Projecting Risks and Addressing Uncertainties

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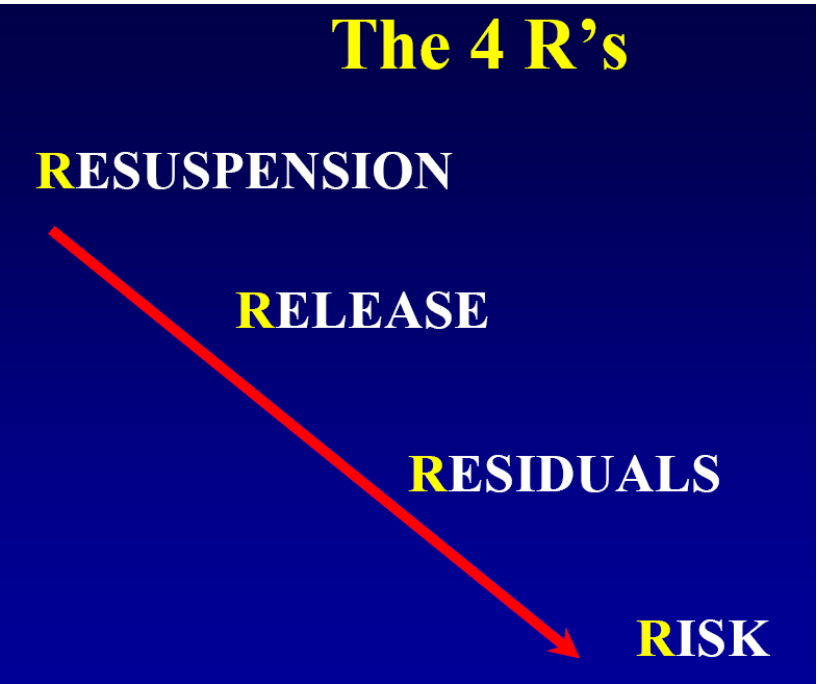
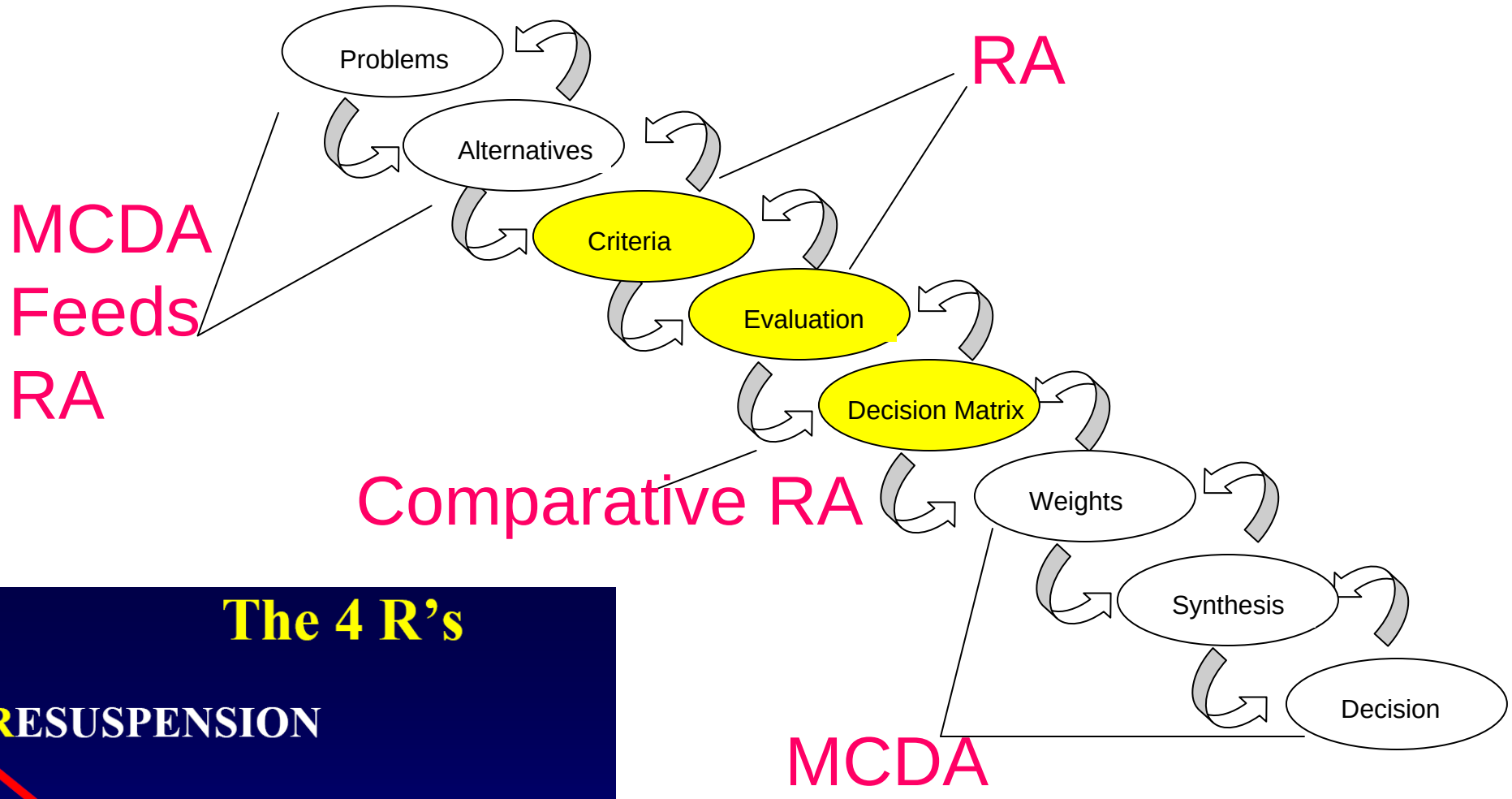
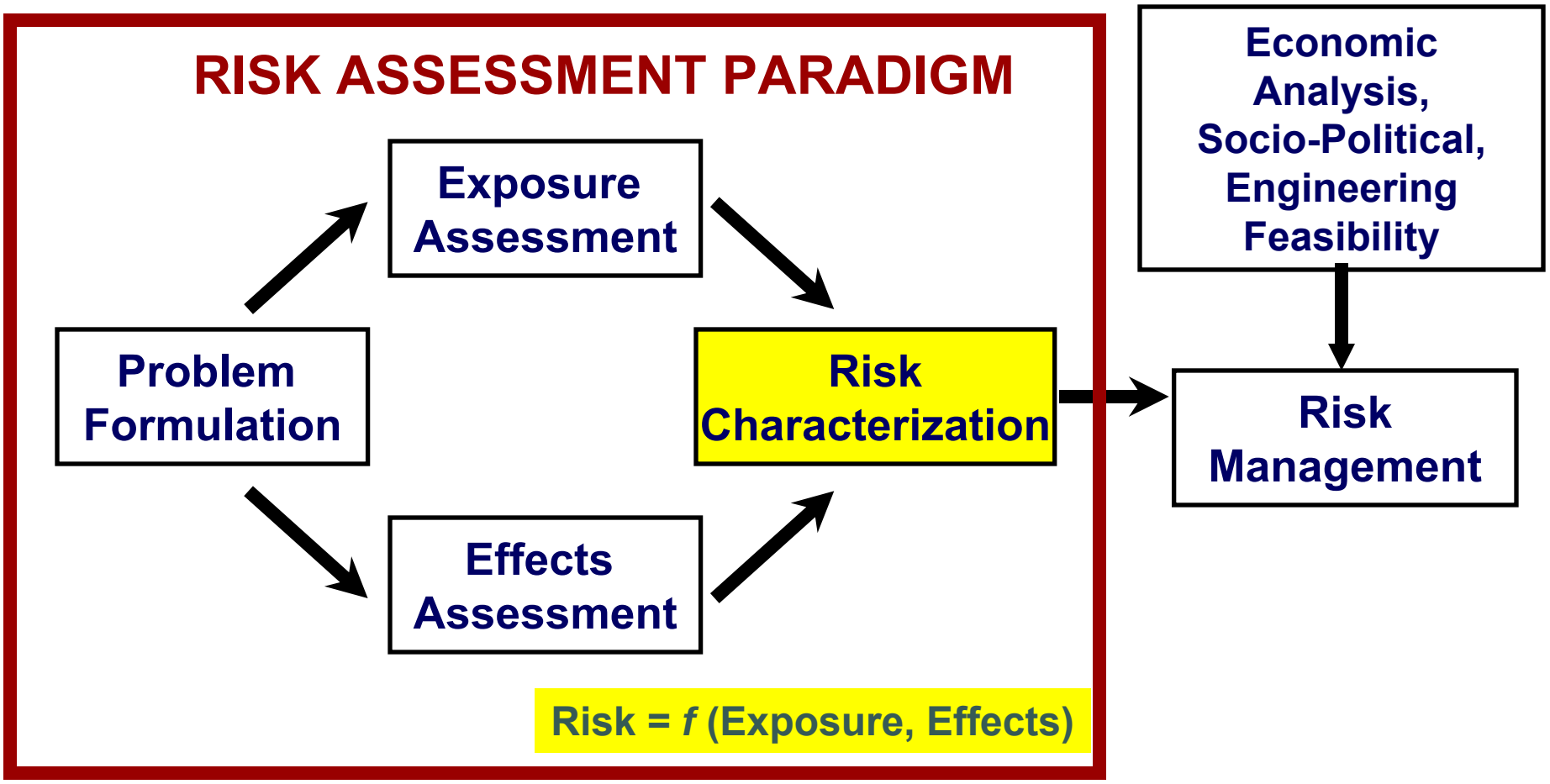




