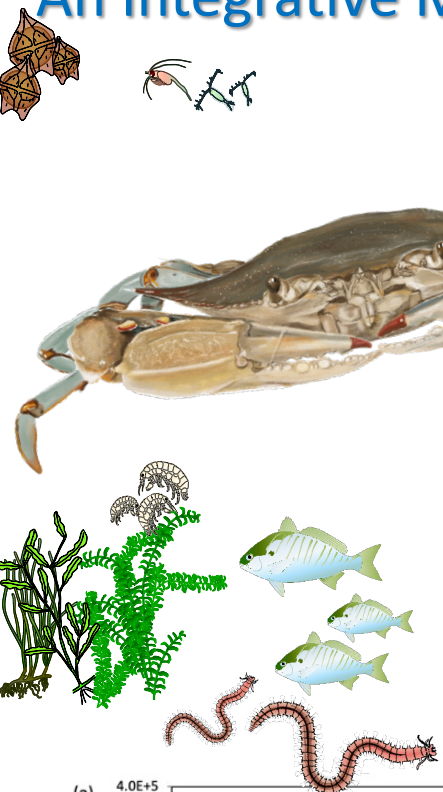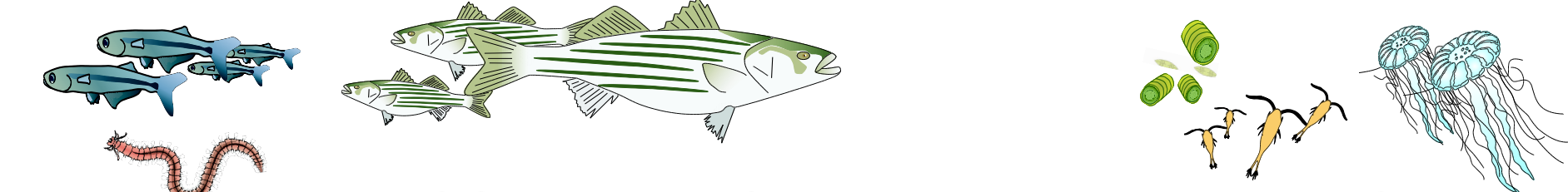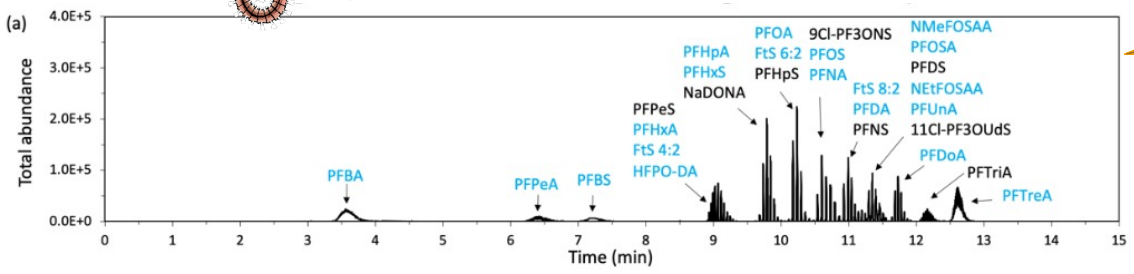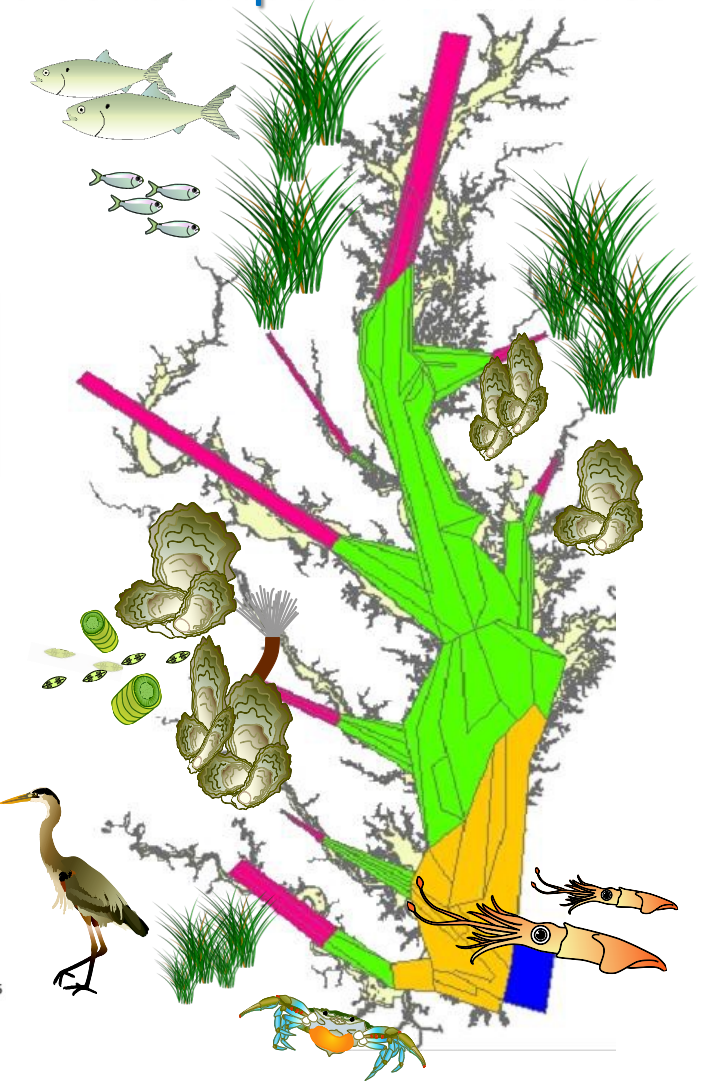# An Integrative Modeling Approach to Support Consumption Advisories

