Projecting Risks and Addressing Uncertainties

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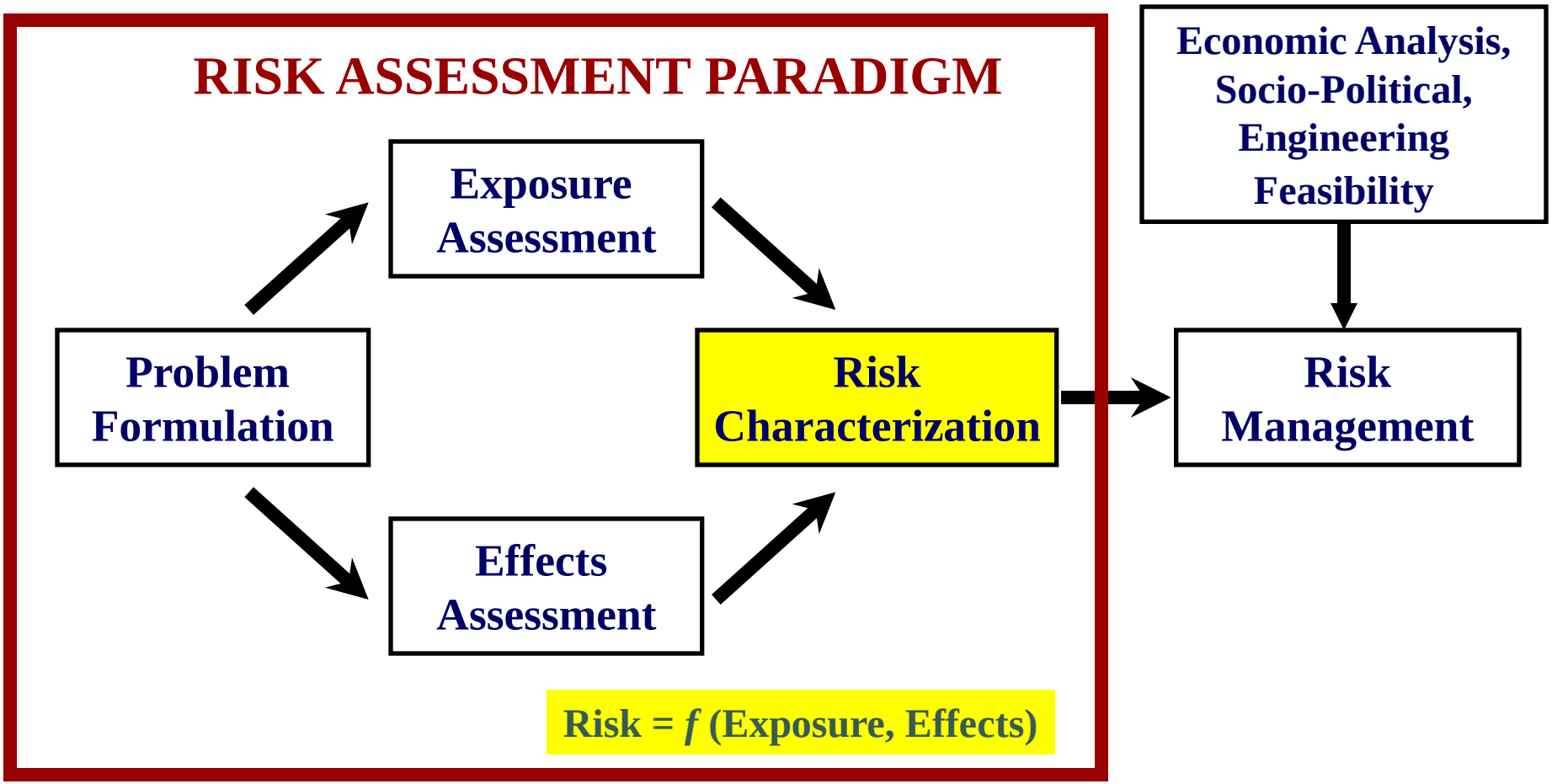
Risk Framework



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
- **Toddistan Risk Characterization**
  - Juvenile Salmonid
  - SAV
- **Using Risk Assessment in Decisions**
  - MCDA Approach
  - Application to Toddistan
- **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**