Decision Framework

Risk Framework



Presentation - Overview

- **Risk Characterization as part of Risk Assessment and Decision Analysis**
- **Approach to Risk Characterization**
  - Quantitative Risk Characterization
  - Qualitative Risk Characterization
  - Criteria/Benchmark Development
- **Toddaho Risk Characterization**
  - Fish migration and spawning
  - Mussels
- **Using Risk Assessment in Decisions**
  - MCDA Approach
  - Application to Toddaho
- **Conclusions**

Risk Characterization

- Risk Characterization is integration of Exposure and Effect Assessments to generate estimates of risk
- Quantitative Risk Characterization – calculation of risk metrics
- Qualitative Risk Characterization – "weight of evidence" discussions

Quantitative Risk Characterization

- **Procedure: Calculate metric and compare to benchmark**

Contaminated Sediments: Cancer Risk

$$CancerRisk = \frac{ConcFish * CancSlpF * FishIngest * ExpDuration}{BW * AverTime}$$

Cancer Risk: Range: 10E-4 – 10E-6

Quantitative Risk Characterization

Contaminated Sediments: **Non-cancer Risk**

$$ToxQuotient = \frac{DoseExposure}{DoseEffects} = \frac{IR_f * C_f}{BW * TRV}$$

Toxicity Quotient: **Comparison to 1**

Quantitative Risk Characterization

Non-chemical Stressors: Response Indicators for Suspended and Bedded Sediments (from EPA, 2007)

	Rivers and Streams	Lakes, Ponds, and Reservoirs	Wetlands	Estuaries	Coastal Marine Waters
Response Indicators					
Biological Measures	●	●	●	●	●
Water Clarity	●	●	○	●	●
Eroding Banks	●	●	○	●	●
Reservoir Filling Rate	●	●	●	●	○
Filter Clogging	●	●	○	○	○

Quantitative Risk Characterization

Non-chemical Stressors: No formal Framework

- **Select response values that protect the designated use:**
  - EPT taxa
- **Select an attribute of the entity**
  - presence/absence
- **Measure a level of the attribute**
  - percentage of species measured

How to Select Benchmark?

- **Acceptable Risk: A delegated authority or body defines the acceptable amount of deviation from historical or recent past observations of aquatic life.**
  - Precedent
    - Criteria have been set in a similar situation
    - The rationale is documented and method appropriate
  - State, Tribal, Federal Regulation
    - value is precisely stated by statute

How to Select Benchmark?

- **Comparison to Background: Characterize contribution of background conditions for selected physical impact metrics**
- **Measurable Difference from Background**
  - Based on statistical analysis of stressor-response relationships, the best achievable measure of the designated use is distinguished from all other lesser conditions.
    - Reproducible
    - Affected by sample size and variability inherent in the data set.
    - Subjective decisions are needed for the test statistic and the chosen significance level.
  - Biological relevance needs to be considered
  - Separate natural and human-induced variations

Toddaho Risk Characterization

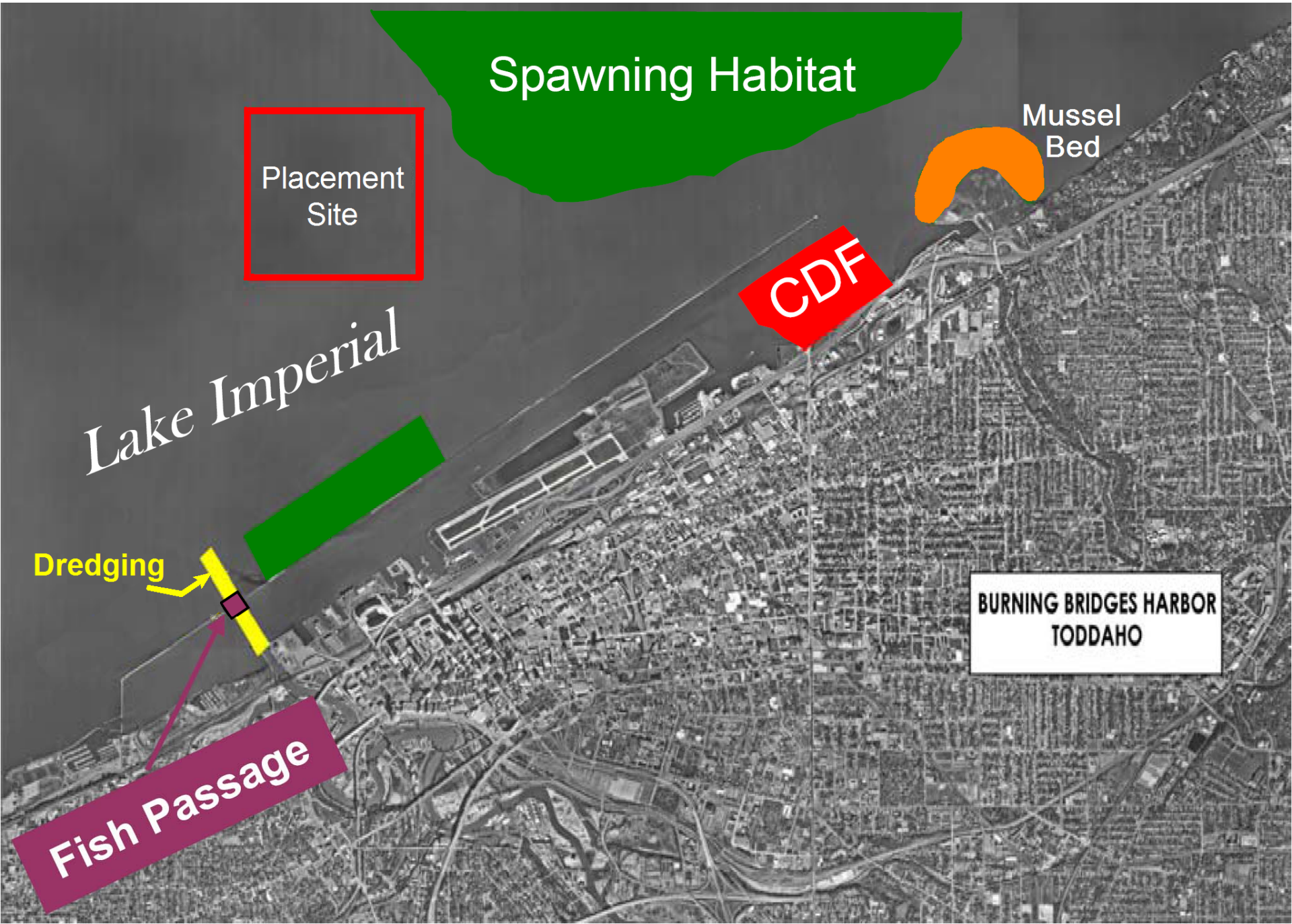
- Environmental Resources
- Exposure Results for Fish Eggs
- Effects Data for Fish Eggs
- Risk to Fish Egg Survival
- Exposure Results for Migrating Juvenile Fish
- Effects Data for Migrating Juvenile Fish
- Risk to Migrating Juvenile Fish
- Exposure Results for Mussels
- Effects Data for Mussels
- Risk to Mussels
- Overall Desired Risk Reduction

