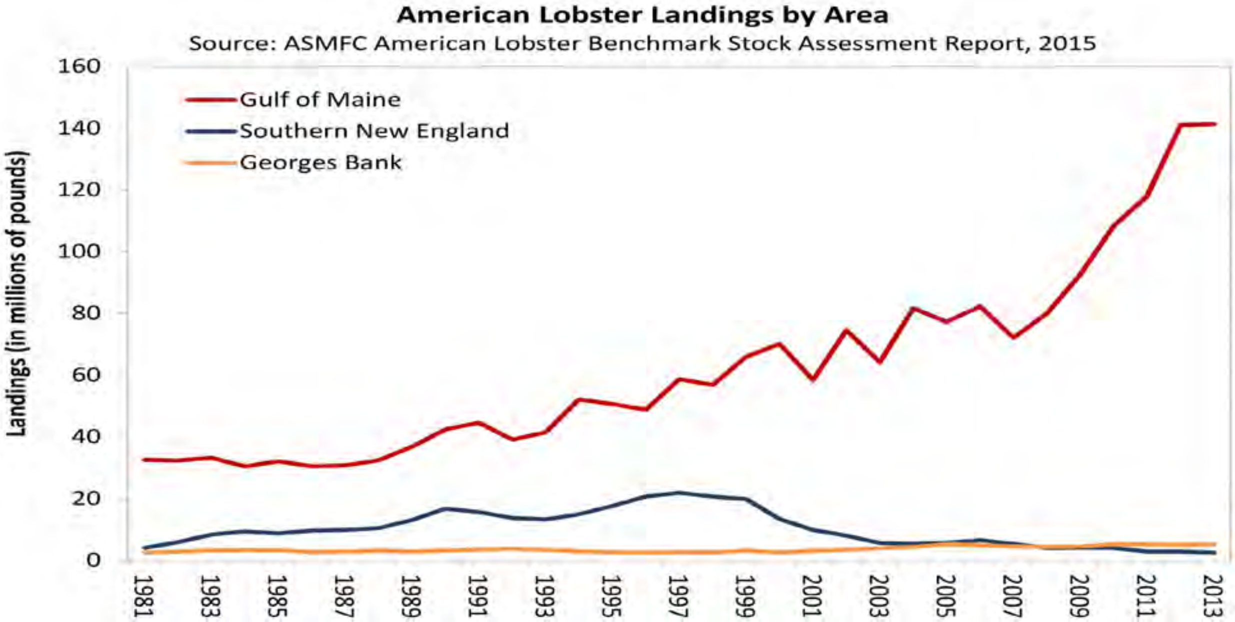
Another species on the move



In Maine, landing increased 219% 1996 -2004

In NY/CT, landings decreased 98%

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Fouling communities

Species in artificial substrates vs natural rocks, ~ 2,000 spp
Ubiquitous, mostly studied as a nuisance and gateway of non-native species

AAAS- Science- 2011

Fouling impacts on economy

ACRDP 2010 Fisheries and Oceans Canada

Ships

- $1M a year on each DDG-51 class ship
- Up to 10 tons of added weight
- Most cost is increased fuel consumption
  minor Hull cleaning/painting (Schultz, 2011)

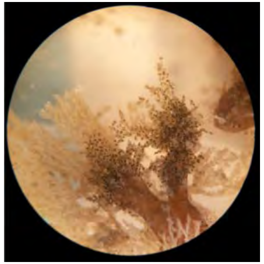
- $36 Billion per year in added fuel cost due to fouling for US shipping industry (Perkins, 2017)

