Modeling Aquatic Exposure - ESA

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Agenda

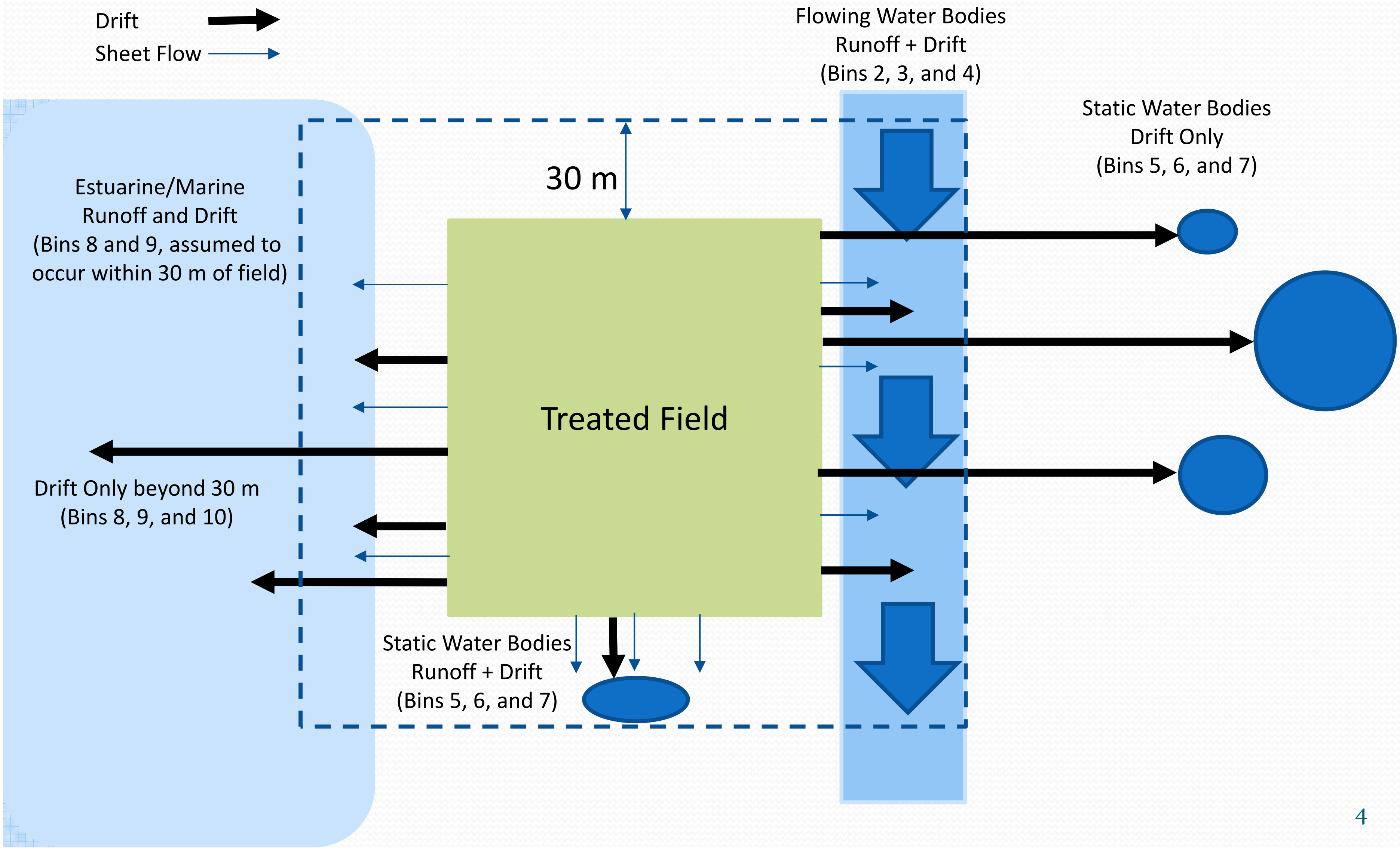
- Conceptual Model and Aquatic Bins / Watershed Sizes
- Surface Water Concentration Calculator (SWCC) Scenarios and Meteorological Stations
- Downstream Estimated Environmental Concentrations (EECs) (“Downstream Dilution”)
- Other Considerations
- Case Study – Shortnose Sturgeon

Aquatic Bins

Generic Habitat	Depth (meters)	Width (meters)	Length (meters)	Flow (m^3/s)
1 – Aquatic-associated terrestrial habitats	NA	NA	NA	NA
2- low-flow	0.1	2	Length of field[1]	0.001
3- Moderate-flow	1	8	Length of field	1
4- High-flow	2	40	Length of field	100
5 – Low-volume	0.1	1	1	0
6- Moderate-volume	1	10	10	0
7- High-volume	2	100	100	0
8- Intertidal nearshore	0.5	50	Length of field	NA
9- Subtidal nearshore	5	200	Length of field	NA
10- Offshore marine	200	300	Length of field	NA

[1]length of field – The habitat being evaluated is the reach or segment that abuts or is immediately adjacent to the treated field. The habitat is assumed to run the entire length of the treated area.