Risk Concerns / Recovery

Eco-Risk	Recovery Time		Weight of Concern
	Sublethal Effect	Lethal Effect	
Fish Eggs	Rapid, weeks to months	Rapid, 1 year	Medium
Juvenile Fish	Rapid, weeks to months	Rapid, 1 year	Low
Mussels	Moderate, 1 year	Slow, decade	High

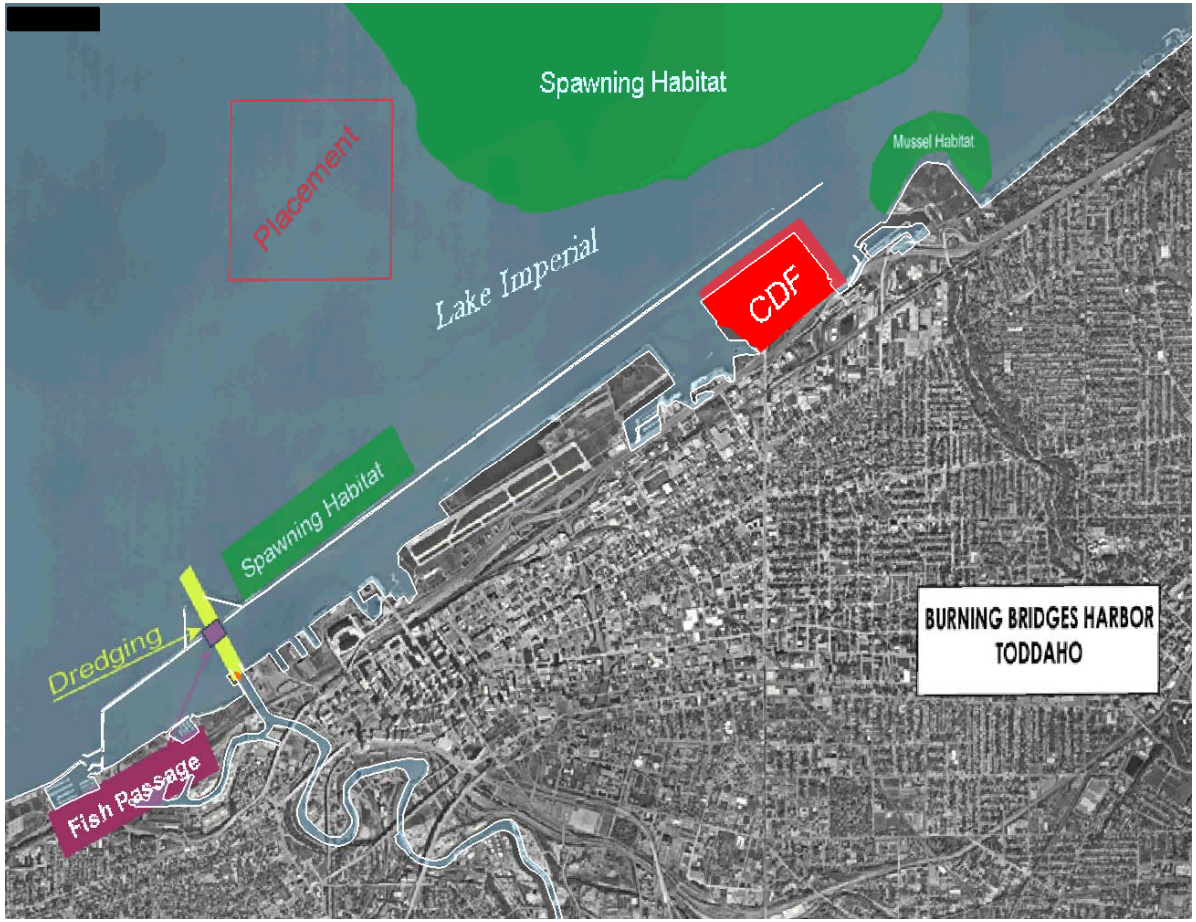
Risk Criteria

Alternative	Cost	Survivability of fish eggs %	Survivability of fish %	Survivability of mussels%
Hopper - No Overflow & Open Water Placement	40	95 DS 40 OWP	95	100
Mechanical - Open Water Placement	60	80 DS 85 OWP	60	100
Mechanical - CDF Placement	100	80 DS 100 OWP	60	99
Environmental Windows –				
Spawning	70	100	NA	100
Fish Passage	70	NA	100	100


Spawning Habitat
Mussel Bed
Placement Site
CDF
Lake Imperial
Dredging
BURNING BRIDGES HARBOR
TODDAHO
Fish Passage

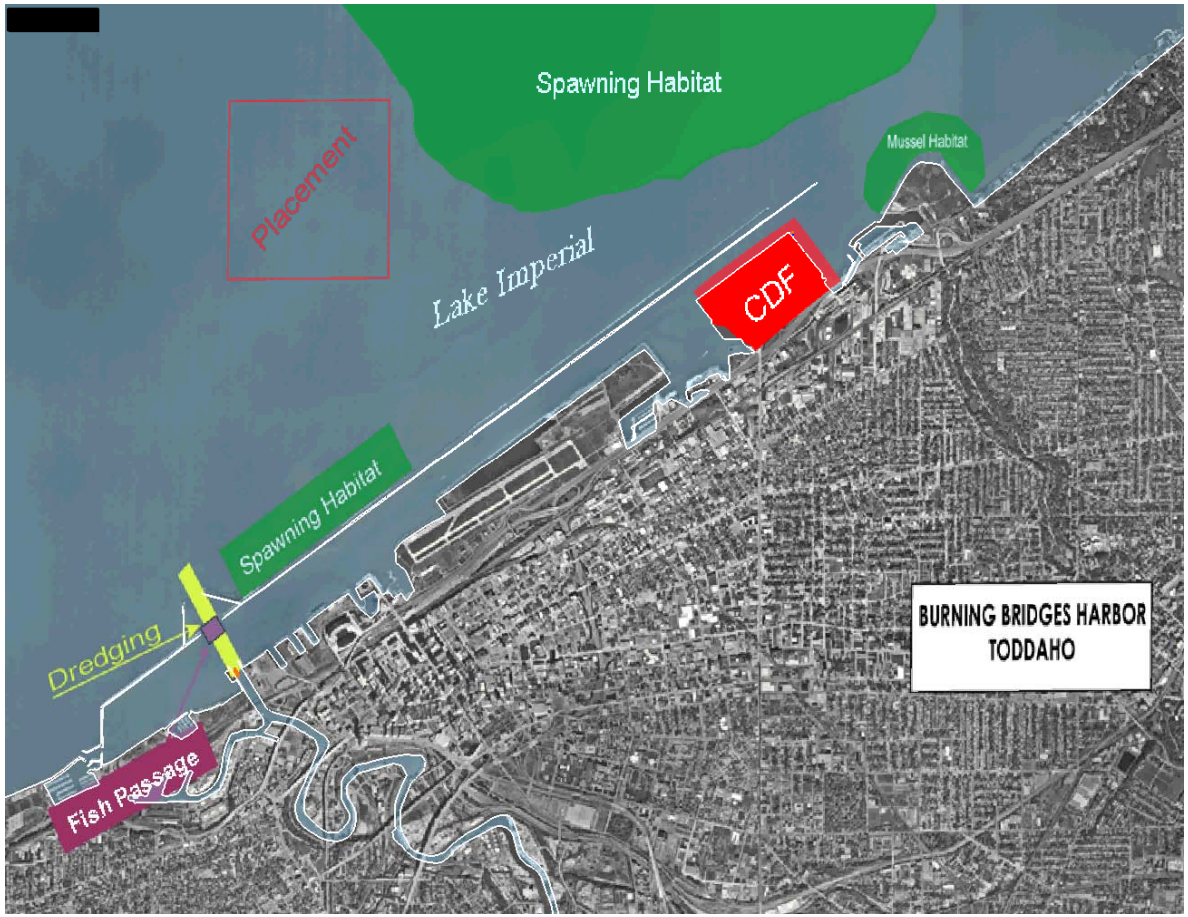
Hypothetical Example: OWP Exposure

PTM 13-day simulation shows most sediment remains in channel, harbor and placement sites. Some transport to spawning areas occurs; no transport to the mussel bed.