Aquaculture

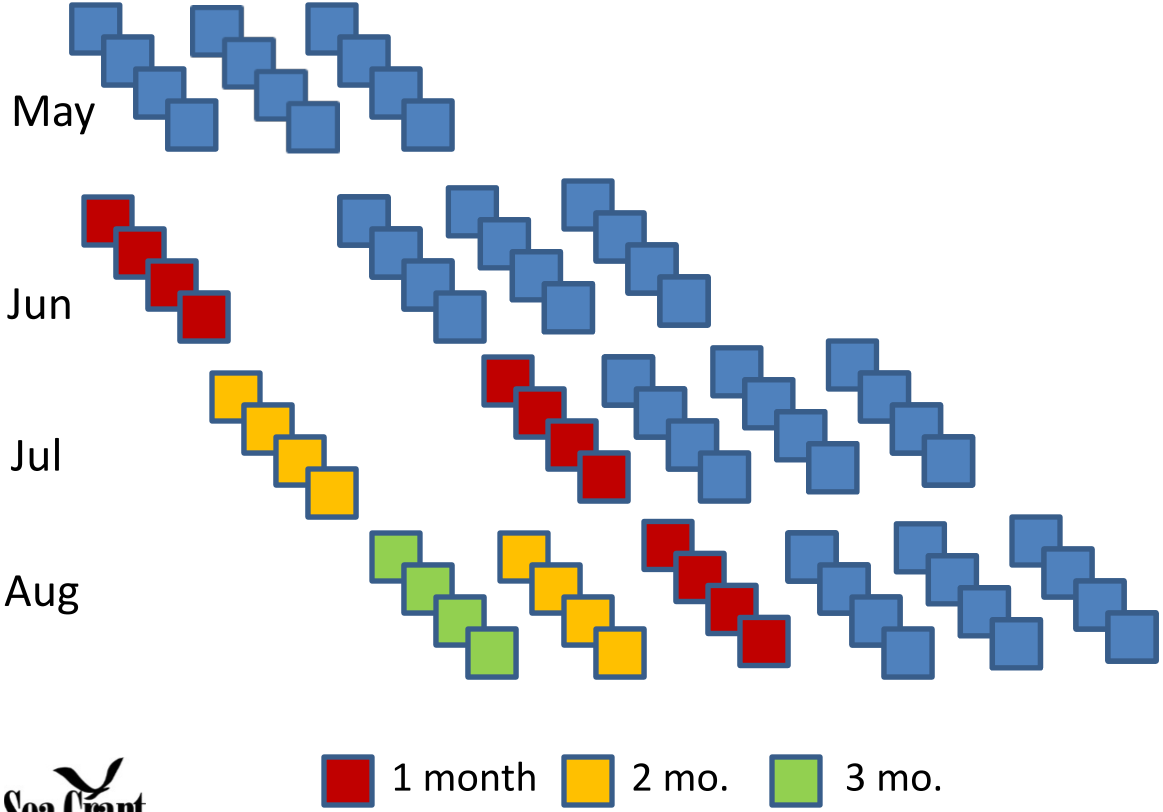
- Mussel in PEI severely affected since 2008 by invasion of 4 ascidians
- Mitigation by pressure cleaning mussel socks reduce 40% of ascidian biomass and double mussel density
- In New Zealand, economic loss of $16.M per year due to biofouling by *M. galloprovincialis* (Forrest and Atalah 2017)

Goals

- Examine differences in the fouling community between two sites in different bioregions
- Assess seasonal pattern for newly established communities
- Compare species occurrence with current and past records



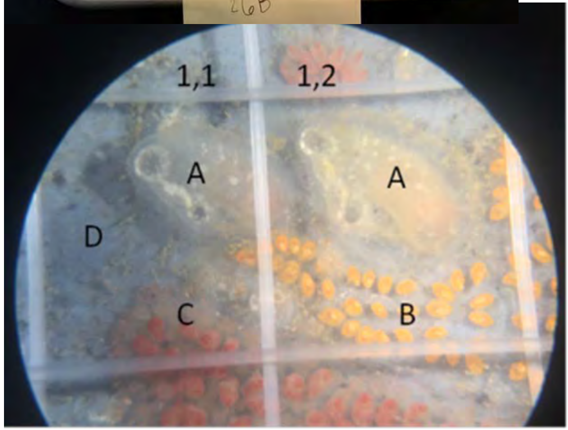
Experimental Design and Methods



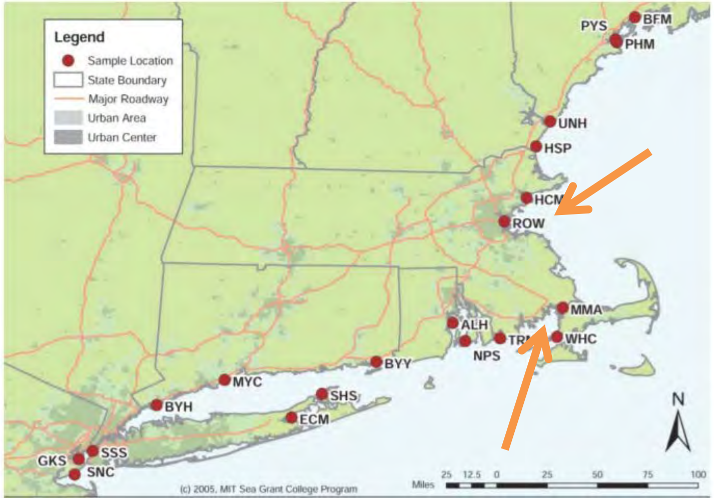
Experimental Design and Methods

Two sites: South and North of the Cape
156 plates at each site
1st installation in May 2016 and last in May 2017

