

Coastal Flooding and Saltwater Intrusion

Holly Michael

Director, Delaware Environmental Institute

Professor, Hydrogeology

Earth Sciences; Civil and Environmental Engineering

University of Delaware

hmichael@udel.edu



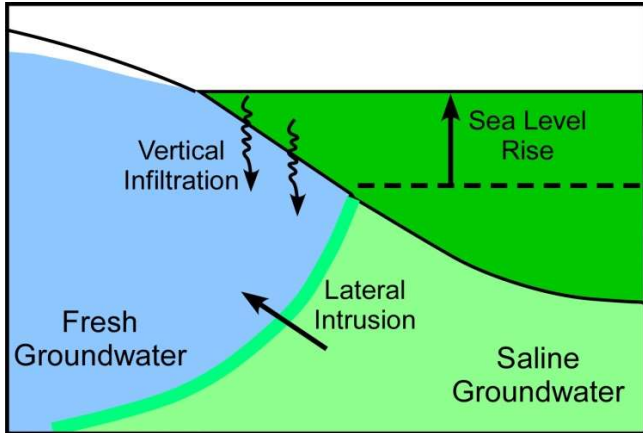
The Coastal Groundwater “Squeeze”



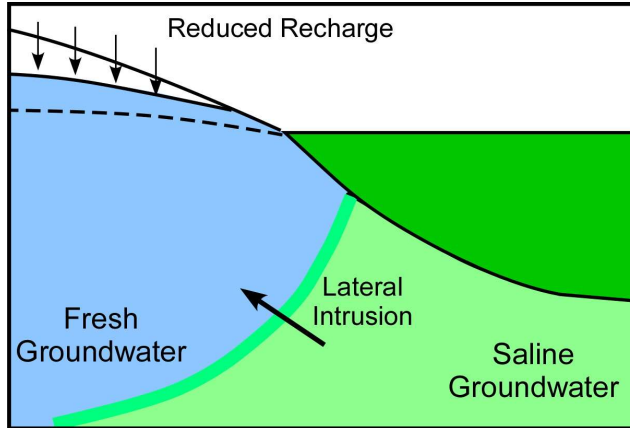
Michael et al., Water Resources Research, 2018

Mechanisms of Saltwater Intrusion

Sea Level-Rise



Reduced Rainfall



Stream Salinization

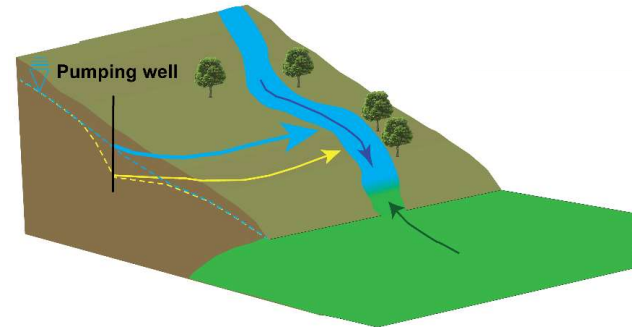
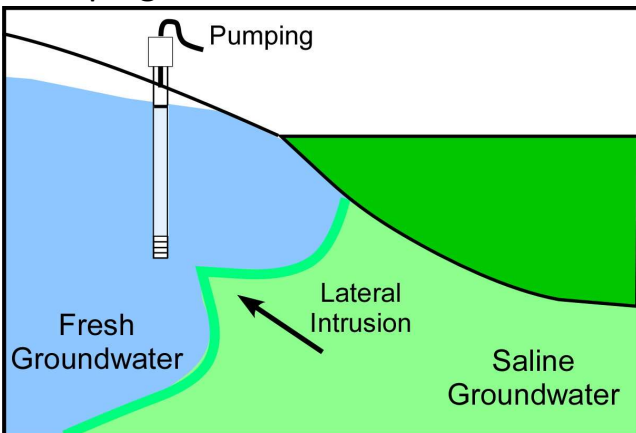
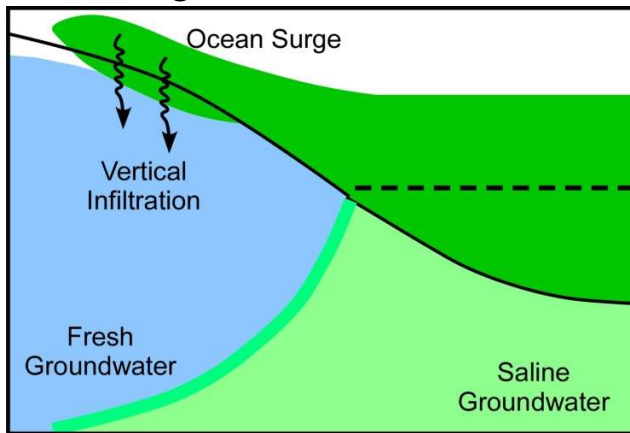