Qualitative 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	●	●	○	○	○

Qualitative 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

Toddistan Risk Characterization

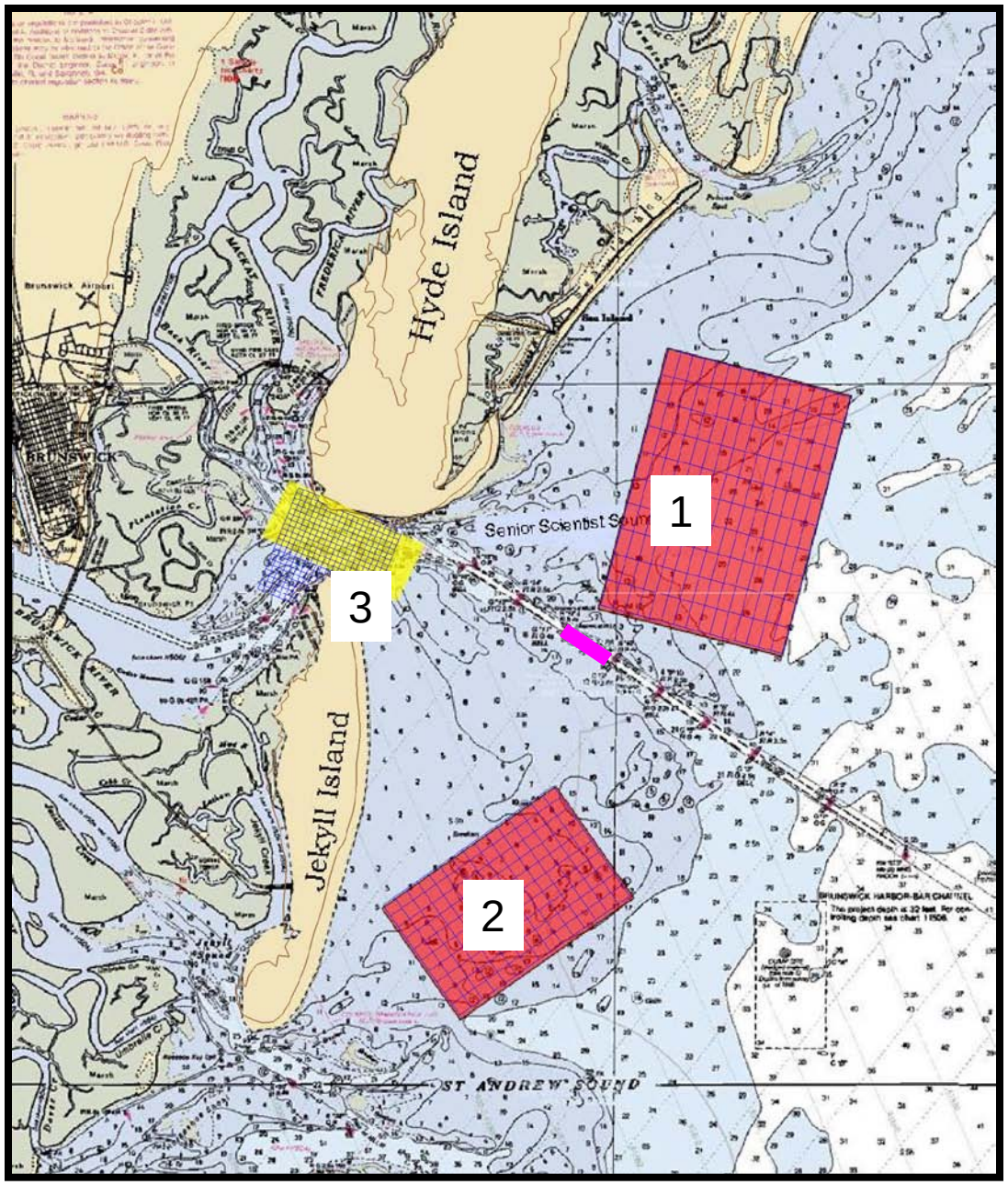
- Environmental Resources
- Risk to Coral Reefs
- Exposure Results for Juvenile Salmonid
- Effects Data for Juvenile Salmonid
- Risk to Juvenile Salmonid
- Exposure Results for SAVs
- Effects Data for SAVs
- Risk to SAVs
- Overall Desired Risk Reduction

Risk Concerns / Recovery

Eco-Risk	Recovery Time		Weight of Concern
	Sublethal Effect	Lethal Effect	
Salmonids	Rapid, weeks to months	Rapid, 1 year	Low
SAVs	Moderate, 1 year	Slow, decade	High
Corals	Very Slow, decade	Very Slow. decades	Very High

Risk Criteria

Alternative	Cost	Survivability of Juvenile Salmonids %	Survivability of SAV
Hopper - No Overflow	100	95	95
Hopper – 15 Min Overflow	70	80	70
Hopper – 30 Min Overflow	60	70	30
Env. Window	80	100	80