Presented here: Jun –Aug both years and Sep 2016:
63 plates in South and 65 in North site



Pederson et al 2005

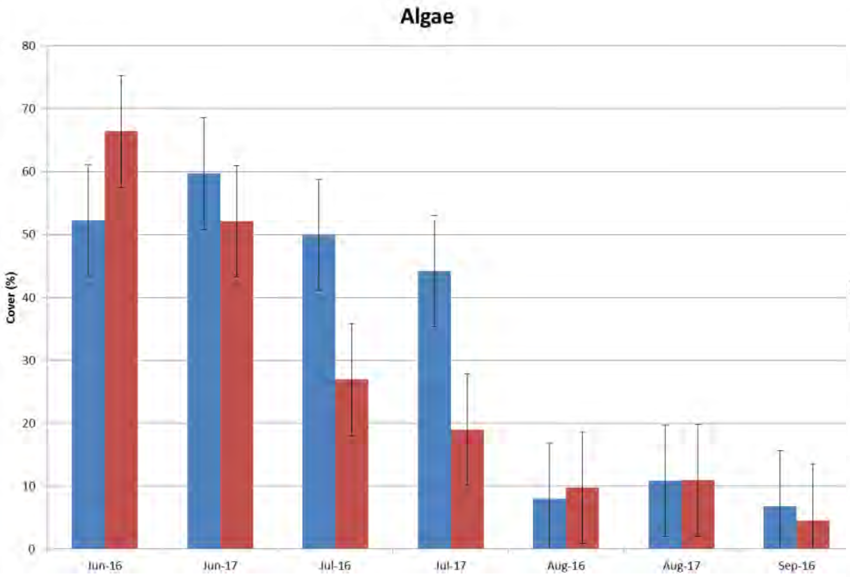


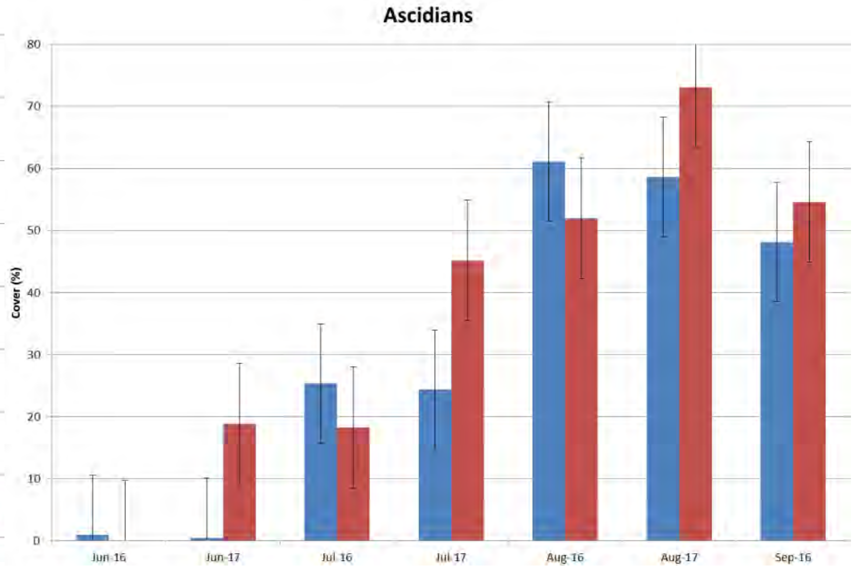
Seasonality of Major Groups

NEA_North

MMA_South

Cover (%)





