Apr 23rd, 4:00 PM - 5:00 PM

The Ellis Island Effect: Invasive Species in the Mid-Atlantic

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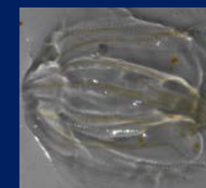
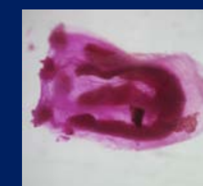
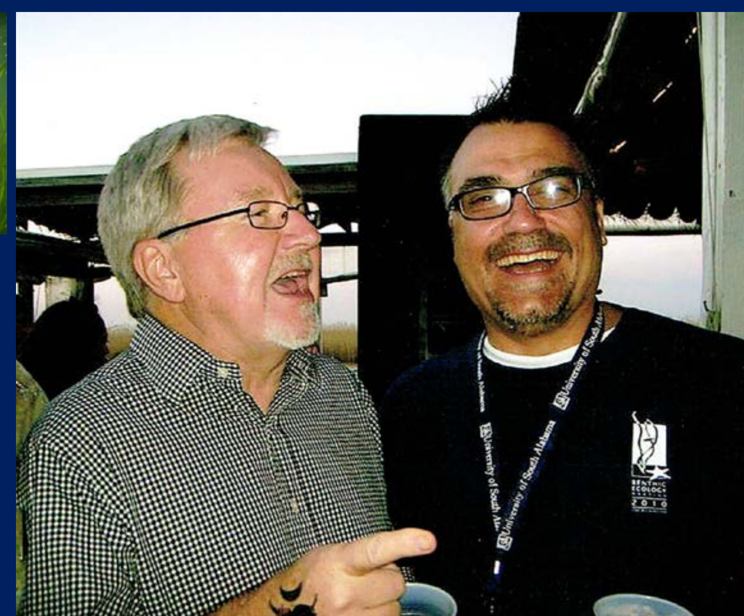
Ellis Island Effect: Invasive Hydrozoans in the Mid-Atlantic and other Jelly Stories

Paul Bologna

Montclair State University







Acknowledgements

- Jack Gaynor, Rob Meredith
- Dena Restaino
- countless students
- NJ Department of Environmental Protection
- Barnegat Bay Partnership
- Save Barnegat Bay
- Jenkinson's Aquarium
- Clean Ocean Action
- Numerous Volunteers
- NJ Jellyspotters on Facebook

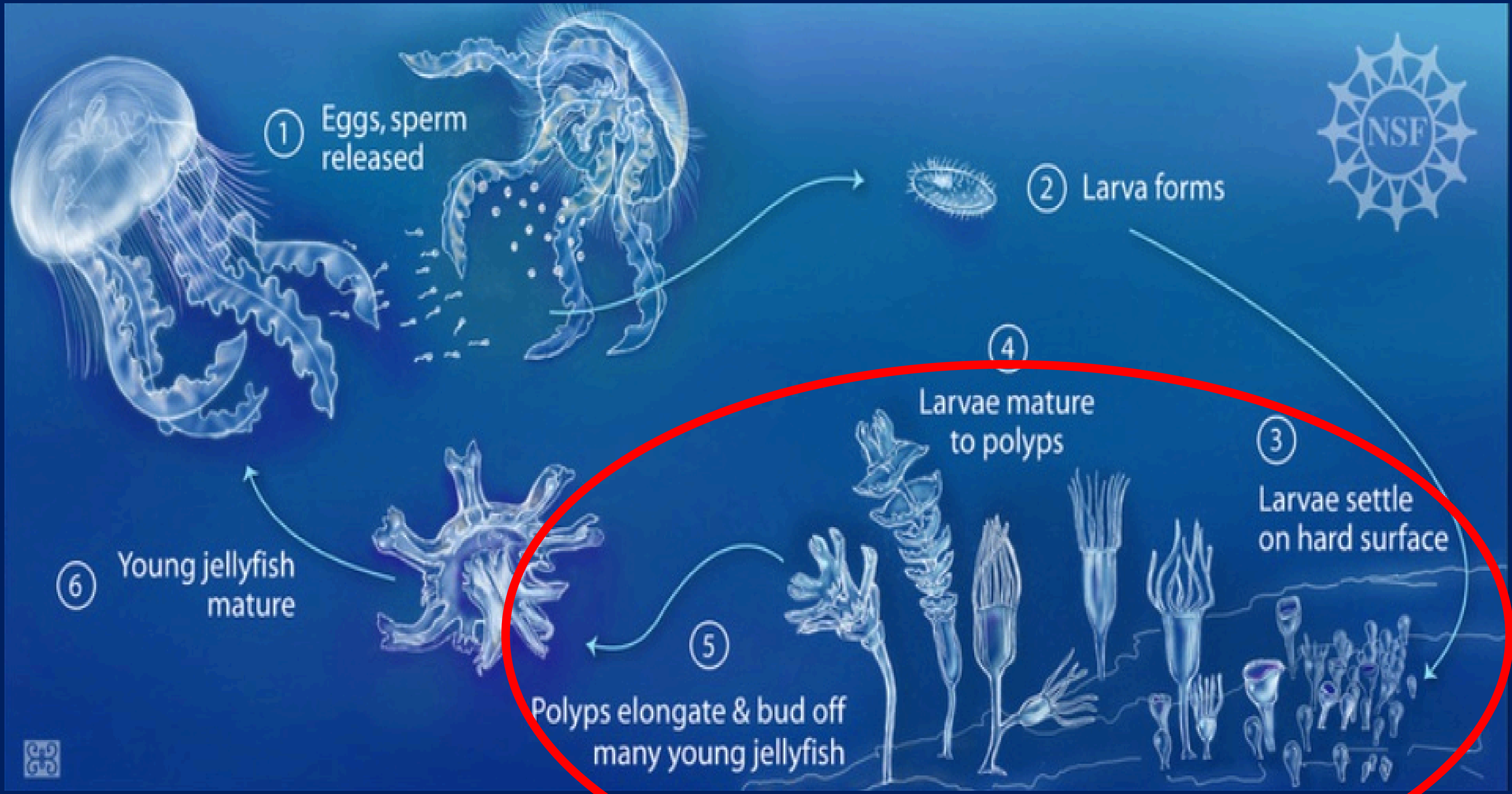
The "New" Jersey Shore

Background on ‘Jellyfish’ Species

- We have Scyphozoans, Siphonophores, Hydrozoans, and Comb Jellies
- True Jellyfish, Hydrozoans, and Siphonophores have Stinging Cells
- Comb Jellies

- All are Vicious and Voracious Predators
  - Fish and Fish Larvae
  - Crab Larvae
  - Clam Larvae

Biology 101: Life History of Jellyfish

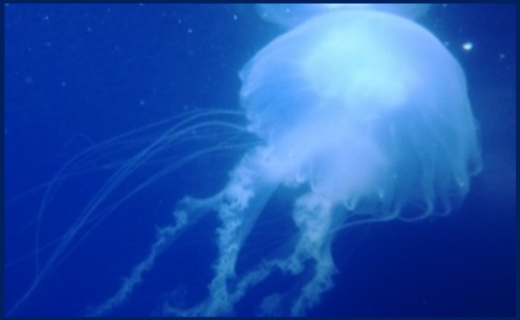


Houston, we don't have a jellyfish problem, we have a polyp problem

http://jellieszone.com/scyphomedusae/

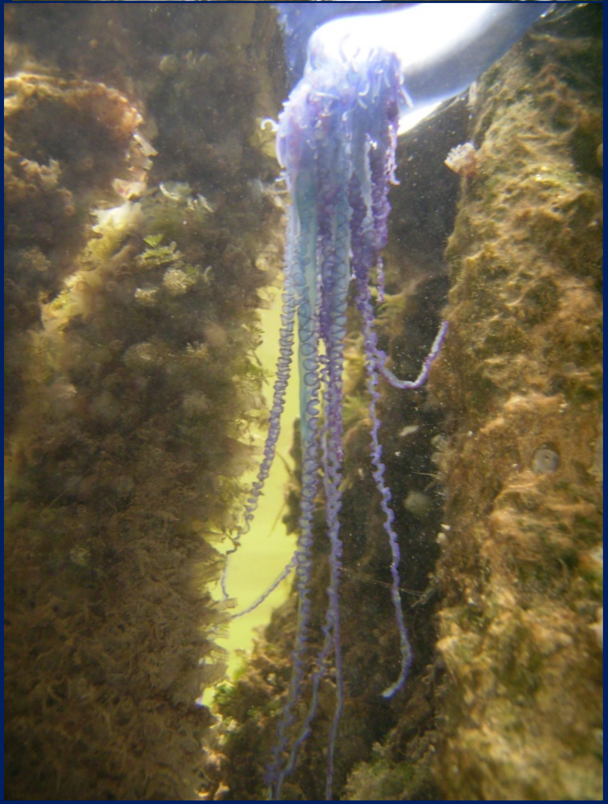
True Jellyfish

- Sea Nettle
- Moon Jellyfish
- Lion’s Mane
- Mushroom Jelly
- *Aequora*
- Box Jellyfish



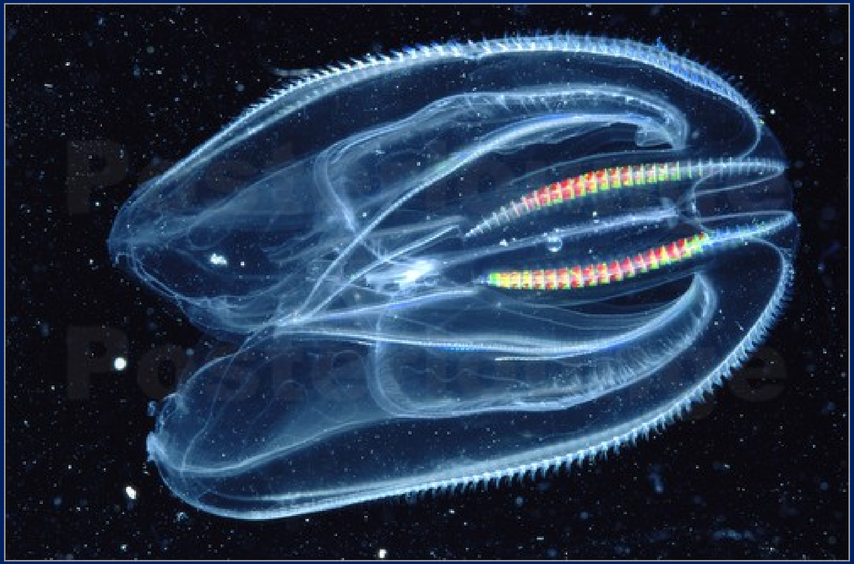
Siphonophores
aka Portuguese Man-of-War

Colonial Organism:
Cloned individuals work together to make the whole


Comb Jellies (Ctenophores)

- Some are Bioluminescent
- Sea Walnuts (*Mnemiopsis*)
- Sea Gooseberry



Global Picture:
Rise of the Jellies

Why should we care?

Blooms have always existed: Life History

Human Exacerbation of Blooms

- **Degraded Water Quality (O$_2$, Nutrients)**
- **Overfishing (Predatory Release)**
- **Shoreline Modification**
  - **loss of coastal wetlands**
  - **Increased polyp habitat**

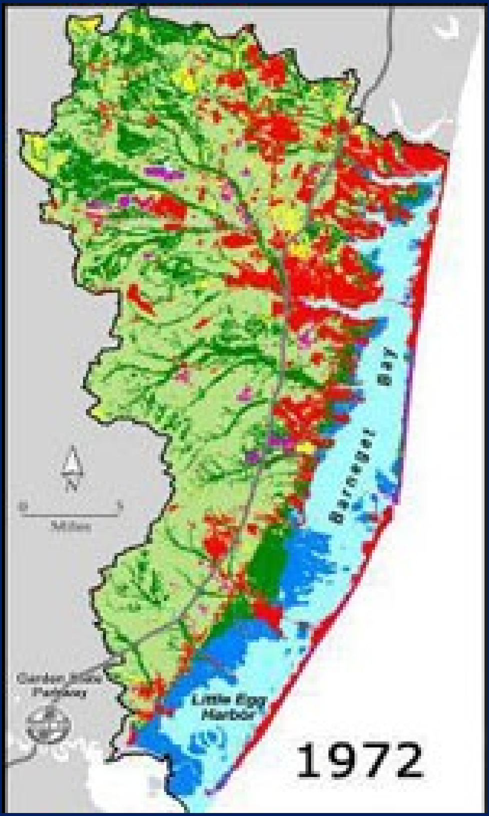
Research Questions
Community Structure Changes

