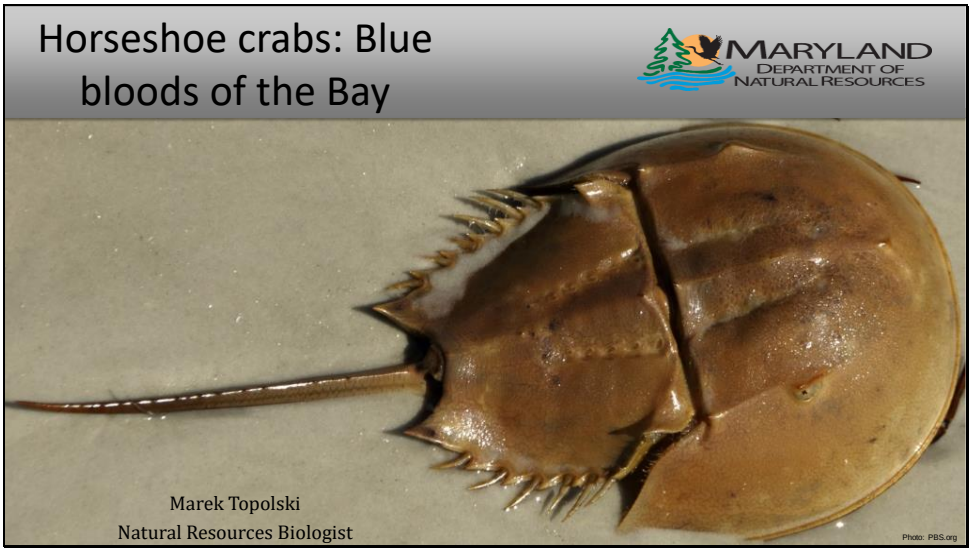
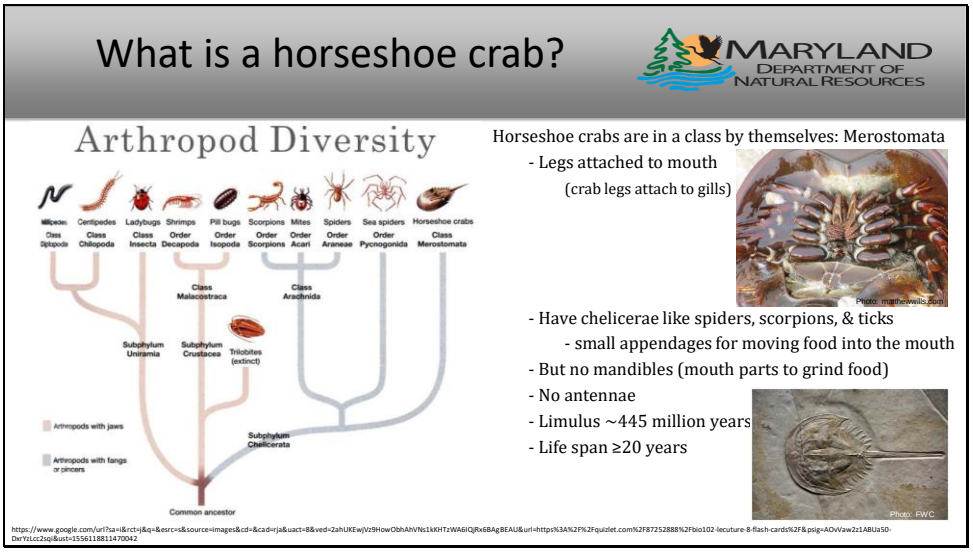
Slide 1



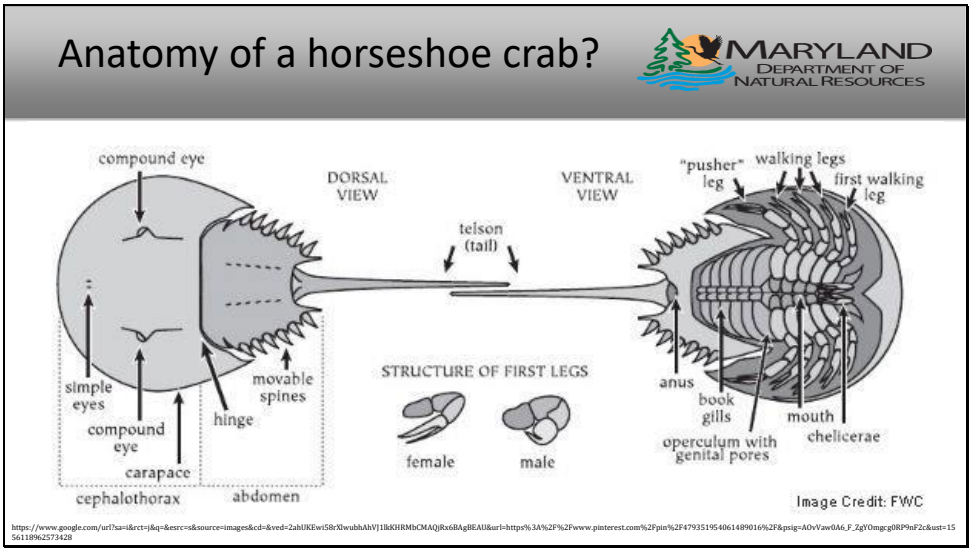
Uniquely charismatic species
Readily recognizable by the general public
Their significance spans ecology, economy, and human health

Slide 2



So, what is a horseshoe crab?
[follow bullet points]
Unique among the arthropods
- due to the structure of mouth & legs
Ancient Class of arthropods
- Early forms evolved in Paleozoic Era, ~445 million years
- Predate dinosaurs & flowering plants
- Survived Paleozoic Cambrian & Permian [marine] extinctions & the Mesozoic Cretaceous [land & marine] extinction

Slide 3



https://www.google.com/url?sa=i&rct=j&q=&esrc=s&source=images&cd=&ved=2ahUKEwi58rXlwubhAhVJ1lkKHRMbCMAQjRx6BAgBEAU&url=https%3A%2F%2Fwww.pinterest.com%2Fpin%2F479351954061489016%2F&psig=AOvVaw0A6_F_ZgYOmgcg0RP9nF2c&ust=1556118962573428

[use diorama & molt]

Heavily armored

Two body segments plus telson

- Cephalothorax / prosoma
- Abdomen / opisthosoma

Numerous eyes [will come back to]

First pair of claws are for feeding (not legs)