Hypothetical Example: CDF Exposure

PTM 13-day simulation shows most sediment remains in channel, harbor and placement sites. Very little is transported to the mussel bed. Some transport to spawning areas occurs.

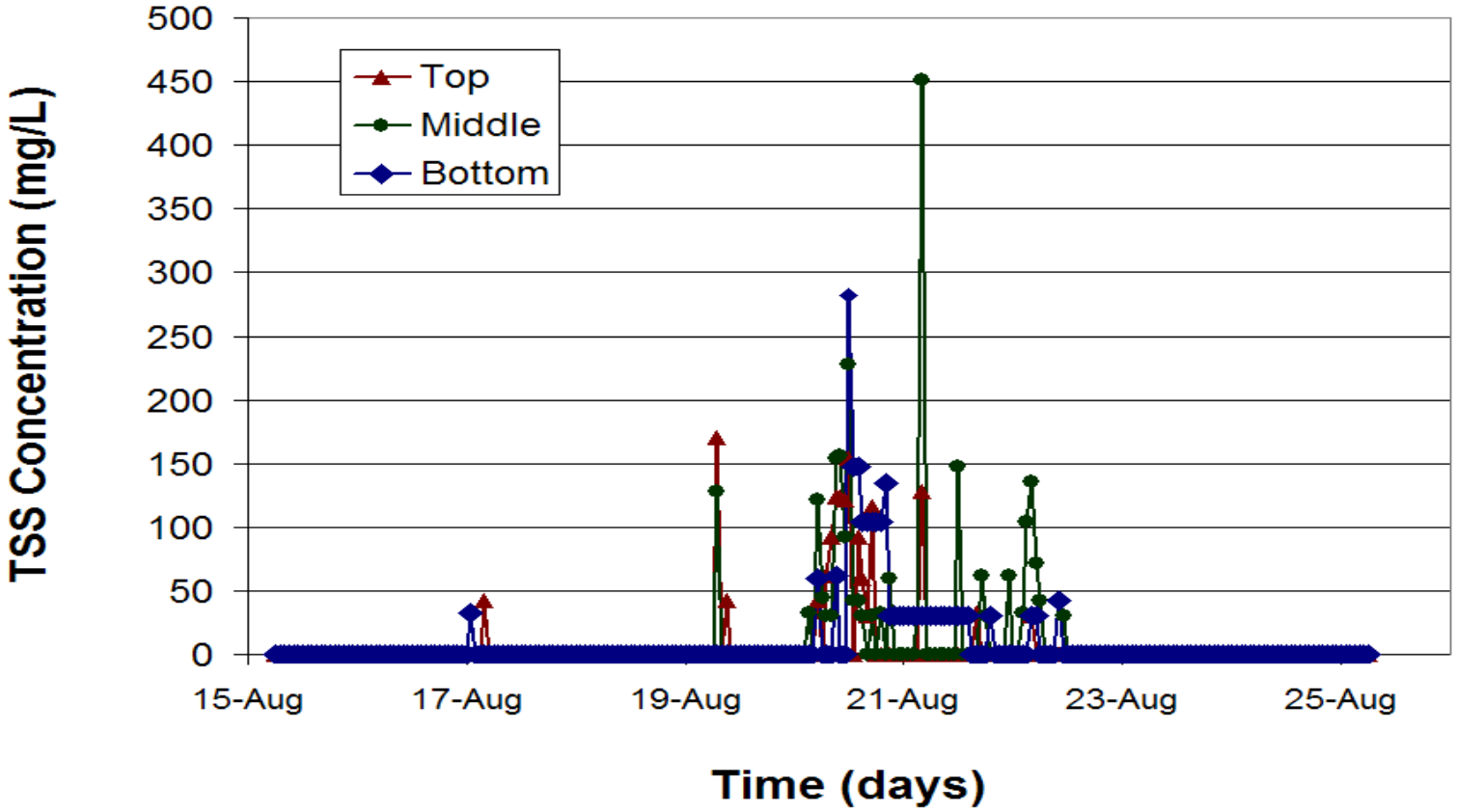


PTM Fate and Transport Results

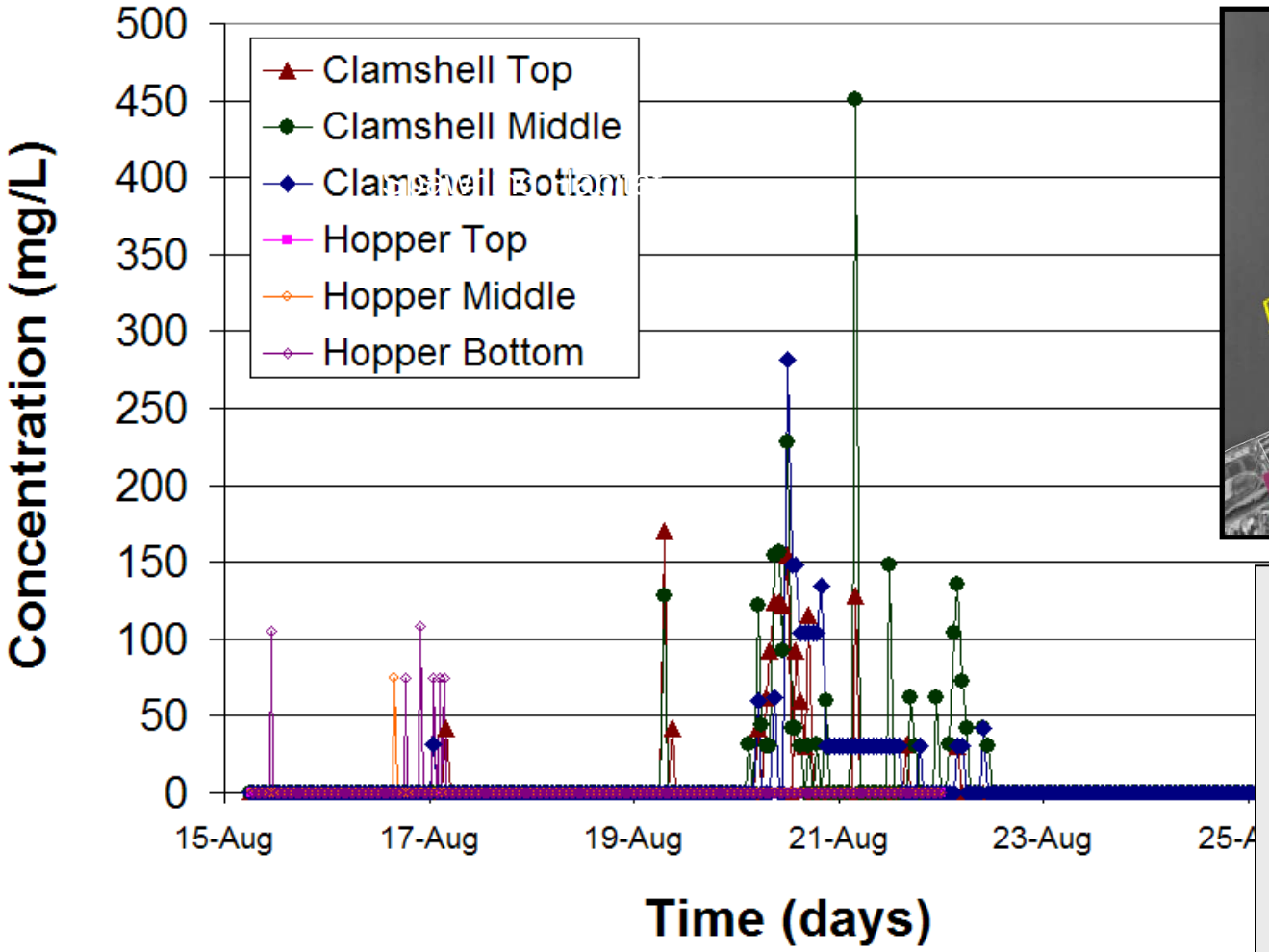
- Very little transport to Mussel Bed; limited discharge and rapid dispersion of TSS from CDF; virtually no deposition on bed; therefore, no risk to Endangered Freshwater Mussel.
- Release of TSS by hopper dredge at dredging site limited to lower water column, allowing limited transport to spawning habitat and limited obstruction of fish passage.
- Release of TSS by clamshell dredge at dredging site throughout water column, allowing transport to spawning habitat and obstruction of fish passage.
- Release of TSS by hopper dredge at open water placement site is much greater than by mechanical operation, allowing greater transport to spawning habitat.