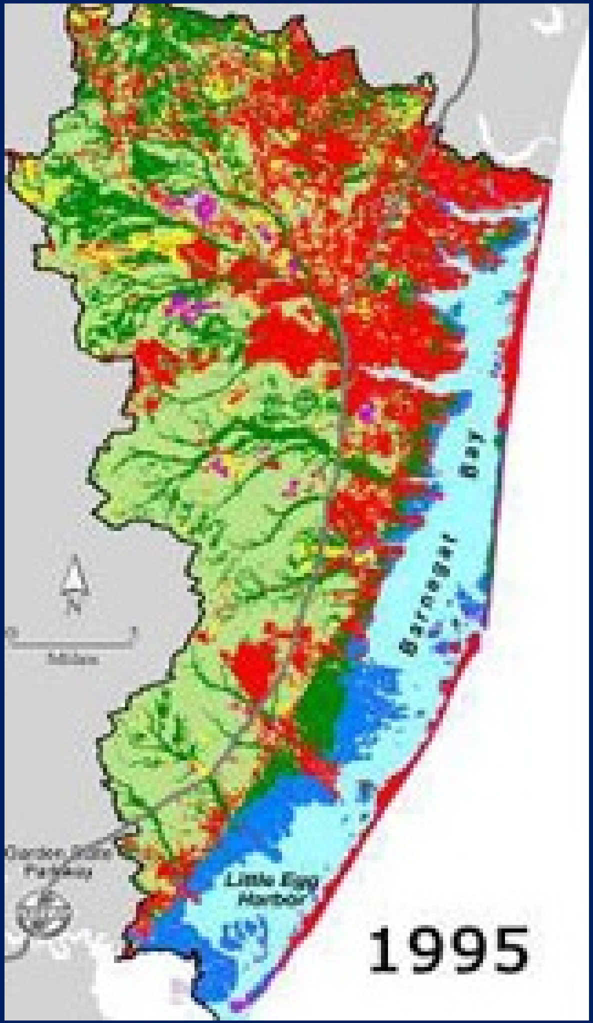
- Communities often defined by dominant Organisms (Sea Nettles, *Chrysaora chesapeakei*)

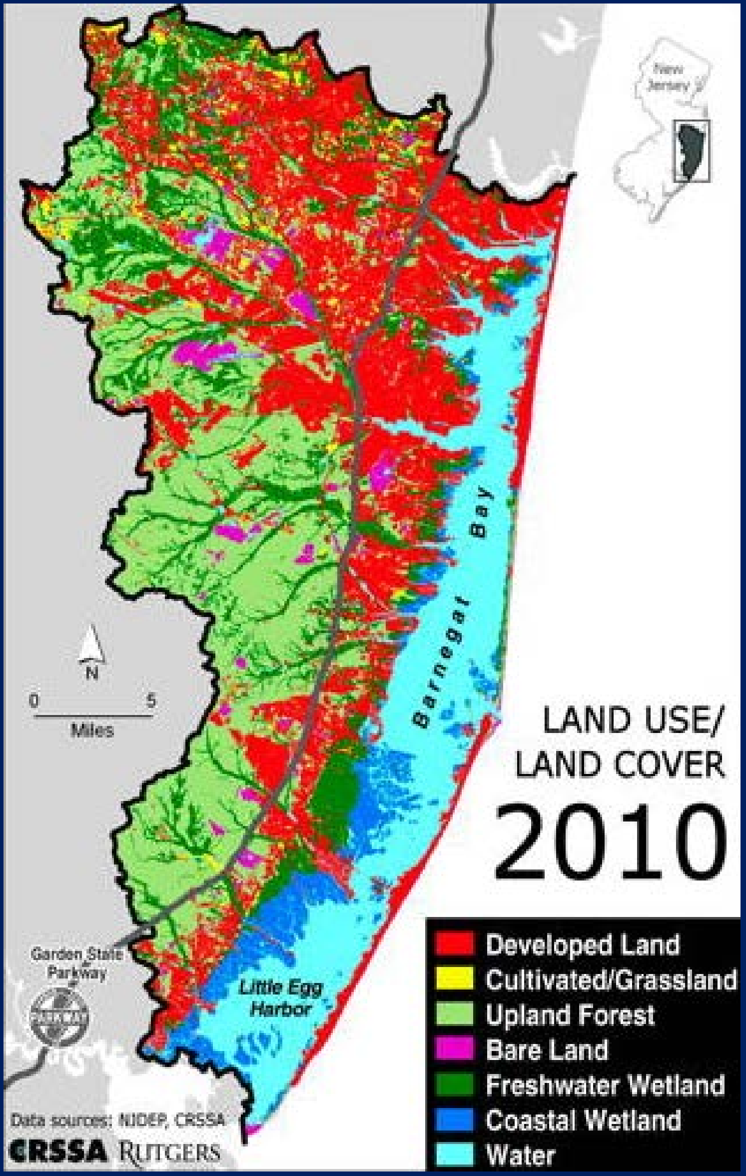
- Community Structure Impacted by disturbances (Man and God)

- Resistance and Resilience determine community succession or shifts to 'Alternate (Stable) States'

Land Use Changes in Barnegat Bay







Man-Made Alterations: Nutrients, Water Quality, Structure

Shoreline Modification

Lagoon Communities

- Restricted Tidal Flow
- Elevated Storm Water Run-off

- Hard Substrates
  - Docks, Bulkheads, etc…

- Replacing toxic materials with ‘green’ building materials
  - Increases Settlement Habitat with limited ‘competition’

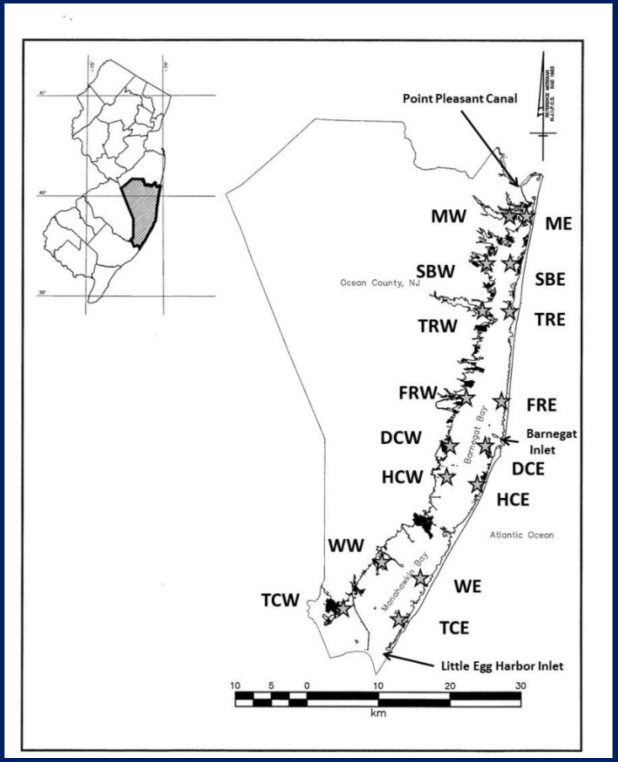
- Jellyfish polyps win by default

Research Objectives

- **Characterize Gelatinous Zooplankton Community**
  - ***No Previous Data***
  - ***Focus on Sea Nettles***
- **Assess Trophic Linkages**
- **Determine the Impact of Hurricane Sandy**

Methodology

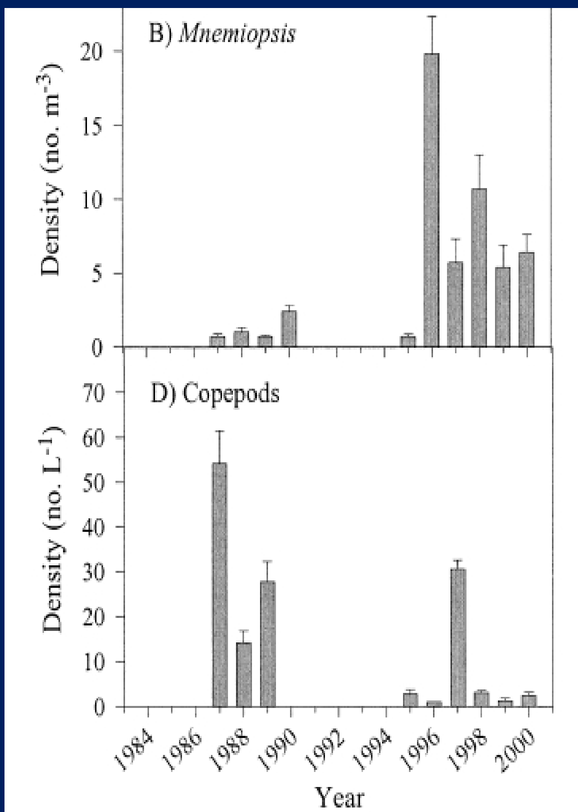
- Monthly Plankton Tows May-September, 2012-2014
- 16 Sites Distributed in the Bay
- Enumeration of *Mnemiopsis leidyi* in field
- Remaining taxa preserved in 95% EtOH
- Laboratory Identification and Enumeration

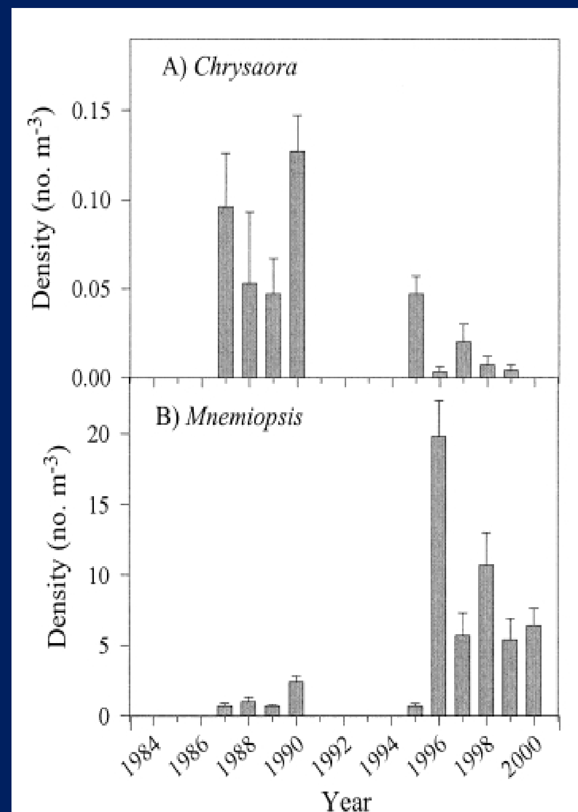


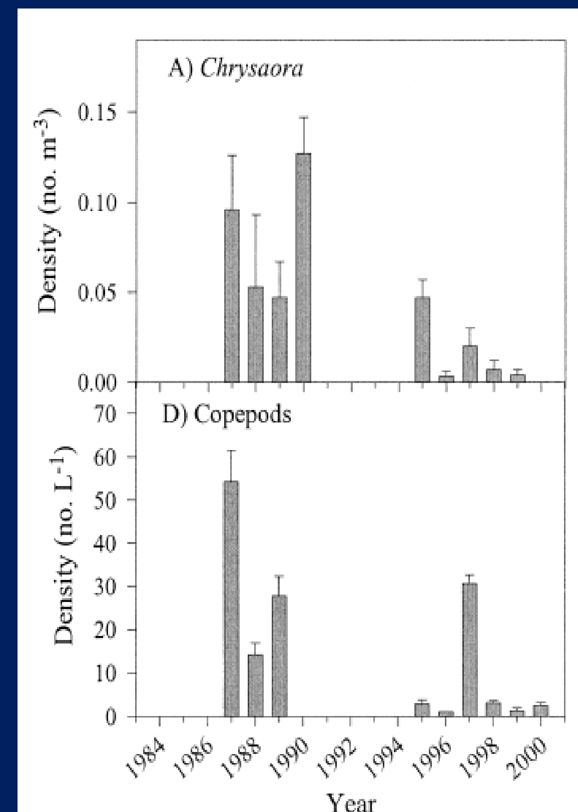
What Role might Sea Nettles Play?