Tom Ihde
Morgan State University – PEARL

Dr. Lee Blaney
University of MD Baltimore County

https://ian.umces.edu/media-library/

PFAS Contamination in the Chesapeake Bay Food Web
(*PFAS == per- and polyfluoroalkyl organic compounds*)

Issues:

- PFAS have been accumulating in the Bay environment since the 1940's
    - Persist over long time periods – degrade slowly
    - Bioaccumulate in muscle tissues
    - Human effects dire:
        - Increased infant mortality
        - Birth defects, including skeletal alteration
        - Neurodevelopmental effects
        - Reduced immune function
        - Cancer
- Testing is difficult, expensive
- Monitoring needs to be spatial (contaminated animals move)
- Consumption advisories likely will require multiple target species

Pilot Study:

Focuses on the development of a cost-effective approach to estimate PFAS concentrations spatially for multiple focal species simultaneously

NIH/Morgan State University Pilot Study:

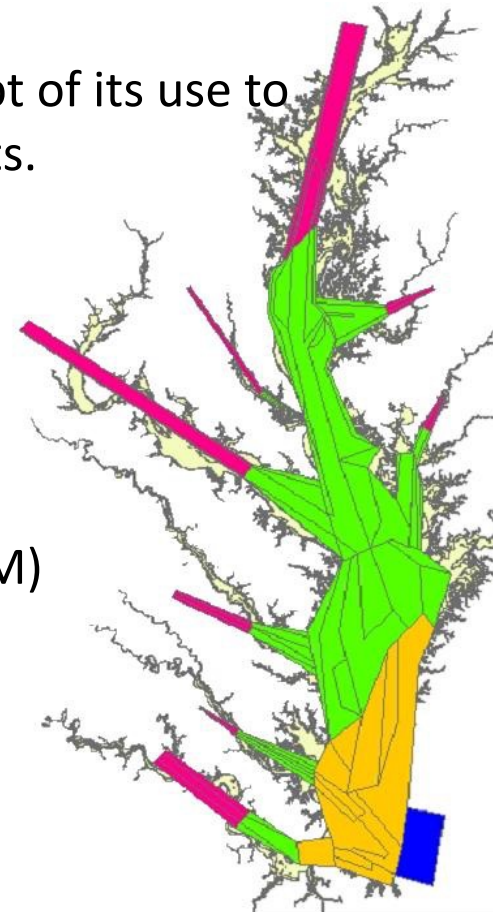**Estimating Toxic PFAS Concentrations in Seafood Spatially in the Chesapeake Bay**