Figure credit: Anner Paldor

Pumping

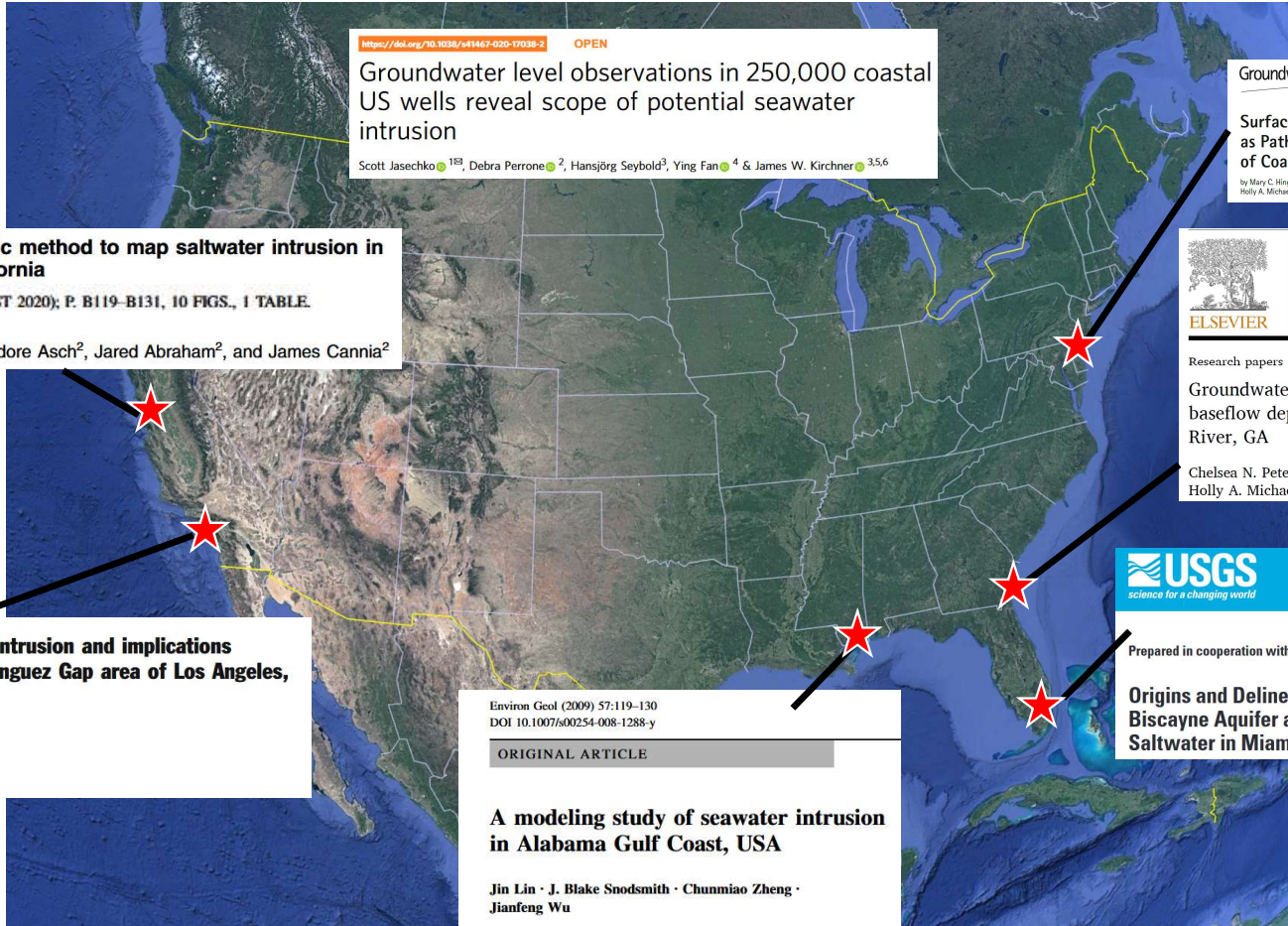


Storm Surges

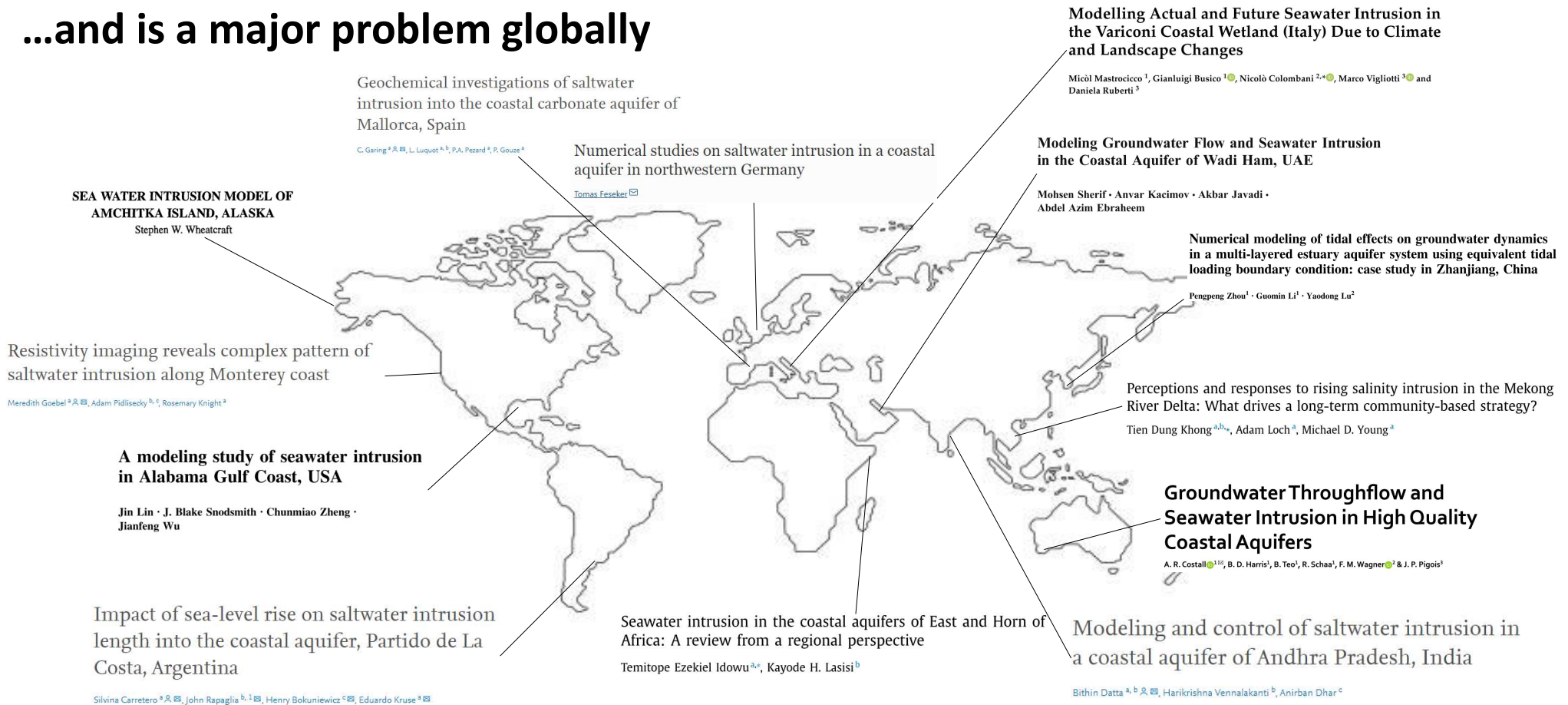


→ Only 2% seawater ruins a freshwater resource!

Saltwater intrusion occurs on all coasts of the US



...and is a major problem globally



>600 million people live within 10m of sea level

~2.4 billion people live within 100 km of a coastline

<https://www.un.org/sustainabledevelopment/wp-content/uploads/2017/05/Ocean-fact-sheet-package.pdf>

Saltwater intrusion & Sea-level Rise → Ecological Change



Salinization

Rising water levels lead to drowning of the root zone



Forest ecosystem effects

CLIMATE CHANGE ON THE DELAWARE BAY
Rising seas leave lifeless landscape in wake

Ghost forests tell the story

Maddy Lauria | Delaware News Journal | USA TODAY NETWORK

As Mark Wells harvested rows of corn from his farm near Fowler Beach, he praised the fertility of eastern Sussex County's soils that sent thousands of golden kernels filtering through his combine. But it wasn't this healthy crop the farmer wanted to point out.