Region 1:
Location of SAV bed

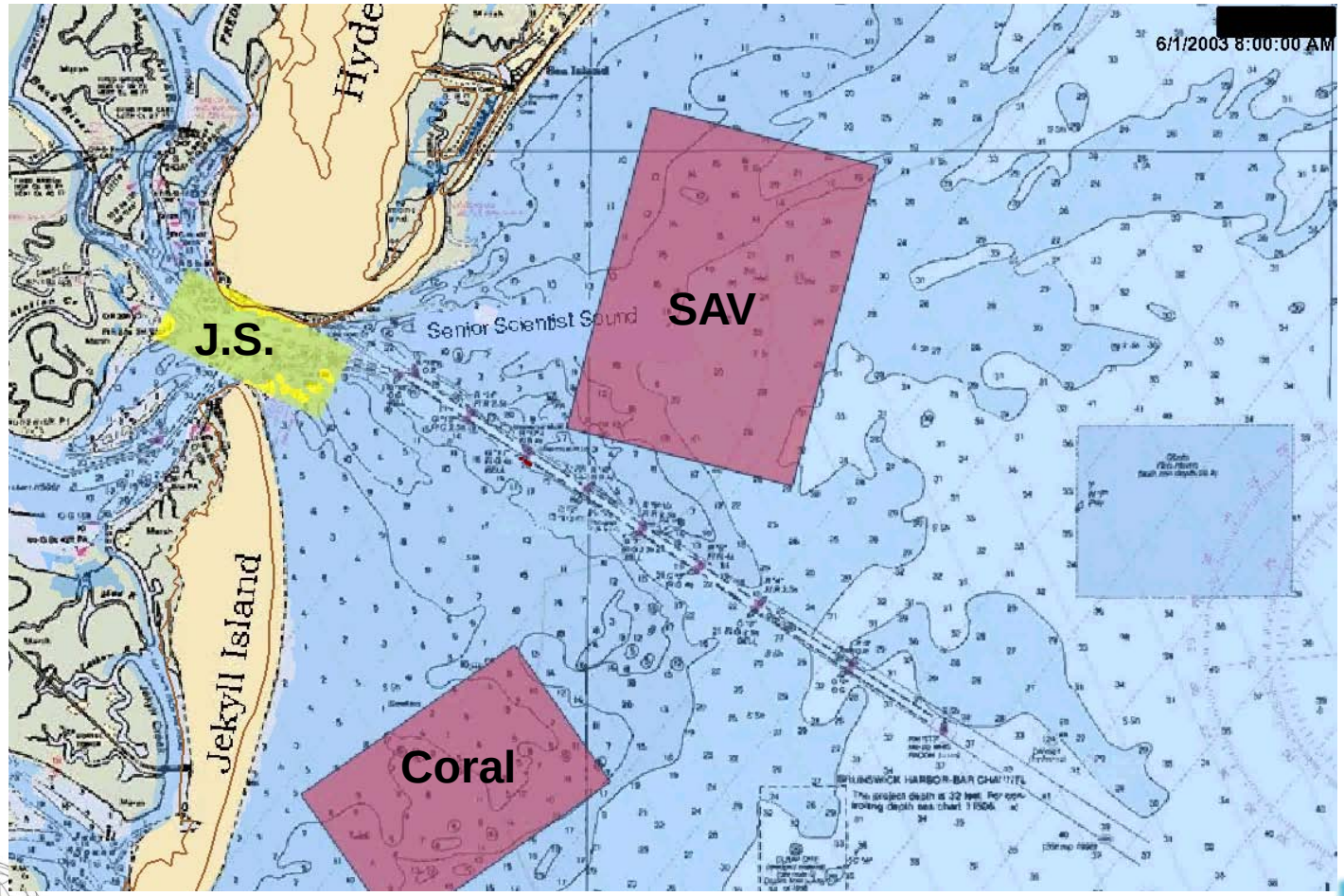
Region 2:
Location of coral reef

Region 3:
Migratory corridor of juvenile salmon

Dredge Reach:

Hypothetical Example: Exposure

PTM 6-day simulation with overflow indicates most sediment remains in channel with some north of channel. Very little near coral reef

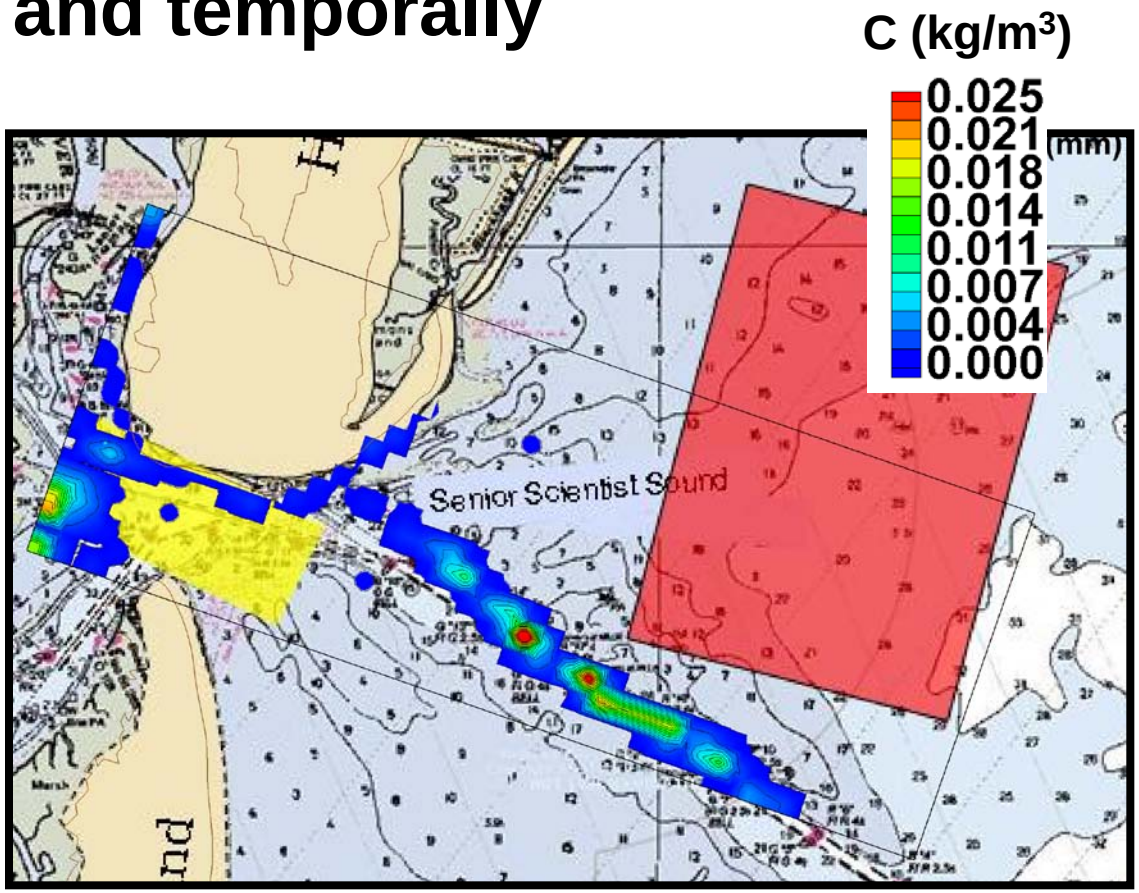


PTM Fate and Transport Results

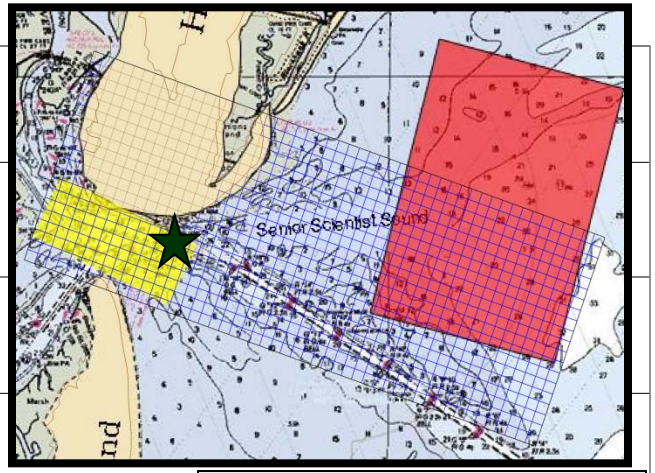
- No transport to Coral Reefs; therefore, no risk to corals
- Transport and deposition of resuspended sediment throughout the Entrance Channel
- Transport and deposition of resuspended sediment across the southern half of the SAV beds
- Characterization of risk to Juvenile Salmonid and SAVs needed
- Exposure to TSS and light attenuation is dynamic; high exposures occur only about 25% of the time
- Intermittent exposure will occur throughout the 5 months of dredging