Aim 1

Predict relative concentrations of PFAS contamination spatially for Chesapeake Bay species.

Aim 2

Test the predictive ability of the model as proof of concept of its use to estimate and map relative concentrations of contaminants.

The Chesapeake Atlantis Model (CAM)

The Chesapeake Atlantis Model
A Holistic Ecosystem Modeling Approach
Incorporating:

Biological environment
- ✓ Primary production
- ✓ Trophic interactions
- ✓ Recruitment relationships
- ✓ Age structure
- ✓ Size structure
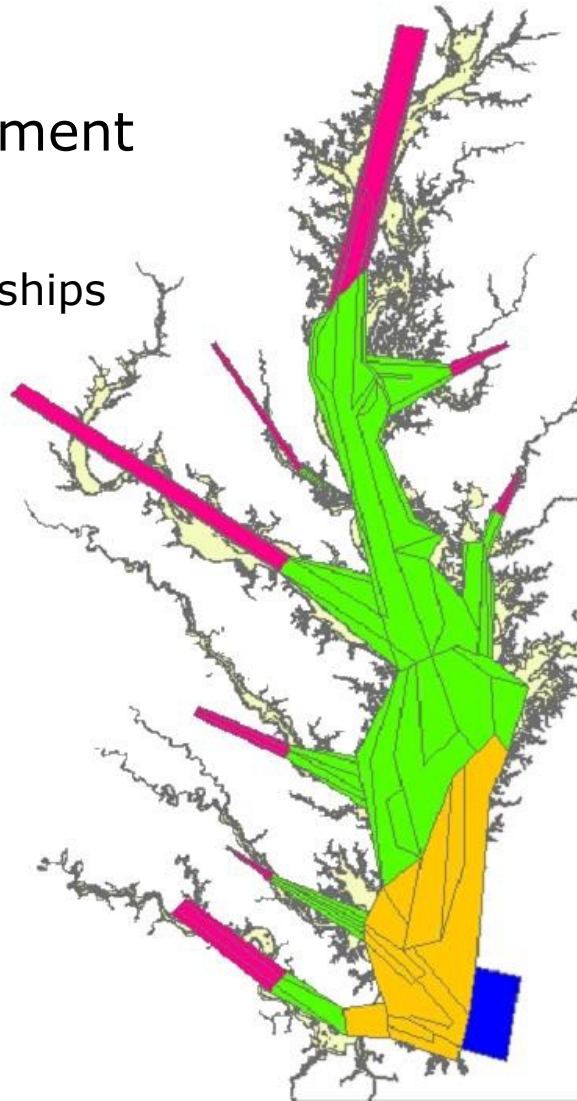- ✓ Life History
- ✓ Refuge Habitat

Fisheries
- ✓ Multiple sectors
- ✓ Gears
- ✓ Seasons
- ✓ Spatially explicit

Physical environment
- ✓ Geology
- ✓ Chemistry
- ✓ Circulation & currents
- ✓ Temperature
- ✓ Salinity
- ✓ Water clarity
- ✓ Climate variability

Nutrient Inputs
- ✓ Currency is Nitrogen
- ✓ Oxygen
- ✓ Silica
- ✓ 3 forms of detritus
- ✓ Bacteria-mediated recycling