Chesapeake Bay

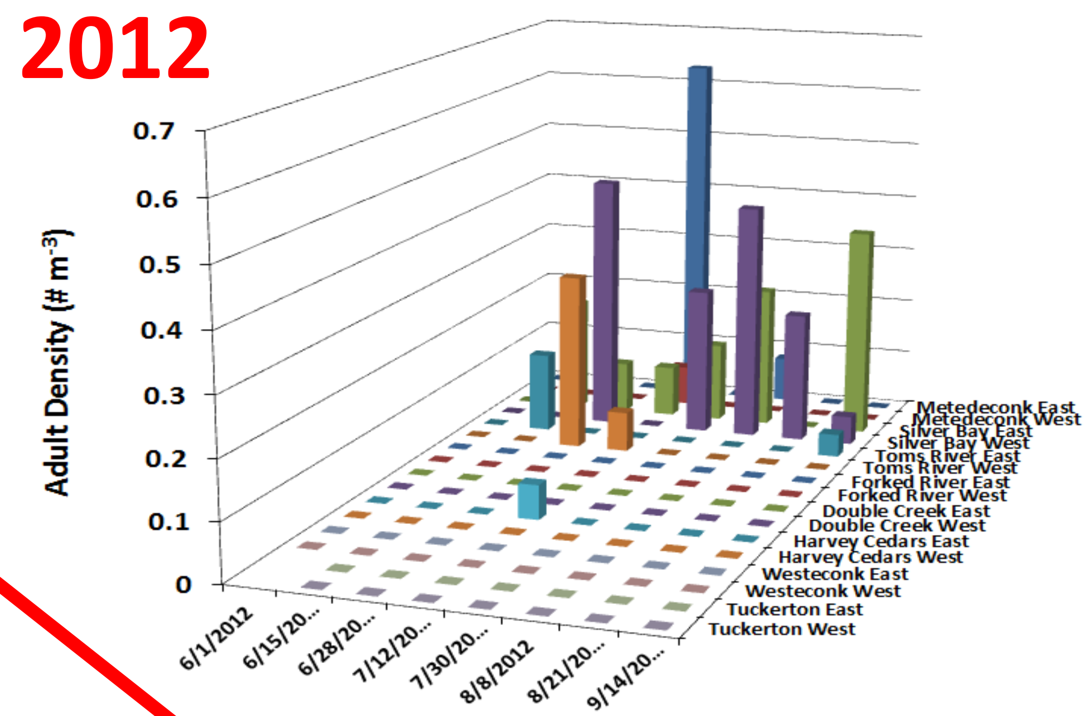
Nettles are top GZ predators, Trophic Cascade

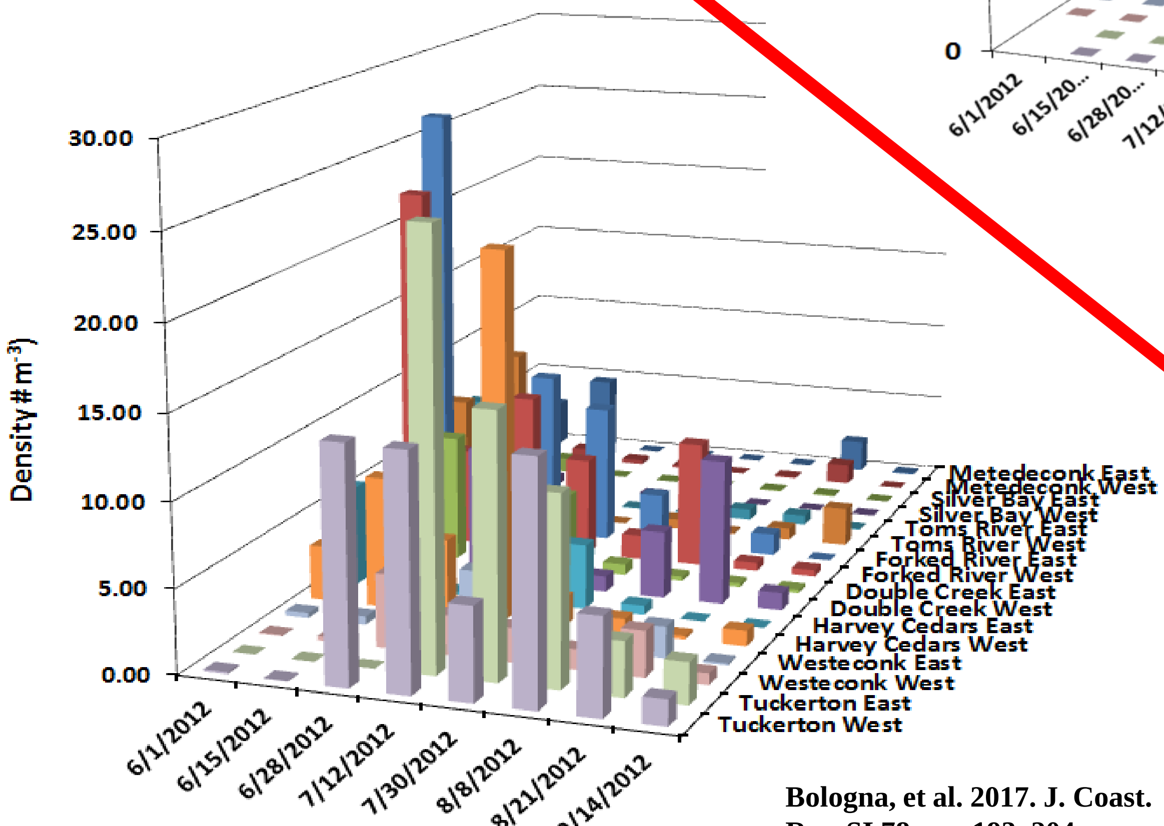






(Purcell & Decker, Limnol. Oceanogr., 50(1), 2005, 376–387)

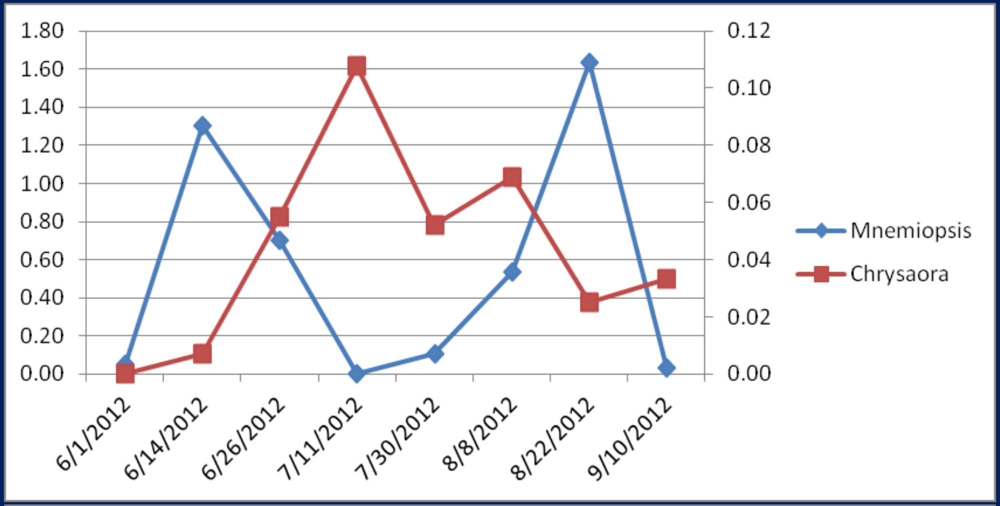


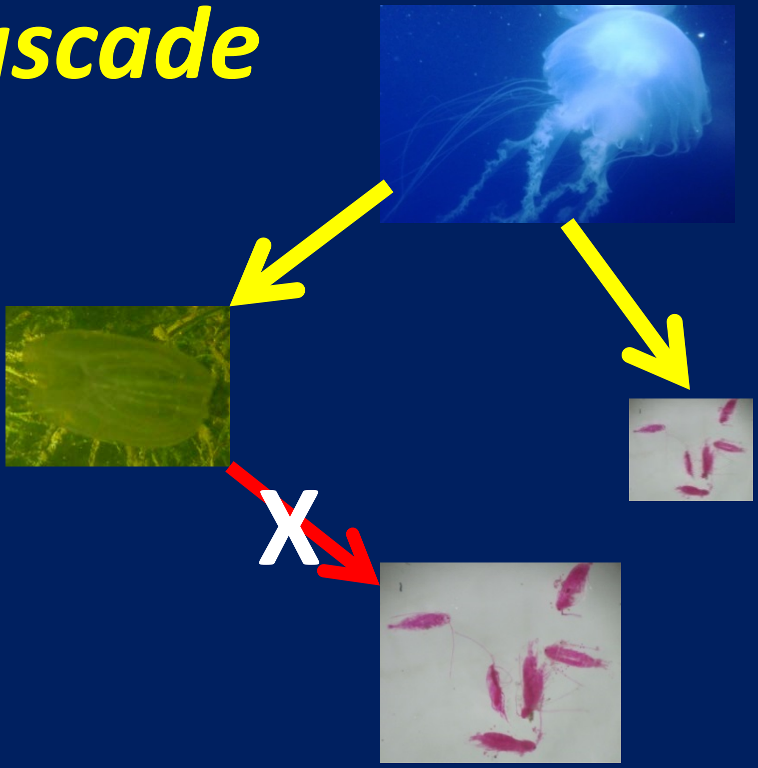


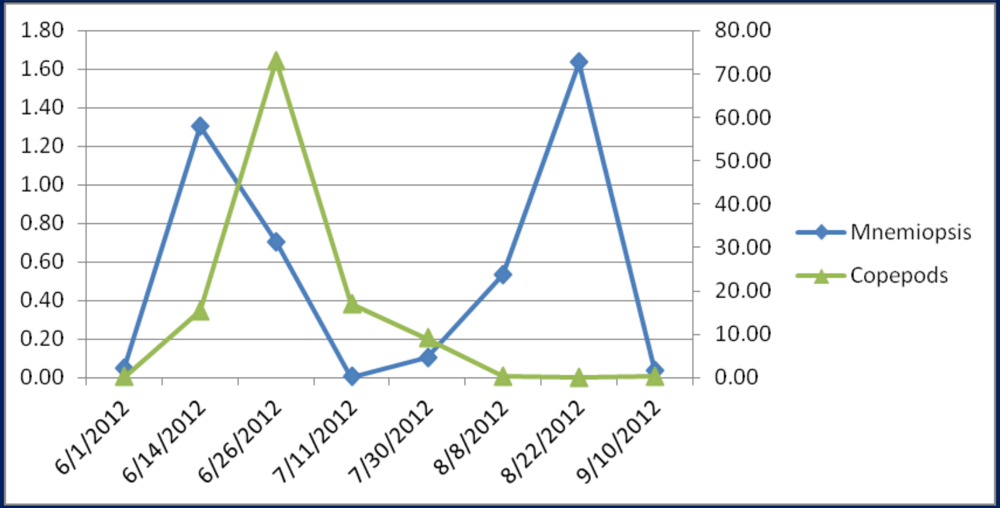
Significant disjoint populations

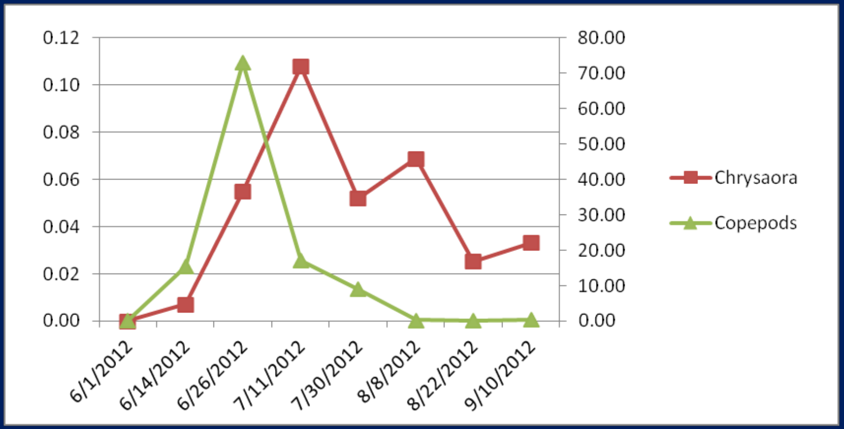
Bologna, et al. 2017. J. Coast. Res. SI 78, pp. 193–204