Conceptual Model – Bins and Distance



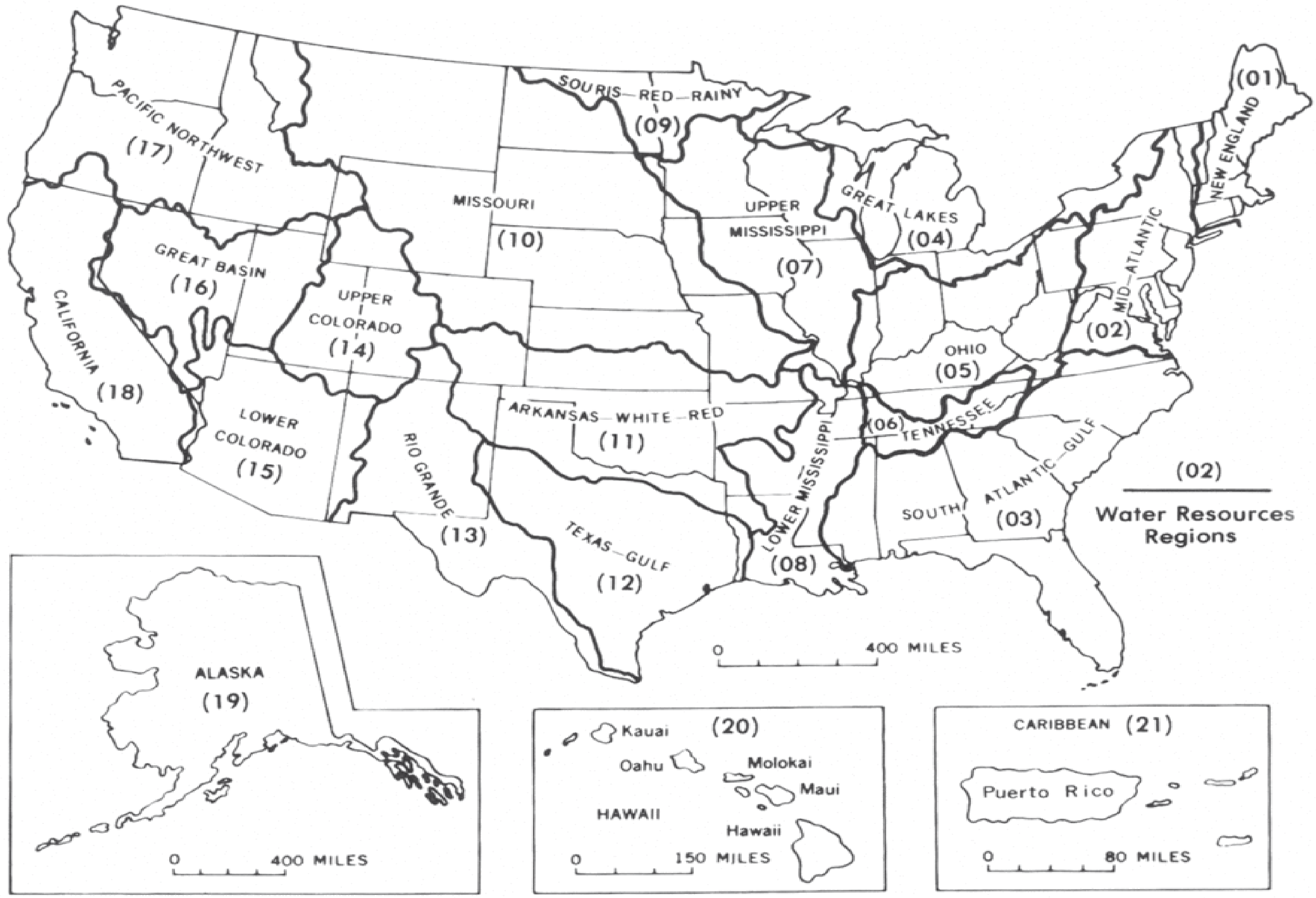
Conceptual Model

- For Step 1, to derive the offsite transport extent of the action area, model EECs in Bin 2 and couple with downstream assessment; model Bin 5 for effects of spray drift only
- For Step 2, model all "representative" aquatic bins
  - Evaluation of estuarine/marine bins would be limited to coastal areas and areas influenced by tidal flux
  - Within 30 m, all flowing and static aquatic bins would receive runoff and spray drift
  - Outside 30 m, static bins would only receive spray drift

Watershed Sizes – Spatial Context

- Given differences in precipitation and evaporation rates across the country, the size of a watershed's contribution to a water body will be different
- Estimate regional watershed size, as well as pesticide loading (*e.g.*, surface water modeling), for a waterbody via hydrologic unit codes or HUCs
  - HUC 2 – 18 regions in the conterminous US, containing the drainage area of a major river or series of rivers, as well as HI, AK and PR
- Efficient way to assess regional differences in environmental concentrations and manage resources needed for modeling