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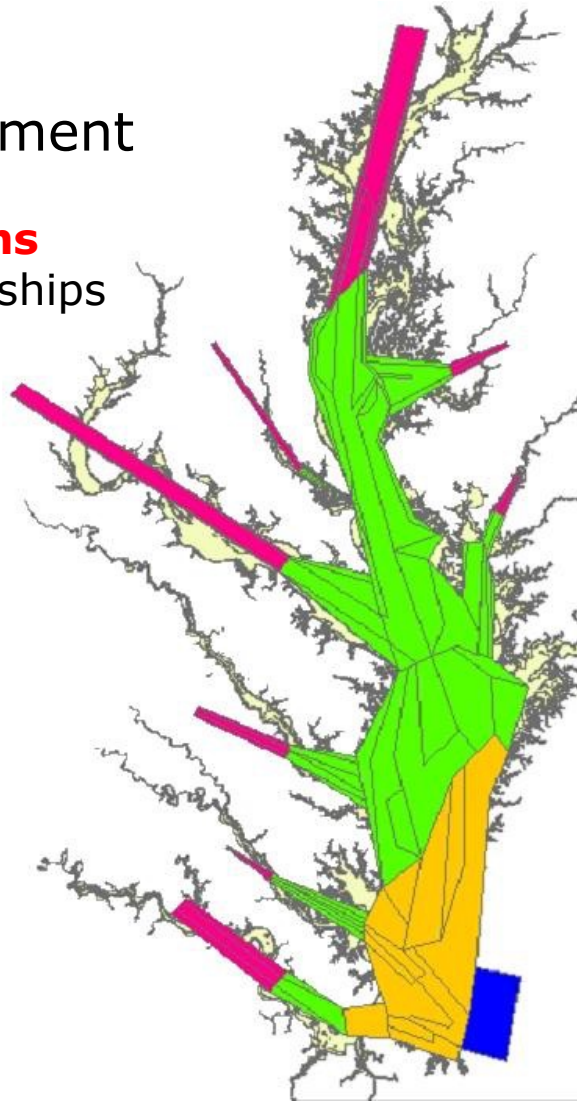- ✓Gears
- ✓Seasons
- ✓**Spatially explicit**

Ecotoxicolgy
- ✓Biomagnification

Physical environment
- ✓Geology
- ✓Chemistry
- ✓Circulation & currents
- ✓Temperature
- ✓Salinity
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Nutrient Inputs
- ✓Currency is Nitrogen
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- ✓Silica
- ✓3 forms of detritus
- ✓Bacteria-mediated recycling

# Ecological Groups: Federal fisheries, Forage, Protected, Habitat

Finfish
- **Alosines** (Amer.Shad, Hickory Shad, Alewife & Herring)
- Atlantic Croaker
- **Bay anchovy**
- Black drum
- **Bluefish**
- **Butterfish**, harvestfish ("Jellivores")
- Catfish
- Gizzard shad
- **Littoral forage fish**: silversides, mummichog
- **Menhaden**
- Striped bass
- **Summer flounder**
- Other flatfish (hogchoker, tonguefish, window pane, winter flounder)
- **Panfish**:
    Euryhaline: Spot, silver perch; FW to 10ppt: yellow perch, bluegill
- **Reef assoc. fish**: spadefish, tautog, black seabass, toadfish
- Spotted hake, lizard fish, northern searobin
- Weakfish
- White perch
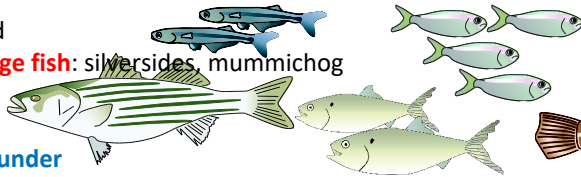
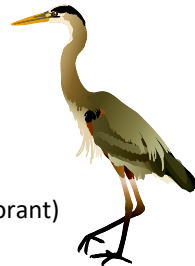## Elasmobranchs
- Cownose ray
- Dogfish, smooth
- **Dogfish, spiny**
- Sandbar shark
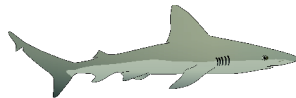
Birds
- **Bald Eagle**
- Piscivorous birds (osprey, great blue heron, brown pelican, cormorant)
- Benthic predators (diving ducks)
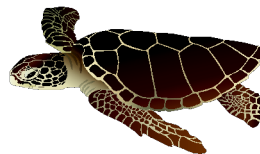- Herbivorous seabirds (mallard, redhead, Canada goose, & swans)
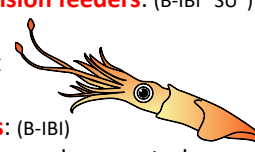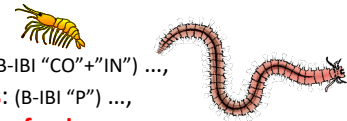
Mammals
- **Bottlenose dolphin**