Hypothetical Example: TSS Exposure

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



Time Series of Concentration → Dose



$$D = \int C dt$$

2.2 kg*hr/m^3

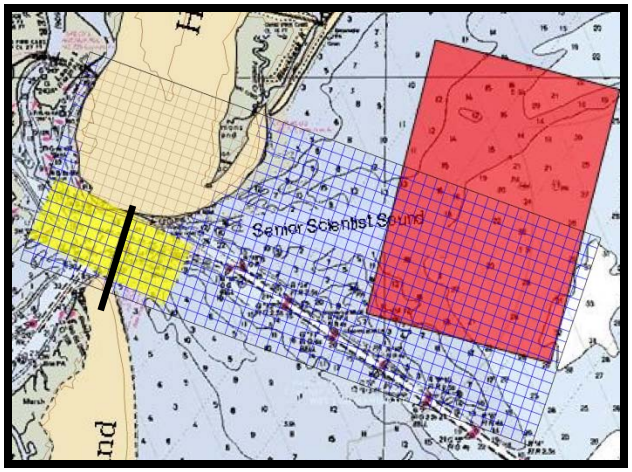
Concentration (mg/l)

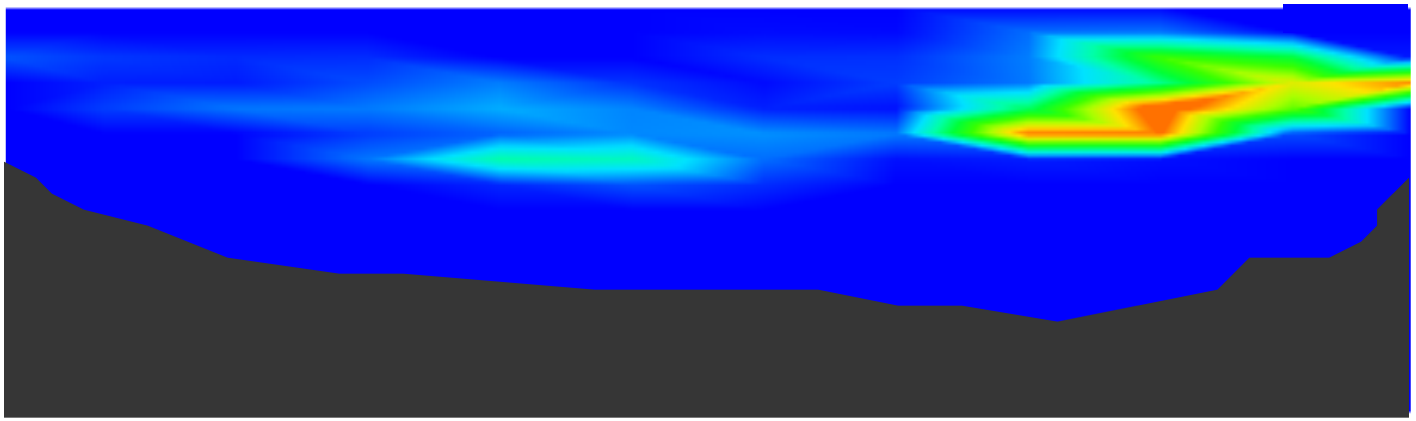
40
35
30
25
20
15
10
5
0

31-May 2-Jun 4-Jun 6-Jun 8-Jun 10-Jun 12-Jun 14-Jun 16-Jun

Time (days)

Cross-Section of Inlet TSS





Depth (m)