HUC 2 Regions



Watershed Sizes – Flowing Bins

- Use NHDplus dataset to assess relationships between drainage area and stream flow rates
- Confine analysis to streams and rivers and eliminated human-modified water bodies (*e.g.*, canals, pipelines, etc.) and artificial pathways
- Generate ln-ln regressions between flow and drainage area for each HUC2 region
- Estimate drainage areas, or watersheds, for each aquatic bin and HUC2

Watershed Sizes – Static Bins

- Conduct analysis using the SWCC, MS corn scenario (determined to be a high runoff scenario) and all available SWCC meteorological stations throughout the country (237 stations)
- Using the runoff estimates from the SWCC runs, and precipitation and evaporation data from meteorological station files, estimate the watershed size required to maintain the volume in the aquatic bins
- Try to achieve a median drainage area to normalized capacity (DANC) value of 5-15 m^2/m^3

Watershed Sizes – Estuarine/Marine

- Uncertain how to estimate watershed sizes and/or model runoff from the watersheds into estuarine/ marine water bodies and aquatic-associated terrestrial habitats
- Issues regarding tidal flux, salinity of receiving water body that current models do not address
- Use static and flowing water body bins as surrogates, generally:
  - Bin 5 for tidal pools
  - Bins 2 and 3 for low and high tide
  - Bins 4 and 7 used for marine species that occasionally inhabit offshore areas