To the north and east of his 126-acre farm at the corner of Fowler Beach Road, dozens of gray stalks of leafless and lifeless trees litter the landscape's edge. The same salt water that killed those trees and created one of the state's most striking ghost forests has left chunks of Wells' fields barren.

As the combine hit those decaying areas, he watched his yield drop by more than half. Wells pointed to the ghost forests skirting his farm and tried remembering where a beloved, huge persimmon tree once stood. He couldn't find it.

Ducks flew out of a pond against a backdrop of dead trees and invasive common reed, or phragmites, that no longer feed the wild deer, raccoons and other critters that once roamed in the now-mummified forest.

Some spots where Wells planted seeds earlier in the season are filled with fruitless, stunted stalks or nothing but grasses, evidence of a crop severely impacted by saltwater intrusion.

"It's practically wasteland," he said. "It goes hundreds and hundreds of yards into the field."

See GHOST FORESTS, Page 4A

The ghost forest next to Fowler Beach Road in Sussex County. JERRY HABRAXEN, DELAWARE NEWS JOURNAL



Moises Velasquez-Manoff, a New York Times contributor, and Gabriella Demczuk, a photographer, traveled to ghost forests in the eastern United States. Ms. Demczuk used seawater collected at each site to create salt prints, a 19th-century technique.

Up and down the mid-Atlantic coast, sea levels are rising rapidly, creating stands of dead trees — often bleached, sometimes blackened — known as ghost forests.

The water is gaining as much as 5 millimeters per year in some places, well above the global average of 3.1 millimeters, driven by profound environmental shifts that include climate change.



Saltwater intrusion laying waste to Delmarva farms as sea level rises



"This is how it starts." Bob Fitzgerald looks over what started as a "little wet spot" that 2-acre void.

Dave Harp

Turning Salt-Damaged Fields into Marshes Could Save Maryland Farmland—and The Chesapeake Bay

As sea levels rise, saltwater is entering farms near the bay, damaging crops and releasing legacy nutrients into already-polluted waterways.