June 16,17 Jul 16, 17 Aug 16,17 Sep 16

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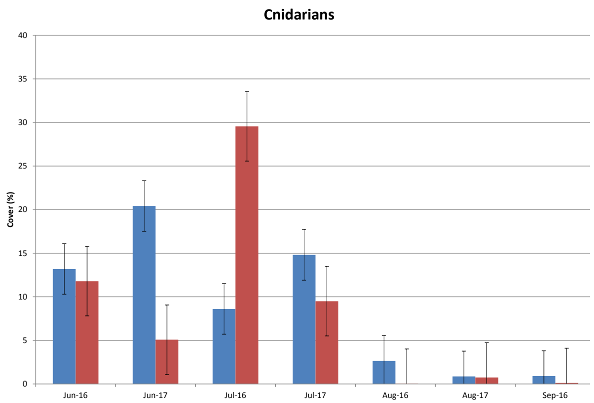
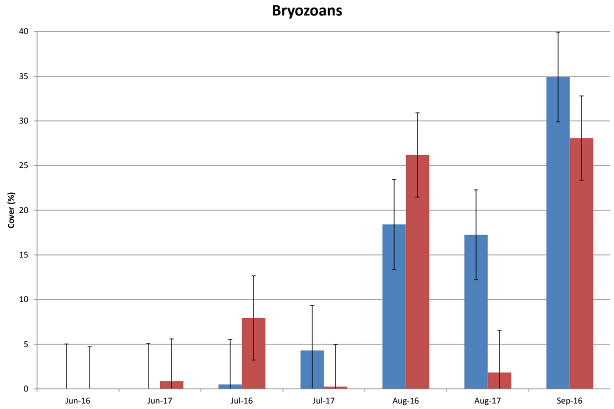
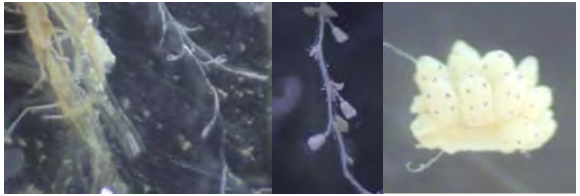
Interannual variability and different species composition







Ectopleura only in the South vs
Obelia / Campanularia spp. more abundant in the North
Could drive differences in nudibranch spp
Eubranchus mostly in the North while *Dendronotus frondosus* and *Aeolidia papillosa* only in the South so far

Amathia vidovici only in the South so far

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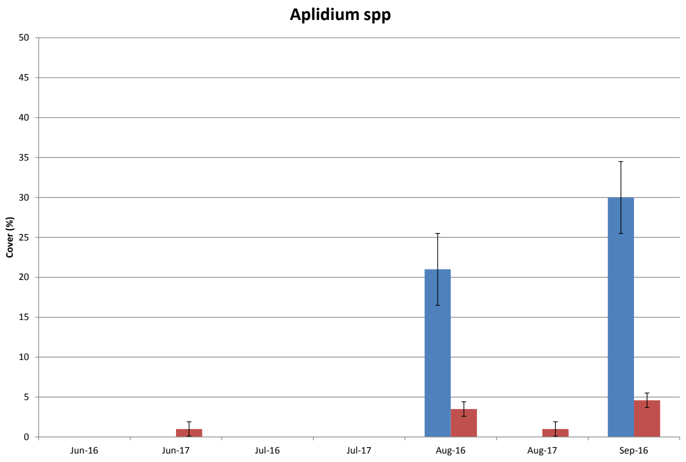
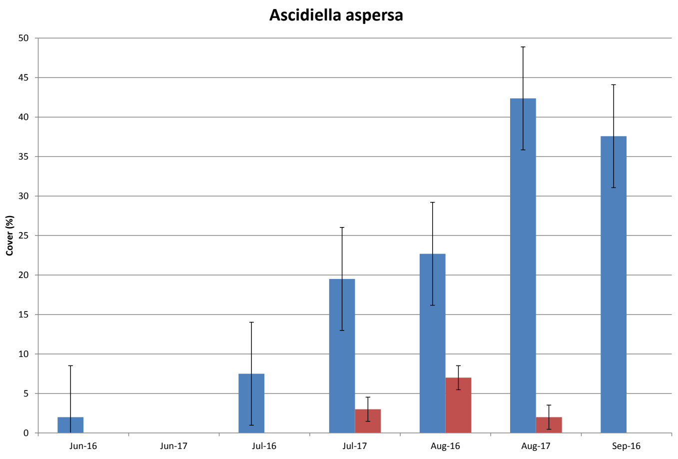
Ascidians with contrasting abundance between sites 1



NEA_North
MMA_South



Solitary ascidian
Introduced from Europe in 1970s
Connecticut to Maine in the US
PEI-Canada 2007
In Ireland, at a site where
min/max T is 6/18 (Lynch et al 2016)