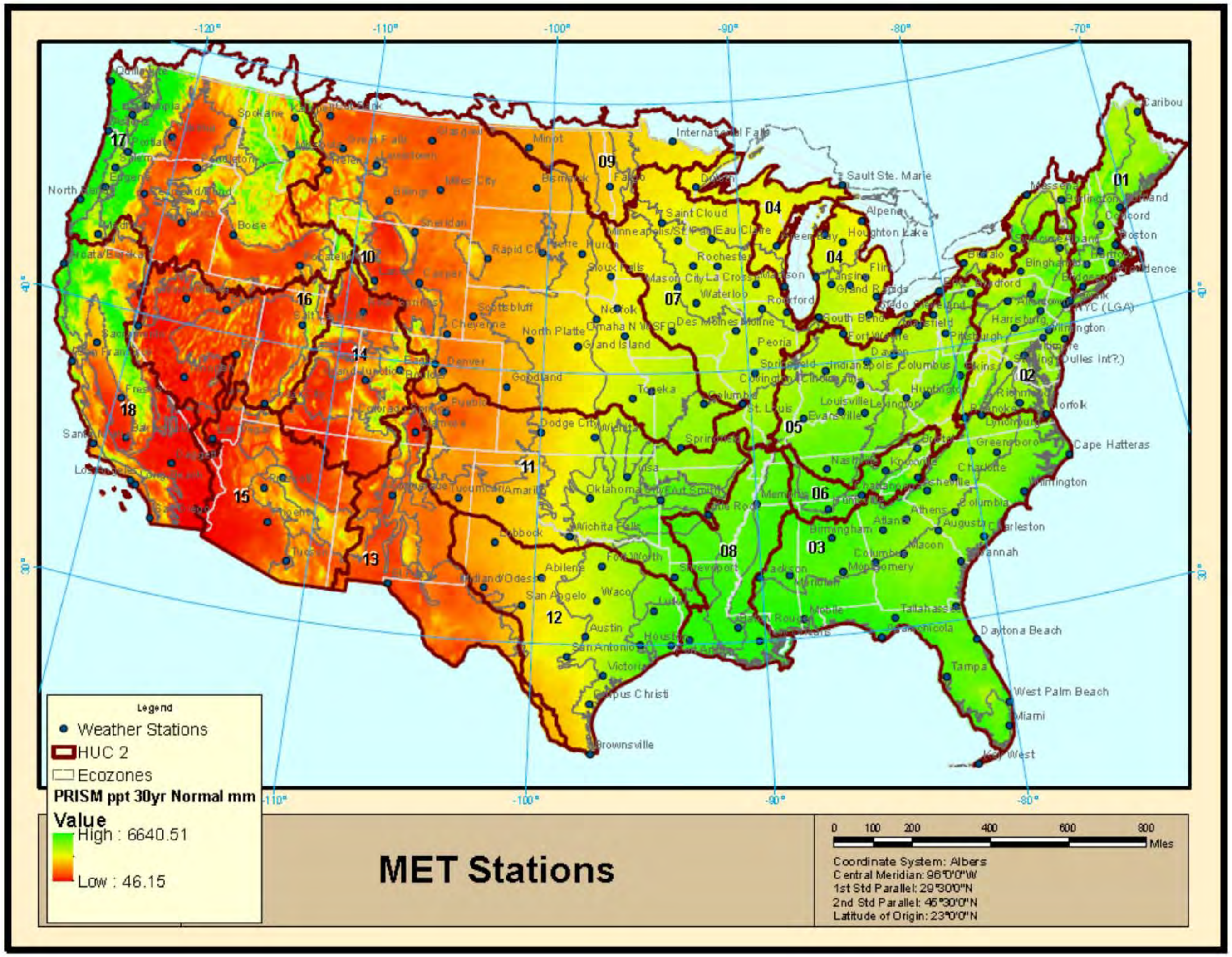
Spatial Modeling - Scenarios

- Over 120 SWCC scenarios are available for modeling pesticide releases to surface water
  - Agricultural – corn, wheat, citrus, etc.
  - Non-agricultural – rights-of-way, impervious surfaces, residential
- Weather data are available for 237 meteorological stations throughout the country
- Scenarios not evenly distributed across US
- In some cases, no current scenario exists for regions of the country (southwest US)

Spatial Modeling - Scenarios

- For Step 2 modeling:
  - Identify current SWCC scenarios for each HUC2 for each of the 11 crop data layer groupings
  - For HUC2 regions that do not have SWCC scenarios, develop a surrogate scenario for use in the HUC2
    - Representative scenario in nearby HUC2 with highest curve number
    - Replace existing meteorological station with representative(s) of the HUC2 region
- Identify most conservative scenario for use in Step 1 analyses

Precipitation in United States



Selection of Meteorological Stations

- Group all available meteorological stations by HUC 2 and estimate cumulative 30-year precipitation value