5 pairs of legs

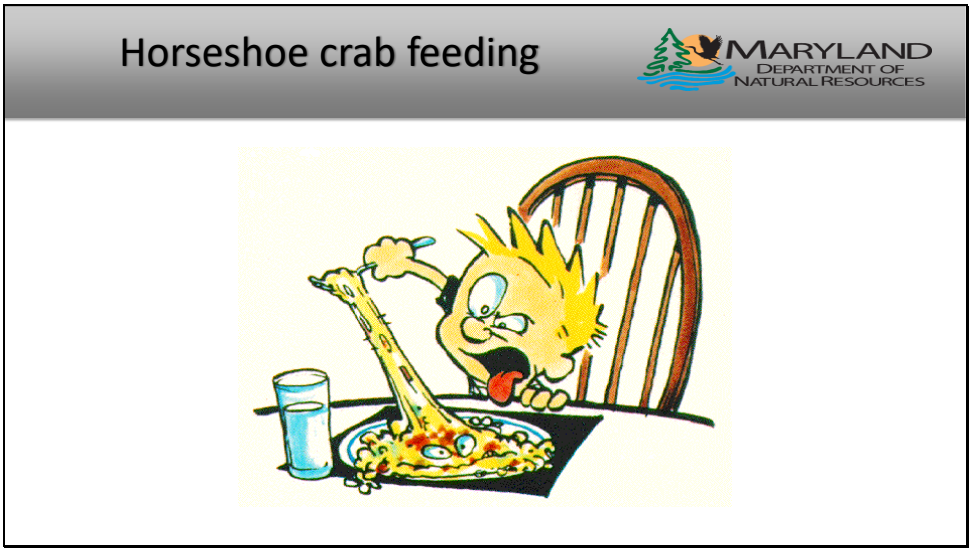
First walking leg is sexually dimorphic

Last pair of legs has modified claw (pusher)

Book gill covers are modified abdominal appendages [will come back to]

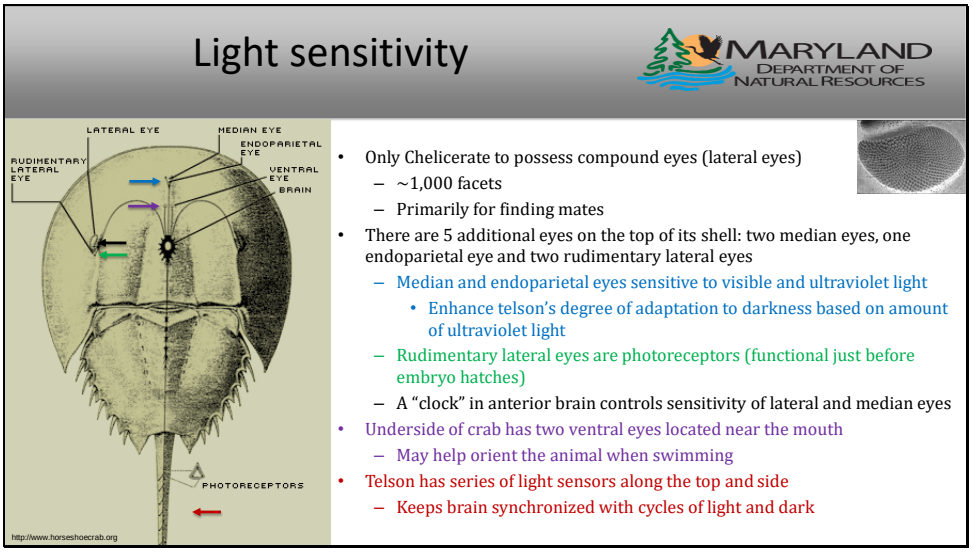
Female ~1/3 larger than male

Slide 4



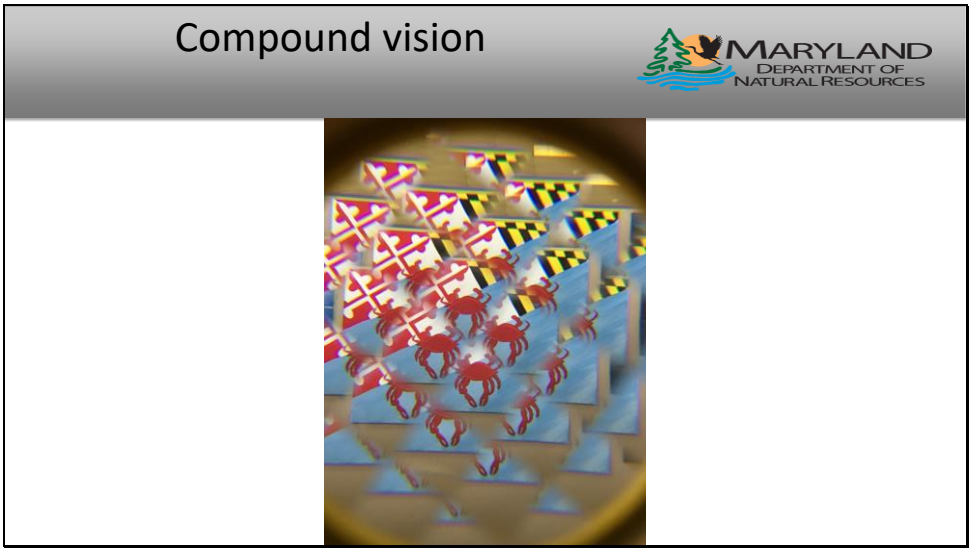
Video of how a horseshoe crab feeds **[hyperlink]**
Feed on invertebrates like marine worms & small molluscs and scavenge
Have a crop and gizzard

Slide 5

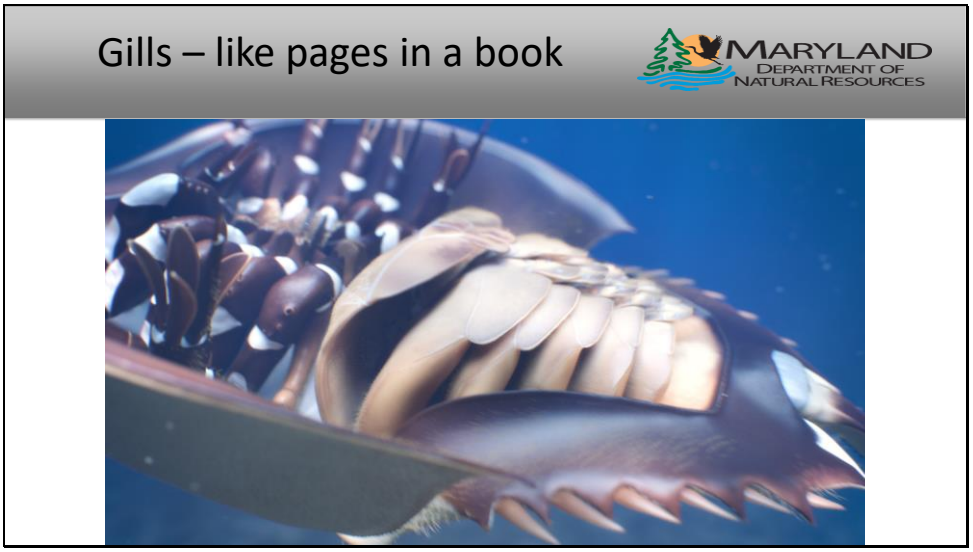


[follow the bullets]
Complex array of light sensitive structures
Compound eyes – pass around the facet simulators
Facets are easily seen on the larger molt
- Molts are fragile, but can be looked at afterward