2012: Strong Top Down Impacts:
No Trophic Cascade

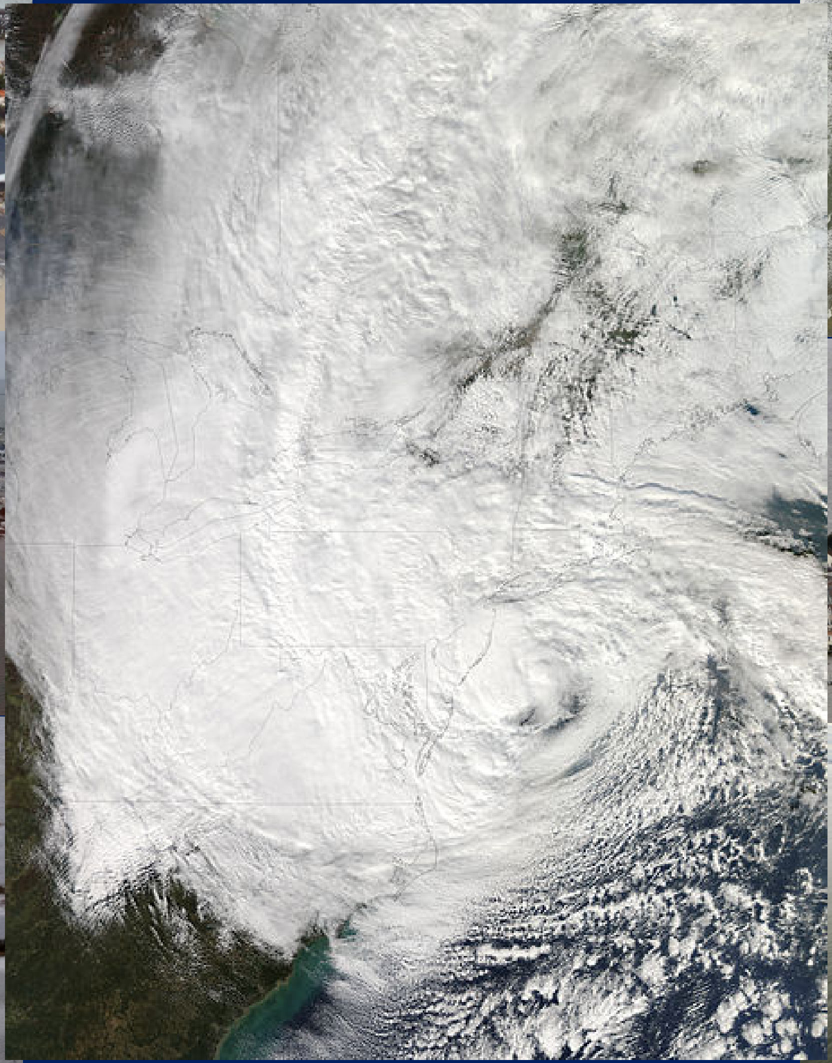




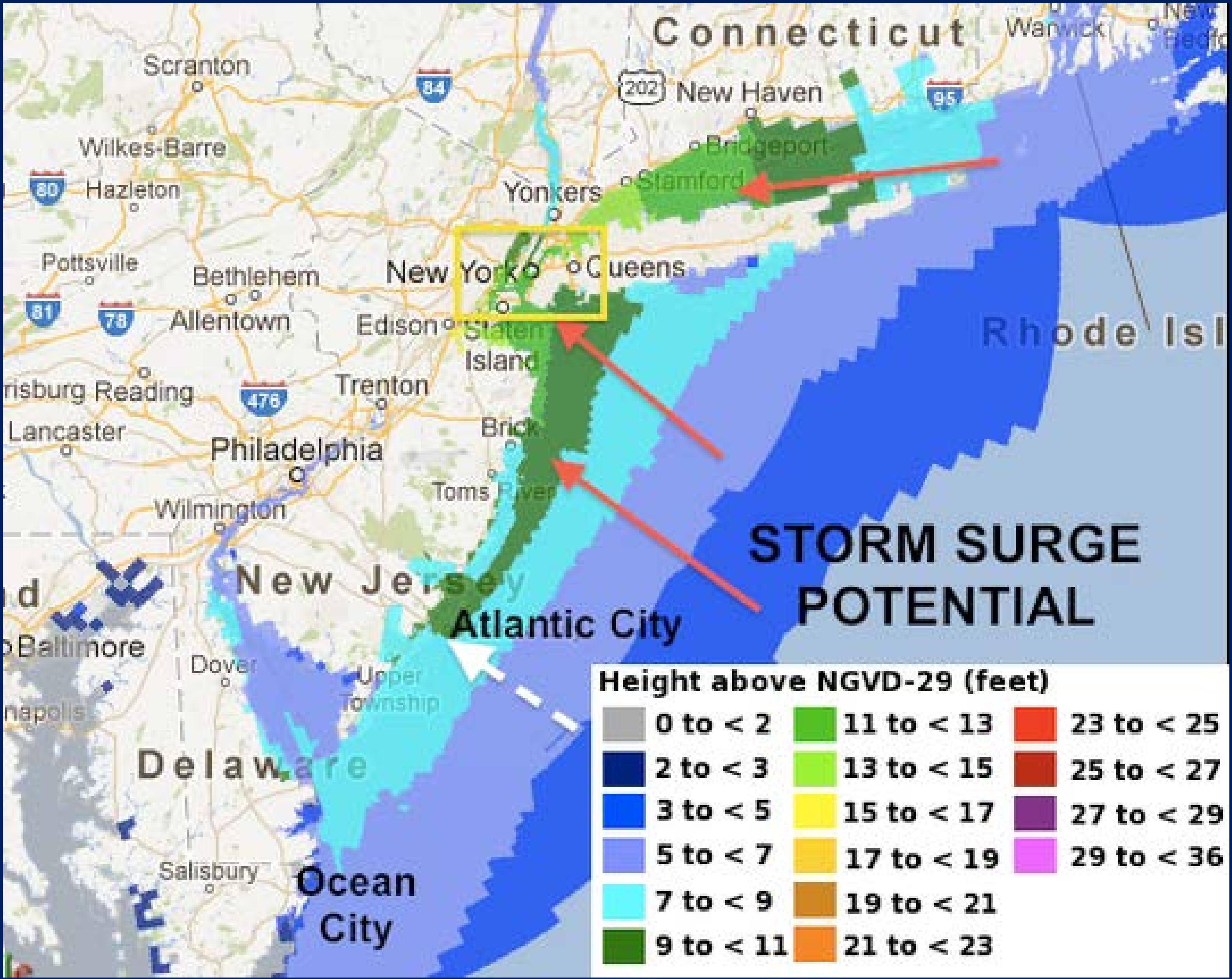




Hurricane Sandy – October 29, 2012



(NASA, US Coast Guard, US Air Force)

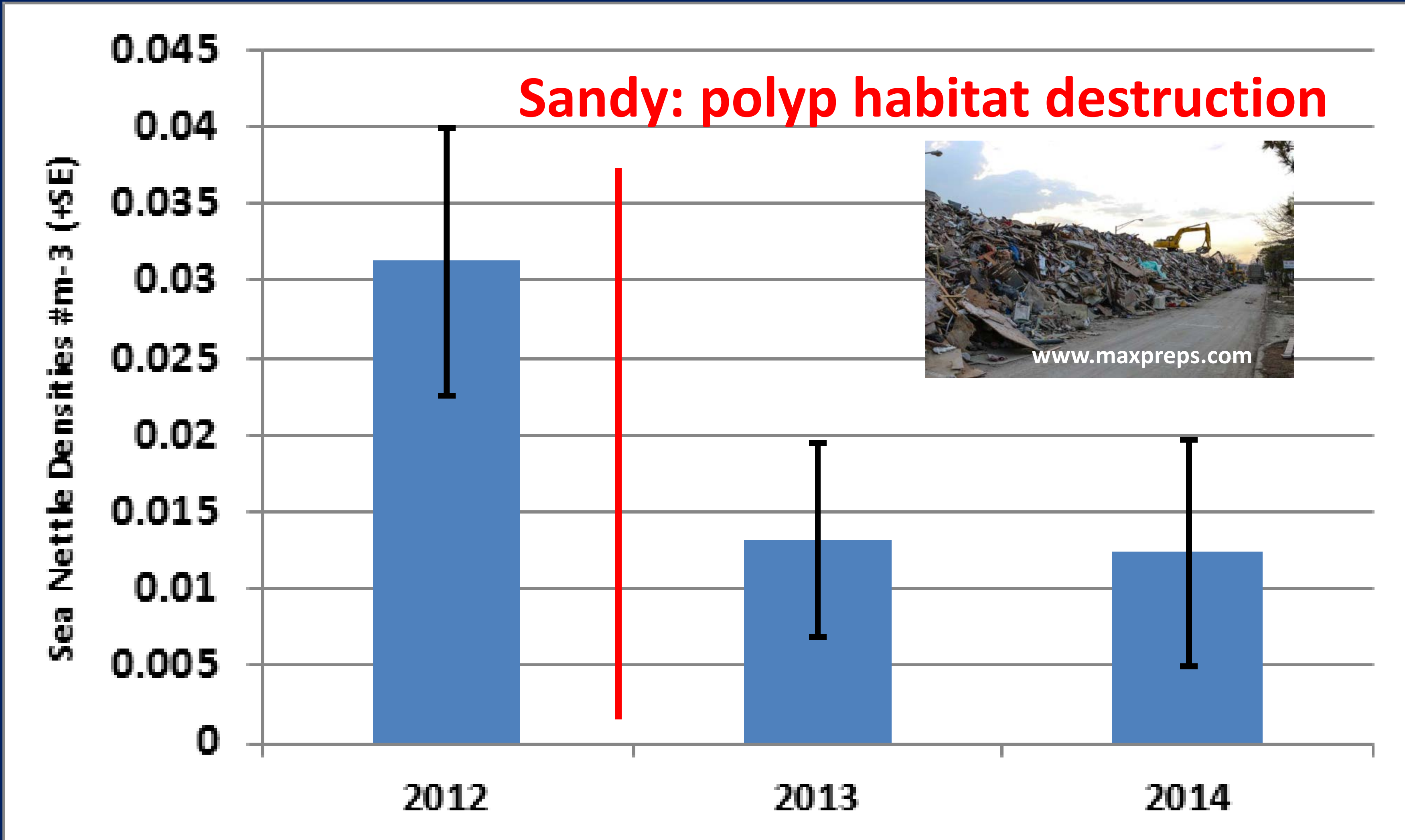


National Hurricane Center

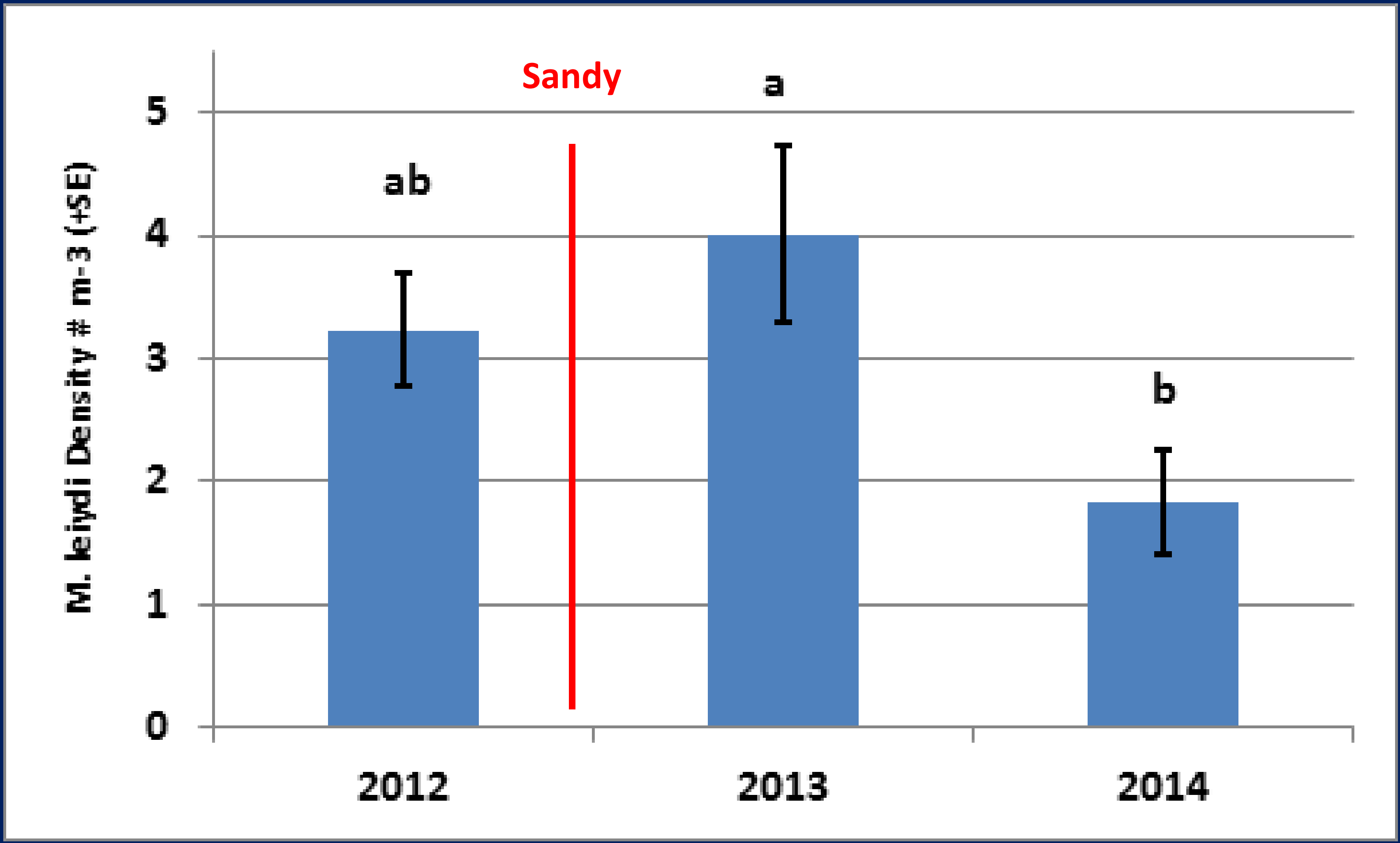
https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&cad=rja&uact=8&ved=0ahUKEwjvsZD0tPPMAhVKPz4KHX6cDtsQjB0IBg&url=http%3A%2F%2Flandsat.gsfc.nasa.gov%2F%3Fp%3D11752&bvm=bv.122676328,d.cWw&psig=AFQjCNGPLPb7FREF7T6Y67mfKPR3T2Ps3w&ust=1464203326510758

Did Sandy Change Community Structure?