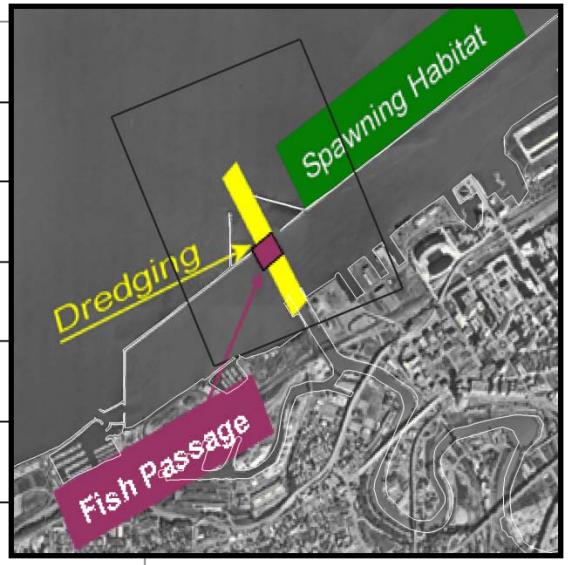
Hypothetical Example: TSS Exposure

- **TSS concentration is highly variable both spatially and temporally**



Time Series of Concentration → Dose



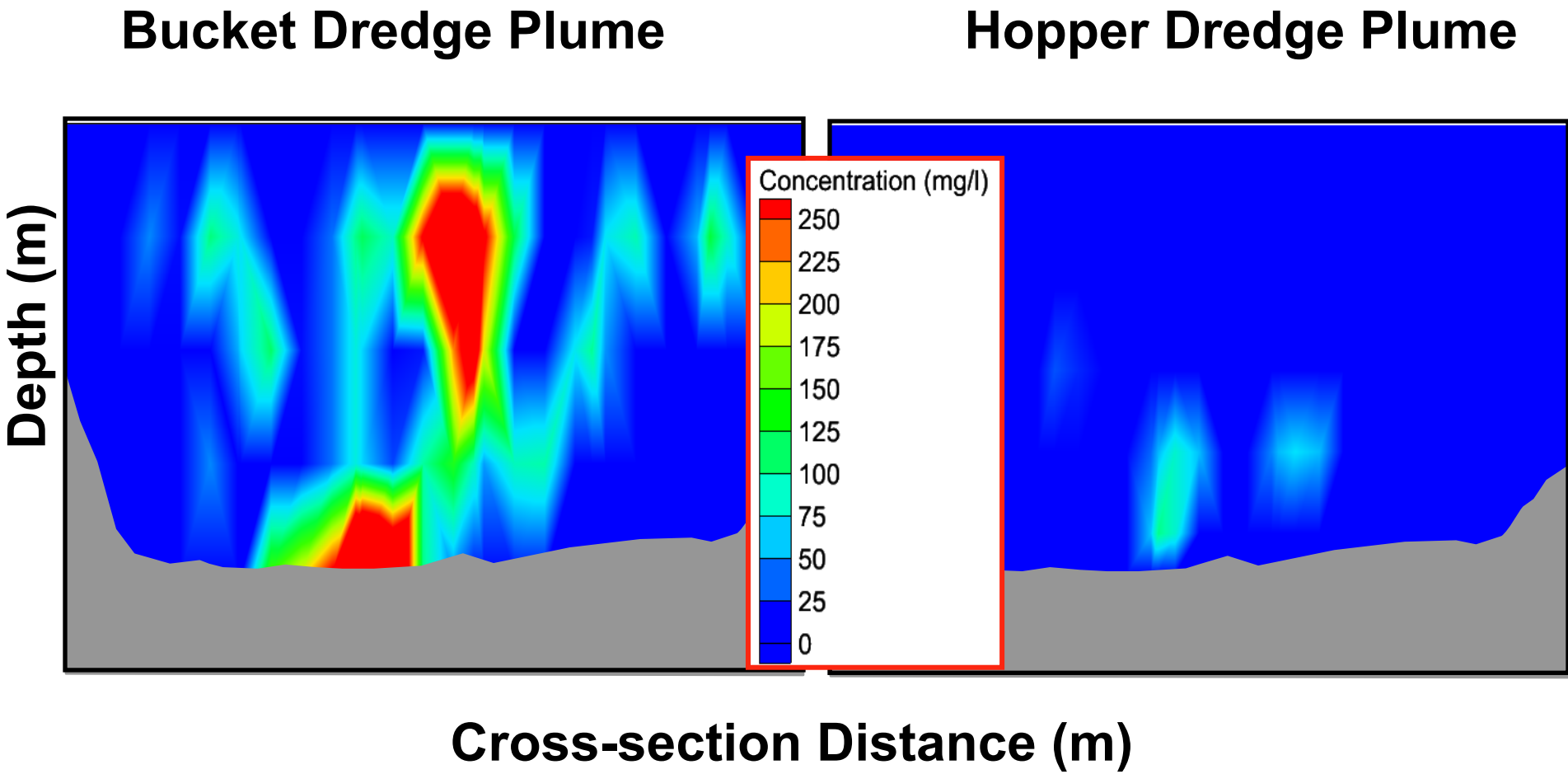


$$D = \int C dt$$

Clamshell - 2.2 kg*hr/m^3

Hopper - 0.3 kg*hr/m^3

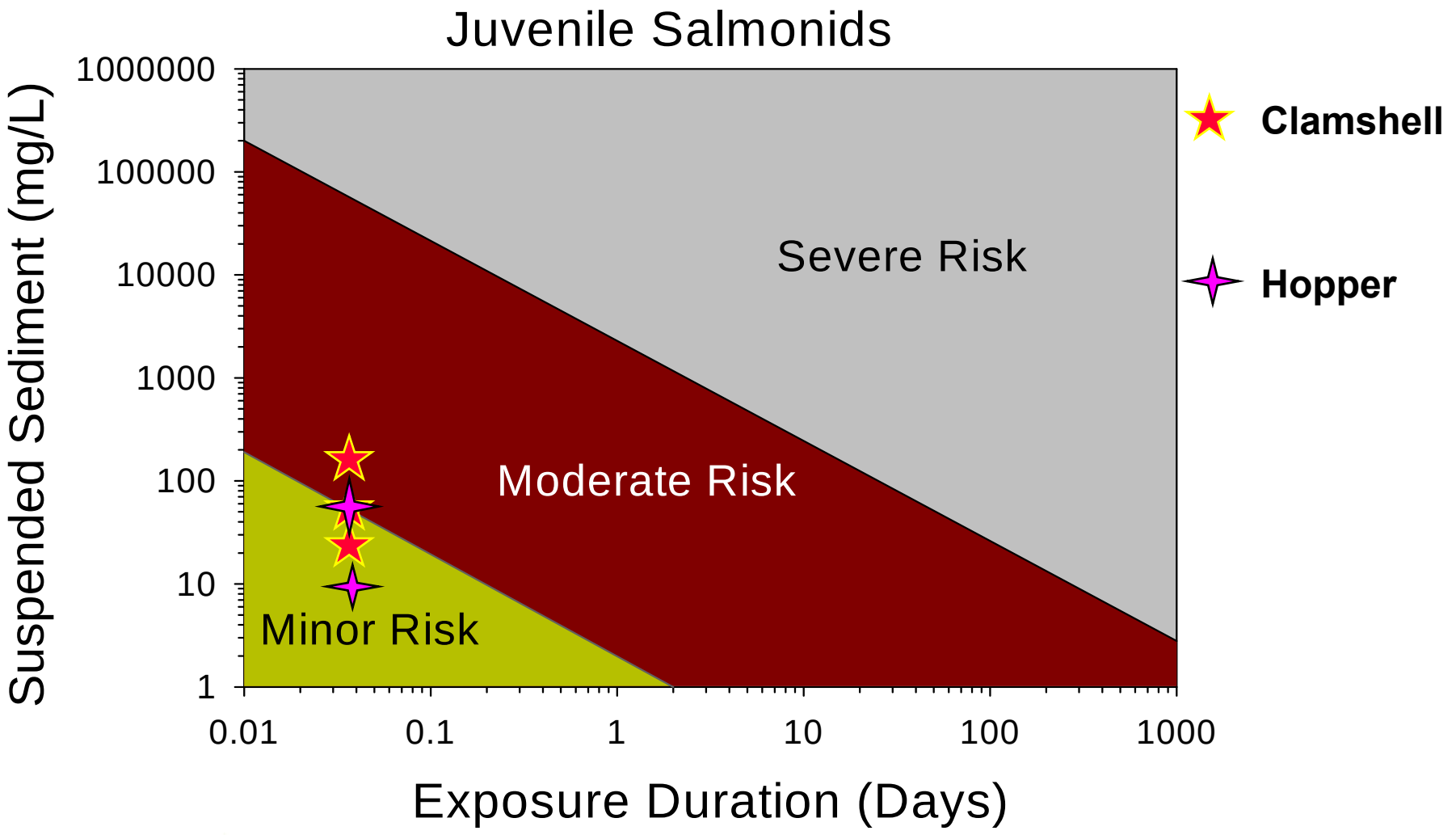
TSS distribution in fish passage



Juvenile Salmonid Exposure Results

- Exposure to TSS is dynamic, varying from 0 to about 450 mg/L with an average concentration of about 150 mg/L in the plume and 60 mg/L across the channel without controls on clamshell dredging.
- Exposure to TSS is dynamic, varying from 0 to about 105 mg/L with an average concentration of about 80 mg/L in the plume and 10 mg/L across the channel without controls on hopper dredging.
- The juveniles are migrating through the channel at a speed of about 1 mile/hour. The bottleneck in the channel is about 0.7 miles long. Therefore, the exposure duration is about 0.7 hours. The peak 0.7-hour TSS concentration in the channel is about 100 mg/L for clamshell dredging without controls and 10 mg/L for hopper dredging.
- The peak concentration is mainly along the dredge path for hopper dredging and there is clear passage readily around the draghead path where a concentration of about 5 mg/L without controls. Similarly, the peak concentration occupies only a 200-ft swath of the 500-ft passage width; the concentration outside the dredging zone is about 20 mg/L.

Juvenile Salmonid Effects Data



SEV	EFFECT
0	No effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
4	Short-term reduction of feeding rate or success
5	Minor physiological stress; coughing or increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation or impaired homing
8	Major physiological stress; long-term reduction in feeding rate or success
9	Reduced growth rate; delayed hatching; reduced fish density
10	0-20% mortality; increased predation; severe habitat degradtion
11	>20-40% mortality
12	>40-60% mortality