- Use the meteorological station with the median cumulative precipitation value for all HUC 2 regions except where there is a large difference in the precipitation values (>3x between min and max stations)
- Where large rainfall difference, estimate the median precipitation and select a median station for both the highest station group and the lowest station group based on cumulative precipitation
- For HUCs 15 and 16, large disparity between the highest precipitation station and others. Select highest precipitation station, along with the median of the remaining stations

Evaluation of Meteorological Stations

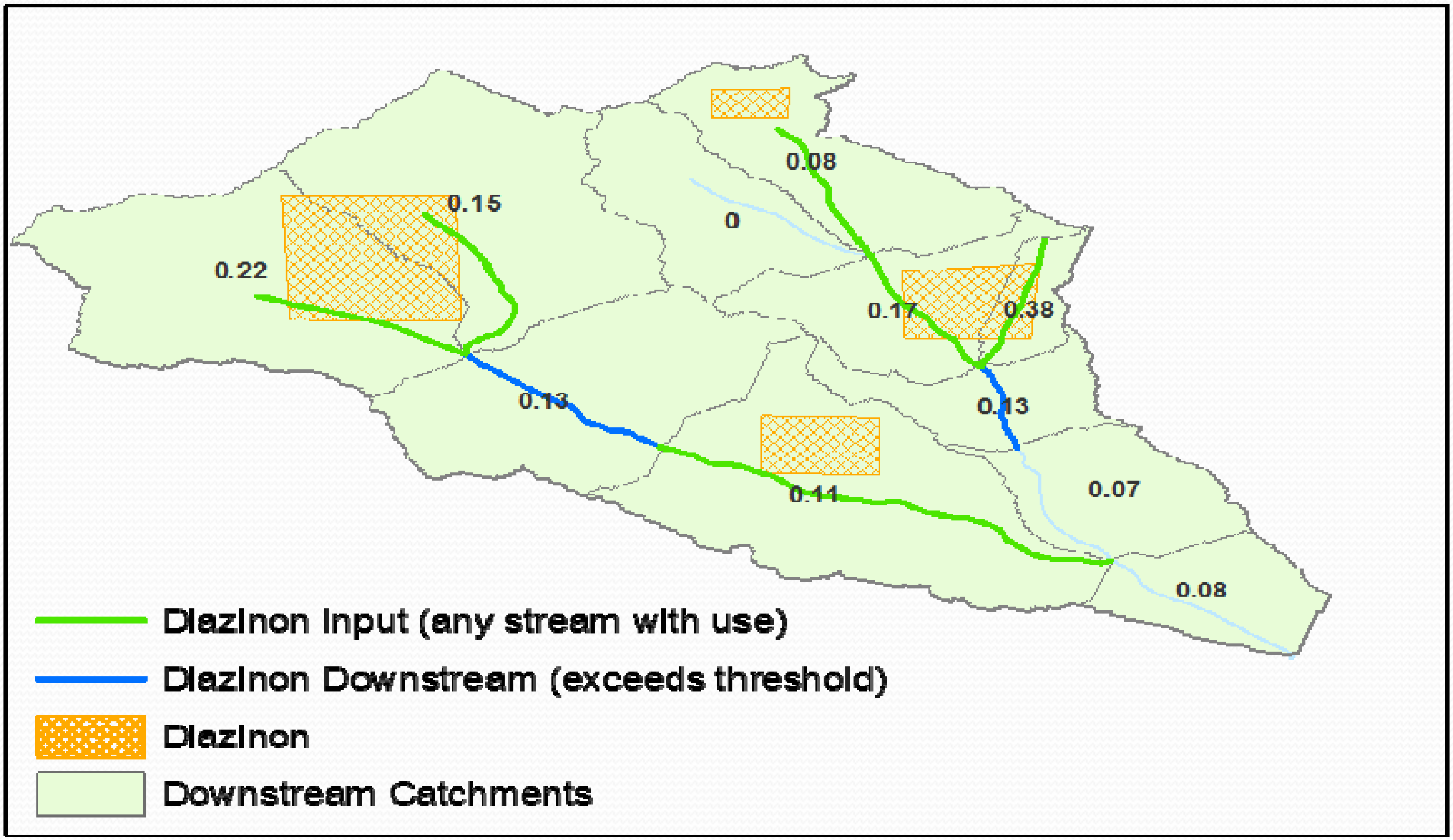
- Evaluate proposal by running SWCC and selected meteorological files, as well as max/min precipitation stations
- Results - all EECs within a HUC 2 region are within an order of magnitude no matter which meteorological data file is used for the model simulation
- The maximum precipitation station does not always result in the highest EECs for a given HUC 2 region
- Application date relative to rainfall event is more important than cumulative rainfall
- Bottom line – use of proposed meteorological stations should generate EECs that are not likely to underestimate exposure