Chrysaora chesapeakei Density

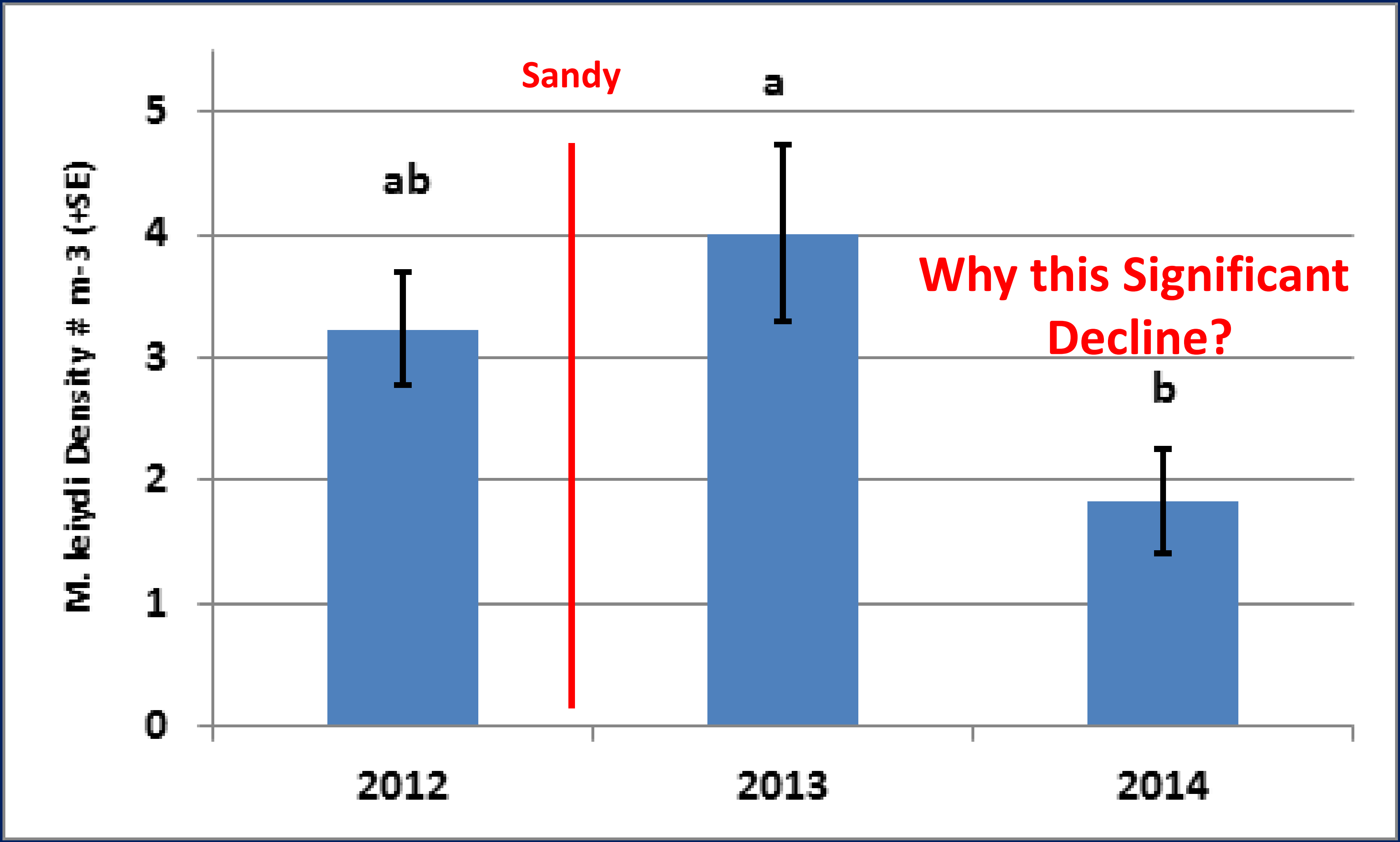


Mnemiopsis leidyi Density



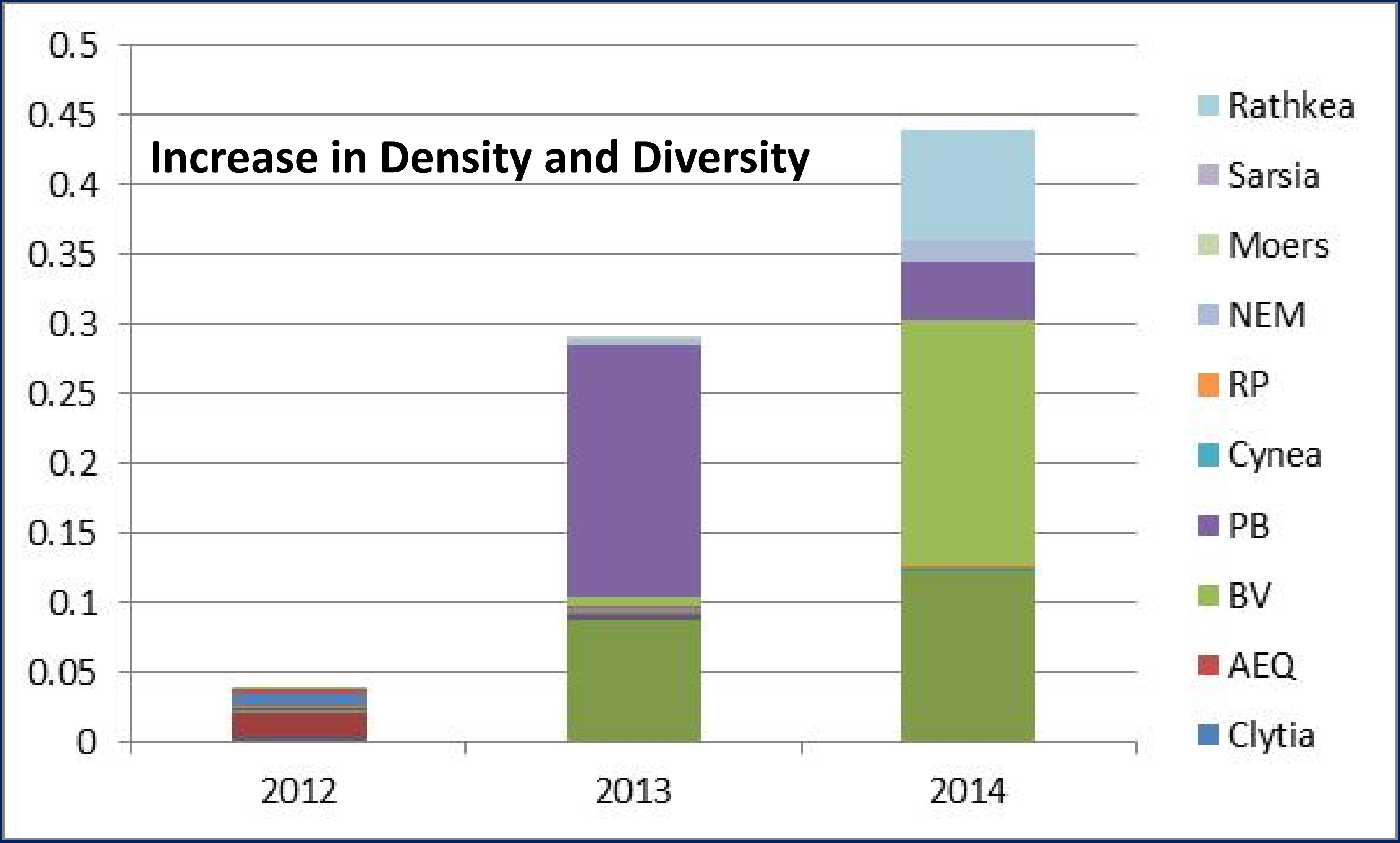
Sea Nettles have little impact post Sandy

Mnemiopsis leidyi Density

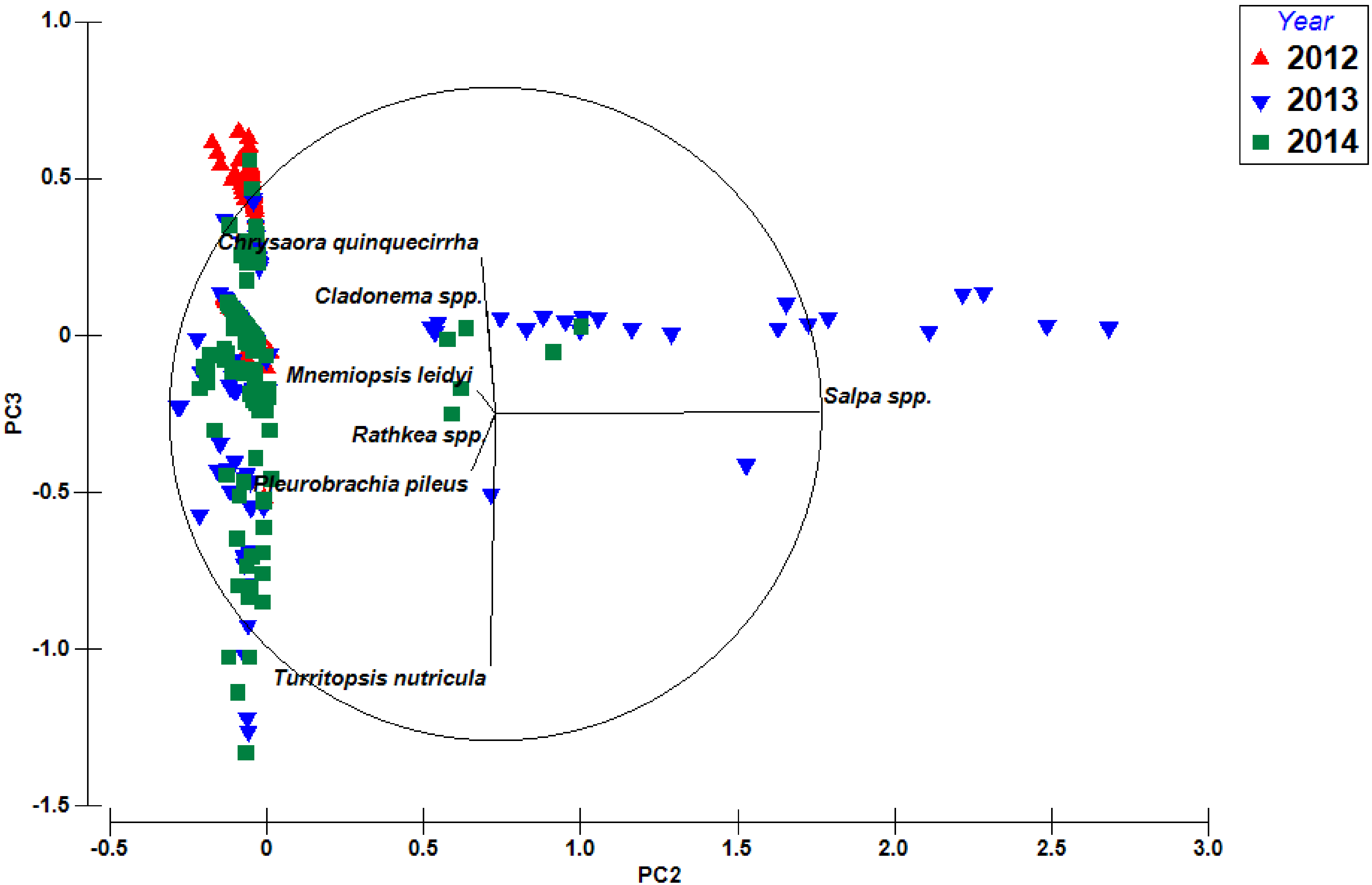


2014 Conundrum

Change in Other Jelly Densities



Defining Community Species



Hurricane Sandy Impacts

- Destroyed *C. chesapeakei* Polyp Habitat
  - Docks, bulkheads, etc…
- Density Declines in *C. chesapeakei*
- Gelatinous Diversity Increased

- Pelagic Community Structure Changed

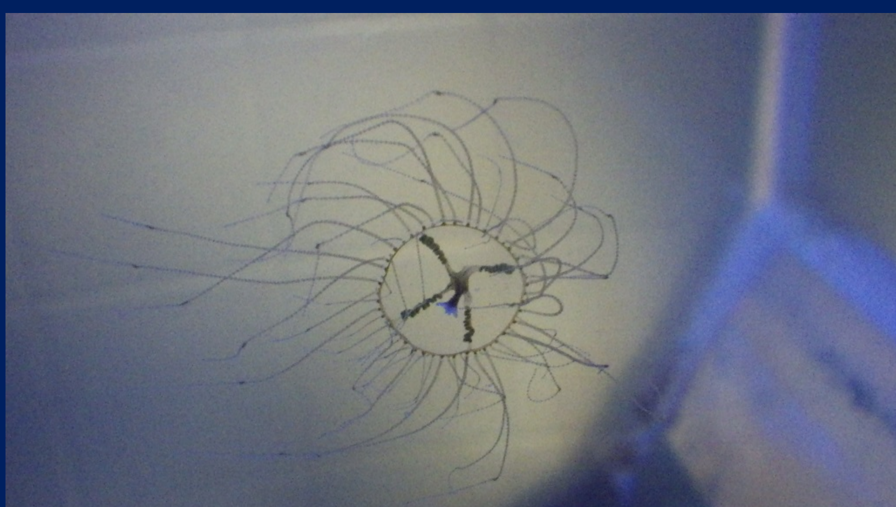
Bologna, et al. 2018. Stochastic event alters gelatinous zooplankton community structure: impacts of Hurricane Sandy in a Mid-Atlantic estuary. Mar. Ecol. Prog. Ser. 591: 217-227.