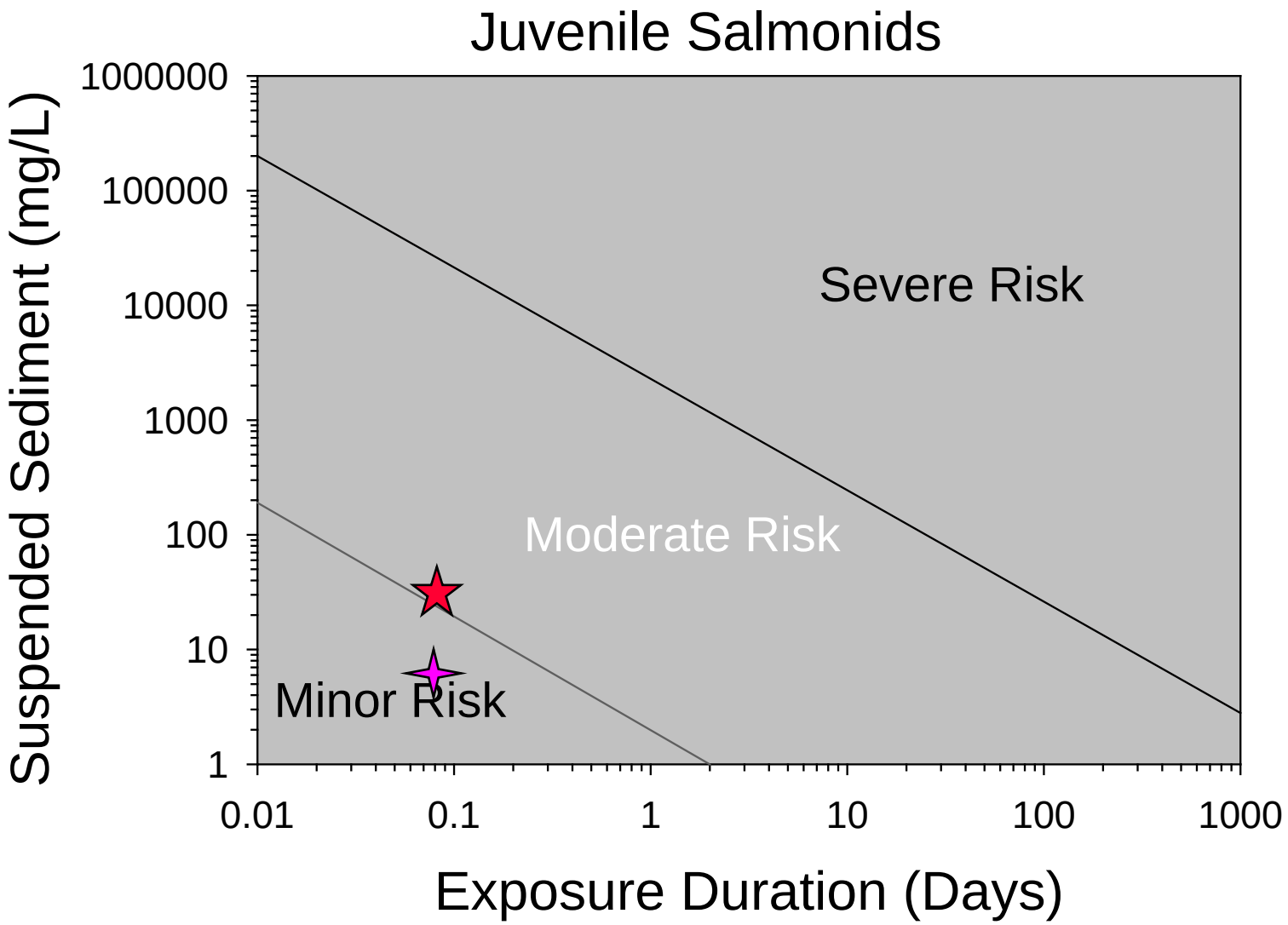
Concentration
0.00315
0.0028
0.00245
0.0021
0.00175
0.0014
0.00105
0.0007
0.00035
0.0

Cross-section Distance (m)

Juvenile Salmonid Exposure Results

- Exposure to TSS is dynamic, varying from 0 to about 35 mg/L with an average concentration of about 5 mg/L in the channel without controls on the dredging.
- The juveniles are migrating through the channel at a speed of about 1 mile/hour. The bottleneck in the channel is about 2 miles long. Therefore, the exposure duration is about 2 hours. The peak 2-hour TSS concentration is about 20 mg/L without controls.
- The peak concentration is mainly within the channel and there is a passage outside of the channel that has a peak concentration of about 5 mg/L without controls.

Juvenile Salmonid Effects Data



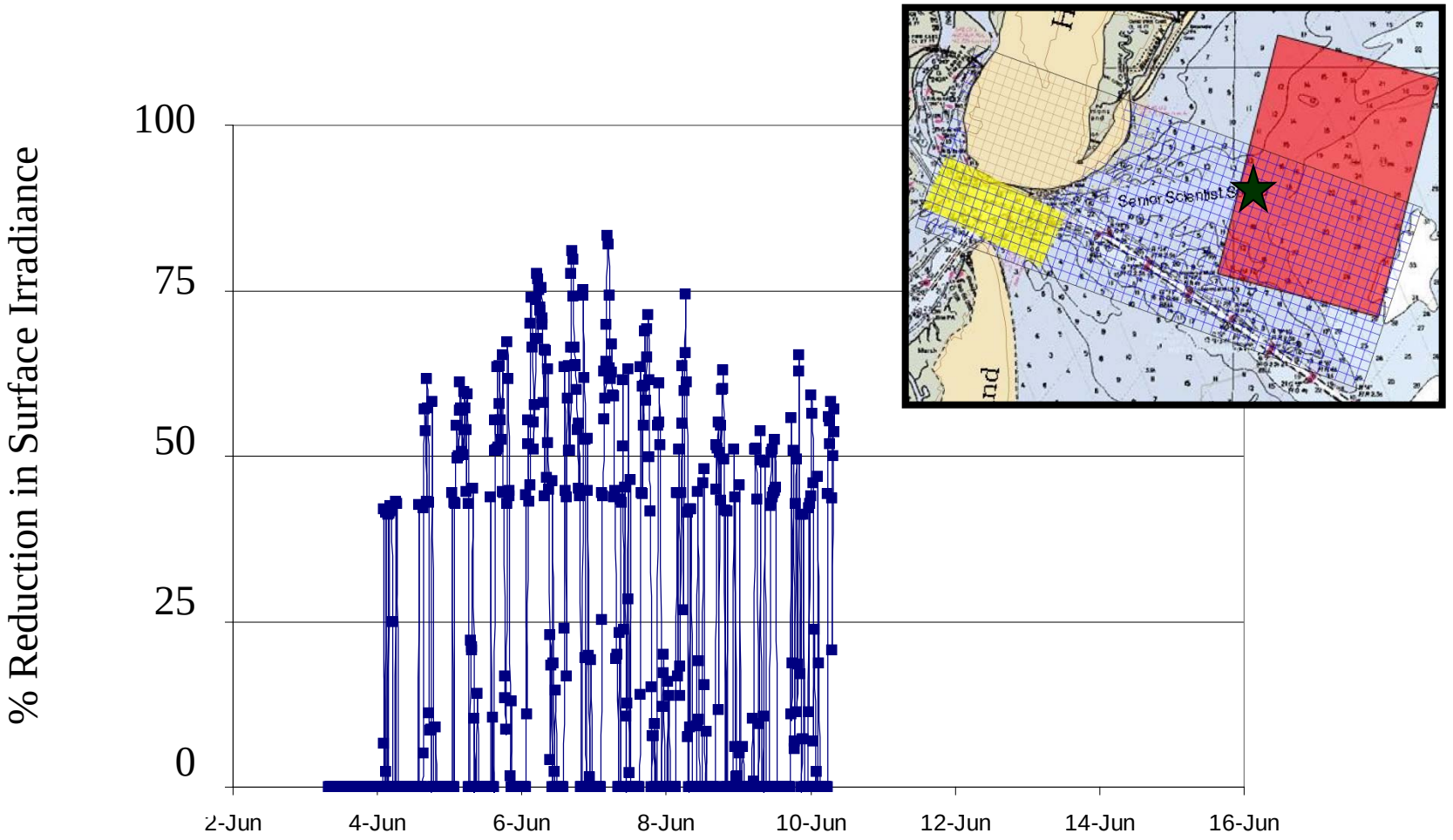
SEV	EFFECT
0	No effects
1	Alarm reaction
2	Abandonment of cover
3	Avoidance response
4	Short-term reduction of feeding rate or success
5	Minor physiological stress; coughing or increased respiration rate
6	Moderate physiological stress
7	Moderate habitat degradation or impaired homing
8	Major physiological 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