Downstream EECs ("Downstream Dilution")

- Step 1 –expand action area to include downstream effects
  - Estimate required "dilution factor" using EECs and threshold
    - e.g. - EEC for Bin 2 is 10 µg/L and threshold is 1 µg/L, need to reduce EEC at least 90% to get below threshold
  - Use NHDplus land cover attributes for chemical to determine the distance to reach an overall percent use area below EEC/threshold dilution factor
- Step 2 –estimate downstream EECs and evaluate exceedance of threshold in listed species habitat
  - Use of process similar to Step 1, but look at breakdown of percent use areas by use category for each chemical to evaluate how each SWCC run impacts species

Downstream EECs ("Downstream Dilution")

Downstream Analysis Using Threshold = .10



Other Considerations

- Mixtures
  - Qualitative line of evidence in effects determination
  - Consider various sources of information
    - Tank mixes/co-formulated products
      - CDPR mixture analyses
      - Labels and recommended tank mixtures
    - Environmental mixtures
      - ECOTOX plus pile
      - NAWQA concentrations and co-occurrence
- Degradates - oxons
  - Total residue method
  - Estimate a weighted EEC

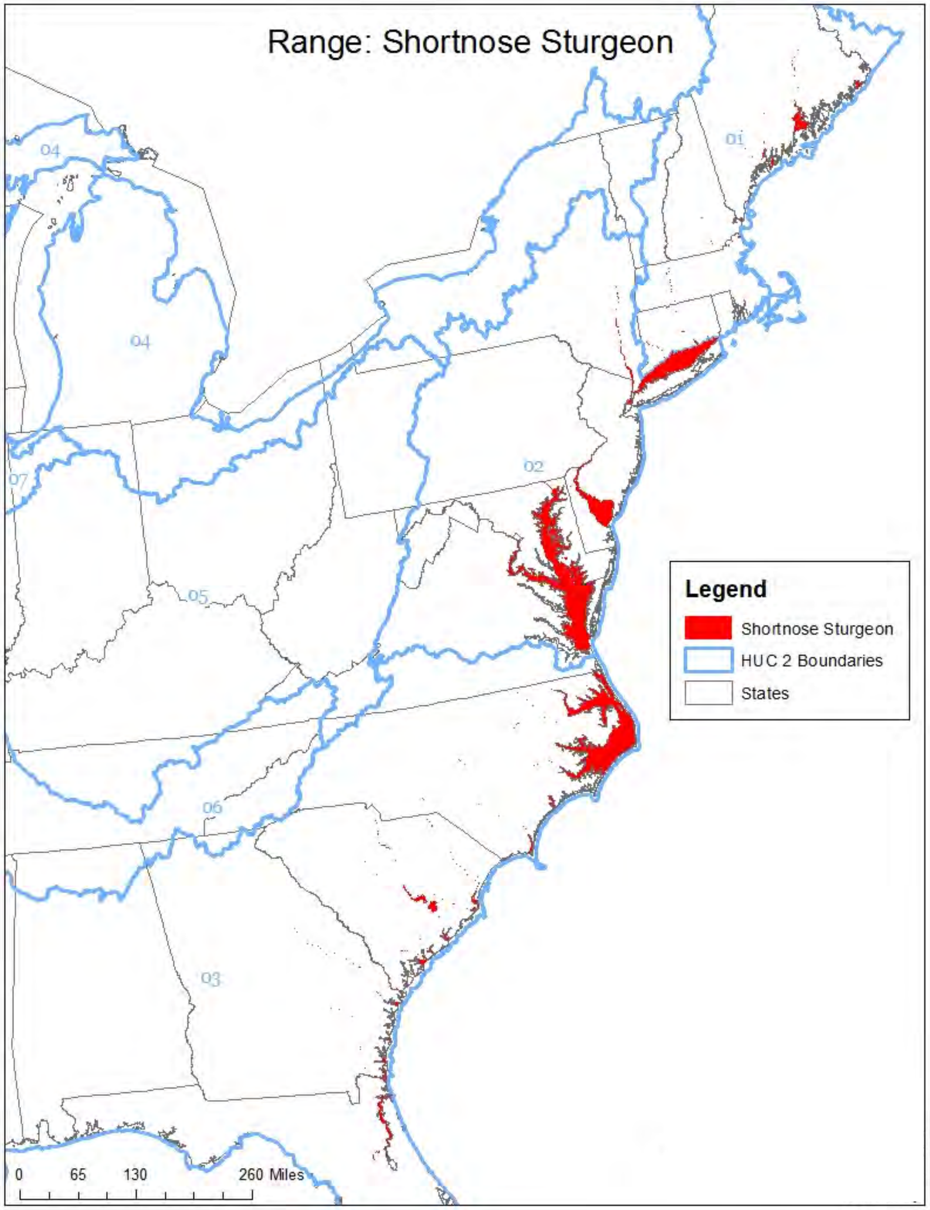
Case Studies Species Info

Shortnose Sturgeon
(*Acipenser brevirostrum*)

NMFS Website

Category	Information
Habitat	Rivers and estuaries along east coast from Canada to Florida Aquatic bins 3 and 4 (flowing), 6 and 7 (static), 8 and 9 (estuarine/marine)
Presence in Freshwater	Juveniles: first 2-3 years Adults: late winter / early spring
Reproductive Timing	Late winter / early spring, depending on location along east coast
Diet	Juveniles: benthic insects and small crustaceans Adults: mollusks and large crustaceans

Species Location



Fate Properties - Chlorpyrifos

- Lab studies - degrades in weeks to months
- Terrestrial studies - dissipates in weeks to months
- Slightly Mobile
- Semi-volatile
- Bioconcentrates, but rapid depuration

Parameter (units)	Input Value
Molecular Weight (g/mol)	350.57
Water Solubility (mg/L) 20 °C	1.4
Vapor Pressure (torr) 25 °C	1.87×10^{-5}
Henry's Law Constant (atm - m^3/mol)	6.2×10^{-6}
Hydrolysis Half-life (days)	0
Aqueous Photolysis (days)	29.6
Aerobic Soil Metabolism Half-life (days)	170.6
Aerobic Aquatic Metabolism Half-life (days)	91.2
Anaerobic Aquatic Metabolism Half-life (days)	203
K_{oc} (mL/g_{oc})	6040