Slide 6



Slide 7



CGI rendition of horseshoe crab
Book gill covers are modified abdominal appendages

- First is genital operculum
- 100”pages of lamellae per appendage

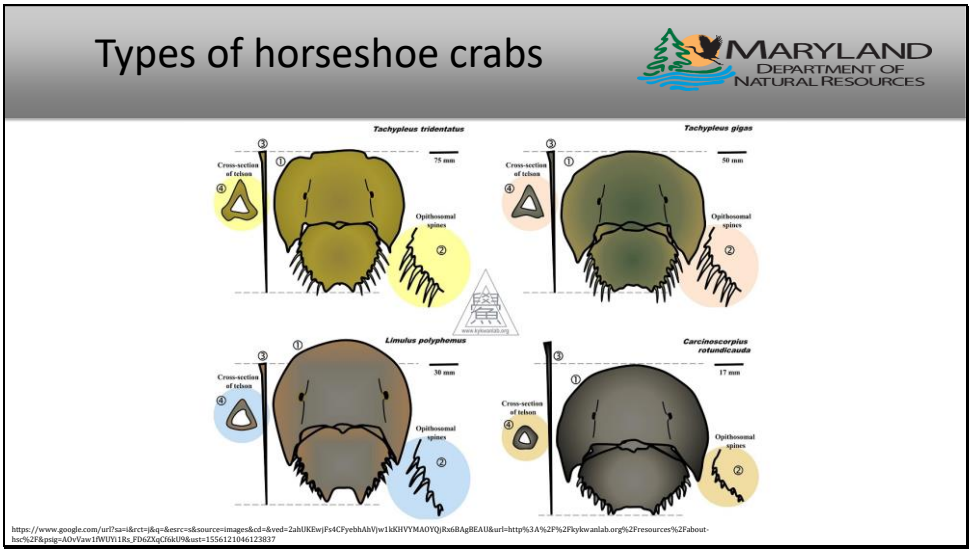
Slide 8

I found a YouTube video of a small horseshoe crab in an aquarium **[hyperlink]**
It is useful to observe horseshoe crab behavior

- Swimming, Walking, Burrowing

<u>This is not an endorsement of collecting horseshoe crabs for personal aquaria</u>
<u>Also, the person had a sturgeon which is prohibited</u>

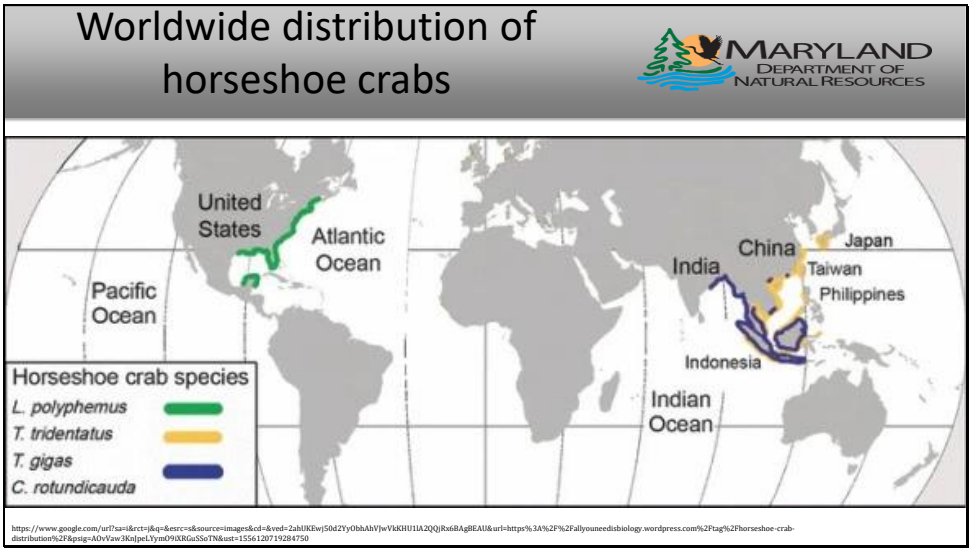
Slide 9



There are 4 species of horseshoe crab
Differentiate them fairly easily

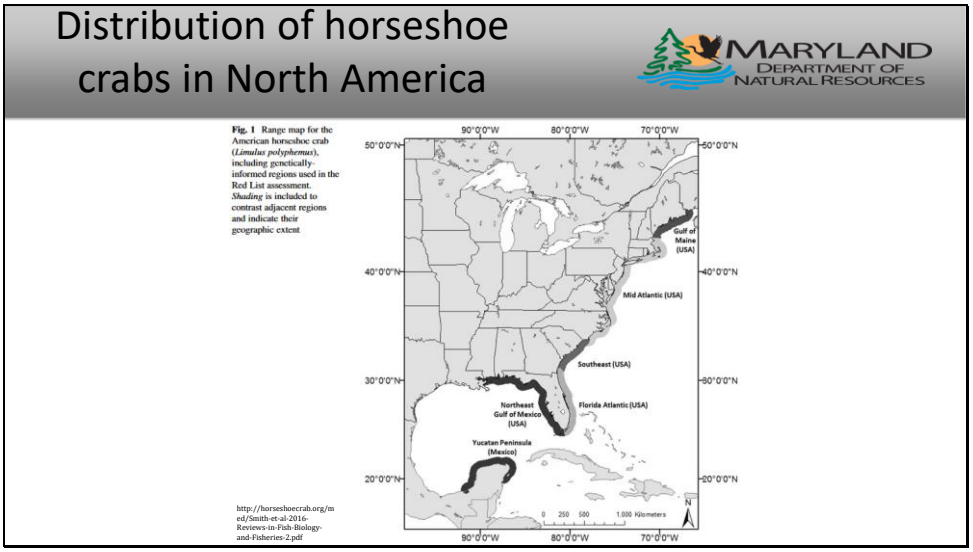
- anterior margin of cephalothorax
- Opisthosomal spine configuration
- Length/width of cephalothorax and abdomen
- Telson length and shape (cross section)