http://www.rimeis.org/

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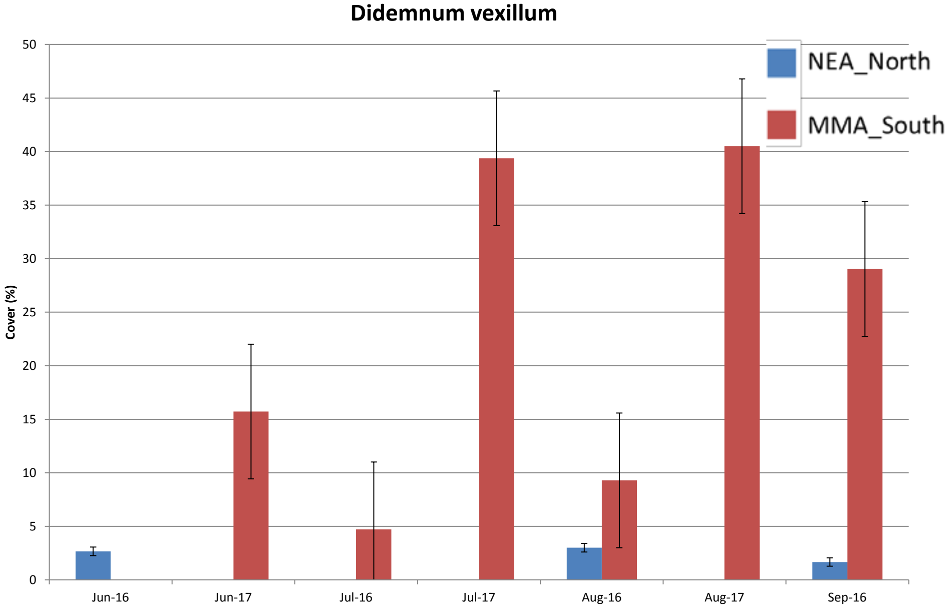
Ascidians with contrasting abundance between sites 2

North example ~4 mm^2
Typically <1 cm^2

South example ~100 cm^2



South site: it might arrive earlier or become less abundant
North site: it can be more abundant

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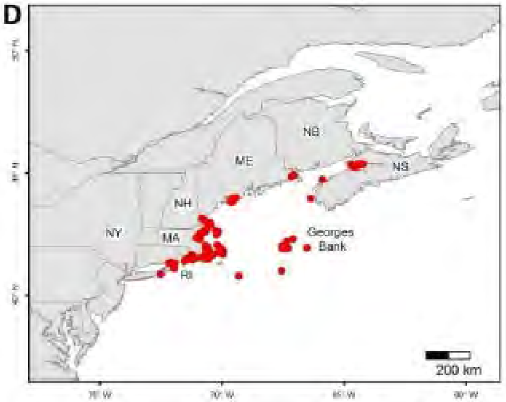
Non-native ascidian *Didemnum vexillum*



Originally from Japan

Now in both US (1980s in the East and 1990s on the West) and Canadian coasts (BC on 2003, 2013 on the East)

Europe: France 1968, The Netherlands 1991, Ireland 2005, UK 2008, Spain 2008, Italy 2012

New Zealand 2001

Survives in – 2 to 24 °C, best at 14- 20, Valentine et al 2009

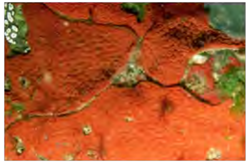
Colonizing poleward in the region but no support of increasing abundance in our North site

McKenzie et al 2017 ICES Cooperative Report No. 335

Northern expansion of species

Taxon	Species	1st Report	ME	East Canada	Gulf of St Lawrence	Newfound-land
Ascidian	*Ascidiella aspersa*	1983, MA	x	2012	------	------
	Botryllus schlosseri	1838, MA	x	decades	2002	1975
	Botrylloides violaceus	1970, MA	x	1997	2002	2007
	Didemnum vexillum	2000, MA (1980, ME)	x	2013	------	------
	Diplosoma listerianum	1980s (RI, NH)	x	2008	2012	------
	Styela clava	1970, MA	x	1997	1997	
	Ciona intestinalis	**Native**	**x**	**1997**	**2004**	**2010**
Bryozoan	*Membranipora membranacea*	1987, NH	x	1990	2003	2002
Amphipod	*Caprella mutica*	2000, MA	x	1990	2000	2006
Decapod	*Carcinus maenas*	1917, 1840	x	1951	2004	2007
Alga	*Codium fragile*	1957	x	1989	1996	2013

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Conclusions and Next Steps

- Dominant species differ between the two sites although major groups are similar. For instance, the non-native ascidian *Didemnum vexillum*, occupied half the space at MMA_South and it almost absent from NEA_North, where few recruits a year did not grow further

- A few taxa are exclusive to one site on plates and will be examined more carefully

- Results will have implications for targets effort to manage species that pervasively affects fishing gear and natural communities but prior to this…..

- Further id is needed to compare presence and abundance with historical records and thermal optima at species level

Thank you!

Acknowledgements

-Funding: MIT Sea Grant

-Access to facilities:

Mass Maritime Academy

New England Aquarium

-Lab work from students: Cristina Rossitto, Stella Engel-Werner, Eleanor Hughes, Maggie LaMaster, Amy Tso

-Field work volunteers: Jessie Wong, Mariah Savoie, Megan Fahey

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