BY VIRGINIA GEWIN
ENVIRONMENT, FARMING, Water
Posted on: February 20, 2019 | 1 Comment

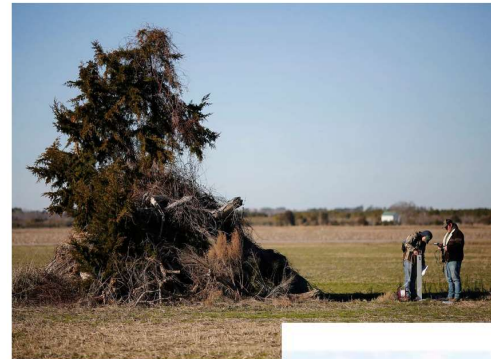


Agricultural effects

The Washington Post

Democracy Dies in Darkness

Ruined crops, salty soil: How rising seas are poisoning North Carolina's farmland



East Carolina University graduate students Trevor Burris, left, and Tyler Pate near Engelhard, N.C., in January. (Eamon Queney/for The Washington Post)

By Sarah Kaplan
March 1



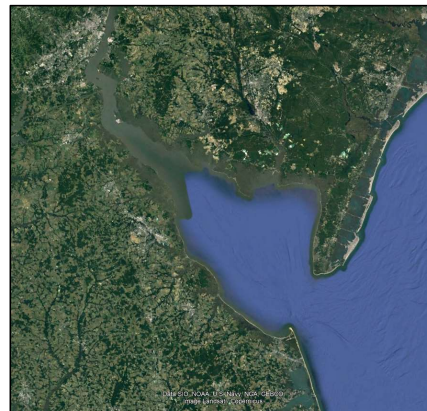
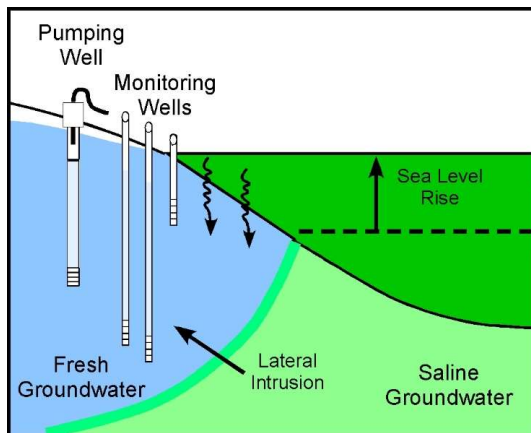
The Southern Maryland Chronicle

What to do?

- Research to understand problem scope, mechanisms, economics, social feedbacks, predict future scenarios
- Communication and education

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- Research to understand problem scope, mechanisms, economics, social feedbacks, predict future scenarios
- Communication and education
- Monitoring
 - Water levels
 - Salinity of surface water, groundwater
 - Contaminant levels and mobility



Helicopter Surveys Delaware Bay For USGS Groundwater Research

By [Maryland-Delaware-D.C. Water Science Center](#) JULY 19, 2022



<https://www.usgs.gov/media/images/helicopter-surveys-delaware-bay-usgs-groundwater-research>

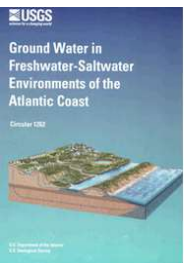
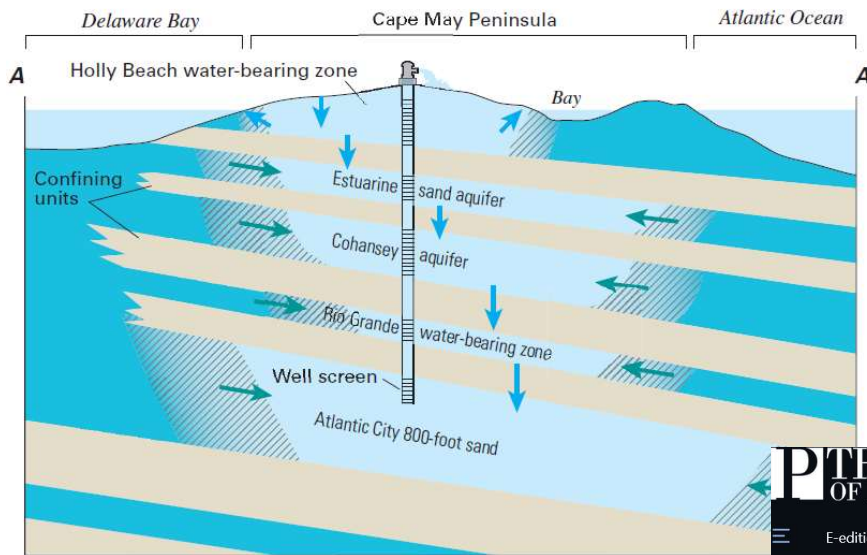
What to do?