13	>60-80% mortality
14	>80-100% mortality

(based on Newcombe and Jensen 1996)

Juvenile Salmonid Risk Results

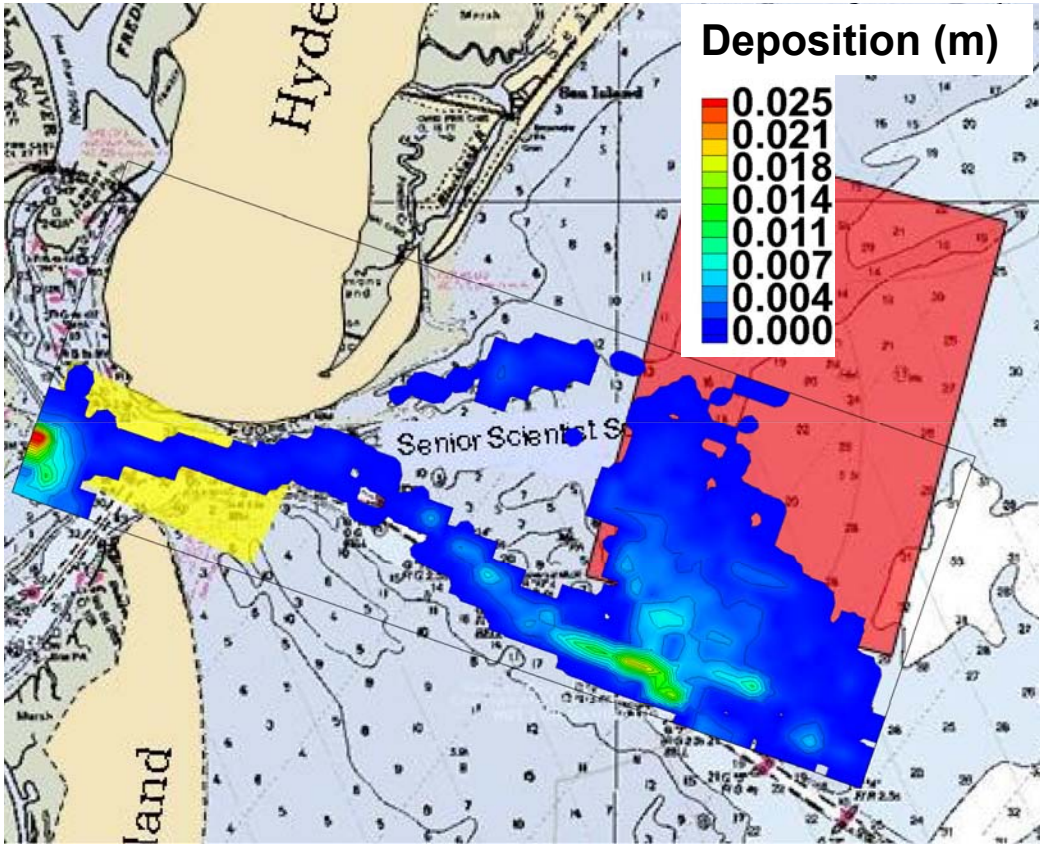
- For clamshell dredging, the risk would be moderate, about 6 on the severity scale, for the few fish migrating under peak TSS conditions without avoiding TSS plume. Effects will be behavioral and sublethal.

  Moderate physiological stress; coughing or increased respiration rate. Short-term reduction of feeding rate or success.

- For hopper dredging, the risk would be minor, about 4 on the severity scale, for the few fish migrating under peak TSS conditions without avoiding TSS plume. Effects will be behavioral and sublethal. ***Avoidance response. Short-term reduction of feeding rate or success.***
- If the juveniles are migrating outside of peak exposure periods or avoid the plume, the risk would be minor without controls, about 3 for hopper dredging or 4 for clamshell dredging on the severity scale. Effects will be behavioral. ***Avoidance response***
- Therefore, the risks to juvenile salmonids are minor and would be acceptable without controls.

Deposition

- Most deposition in channel, open water placement site or in harbor
- In-Harbor deposition will not impact juvenile salmonid, where exposure pathway is the water column
- Some deposition occurs in Fallguy spawning habitat
- No transport to endangered mussel bed



Effects of SS on Fish Eggs

Acute Exposure

- Abrasion/occlusion of chorion
- Plugging of micropyle

Chronic Exposure

- Delayed hatching mediated by physiological response to impaired gas exchange
- Accelerated hatching mediated by turbidity-induced change in water temperature regime

Effects of Sedimentation on Fish Eggs

Sublethal

- Interference with fertilization
- Abraded surface membranes and impaired gas exchange
- Loss of adhesion (for adhesive eggs)
- Delayed cell cleavage and differentiation
- Interrupted or incomplete development
- Delayed hatching and impaired larval development