Slide 10



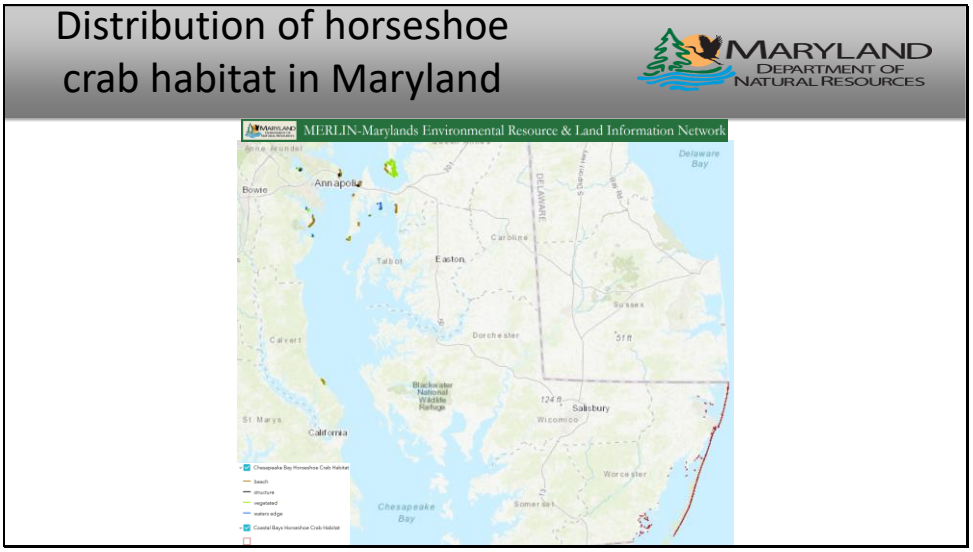
Distributed in IndoPacific and western Atlantic
Only one species in western Atlantic

Slide 11



Several genetic populations of *Limulus polyphemous*
Largest spawning population is in the Delaware Bay region
- Notable spawning activity in Chesapeake Bay has been reported

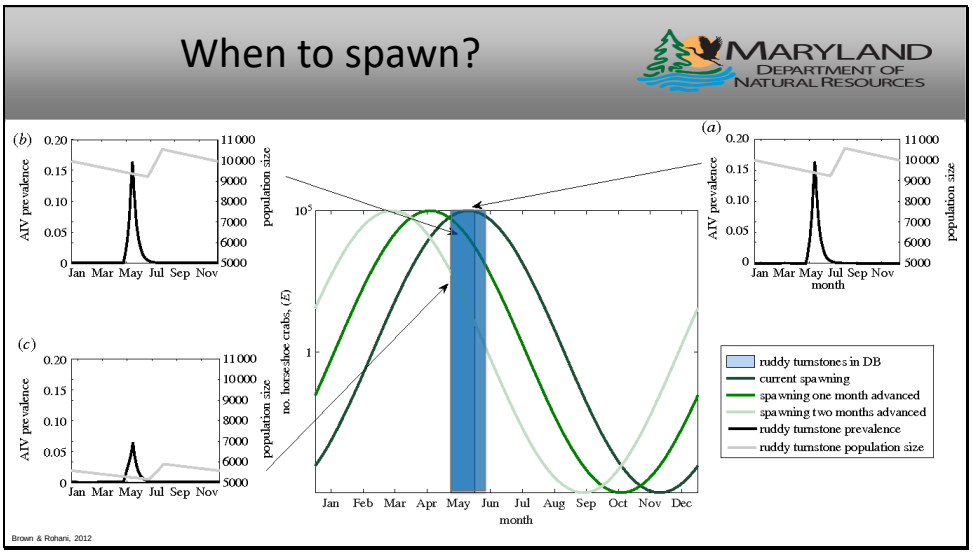
Slide 12



Horseshoe crab spawning habitat has been poorly characterized in Chesapeake Bay
Under-represents actual activity & habitat

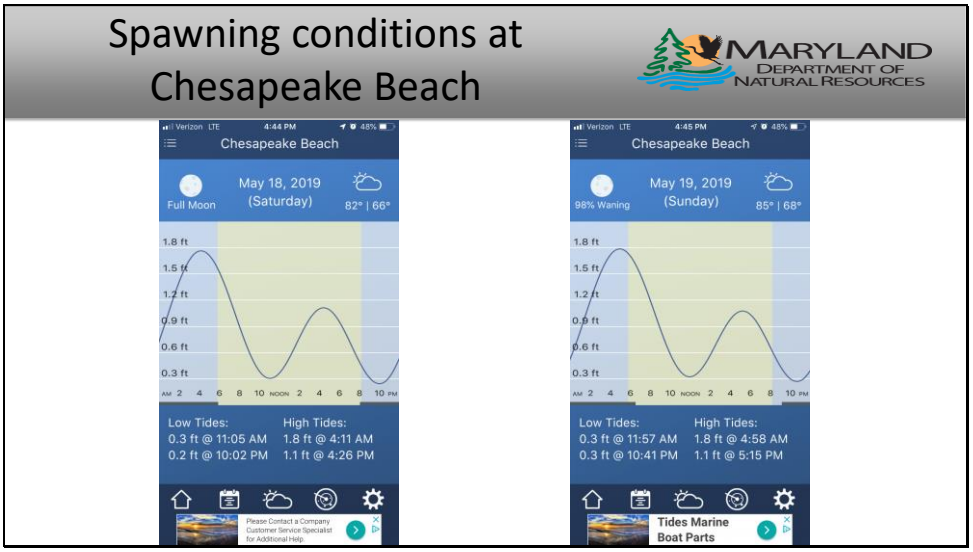
- Problematic for effective management
- Limited resources and it is not a major priority

Slide 13



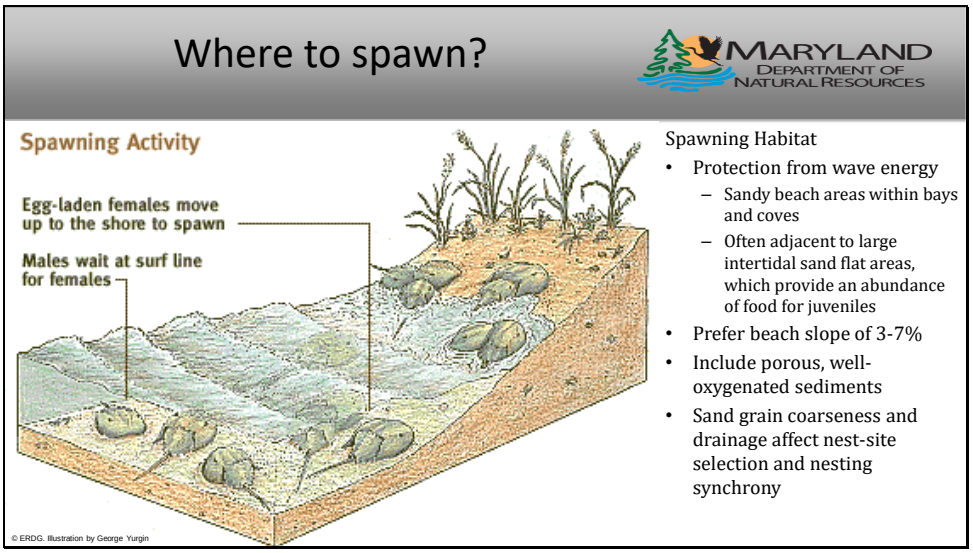
This is a model of Delaware Bay horseshoe crab spawning and there is some variability in timing
Water temperature ≥ 58˚F
Usually mid-May into June
Hightide at night
Preferably during new & full moons when spring tides occur, these are the highest tides