- Research to understand problem scope, mechanisms, economics, social feedbacks, predict future scenarios
- Communication and education
- Monitoring
 - Water levels
 - Salinity of surface water, groundwater
 - Contaminant levels and mobility
- Develop solutions
 - **Management!**
 - Engineering solutions (hydraulic barriers, gray/hardened infrastructure)
 - **Green infrastructure** – reduce feedbacks with climate change
 - **Science-based policies!**

Desalination - Engineering Solution

High energy requirement, costly maintenance

Example: Cape May, NJ, 1998 installation



Ground water in freshwater-saltwater environments of the Atlantic Coast

Circular 1262

By: Paul M. Barlow

<https://doi.org/10.3133/cir1262>



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TOP STORY BREAKING

Cape May looks for answers, and funding, for new desalination plant

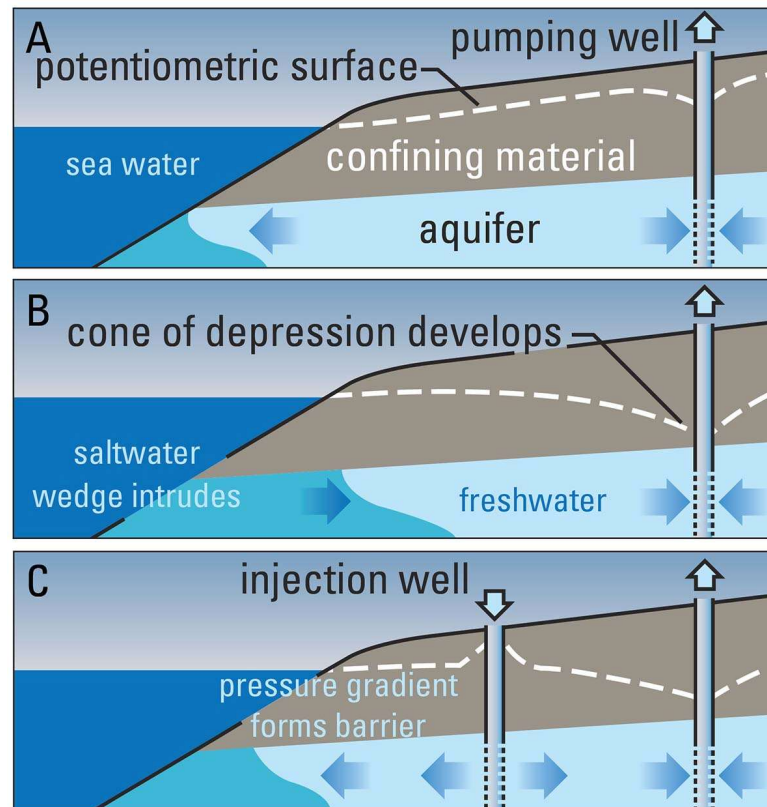
Bill Barlow Dec 12, 2022 0

Artificial Recharge – Engineering solution

Inject freshwater to raise freshwater level, slowing or reversing saltwater intrusion

Example: Los Angeles, CA

High energy requirement, requires water



USGS California Water Science Center-
<https://ca.water.usgs.gov/sustainable-groundwater-management/seawater-intrusion-california.html>

Green vs. Gray Infrastructure – natural vs. hardened shorelines

Green infrastructure has benefits beyond flood protection

NOAA green infrastructure examples



NOAA Digital Coast-
<https://coast.noaa.gov/data/digitalcoast/pdf/gi-benefits.pdf>