Reptiles
- **Diamond-back Terrapin**
- **Seaturtles**

Invertebrates
- **Benthic feeders**: (B-IBI "CO"+"IN") ...,
- **Benthic predators**: (B-IBI "P") ...,
- **Benthic suspension feeders**: (B-IBI "SU")
- Blue crab YOY
- Blue crab adult
- **Brief squid**
- **Macoma clams**: (B-IBI)
- **Meiofauna**: copepods, nematodes, ...,
- **Oysters**

Primary Producers
- Benthic microalgae ("microphytobenthos" benthic diatoms, benthic cyanobacteria & flagellates)
- **"Grasses:"**
    SAV – type varies with salinity
- **Marsh grass**
- Phytoplankton – Large: diatoms & silicoflagellates (2-200um)
- Phytoplankton – Small: nannoplankton, ultraplankton, aka "picoplankton" or "picoalgae" (0.2-2um), cyanobacteria included (2um)
- Dinoflagellates (mixotrophs) (5-2,000um)
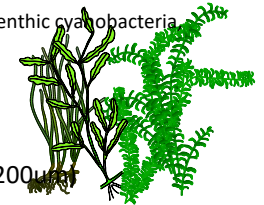
ZooPlankton
- Ctenophores
- Sea nettles
- Microzooplankton (.02-.2mm): rotifers, ciliates, copepod nauplii
- Mesozooplankton (.2-20mm): copepods, etc.
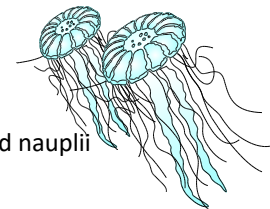
Detritus
- Carrion
- Carrion (sediment)
- Labile
- Labile (sediment)
- Refractory
- Refractory (sediment)

## Bacteria (.2-2 um [.002 mm] - feed microzooplankton food chain)
- Benthic Bacteria (sediment)
- Pelagic Bacteria: (free-living)

Images courtesy of ian.umces.edu/imagelibrary/

Over the next Year:

1. Parameterize CAM to estimate biomagnified concentrations of PFAS
2. Run the model
3. Choose two tributaries for field testing
4. Collect Blue Crabs in the test tributaries