Slide 14



I looked up the tidal forecast for this weekend at Chesapeake Beach for planning purposes

Slide 15



Beaches can be very small
Avoid high peat content
Do not have beach fidelity each year of spawning
Waves less than 1 ft to avoid being flipped

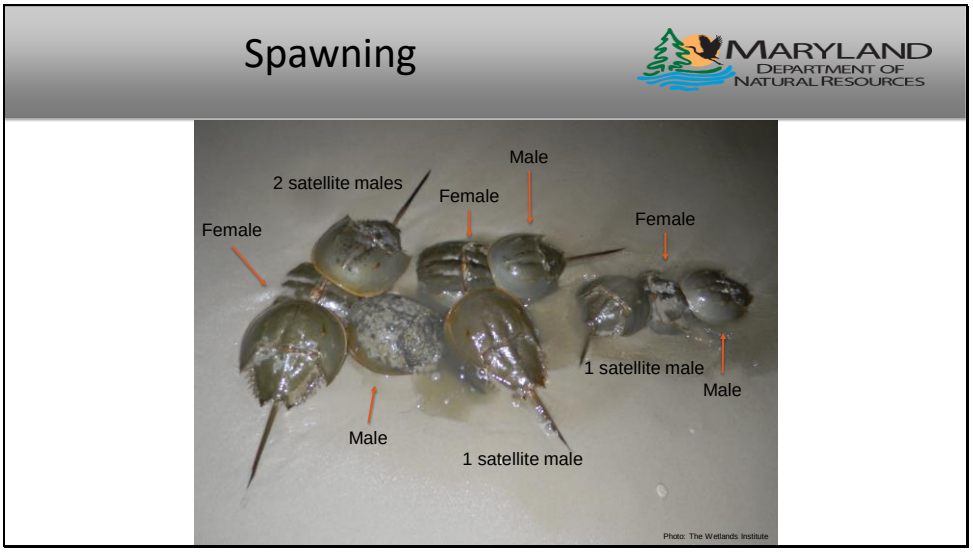
Slide 16

A little blurry, but we can see the male first walking leg hooked onto the female abdomen

Slide 17

Eggs are stored/develop throughout the cephalothorax

Slide 18



Males hitch a ride from the shallows to where the female will lay eggs
- They are not spawning
- National Geographic video at minute 1:07 **[hyperlink]**

Satellite males congregate around female in an effort to also fertilize eggs

Slide 19

Here is a buried female laying eggs
Eggs are deposited 6-10 inches below surface just above high tide line
This female has been tagged – white disk

Slide 20

Eggs are green
They somewhat blend in

Slide 21

Hatching takes two weeks to several months depending on conditions
The warmer the water and the higher the salinity, the more rapid the development
No distinct telson at hatch
Telson is prominent after first molt

Slide 22

Growth

17 molts during first 9-11 years to reach full size and sexual maturity
- Then one molt per year
Exit the front of the shell
- Many crustaceans exit through the back
Tissue expands with water prior to hardening of shell
If a horseshoe crab shell has a split along the front, it is a molt

Slide 23

Juvenile & adult habitat

Nursery Habitat
- Shoalwater and shallow water areas of bays (such as Delaware Bay and Chesapeake Bay) are essential nursery areas.
- 99% of juveniles found in waters >5 parts per thousand
- Juveniles usually spend first two years on intertidal sand flats
- After two years juveniles migrate to deeper bay and ocean waters until sexually mature

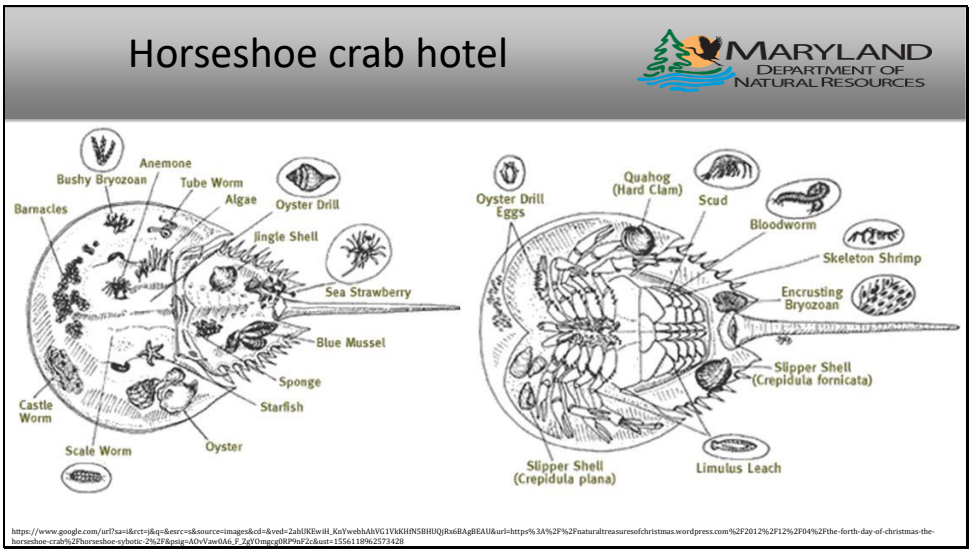
Adult Habitat
- Specific requirements are not known
- Have been found at depths > 200 meters (656 feet)
- May prefer depths < 30 meters (98 feet)
- During the spawning season, adults typically inhabit bay areas adjacent to spawning beaches
- In the fall, adults may remain in bay areas or migrate into the Atlantic Ocean
- May overwinter on the continental shelf

[follow the slides]