The Environmental Cost of Shoreline Hardening

Posted by Kristen Goodhue on June 21st, 2017

New study shows hardened shorelines may mean fewer fish and crustaceans. [Printer/PDF-friendly version](#)

by Ryan Greene



A NEW SERC STUDY SHOWS THAT BOTH BULKHEADS (LEFT) AND RIPRAP REVETMENT (RIGHT) ARE ASSOCIATED WITH LOWER ABUNDANCE OF SEVERAL SPECIES OF FISH AND CRUSTACEANS IN THE CHESAPEAKE BAY AND THE DELAWARE COASTAL BAYS. CREDIT: SERC

Water Resources Research

RESEARCH ARTICLE
10.1029/2020WR028326

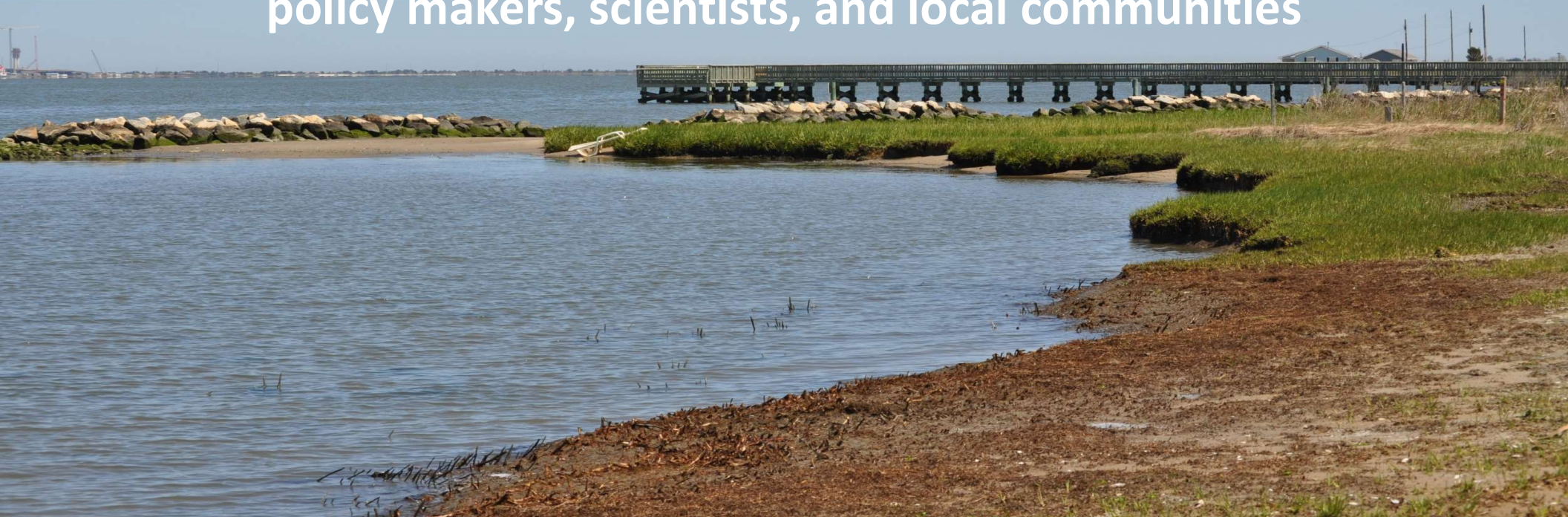
Special Section:
Coastal hydrology and
oceanography

Effects of Marsh Migration on Flooding, Saltwater
Intrusion, and Crop Yield in Coastal Agricultural Land
Subject to Storm Surge Inundation

Julia A. Guimond¹ and Holly A. Michael^{1,2}

**Saltwater intrusion is a complex and growing issue in
the U.S. and worldwide**

**Mitigation and prevention requires collaboration among
policy makers, scientists, and local communities**



Thank you!