5. Quantify actual PFAS levels (29) in tissues
6. Tune the model for Blue Crab
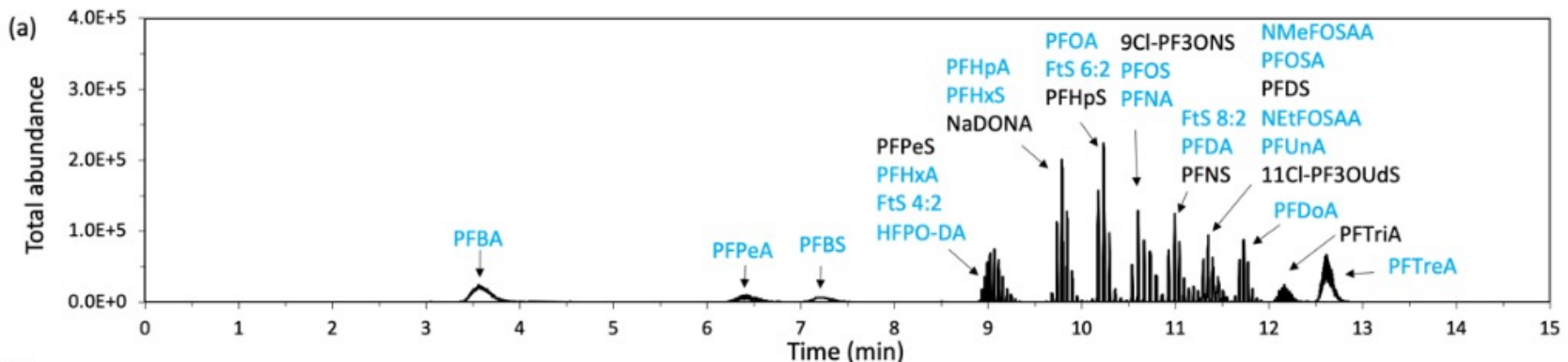
Thank You!

Questions: Thomas.ihde@morgan.edu

Funding:

EXTRA SLIDES

Table 1. PFAS to be investigated in this project. Note, * indicates mass-labeled PFAS (MPFAS).