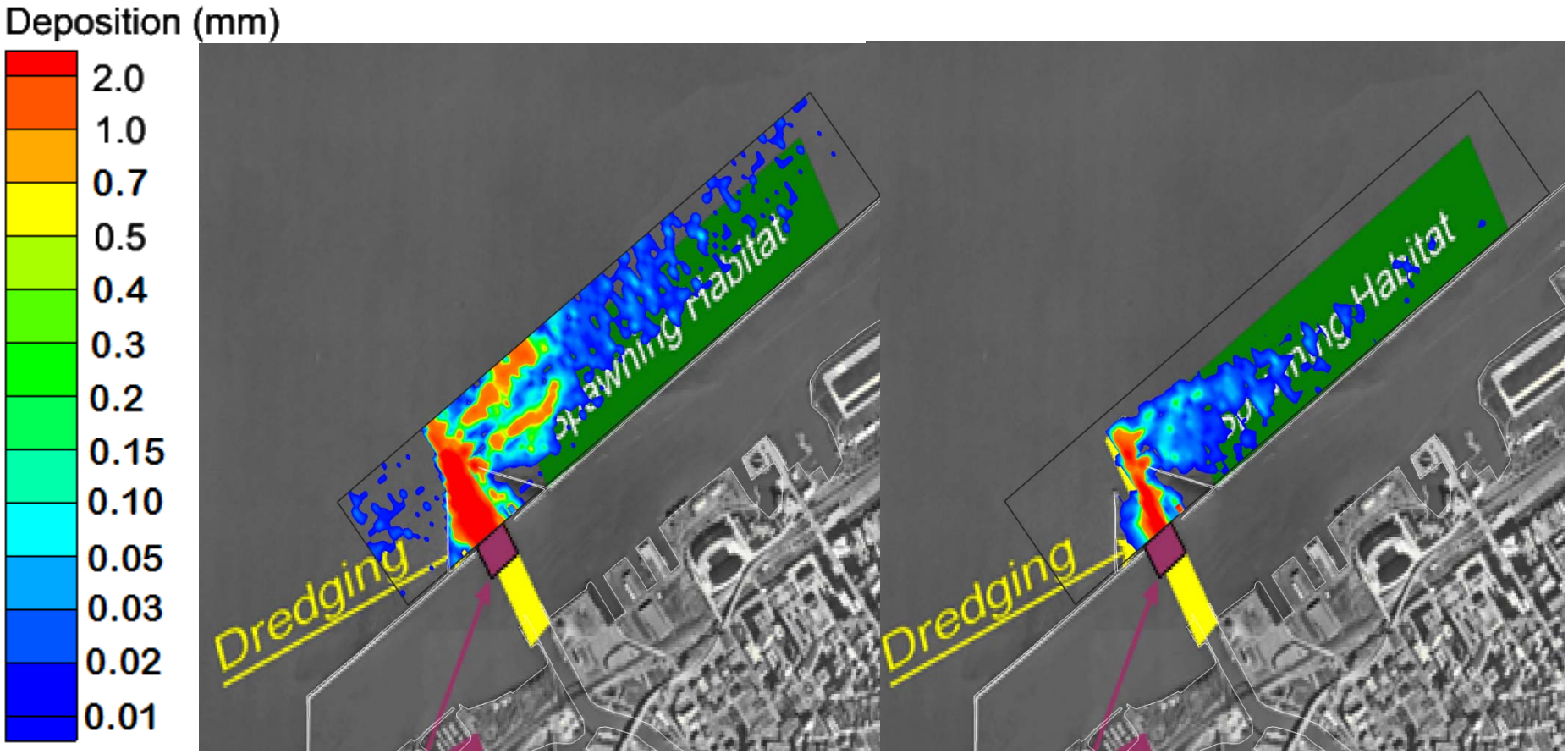
Lethal

- Physical removal during dredging process
- Mortality associated with partial or total burial

Summary of Effects on Fish Eggs

- Timing of acute exposure could be critical
- Once fertilized, most eggs are relatively tolerant of SS
- Net deposition of less than half an egg diameter should be tolerated by most species
- Fallguy egg diameter is 1 mm