Chlorpyrifos Uses – HUCs 1-3

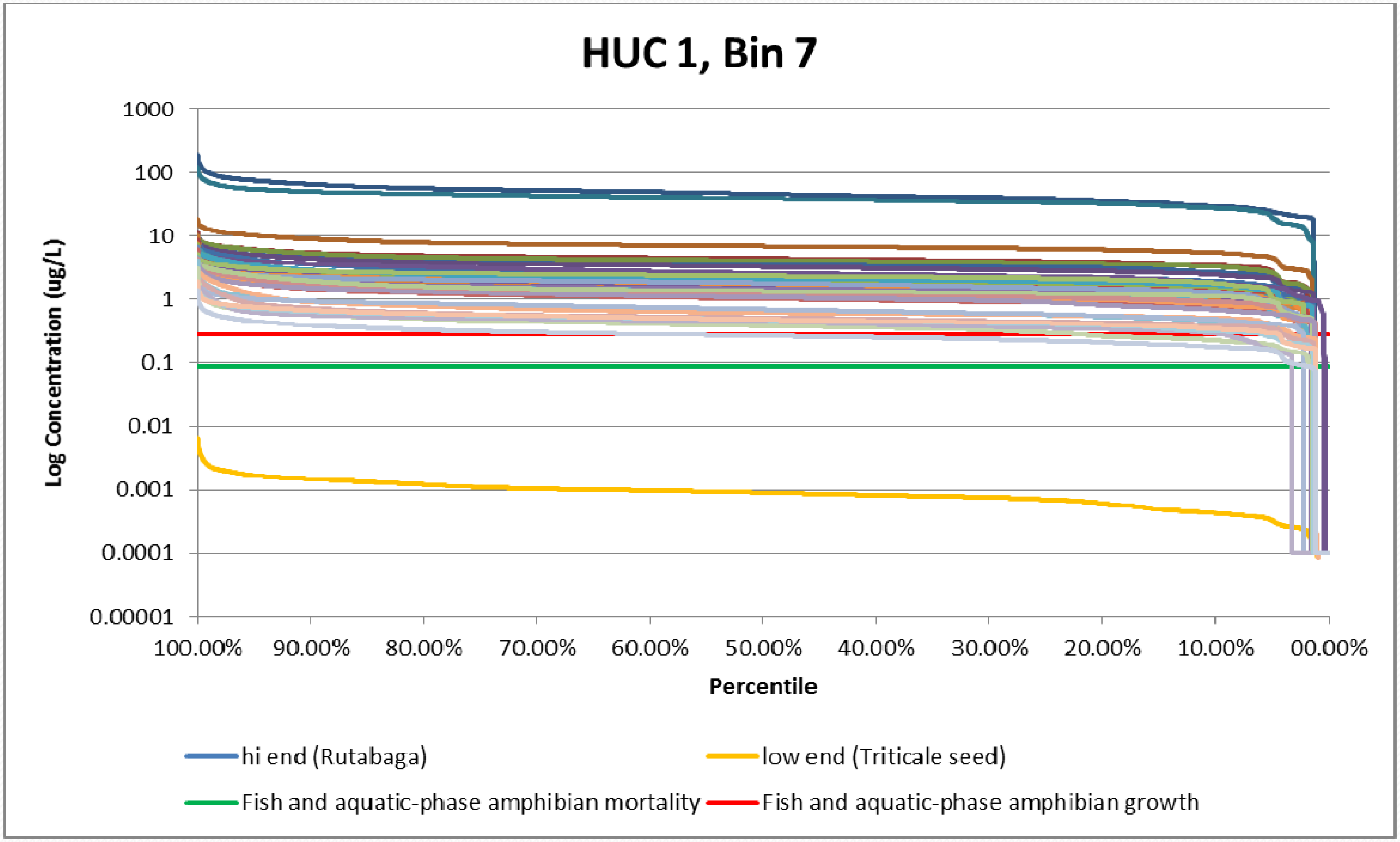
Crop	Rates (lbs a.i./A)	# apps	RTI	Crop	Rates (lbs a.i./A)	# apps	RTI
Alfalfa	1 x 4	4	10	Peach (HUC 3)	3, 2.5, 2.5	3	Varies
Apples	2, 1.5	2	Varies	Peanut	2 x 2	2	Varies
Asparagus	1 x 3	3	Varies	Peas, seed	0.3	1	--
Beans, seed	0.348	1	--	Pecans	2, 4.3, 2, 4.3	4	10
Brussel sprout, cauliflower	2.25, 1, 1, 1	4	Varies	Peppers	1 x 8	8	10
Cherries, tart	2, 4, 4, 2, 2.5	5	Varies	Plums, prunes[2]	2, 2.5	2	Varies
Citrus[3]	4, 3.5, 1, 1, 1	5	Varies	Radish	3 x 3	3	30
Cole crop	2, 2, 1, 1, 1, 1	6	10	Right of way	1 x 2	2	7
Corn	1.6, 2, 1.5, 1.5, 1.5, 1.5	6	10	Rutabaga	2.4 x 4	4	10
Cotton[2]	1 x 3	3	10	Seed orchard trees	1, 1, 1, 2.5, 0.3	5	7
Cranberry[1]	1.5 x 2	2	10	Sorghum	1.5, 0.01, 1, 0.5	4	Varies
Cucumber, seed	0.4	1	--	Soybean	2.2, 0.8	2	10
Filbert/hazlenut	2 x 4	4	Varies	Soybean	1 x 3	3	15
Christmas tree plantation	1 x 6, 0.34	7	7	Strawberry (HUC 3)	1 x 2	2	14
Fruit and nuts	4, 2	2	Varies	Strawberry (HUC 1, 2)	2, 1, 1	3	Varies
Golf course	1 x 2	2	7	Sugar beet	1 x 3	3	10
Grapes	2.25	1	--	Sunflower	2, 1.5, 1.5	3	Varies
Legume	1	1	--	Sweet potato	2.1	1	--
Nectarine	3, 2.5	2	Varies	Tobacco	2	1	--
Nursery	1 x 3	3	7	Triticale, seed	0.003	1	--
Nursery	4	1	--	Turnip	2.3 x 2	2	Varies
Onions[2]	1 x 2	2	9	Walnut	2, 2, 2, 4	4	Varies
Peach	3, 2.5	2	Varies	Wheat	0.003, 1, 1	3	Varies