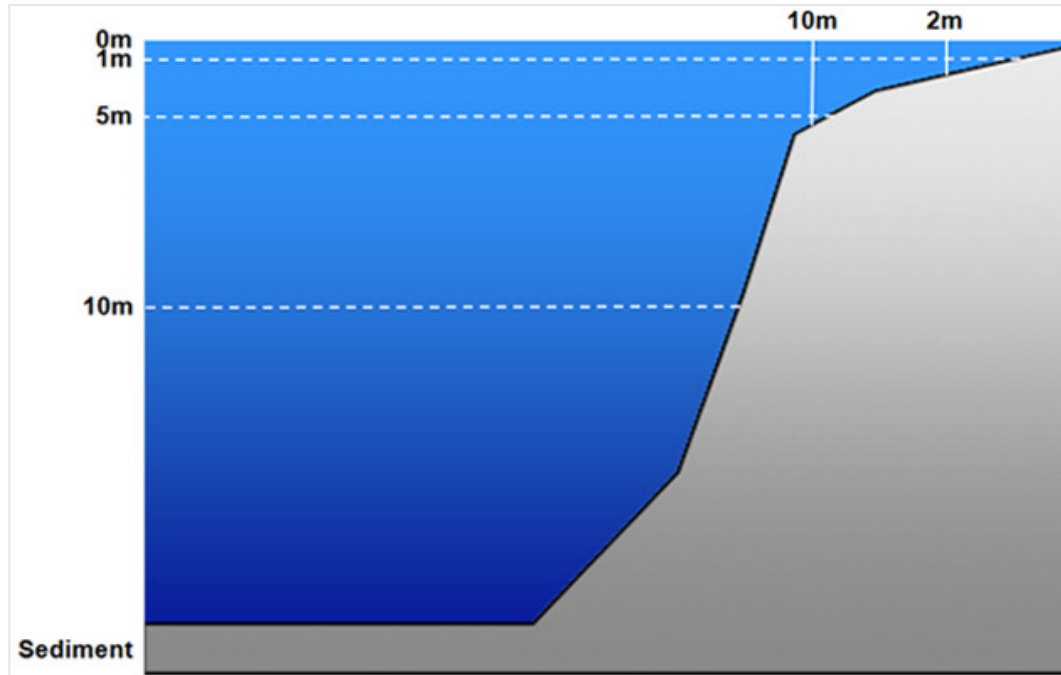| Class (#)	PFAS molecule (acronym)
Perfluorocarboxylic acids (11)	perfluorobutanoic acid (PFBA)*; perfluoropentanoic acid (PFPeA)*; perfluorohexanoic acid (PFHxA)*; perfluoroheptanoic acid (PFHpA)*; perfluorooctanoic acid (PFOA)*; perfluorononanoic acid (PFNA)*; perfluorodecanoic acid (PFDA)*; perfluoroundecanoic acid (PFUnA)*; perfluorododecanoic acid (PFDoA)*; perfluorotridecanoic acid (PFTriA); perfluorotetradecanoic acid (PFTreA)*
Perfluorosulfonic acids (7)	perfluorobutanesulfonic acid (PFBS)*; perfluoropentanesulfonic acid (PFPeS); perfluorohexanesulfonic acid (PFHxS)*; perfluoroheptanesulfonic acid (PFHpS); perfluorooctanesulfonic acid (PFOS)*; perfluorononanesulfonic acid (PFNS); perfluorodecanesulfonic acid (PFDS)
Fluorotelomers (3)	fluorotelomer sulfonic acid 4:2 (FtS 4:2)*; FtS 6:2*; FtS 8:2*