- If the juveniles do not avoid TSS plume, the risk would border between minor and moderate, about 5 on the severity scale, for the few fish migrating under peak TSS conditions without controls. Effects will be behavioral and sublethal. ***Short-term reduction of feeding rate or success Minor physiological stress; coughing or increased respiration rate***
- If the juveniles are migrating outside of peak exposure periods or avoid the plume, the risk would be minor without controls, about 3 on the severity scale. Effects will be behavioral. ***Avoidance response***
- Therefore, the risks to juvenile salmonids are minor and would be acceptable without controls.

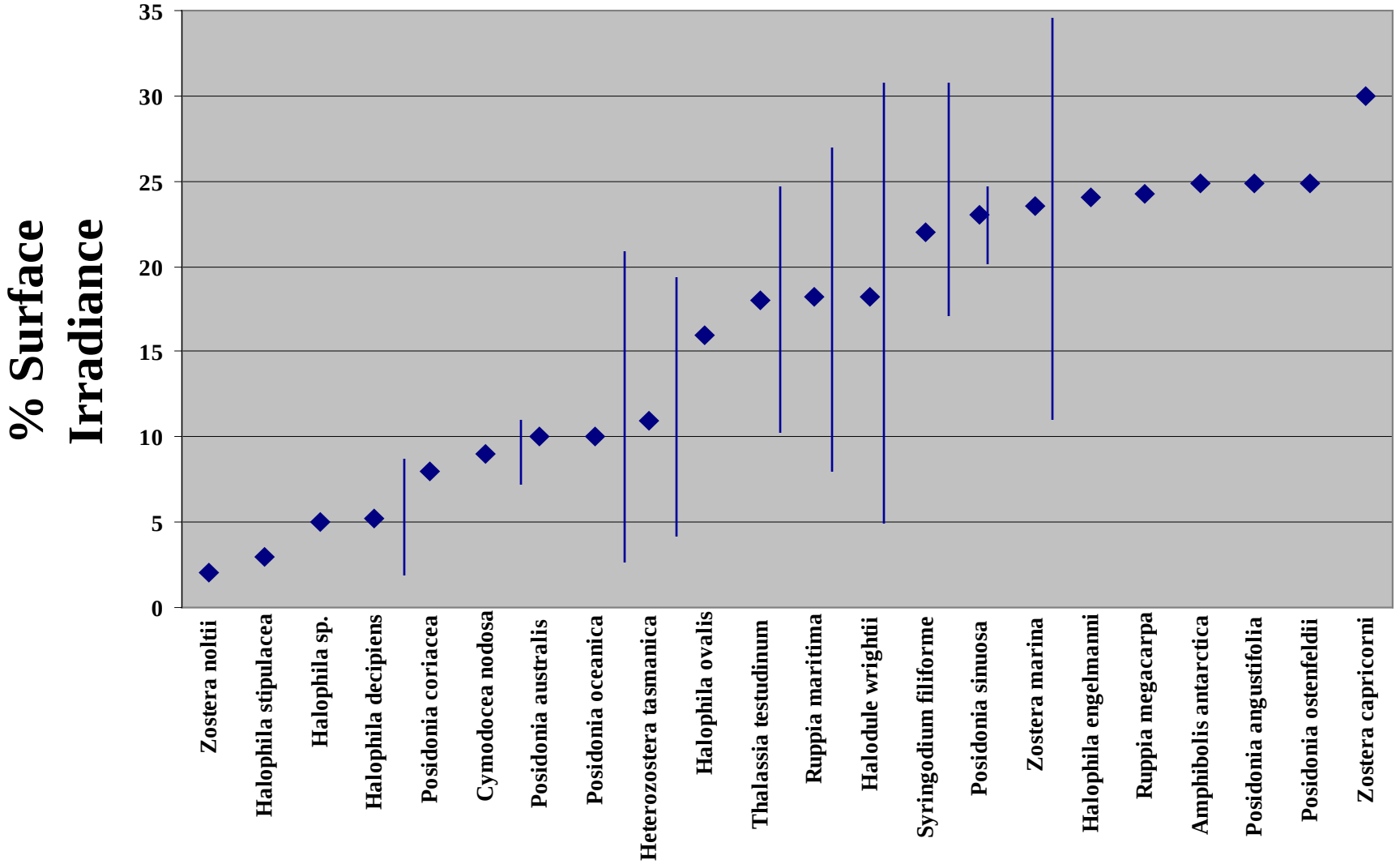
Light Attenuation at SAV Site



SAV Light Attenuation Exposure Results

- Light attenuation is dynamic, varying from 0 to about 85% of surface irradiance in the absence of any background light attenuation and without controls. The average attenuation from the resuspended sediment is about 45% of the surface irradiance in the southern half of the SAV beds and about 15% in the northern half.