Holly Michael
Director, Delaware Environmental Institute
Professor, Hydrogeology
Earth Sciences; Civil and Environmental Engineering
University of Delaware
hmichael@udel.edu



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Resources

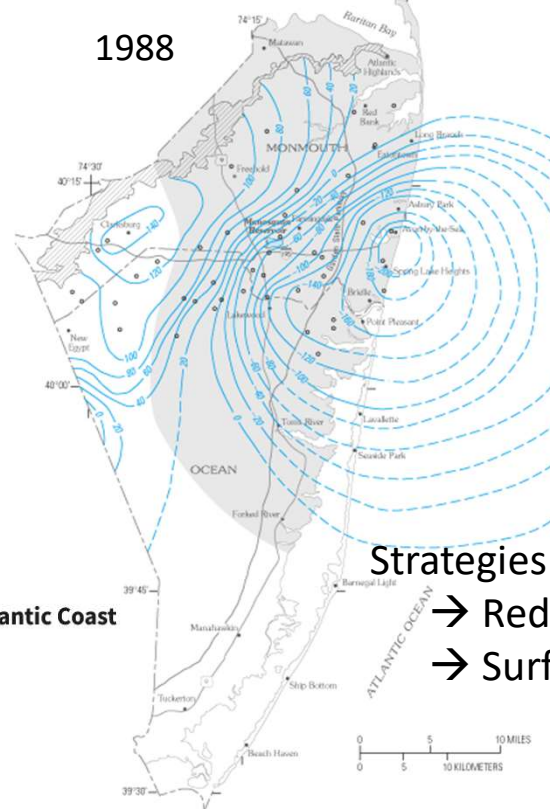
- Our lab website: <https://sites.udel.edu/michaelhydrolab/>
- Our Coastal Critical Zone Project- <https://czn.coastal.udel.edu/>
And short film, “Salted Earth”- <https://czn.coastal.udel.edu/salted-earth/>
- USGS information on saltwater intrusion- <https://www.usgs.gov/mission-areas/water-resources/science/saltwater-intrusion>
- EPA information on Climate Adaptation and Seawater Intrusion- <https://www.epa.gov/arc-x/climate-adaptation-and-saltwater-intrusion>
- Barlow (2003)- <https://pubs.er.usgs.gov/publication/cir1262>
- <https://coast.noaa.gov/digitalcoast/topics/green-infrastructure.html>

Groundwater Management

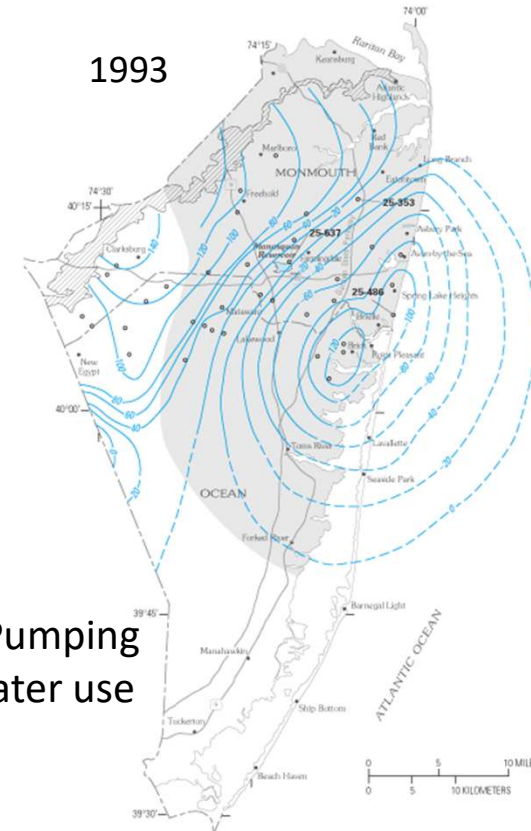
Example: New Jersey reversal of overpumping



New Jersey water levels after >100 years of pumping

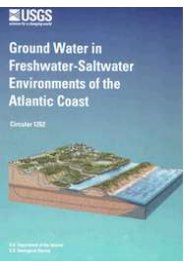


New Jersey water levels after pumping reductions (>120 ft recovery in some areas)



Strategies:

- Reduced Pumping
- Surface water use



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