1. HUCs 1 and 2 only
2. HUCs 2 and 3 only.
3. HUC 3 only

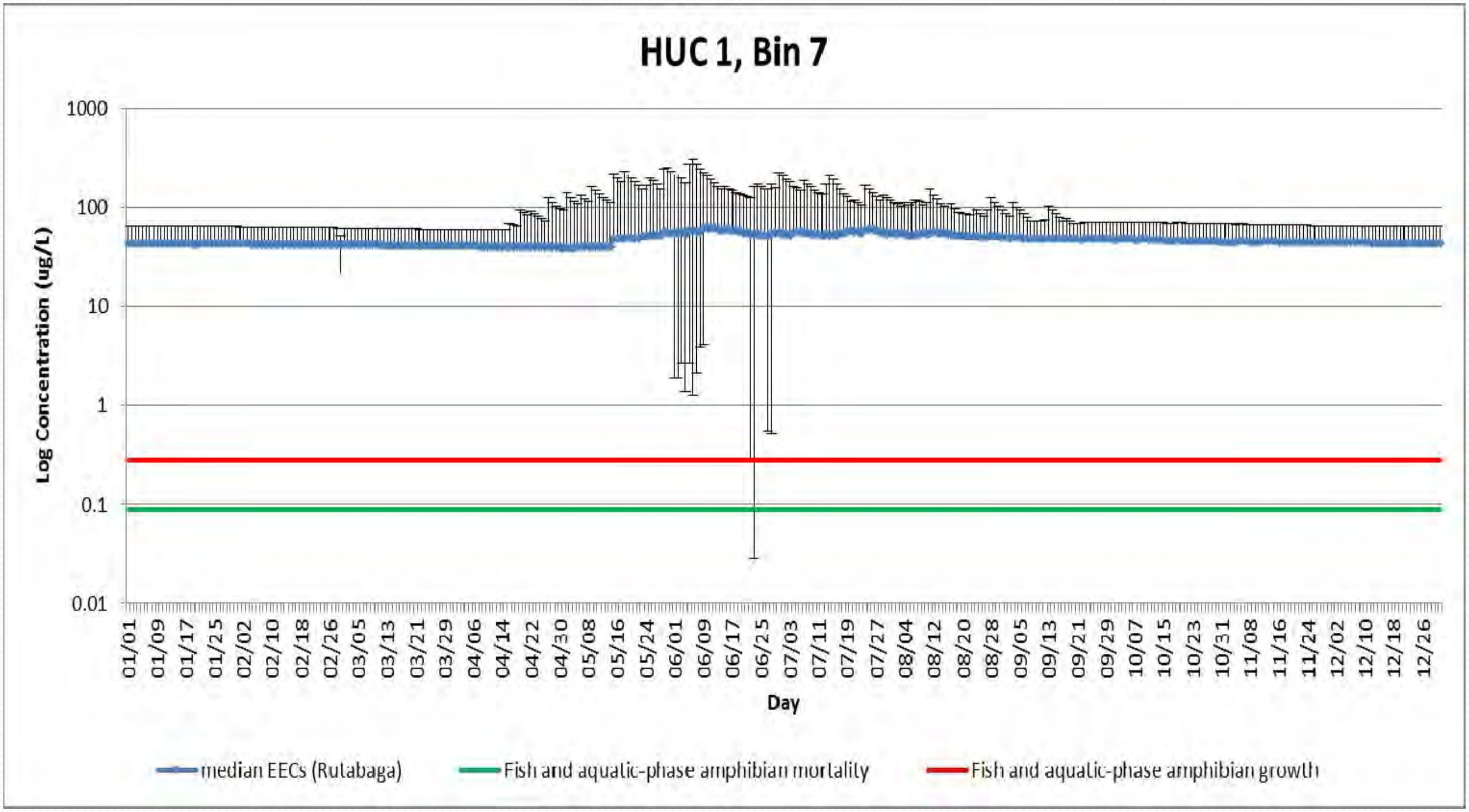
Chlorpyrifos Effects Thresholds

Effect (endpoint)	Value (µg/L)	Test species	Duration of exposure
Mortality (1/million)	0.088	HC_{05} from SSD	96 hours
Sublethal (growth)	0.28	Atlantic silverside	28 days

Range of EECs



Range of EECs Over Course of Year



Exposure Considerations

- Relevance of environmental exposure models for generating EECs for receiving waterbody habitats
  - High certainty in models developed to predict concentrations in species' habitats
  - Less certainty in models that were not developed specifically to address species' habitats, but adapted to achieve this purpose
- Robustness of fate data used to derive EECs
  - High certainty in EECs when a robust fate data set is available
  - Less certainty in EECs when an incomplete fate data set is available
- Targeted monitoring data comparable to EECs
  - Strengthens the confidence in the values, but lack of targeted monitoring data does not weaken it

Effects Determination

- Use weight of evidence approach to evaluate exposure and effects data for multiple lines of evidence
    - Mortality
    - Growth
    - Reproduction
    - Impacts to behavior
    - Sensory effects
    - Indirect Effects
    - Other stressors (chemical and non-chemical)
- Evaluate the overlap of exposure and effects (risk) and the confidence in the data (weight) for each line of evidence to arrive at effects determination
- Lines of evidence for mortality and growth suggest a likely to adversely affect determination, but a thorough evaluation of all of the lines of evidence would need to be done before the analysis is completed

Questions?