- Due to the relatively deep water at the SAV, background light attenuation is 40%. The background light attenuation may increase over the life of the project due to the infusion of fines in the system by the dredging.
- The exposure duration for the SAVs is the dredging duration, estimated to be 5 months without controls.

Critical Light Availability Threshold Values



SEAGRASS SPECIES

(from Erftemeijer and Short 2006)

Seagrass Species	Light Availability	Survival (Month)
Halodule pinifolia	0	3-4
Halodule wrightii	13-15% SI	9
Halophila ovalis	0	1
Heterozostera tasmanica	9% SI	10
Heterozostera tasmanica	2% SI	2-4
Posidonia sinuosa	12% Ambient	24
Thalassia testudinum	10% SI	11
Zostera capricorni	5% SI	1
Zostera noltii	<2% SI	0.5

(from Erftemeijer and Short 2006)

SAV Risk Results from Light Attenuation

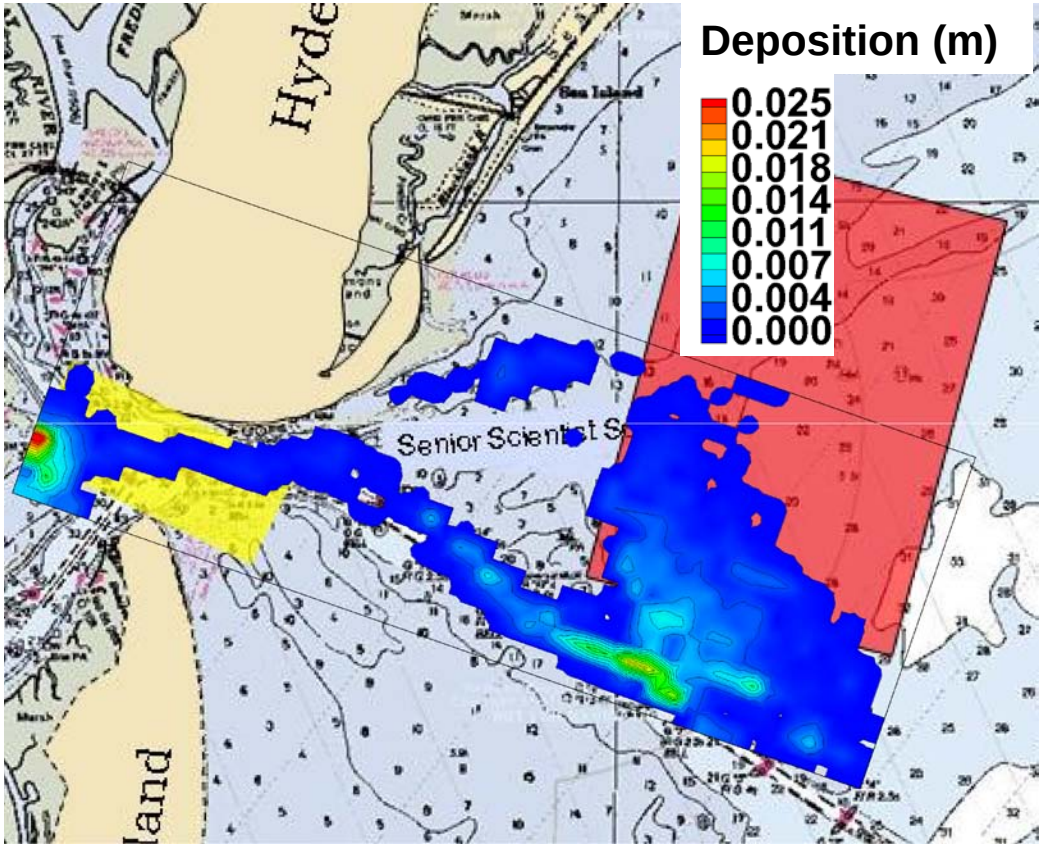
- The critical %Surface Irradiance ranges from about 5 to 25% for a duration of about 5 months .
- The average reduction due to resuspended sediment is about 45% in the southern half of the SAV beds without controls and 15% in the northern half of the SAV beds.
- Since the background reduction is 40%, the net %Surface Irradiance is estimated to be about 15% in the southern half of the beds and 45% in the northern half of the beds.