Changes in Jellyfish Research Directions

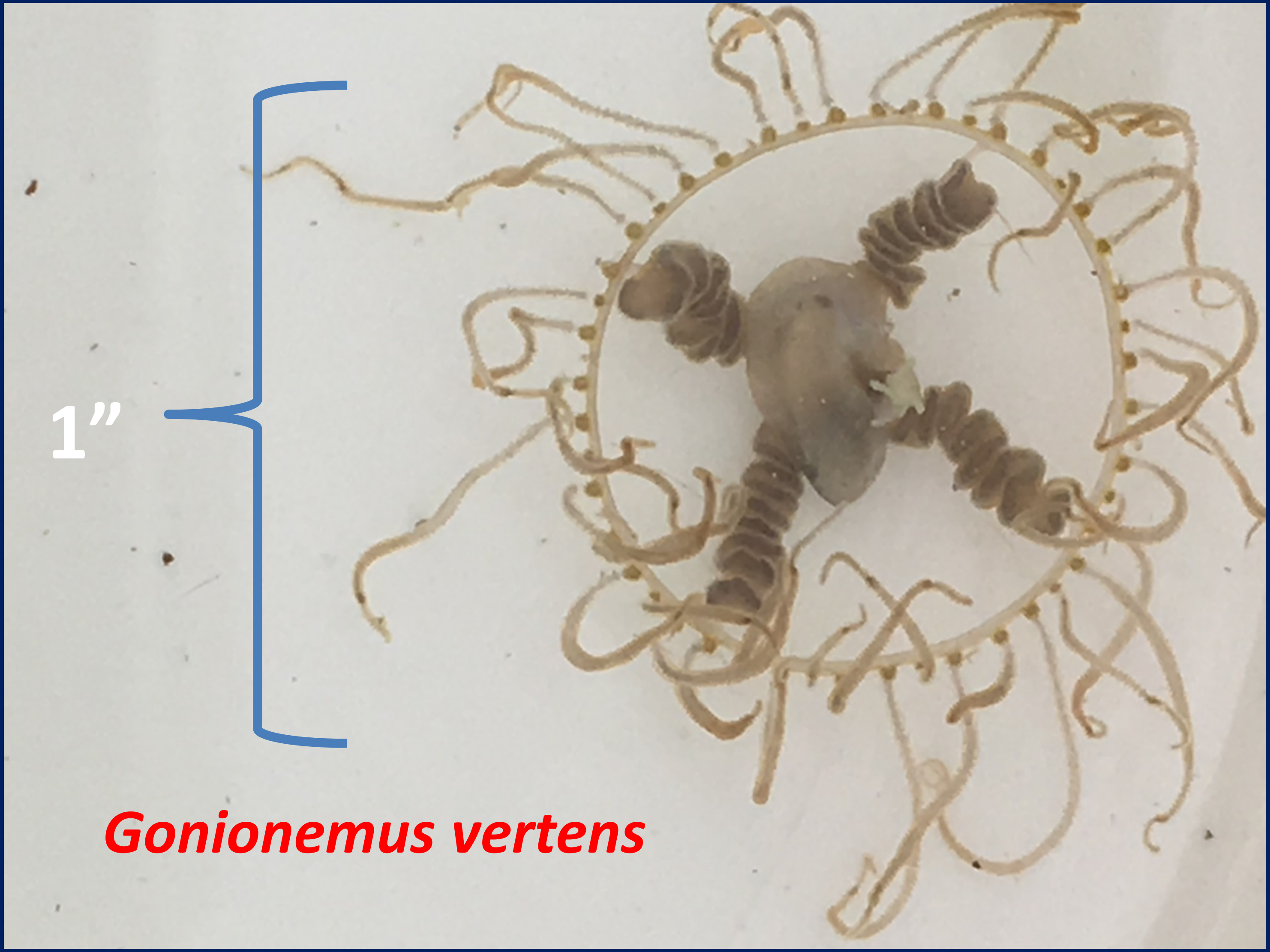
- **Conference Interactions led to new research directions**

5th International
Jellyfish Bloom
Symposium
Barcelona 2016

- ***Intention to search for 'clinging jellyfish' in NJ***
  - *It found us*
  - *Fisherman found one*



New Kid on the Block



Clinging Jellyfish

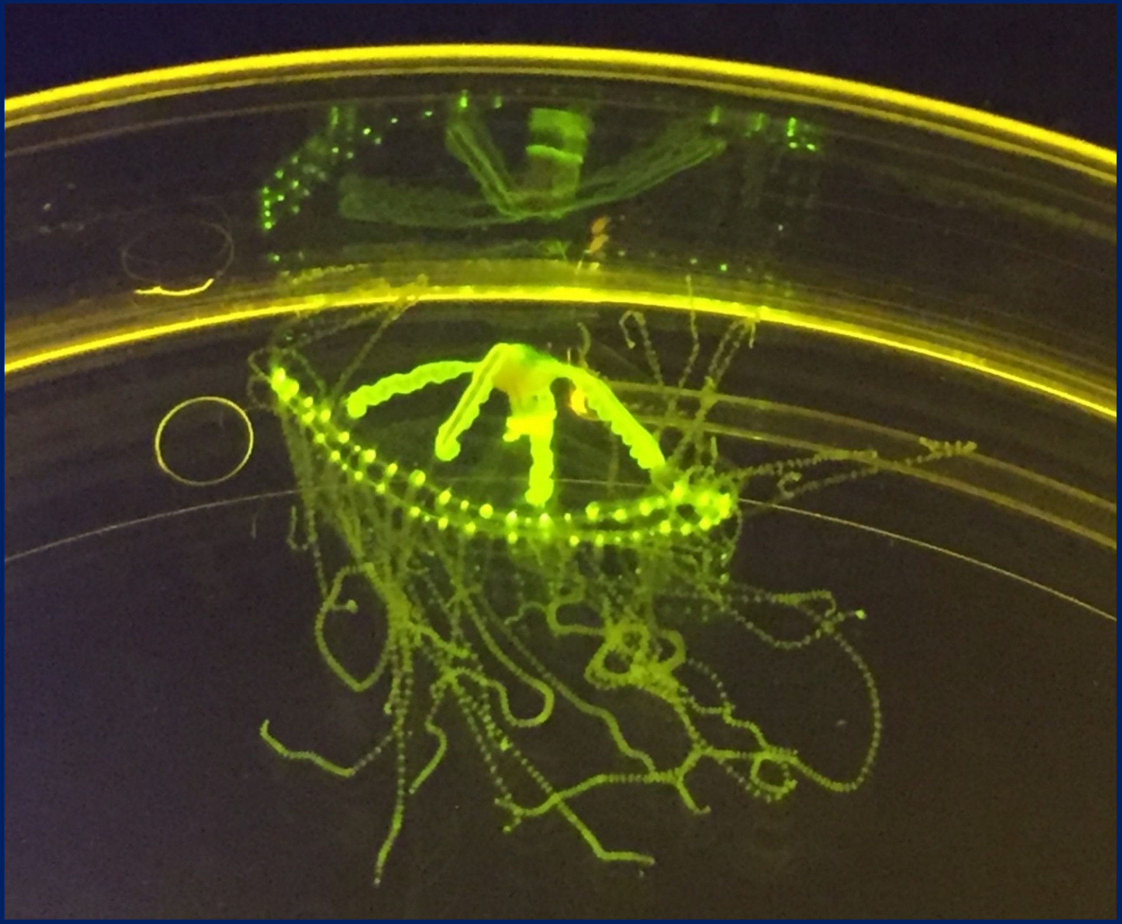
- Invasive, Non-Native Hydrozoan
- Pacific Native, but strong presence in Mediterranean
- First NJ Report
  - Manasquan River
- Small
- Highly Venomous
- Live in Vegetation

Findings to Date

- **DNA confirmation of the Clinging Jellyfish**
  - Gaynor, J., **Bologna, P.**, Restaino, D., Barry, C. 2016. First Occurrence of the invasive hydrozoan *Gonionemus vertens* (Cnidaria: Hydrozoa) in New Jersey, USA. BioInvasions Records 5: 233–237
- **Confirmed Sting Requiring Hospitalization**
  - ***2 Days on Morphine Drip***
- **Active recruitment to our JADs**

Discoveries

- **Clinging Jellyfish Glow in the Dark!**
- **(Fluorescent under blue light)**

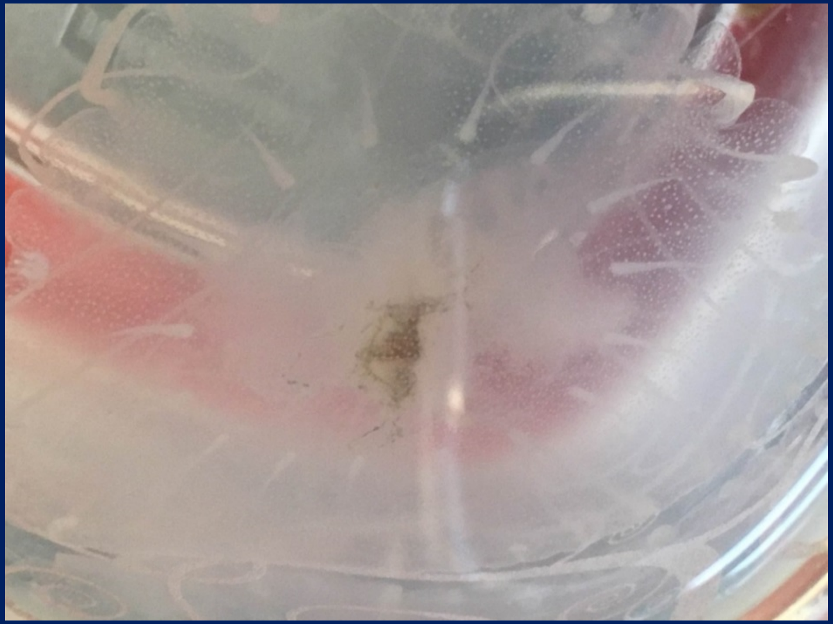


Good News-Bad News

Sea Nettles Eat Clinging Jellyfish

Sea Nettle Diet

- Strong Top-Down Impacts (Bologna et al. 2017)
- Actively feed in vegetation (seagrass and macroalgae)
- Actively feed **ON** the benthos, tentacle dragging (benthic-pelagic coupling)
- Widely varied diet (pelagic and benthic) confirmed through molecular analyses (Meredith, Gaynor, Bologna (2016) Diet Assessment of the Atlantic Sea Nettle *Chrysaora quinquecirrha* in Barnegat Bay, New Jersey using Next Generation Sequencing. Mol. Ecol. 25(24):6248-6266)



Seeing is Believing

Fluorescence

Might allow us to understand Cnidarian digestion

Hooray for Sea Nettles!!!

Despite 5 years of trying to eradicate them

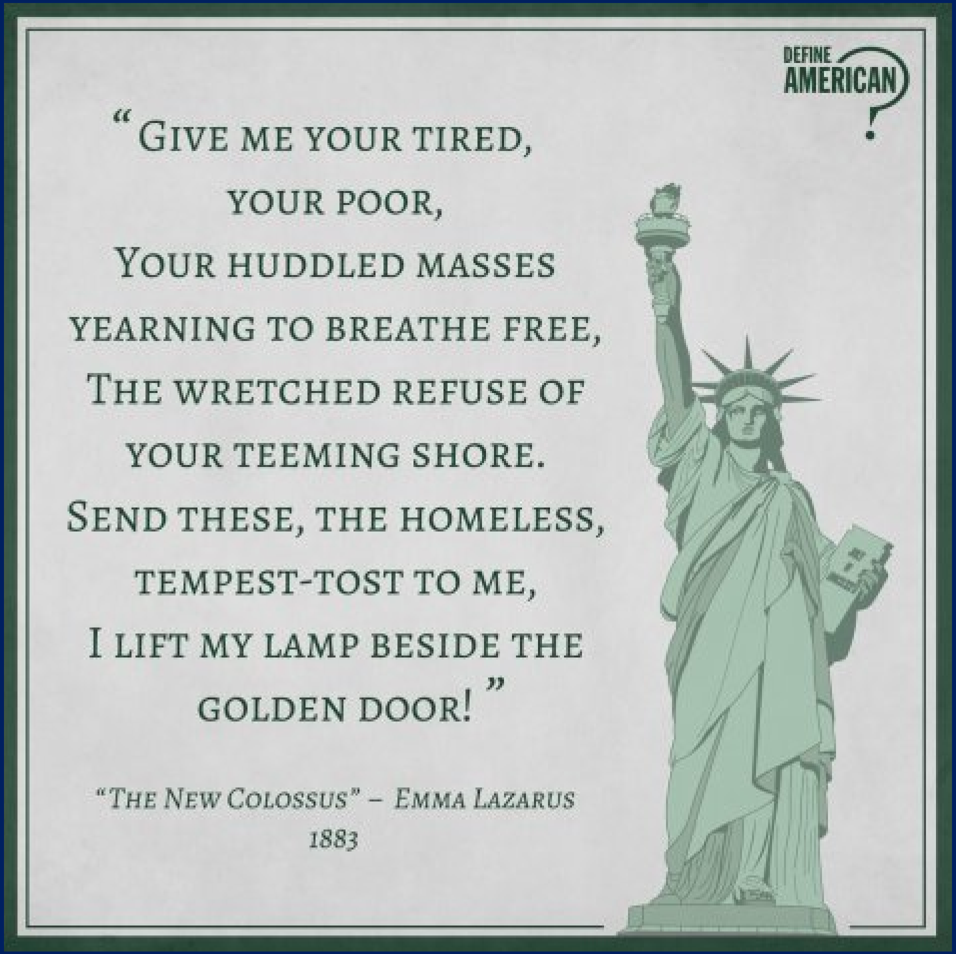
Invasion leads to New Questions

- Regional Distributions (CT and MA)
- Invasion origins (Population Genetics)
- Trophic Interactions
- Recruitment Dynamics
- *What Else is out there?*