Other (8)	4,8-dioxa-3H-perfluorononanoic acid (ADONA); 2-(N-methylperfluorooctane-sulfonamido)acetic acid (NMeFOSAA)*; 2-(N-ethylperfluorooctane-sulfonamido)acetic acid (NEtFOSAA)*; hexafluoropropylene oxide dimer acid (HFPO-DA, also known as GenX)*; perfluoro(2-ethoxyethane)sulfonic acid (PFEESA); perfluorooctanesulfonamide (PFOSA)*; 9-chlorohexadecafluoro-3-oxanonane-1-sulfonate (9Cl-PF3ONS); 11-chloroeicosafluoro-3-oxaundecane-1-sulfonate (11Cl-PF3OUdS)
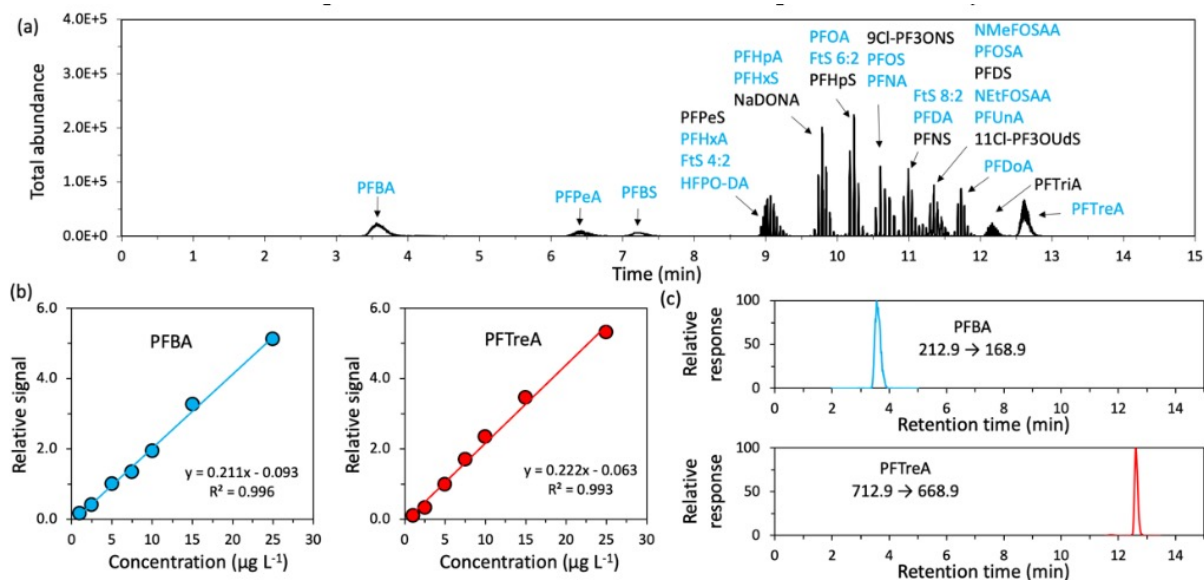
Figure 2. (a) The total ion current for a solution containing 10 µg L^{-1} of 28 PFAS (black and blue labels) and 5 µg L^{-1} of 23 mass-labeled internal standards (blue labels); example (b) calibration curves for the 1-25 µg L^{-1} range and (c) chromatograms with quantitative ion transitions for PFBA and PFTreA.
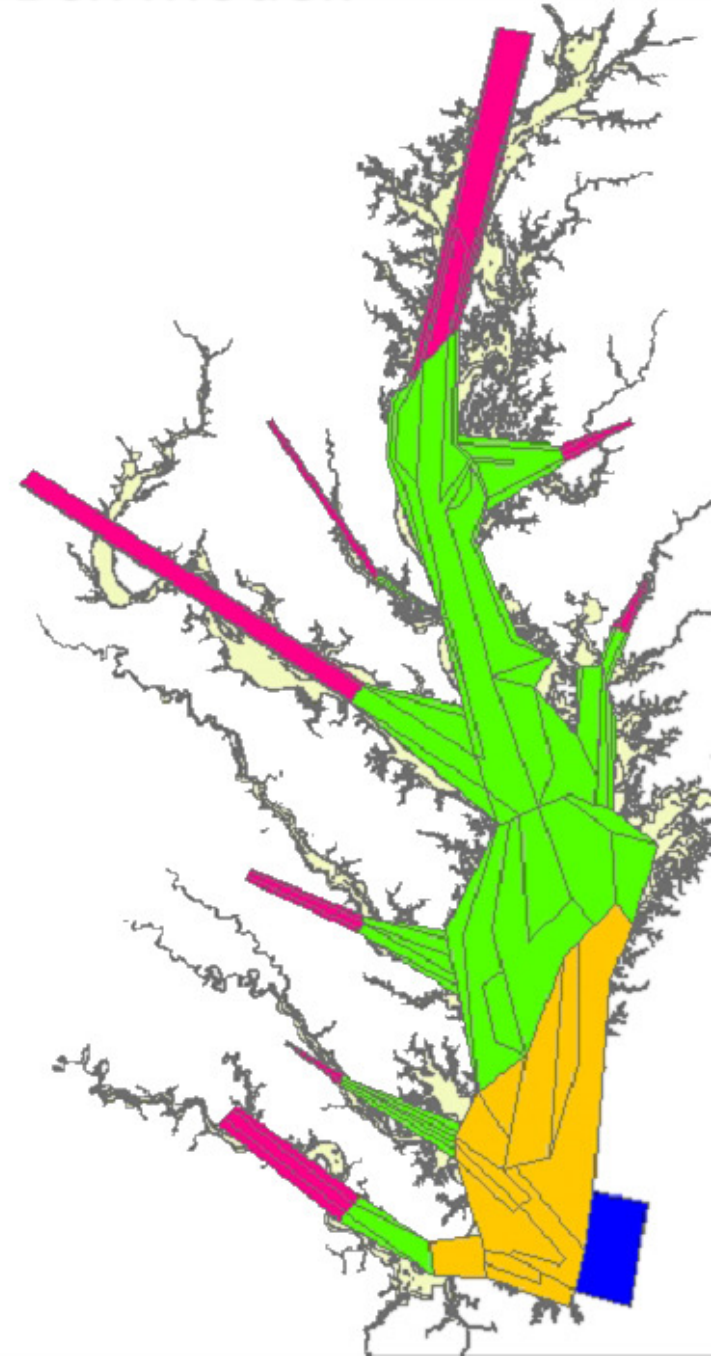
The Chesapeake Atlantis Model

Design

CAM Design: 3-Dimensional Box Model:

Salinity

- ■ (blue)
- ■ 1-10
- ■ 10-18
- ■ 18-30

CAM: River Box Structure