Slide 24

Between molts, the shell becomes a complex mobile reef

Slide 25

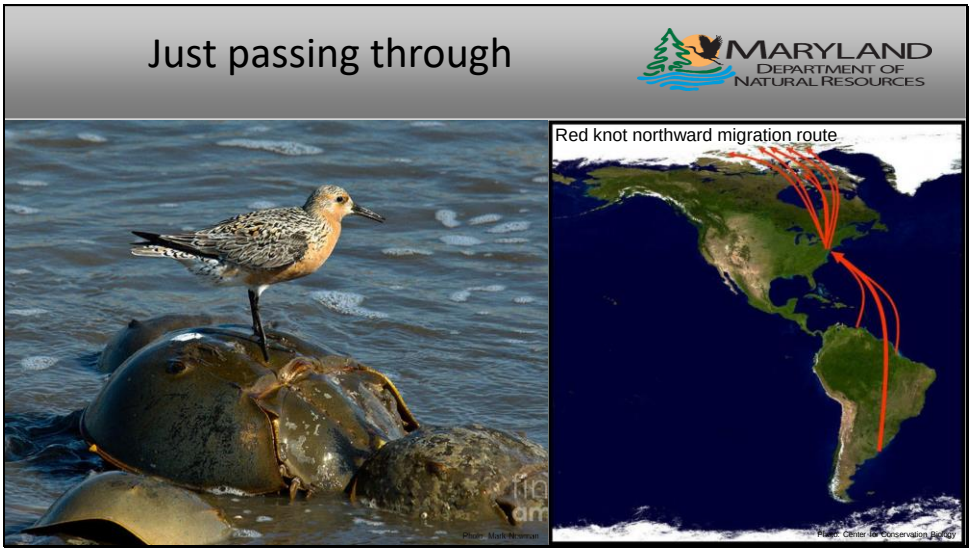


[point out the different types of potential encrusting and parasitic organisms]

Slide 26

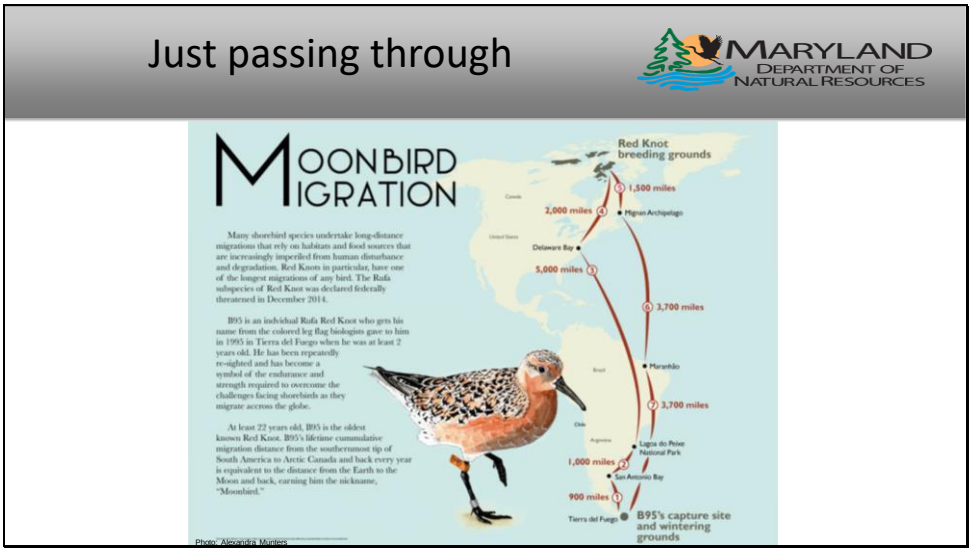
Migratory shore birds are a primary predator of horseshoe crab eggs
Red knot will double body weight
They are an important food resource without which successful migration would not be possible

Slide 27



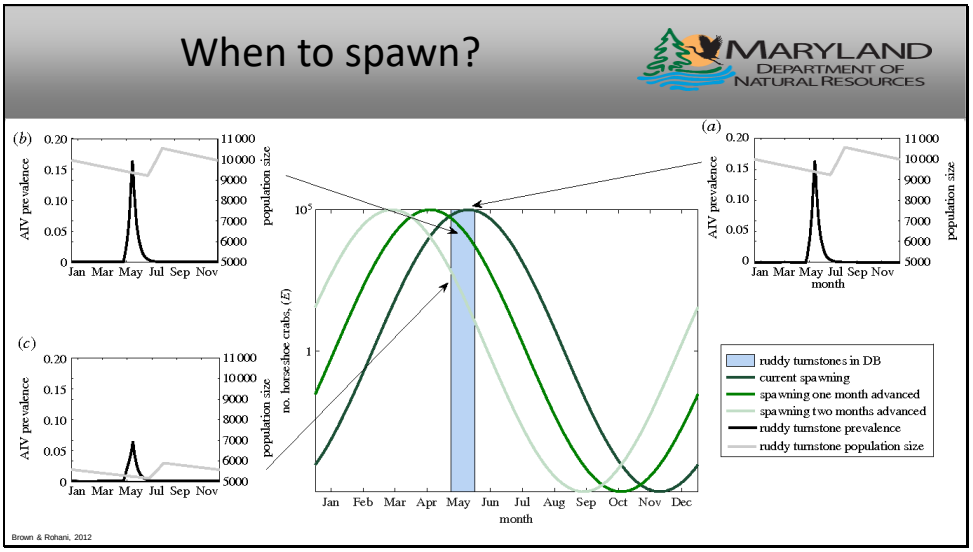
Migration can be up to ~9,300 miles
Do it in ~1,500 mile stages

Slide 28



Band number B95
Tagged in 1995 in Tierra del Fuego, Argentina/Chile at age 2-3
Flown distance to moon and back, hence the name “Moonbird”

Slide 29



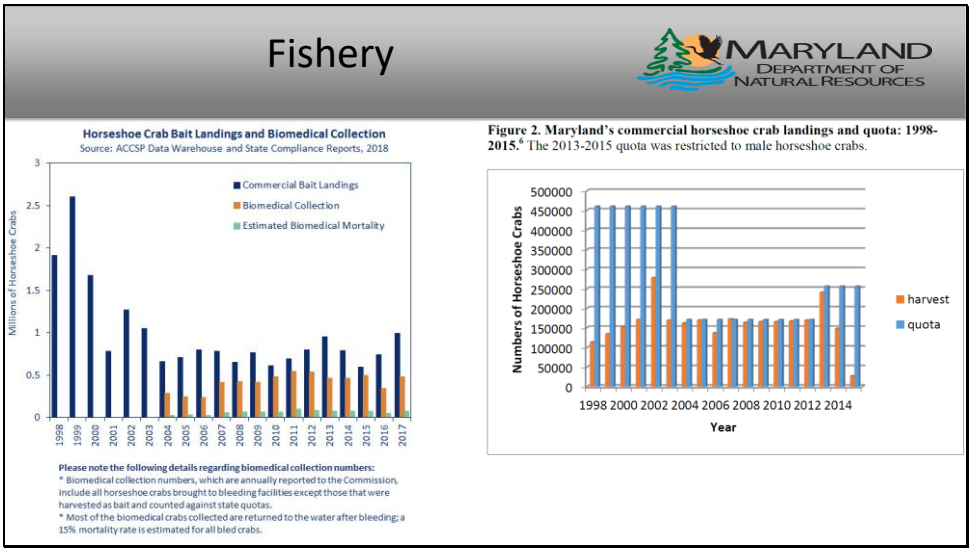
We saw this graph before
It is important because it indicates how bird migration is timed to horseshoe crab spawning
If horseshoe crab spawning season shifts to earlier in the year, eggs are not available to migrating birds
Why a shift, climate change