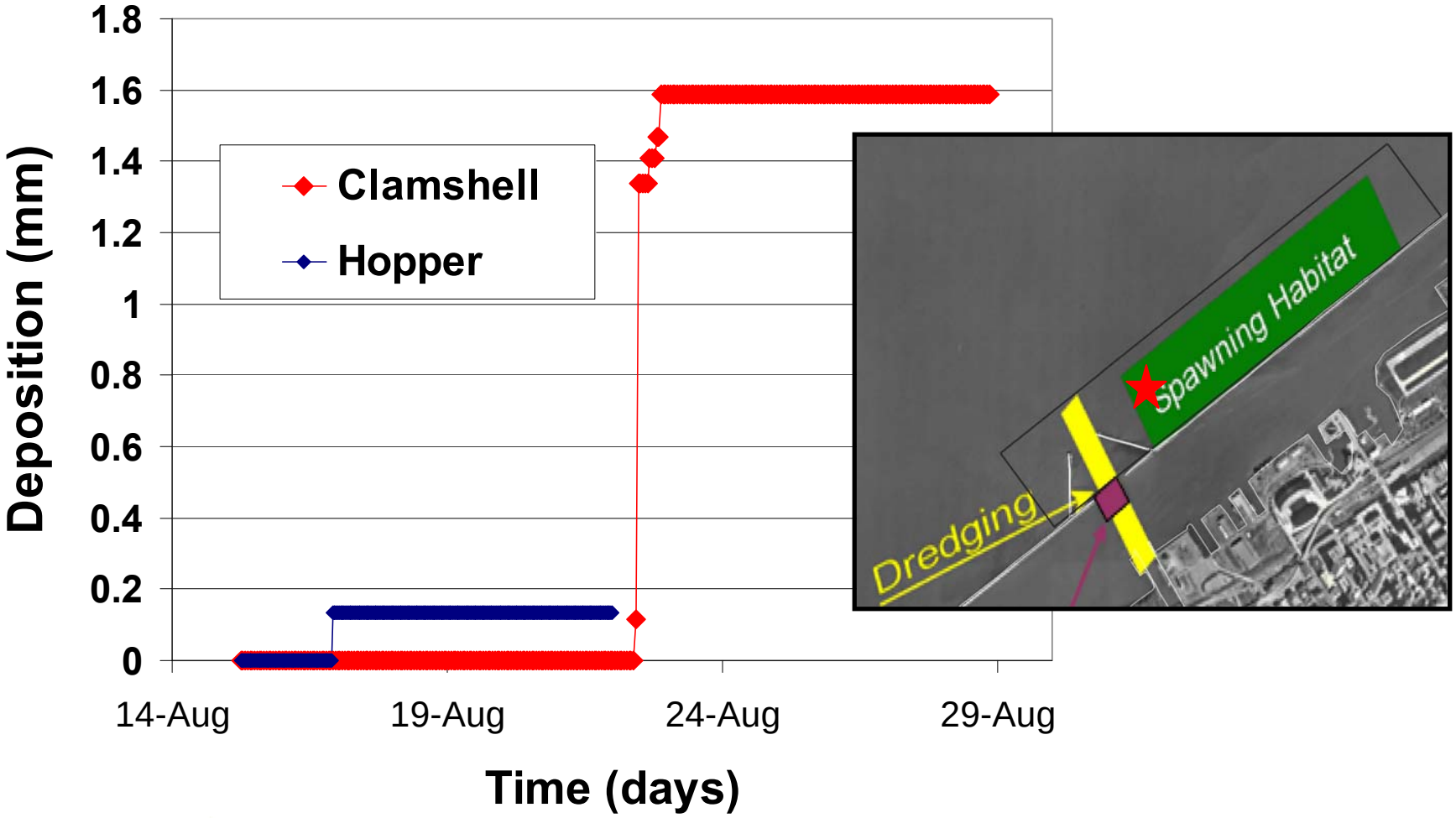
Deposition Near Dredging Site



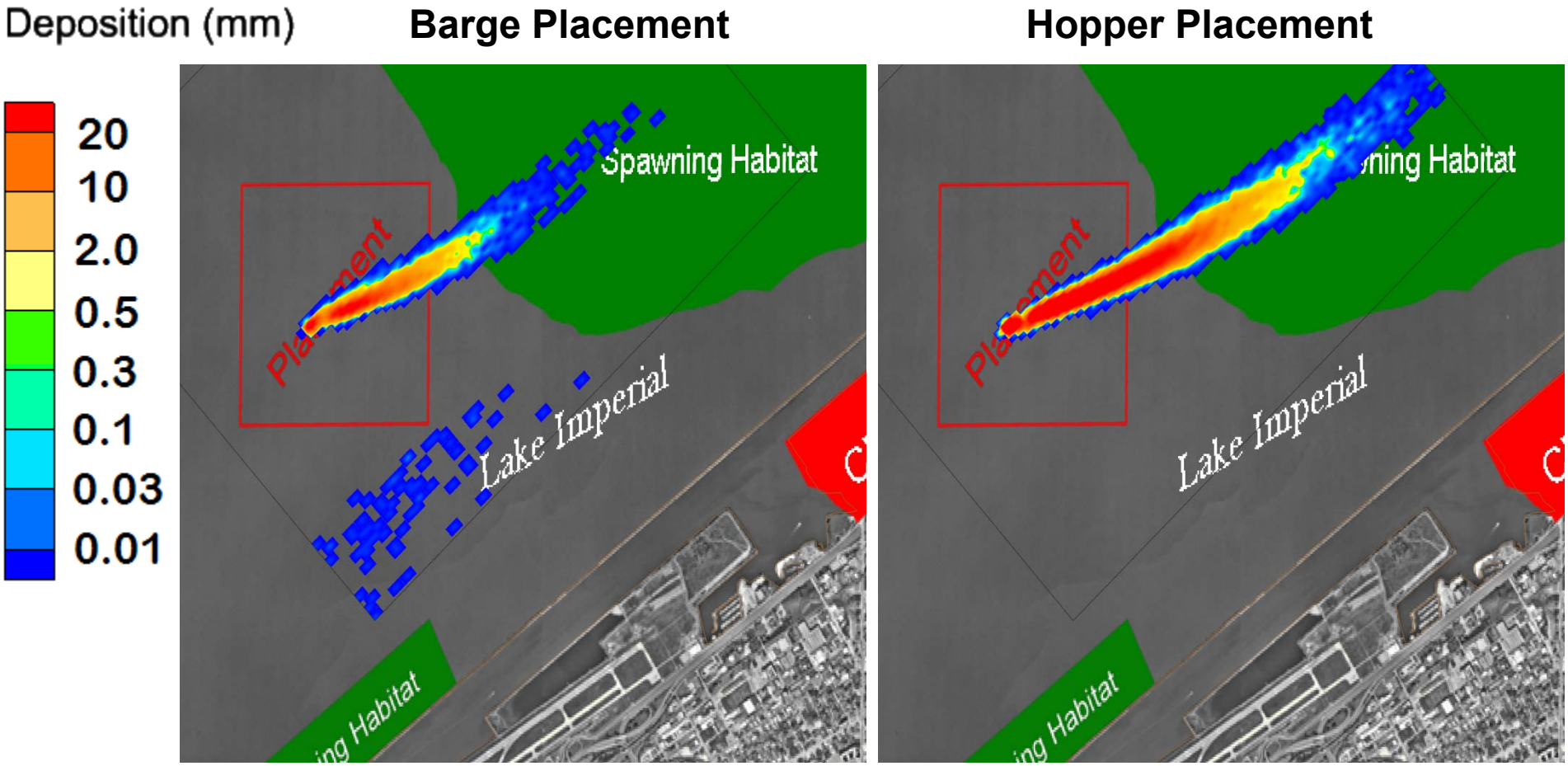
Clamshell Dredge

Hopper Dredge

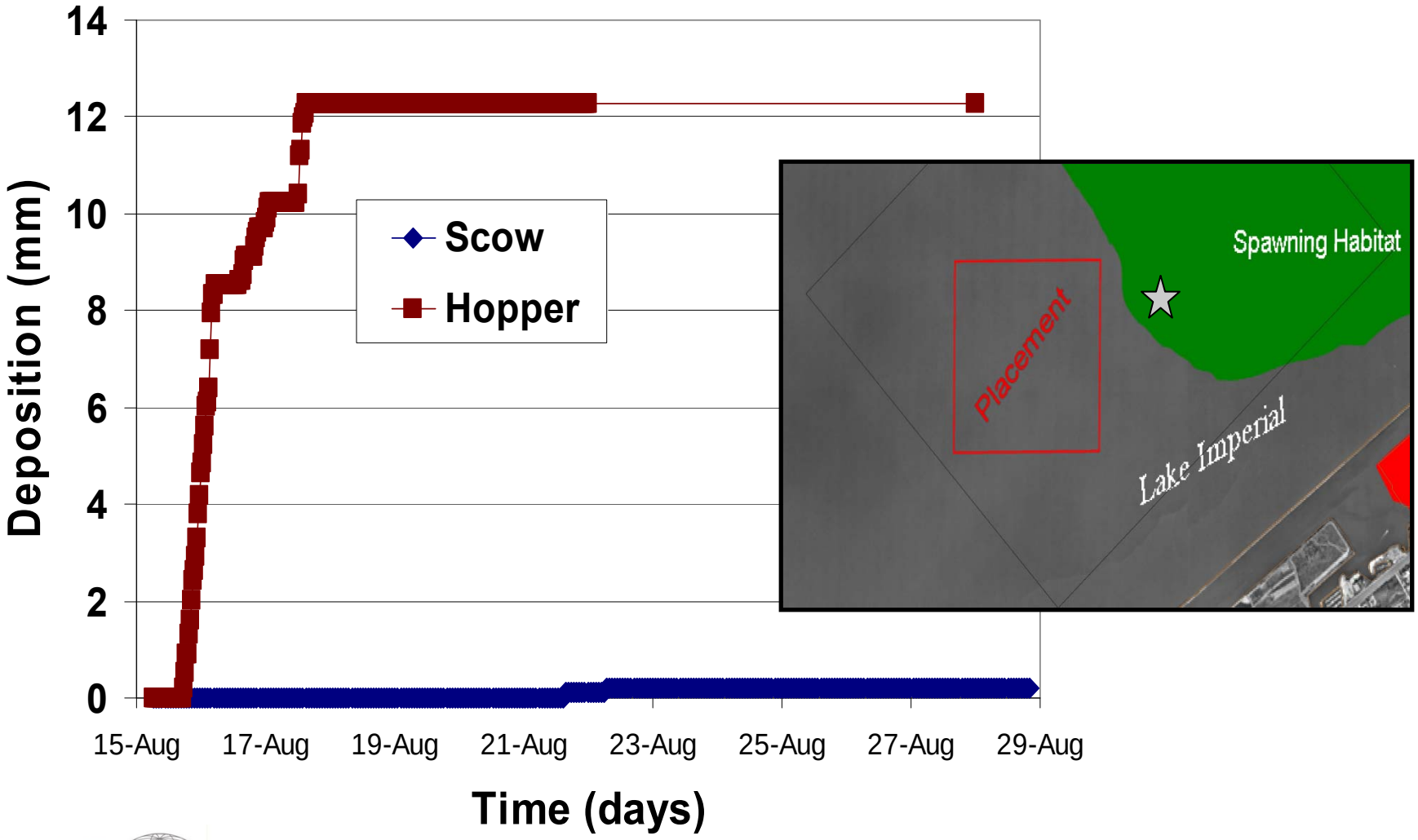
Time Series of Deposition



Deposition at Open Water Placement Site



Time Series of Deposition



Near Dredging Deposition

Dredge	Deposition Coverage	Peak Deposition	Deposition Coverage >0.5 mm
Clamshell	35%	1.6 mm	4%
Hopper	30%	0.15 mm	0%

Deposition Near Open Water Placement

Dredge	Deposition Coverage*	Peak Deposition	Deposition Coverage* >0.5 mm
Clamshell	35%	0.6 mm	5%
Hopper	125%	16 mm	60%

* Relative to area of near dredging spawning habitat

Exposure Results for Fallguy Spawning

- Deposition in spawning habitat near dredging reach is very small. Only clamshell dredging has deposition in excess of 0.5 mm and then only over 4% of the area. Impact on fish population is not likely to be significant.
- Deposition in spawning habitat near open water placement is greater. Open water placement has deposition in excess of 0.5 mm and poses risk to an area equal to 60% and 5% of the near dredging spawning habitat for hopper dredging and clamshell dredging, respectively. Impact on fish population is unknown.
- TSS concentration is not likely to have a significant impact due to low velocities and concentrations in the water column in the spawning areas.

Summary

- Resuspension and open water placement will result in some level of short-term risk at the site.
- Risk assessment provides the context for understanding the significance of the exposures that result from resuspension processes.
- Suspended solids move into the juvenile salmon migration pathway but significantly covers only a portion of the channel cross-section.
- Effects on juvenile salmon are expected to be minor, predominantly behavioral, and acceptable without controls.

Summary

- No transport exists for exposure to the mussel bed except for placement in the CDF, which poses no significant exposure.
- Deposition occur over a fraction of spawning habitat located closest to the dredging and placement.
- Deposition pose significant risk to the fish eggs only near the placement site.
- 95% reduction in resuspension mass at the placement site is required for hopper dredging to reduce the unacceptable risks while only a 20% to 70% reduction in resuspension mass is required for clamshell dredging .

Questions?