Ellis Island Effect: Invasive Hydrozoans

National Park Service

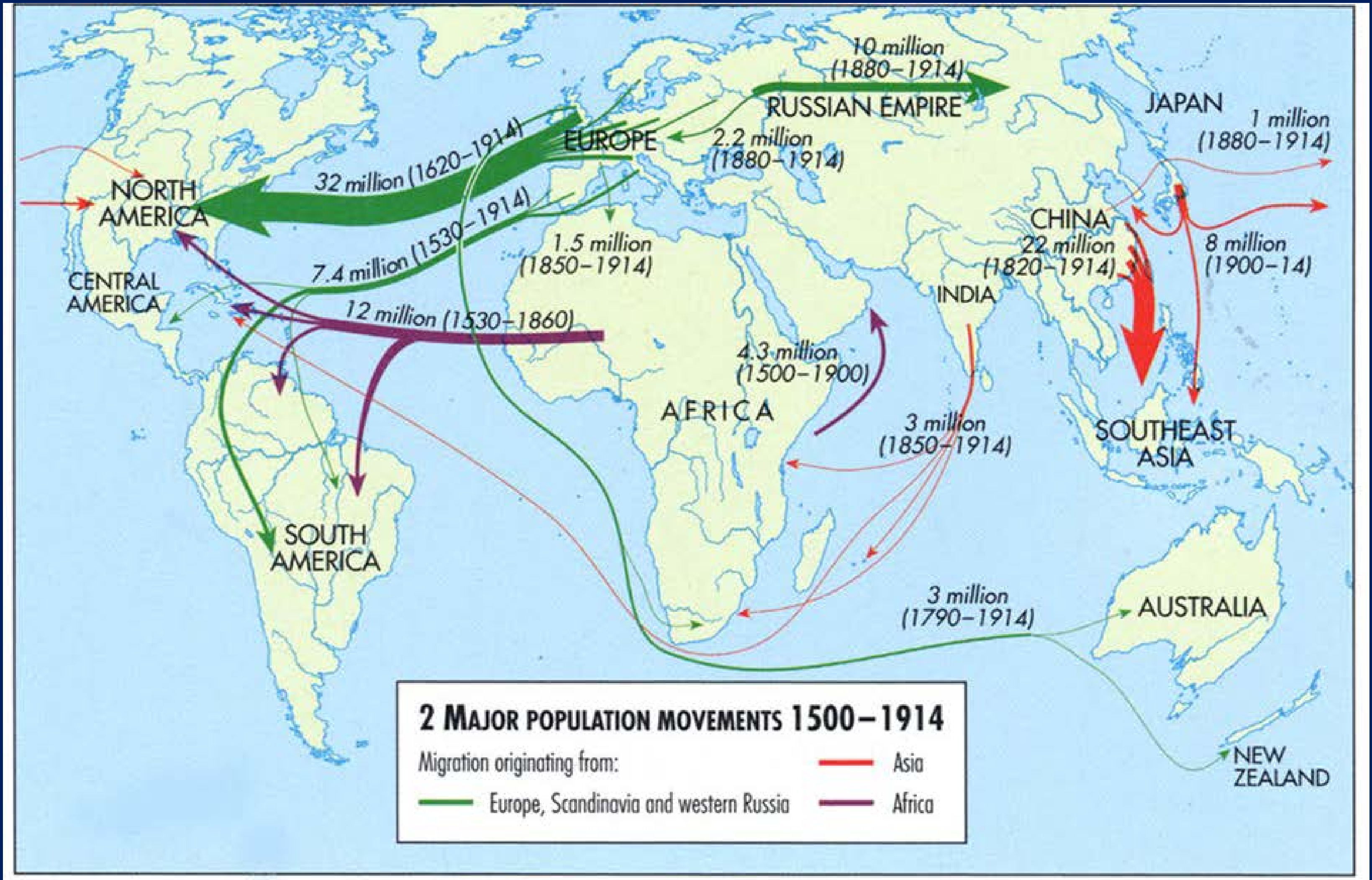
Promise of the United States



https://goodolewoody.files.wordpress.com/2016/09/cmq ln6qucaakmg5.jpg?w=474

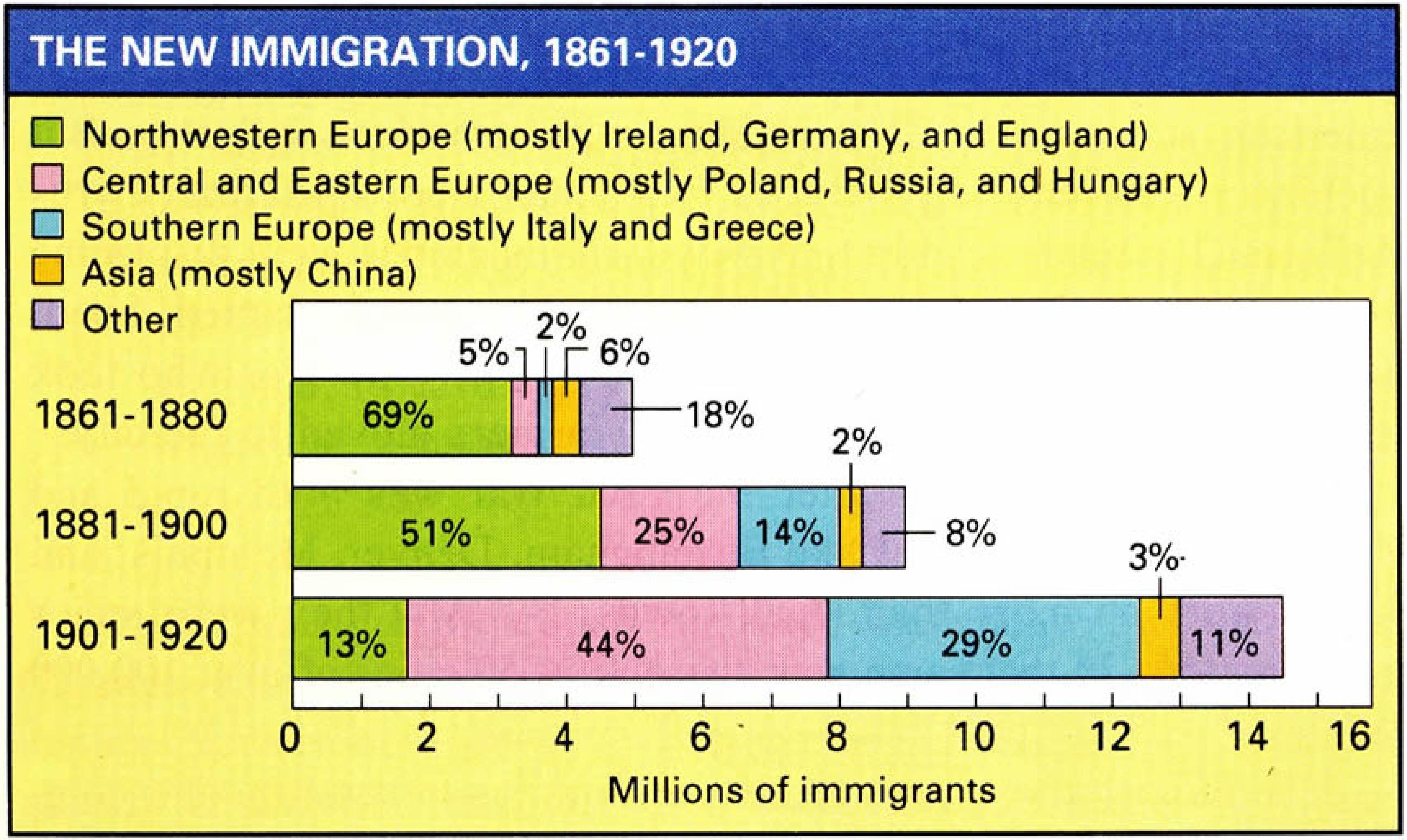
http://www.cglearn.it/mysite/wp-content/uploads/2012/06/ellis.jpg

Human Mass Migrations



Source: *Philip's Atlas of World History*

Human Mass Migrations



Source: *Historical Statistics of the United States*

Mediterranean Connection

- >24 Million Immigrants 1800s through Early 1900s
- 12 Million Pass through Ellis Island

https://assets.libertyellisfoundation.org/cms/editor/wseix_img_grphs1880.jpg

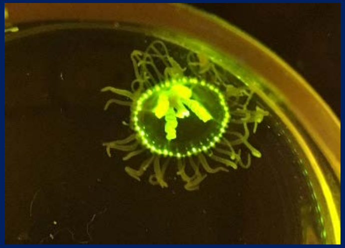
Invasion Pathways

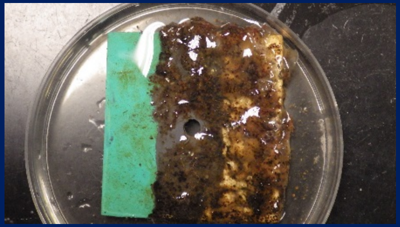
- Ship Hulls and Fouling Organisms
  - Wooden ships then steel
- Ballast (solid and water)
- Fishing and Plastic debris
- Canals (Panama, Suez)
- Aquaculture
- Accidental Release
  - lion fish

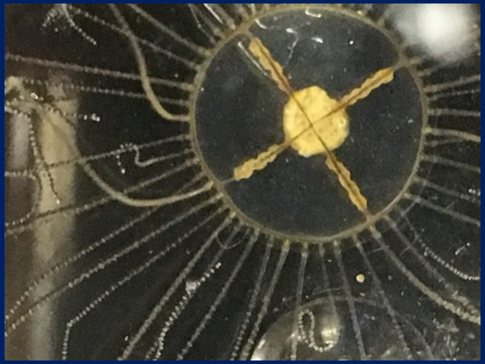
Invasion Identification

- Big Organisms – Easy
  - Visual Spotting at a Distance!
- Small and Cryptic Species?

- Alternative Approaches
  - Settling Plates
  - Fluorescence
  - ***Molecular Approaches***

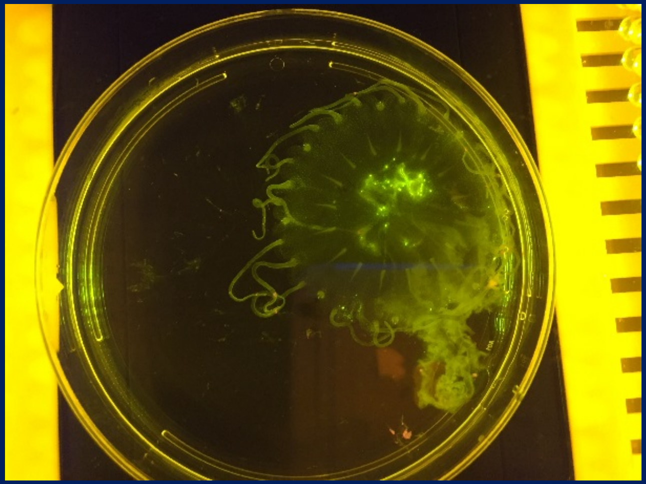






Molecular Approaches

- Sequencing of Unknowns
  - Targeting identified individuals
- Bar Coding Approaches
  - Shot-gun
- Predator find the prey
  - Diet Analyses



Invasive #1 *Gonionemus vertens*

‘Clinging Jellyfish’

Native Range: Pacific (Mediterranean)

First Identified in NJ in 2016

Highly Venomous

Excellent source of Media Buzz!


A22 N

A First-Time Tourist Has Arriv

By TATIANA SCHLOSSBERG

When Paul A. X. Bologna heard that a local fisherman had brought a dime-size jellyfish to a New Jersey aquarium, he had a hunch that it might be a Gonionemus vertens, or clinging jellyfish.

So Dr. Bologna, a biologist and ecologist at Montclair State University, brought the animal back to his lab. There he extracted, analyzed and sequenced its DNA, and

Oceanographic Institution.

The population has fluctuated over time, Dr. Carman said, possibly after a “wasting disease” infected the local eelgrass population, causing much of the grass to die off and leaving the clinging jellyfish without enough habitat.

But Dr. Carman, who has studied these jellyfish since the first sting on the East Coast was reported in 1990, said they had never totally disappeared from the water around New England.