- Waters warm sooner so spawning is sooner
- Would bird migration also shift to earlier, that is not certain

Slide 30

Humans have a history of utilizing horseshoe crab
Historical use was fertilizer
Modern use is for bait

Slide 31



Horseshoe crab harvest and utilization have been monitored and managed for several decades
Majority of recent landings have been for bait

- Landings are tightly regulated
- Harvest has dipped below quota in recent years

Collection for biomedical use for the past ~25 years

Slide 32

Fishery management

MARYLAND DEPARTMENT OF NATURAL RESOURCES

Quota

The annual total allowable landings of male horseshoe crabs for the commercial fishery is 255,980. There is no female harvest permitted.

Season

1. May 1, 2019 through July 7, 2019:
   a. A person may catch or land horseshoe crabs outside of 1 mile of the Atlantic coast.
   b. A person may catch or land horseshoe crabs in Maryland's coastal bays and their tidal tributaries.
   c. A person may not catch or land horseshoe crabs within 1 mile of the Atlantic Coast, or the Chesapeake Bay and its tidal tributaries.
2. July 8, 2019 through November 30, 2019: A person may catch or land horseshoe crabs from the tidal waters of the State.
3. December 1, 2019 through April 30, 2020: A person may not catch or land horseshoe crabs in Maryland.

Catch Limits

1. An individual may not land more than 25 male horseshoe crabs unless they are in possession of a valid horseshoe crab landing permit.
2. May 1, 2019 through July 7, 2019: A permittee may not land more than 150 male horseshoe crabs per day.
3. July 8, 2019 through November 30, 2019: A permittee may not land more male horseshoe crabs than the amount specified on their permit.

All other rules remain the same (Code of Maryland Regulations 08.02.10.01).

Harvest is managed with annual quota, catch limits, and landing permits
No female harvest permitted
Regulations designed to reduce pressure on spawning individuals – females in particular (includes pre-spawning individuals)
- Bird nesting beaches are often used and also protected areas

Slide 33

Horseshoe crab bleeding

MARYLAND DEPARTMENT OF NATURAL RESOURCES

https://geneticliteracyproject.org/2018/05/21/the-end-of-using-horseshoe-crabs-for-drug-testing/

- Hemocyanin – blue blood
  - Copper based
  - Helps survive hypoxia
- Up to $15,000 per quart
  - The Atlantic, 2018

[pass around the vial of blood]
Blood is blue because it is copper based
- Mammalian blood is iron based
Makes it easier to survive hypoxia

Slide 34

Horseshoe crab blood use

- Humans can become sick if exposed to bacterial endotoxin
  - Endotoxins are a type of fever-causing agents
  - Is a component of the exterior cell wall of Gram-negative bacteria
  - Especially dangerous if sufficient amount of endotoxin enters blood stream or spinal fluid (such as from an injectable drug)
  - Symptoms can include fever, shock, organ failure, and even death
  - All injectable drugs and medical devices that come in contact with blood stream or spinal fluid are tested for endotoxin
- Horseshoe crab has an immune and blood coagulation system that protects it against infection
  - Inside blood cell (amebocyte) are protiens that cause blood to clot around the injury and bacteria
  - Research showed that their blood is very sensitive to endotoxin (1960s)
  - Blood gels & clots when it comes in contact with endotoxin
  - *Limulus* amebocyte lysate (**LAL**) test developed and was commercialized in the United States in the 1970s. (similar test, **TAL,** from *Tachypleus tridentatus*)
  - A version of the LAL test for diagnosis of invasive fungal infections is being developed

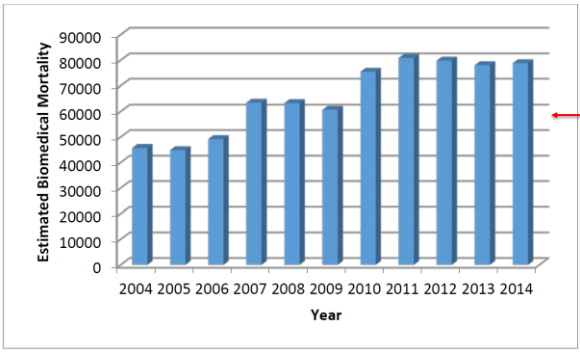
http://www.horseshoecrab.org

[follow the bullets]

Slide 35

Horseshoe crab bleeding mortality

Figure 3. Estimated mortalities of horseshoe crabs bled for the biomedical industry: 2004-2014.[3] The 2015 mortality estimate was not available at the time of this report. Mortality does not include crabs returned to the bait industry. Threshold is 57,500.



Estimates of bleeding mortality vary, but 15% is assumed
Management problem, total bleeding mortality often exceeds the threshold

Slide 36

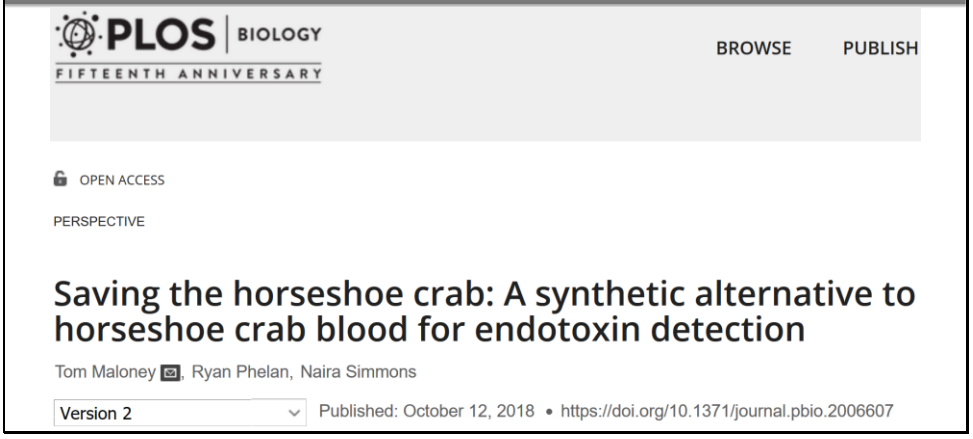
Horseshoe crab bleeding mortality

- Best practices to reduce mortality
  - Keep crabs cool and moist (transport & facility)
  - Do not bleeding injured crabs
  - Separate unbled from bled to avoid rebleeding
  - Use of sterile needle
  - Allow blood to flow or drip into the container until the flow stops naturally
  - Bleeding horseshoe crabs to death is not an acceptable practice in the U.S.
  - Return to ocean waters from harvest site within 24 hours
  - Mark prior to return to avoid a second bleeding within a year
  - Bleed horseshoe crabs caught for use as bait
  - Return to the ocean at their harvest site.
- Alternatives are being developed that will reduce the use of horseshoe crab blood