SAV Risk Results from Light Attenuation

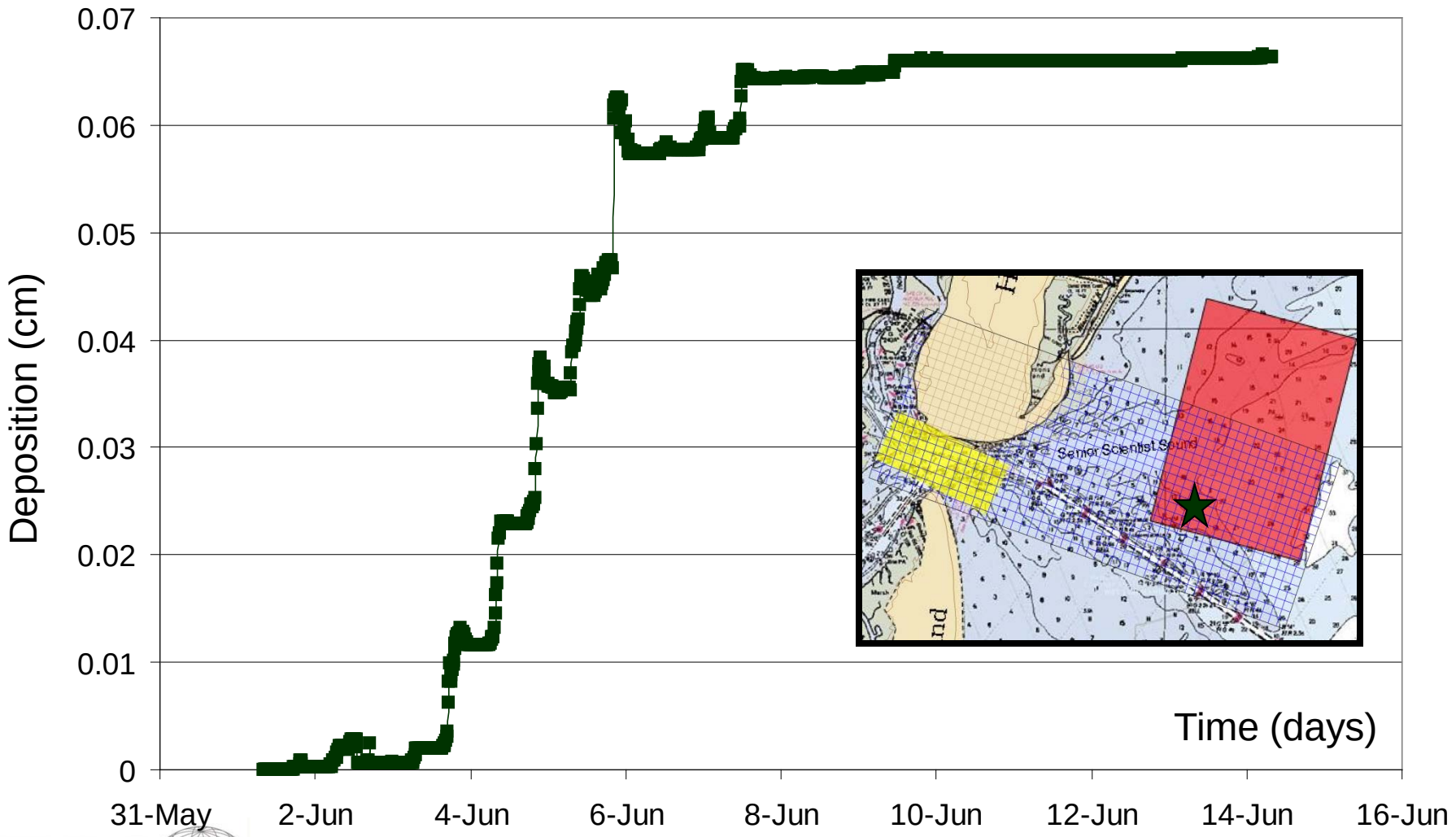
- These results indicate significant risk to the southern half of the SAV beds from dredging in reaches near the beds without controls. A reduction of turbidity or TSS concentration from resuspension of at least 35% is needed to safely provide the critical %Surface Irradiance.
- The result for the northern half of the beds indicates that the northern half of the SAV beds should not be at risk by dredging without controls.
- The northern half of the SAV beds are at least 6 km from the dredging reaches as opposed to the southern half of the beds, which is as close as 1 km to the dredging reaches.

Deposition

- Most deposition in channel or in harbor
- In-Harbor deposition will not impact juvenile salmonid, where exposure pathway is the water column
- Some deposition occurs in SAV habitat
- No pathway to coral reef
- SAV exposure may be season-dependent



Time Series of Deposition



Deposition Exposure Results for SAVs

- The deposition rate in the southern half of SAV beds is about 0.2 mm/day or about 6 cm/year without controls. The net deposition for the duration of the project is projected to be about 2.5 cm.
- In the northern half of the SAV beds, the deposition rate is expected to one quarter of the rate in the southern half, 0.05 mm/day or 1.5 cm/yr. The net deposition for the duration of the project without controls is projected to be about 0.6 cm.
- Due to the relatively deep water at the SAV and distance from a drainage basin, background net deposition is less than 0.2 cm/year. The future deposition may increase due to the infusion of fines in the system by the dredging but is unlikely to rise above 0.5 cm/year.

Seagrass Species	Critical Threshold for Sedimentation (cm/yr)
Cymodocea nodosa	5
Cymodocea rotundata	1.5
Cymodocea serrulata	13
Enhalus acroides	10
Halophila ovalis	2
Posidonia oceanica	5
Zostera noltii	2

(from Erftemeijer and Short 2006)

SAV Risk Results from Deposition

- Critical deposition rates range from about 1.5 to 5 cm/year.
- The deposition rate from dredging reaches adjacent to the southern half of the SAV beds is 6 cm/yr without controls, yielding 2.5 cm of deposition. A solids reduction of at least 50%, and perhaps 75%, is needed to reduce the deposition below the critical rate for sensitive species.
- The deposition rate in the northern half of the SAV beds is 1.5 cm/yr without controls, yielding 0.7 cm of deposition. The deposition rate is sufficiently low to permit dredging without controls.

Summary

- Resuspension 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 pathway exists for exposure to coral reef.
- Deposition and light attenuation occur primarily over southern half of the SAV beds.
- Both deposition and light attenuation pose significant risk to the SAVs in the southern half of the beds from dredging near the beds without controls.
- 50 to 75% reduction in resuspension mass and 35% reduction in turbidity or TSS concentration from resuspension is needed to reduce the unacceptable risks.

Questions?