A First-Time Tourist Has Arrived in New Jersey. Fortunately, It Is Not a Fan of the Beach.

By TATIANA SCHLOSSBERG

When Paul A. X. Bologna heard that a local fisherman had brought a dime-size jellyfish to a New Jersey aquarium, he had a hunch that it might be a Gonionemus vertens, or clinging jellyfish.

So Dr. Bologna, a biologist and ecologist at Montclair State University, brought the animal back to his lab. There he extracted, analyzed and sequenced its DNA, and determined that it was indeed the clinging jellyfish, spotted in New Jersey for the first time.

While he was testing the DNA, he heard that a swimmer had been stung in the Shrewsbury River and that more jellyfish had been found in a third location, raising the prospect that there could be a sizable population.

“I’ve worked in eelgrass beds,” the animals’ preferred habitat, “for about 15 years, and I’ve never seen them,” Dr. Bologna said. “But they’re so small, maybe I just overlooked them.”

While these particular jellyfish mostly live in the Pacific Ocean, they have been found in the Atlantic Ocean since 1894, when they were discovered near Woods Hole, Mass., according to Mary Carman, an ecologist and researcher at the Woods Hole Oceanographic Institution.

The population has fluctuated over time, Dr. Carman said, possibly after a “wasting disease” infected the local eelgrass population, causing much of the grass to die off and leaving the clinging jellyfish without enough habitat.

But Dr. Carman, who has studied these jellyfish since the first sting on the East Coast was reported in 1990, said they had never totally disappeared from the water around New England.

It was only after 1990 that they popped up regularly, leading Dr. Carman to believe that a second wave of jellyfish was introduced to this part of the world, this one with a higher level of toxicity than the first population.

Dr. Carman and Dr. Bologna don’t have a definitive answer to how the jellyfish got to the East Coast in first place. Maybe they arrived in the water used for ships’ ballasts, or as polyps attached to barnacles on ships’ hulls; in shellfish imports, or perhaps they drifted across the Arctic Ocean.

Dr. Carman said that clinging jellyfish from Japan and Russia were known to have powerful stings, but that those from the northeast Pacific — California and elsewhere — were relatively harmless.

Toxic or not, New Jersey is virgin territory for the animal, which prefers relatively sheltered water, unmoved by winds, wave and tides, with plenty of eelgrass.

Dr. Carman said they are unlikely to be in places where most people swim: open coastline, sandy beaches, places with waves. “Not very many people choose to swim in eelgrass,” she said.

But some people cannot avoid it: Annette Govindarajan, a research associate at Woods Hole who works with Dr. Carman, said most of the people who get hurt are eelgrass researchers, including Dr. Carman, who was stung on the lip in 2013 while looking for clinging jellyfish in eelgrass.

She described the pain as “like being stabbed with five hypodermic needles at once.”

Dr. Carman and Dr. Govindarajan, who are among a relatively small number of jellyfish researchers, said there were no definitive explanations for seemingly growing jellyfish populations and the spread of many species beyond their traditional habitats.

“Jellyfish blooms seem to be enabled by warmer temperatures,” Dr. Carman said. But beyond that, one of their big research questions is whether climate change has enabled the spread of this and other species of jellyfish.

Some effects of human activity, such as ocean acidification, could also have an impact on jellyfish habitats and populations, but Dr. Govindarajan said that remains a mystery. However, both researchers said that overfishing of populations that feed on jellyfish was not the cause of range expansion or of population growth in this case.

While most recreational swim-mers at beaches in New Jerse[y] and northward are unlikely to ge[t] stung by this particular ocea[n] creature, all of the scientist[s] stressed that its sting can be pa[r]ticularly painful, which is why a[p]pearances often make the news

“There are many different rea[c]tions to the sting,” Dr. Carm[an] said. “But it was so painful th[a]... won’t forget it anytime soon.”

WOODS HOLE OCEANOGRAPHIC INSTITUTION

A clinging jellyfish, which is about the size of a dime, has turned up in New Jersey.

Well Established in NJ

Serious Public Health Problem

Evaluation of Old Settling Plates

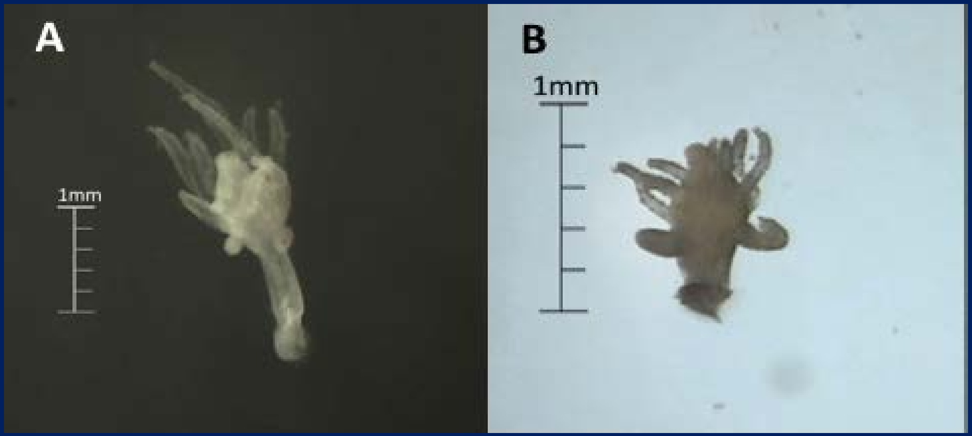
- Extensive Settling Plate Data from 2014
- Re-evaluated looking for *G. vertens*
- No *G. vertens,* but…. Unknown Polyps
- Lots of Nudibranchs

Polyps: Let the DNA tell the Story

- Isolate individual polyps
- DNA extraction
- Amplification with Cnidarian Primers
- Sequence Alignment
- Analyze against GenBank for Matches

Results: Invasive #2 *Moerisia* sp.

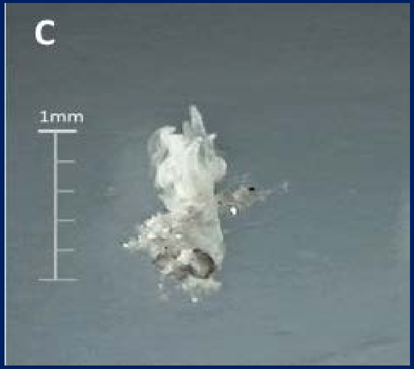
Location	GenBank Accession #	Species Identified	MG575535 Match	Homology	MG575536 Match	Homology
Brazil	KT266626*	*Moerisia inkermanica*	99%	573/575	99%	571/573
California	EU876555	*Moerisia sp.*	99%	573/575	99%	571/573
California	KX355402	*Moerisia sp.*	100%	568/568	99%	565/596
California	AY512534	*Moerisia sp.*	99%	511/512	99%	506/508
China**	KF962500*	*Moerisia inkermanica*	99%	496/500	99%	491/496
Virginia	TBD	*Moerisia sp.*	100%	567/567	99%	562/563

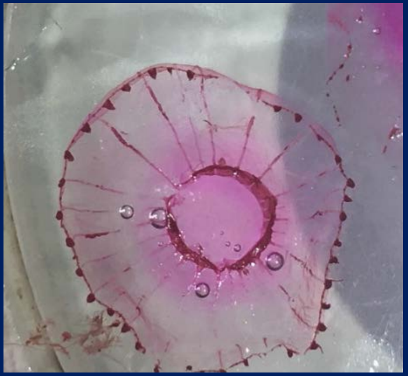


Poorly Studied
Unresolved Taxonomy
Non-Native Origins
Mediterranean Origin Pathway

Results: Invasive #3 *Aequorea* sp.

- Polyps Identified 2014, Medusa identified in Plankton tows in 2017
- Sequencing Data
    - Closest Match is *A. australis* (Pacific)
    - New Invasive or Undescribed Species





Species in Genbank	Accession #	Location	Locus	% Match	Homology
Aequorea Australis	JQ716017	China	16S	96%	533/555
Aequorea Australis	JQ716015	China	16S	96%	533/555
Aequorea Australis	JQ716013	China	16S	96%	533/555
Aequorea Australis	JQ716016	China	16S	96%	532/555
Aequorea sp.	KY363940	England	16S	90%	483/539
Aequorea coerulescens	KT266599*	Japan	16S	90%	495/550
Aequorea Victoria	EU305469*	California	16S	89%	455/506
Aequorea sp.	KT982731	Thialand	16S	89%	483/540
Aequorea aequorea (forskalea)	AY512518**	Massachusetts	16S	89%	481/538

Invasive #4: *Bougainvillia triestina*

- Adult medusa identified in Plankton tows in 2017
- Sequencing Data didn't match Regional Knowns
- Mediterranean Species
- Poorly Studied

Species in Genbank	Accession #	Location	Locus	% Match Bougainvillia sp.	Homology
Bougainvillia triestina	KJ660344	Croatia	16S	96%	545/570
Bougainvillia triestina	KJ660345	Croatia	16S	96%	494/515
Bougainvillia fulva	EU305470*	Eastern Pacific, USA	16S	90%	514/568
Bougainvillia britannica	AM183127	United Kingdom	16S	88%	497/567
Bougainvillia britannica	MF000551	Norway	16S	88%	497/567

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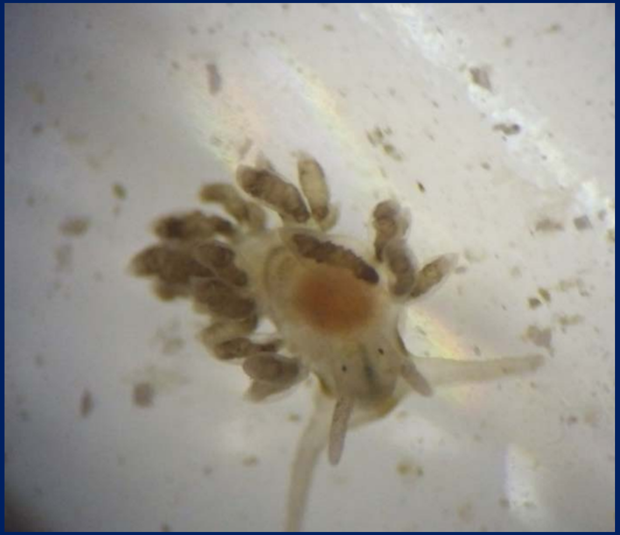
ORIGINAL ARTICLE

The case of *Bougainvillia triestina* Hartlaub 1911 (Hydrozoa, Cnidaria): a 100-year-long struggle for recognition

Mirna Batistić & Rade Garić

Institute for Marine and Coastal Research, University of Dubrovnik, Dubrovnik, Croatia

Predators Tell the Tale



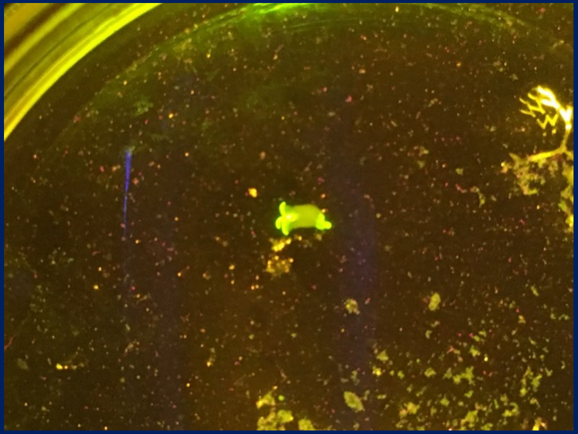
- Nudibranch kleptocnidae
  - Nudibranchs feed on cnidarians
  - Steal or sequester cnidoblasts
  - Translocate them intact for defense
  - ‘Retain’ Cnidarian DNA for an extended period
- Field Collected Nudibranchs from Settling Plates
- Extract DNA, Amplify with Cnidarian Primers
- Sequence Analysis

Molecular Matches

Observed Cnidarians	Molecular Identified Species	Homology	Matching Accession #	GenBank Accession #
Hydroids	*Tenellia adspersa*	99%	KY128876	SUB3591702
Hydroids	*Obelia bidentata*	99%	KX665313	SUB3592536
Hydroids	*Obelia bidentata*	99%	KX665313	SUB3592971
Hydroids	*Bosellia sp.*	87%	HQ616834	SUB3593142
Hydroids	*Ercolania sp.*	87%	KM204242	SUB3593268
C. quinquecirrha Hydroids	*C. quinquecirrha* *Moerisia inkermanica*	100% 100%	KY610694 & GU300724 KT266626 & EU87655	SUB3593396 SUB3593308
C. quinquecirrha Hydroids	*Moerisia inkermanica*	100%	KT266626 & EU87655	SUB3593330
Hydroids	*Obelia bidentata*	98%	KX665311	SUB3593348
Hydroids	*Obelia bidentata*	99%	KX665313	SUB3593350
Hydroids	*Obelia bidentata*	99%	KX665313.1	SUB3593371
Hydroids	*Tenellia adspersa*	99%	KY128875.1	SUB3593374
Hydroids	*Obelia bidentata*	99%	KX664313.1	SUB3593373

Nudibranch Genera ~ Lateral Gene Transfer

Unresolved Unknowns



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