[follow the bullets]

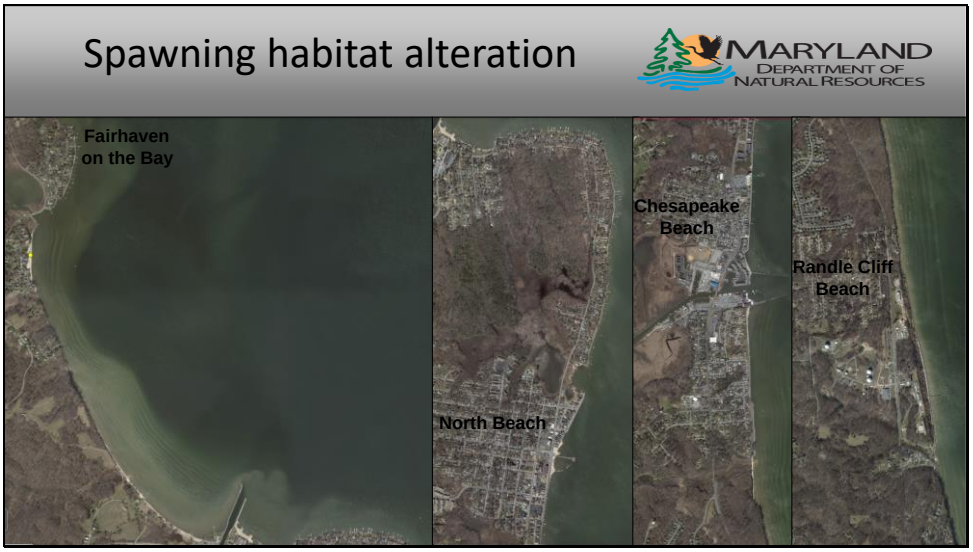
Slide 37

Reduction of LAL extraction



Research is being conducted to develop a synthetic version of LAL
Possibility to reduce LAL use by 90%

Slide 38



Spawning challenges in the Chesapeake Bay are largely due to habitat alteration and loss
Here are aerial images of the shoreline in this area

Slide 39

This is an example of shoreline hardening and loss of sandy beach

Slide 40

The contrast in spawning success and survival for repeat spawning is stark
Return to water and “Just flip ‘em”

Slide 41

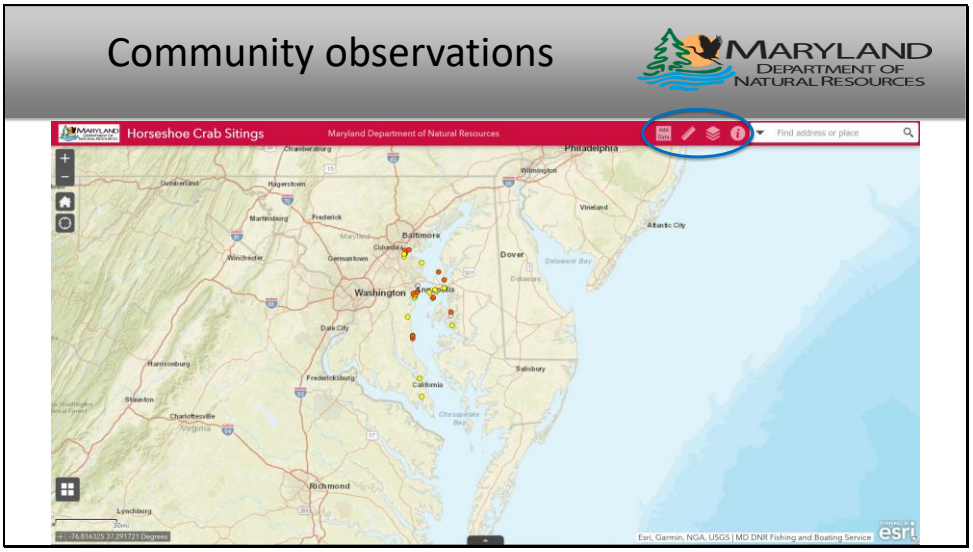
In the absence of resources and a survey, we rely on public reports of horseshoe crab activity

- Location
- Spawning or not
- Abundance
- Habitat characteristics
- Photos - sometimes

How to report

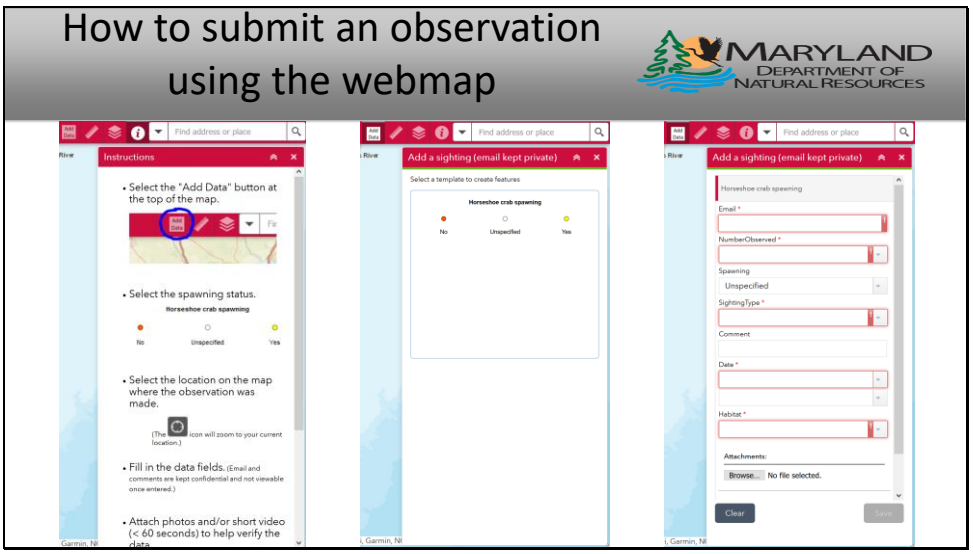
- Phone
- Email
- Webmap (DNR website & mobile app)

Slide 42



Webmap is mobile friendly **[hyperlink]**
[walk through how it works]

Slide 43



Click the observation location on the map
Select the type of horseshoe crab activity (spawning, no spawning, not sure)
Fill in the siting form and save
Observation will not be visible on the map until it has been confirmed by DNR