Bioaccumulation Dynamics

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Relevant Background Information

Term	Definition
Contamination	Harmful substances (like mercury and methylmercury) that can be found in the environment and affect fish health.
Suspended Particulate Matter (SPM)	Tiny floating particles in the water that can carry pollution and be absorbed through skin and gills exposure.
Stress	The strain a fish feels when something in the environment changes (like temperature, or salinity) that makes it harder for them to stay healthy.
Bioaccumulation	The buildup of harmful chemicals (like mercury and methylmercury) inside a fish over time, leading to fish toxicity.

Model Objectives

Purpose: Simulates exposure to contamination as fish move through the system
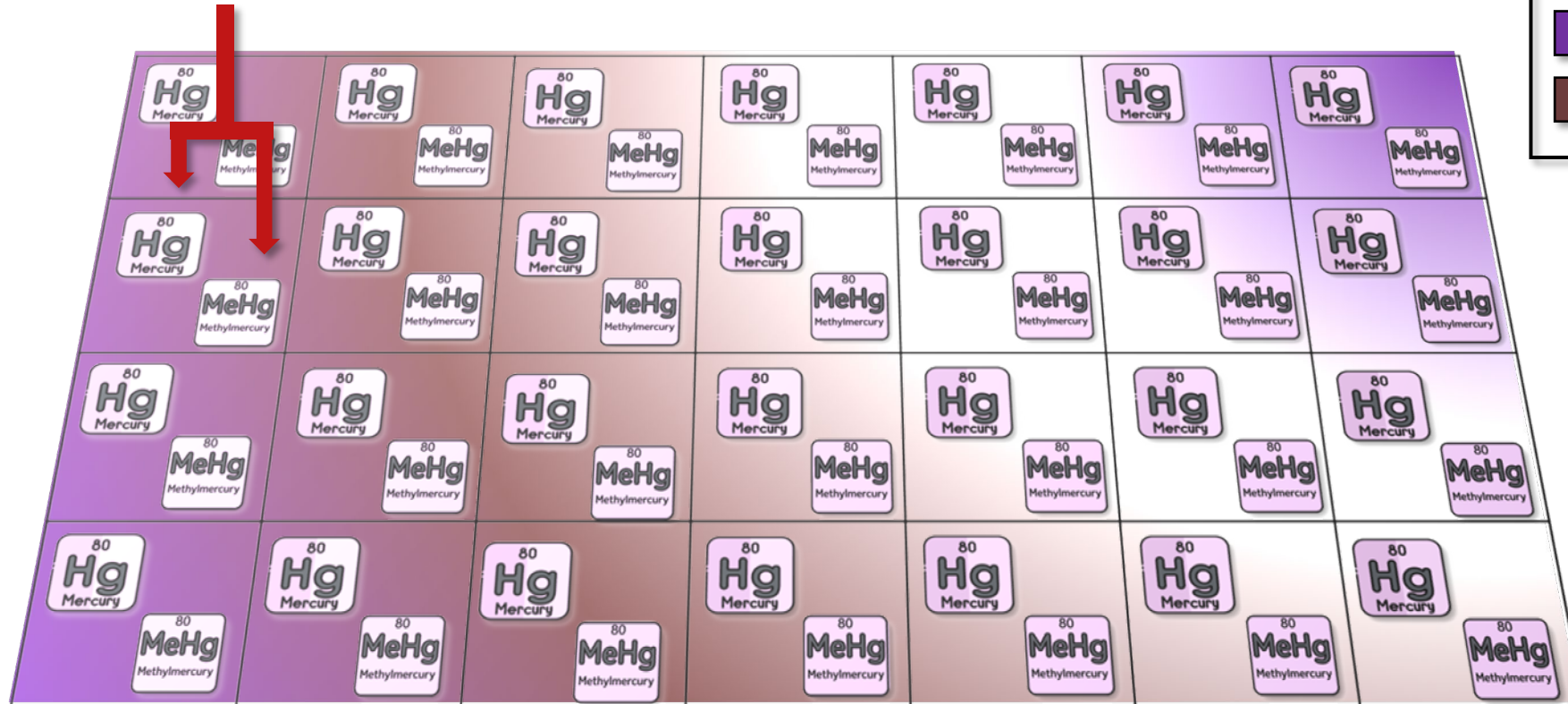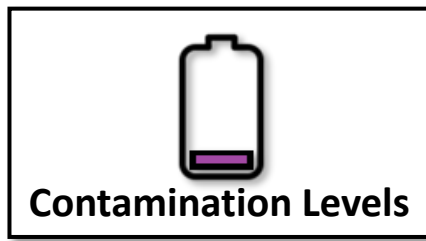
Objectives:

1. **Simulate exposure dynamics**
   Track how migratory fish encounter and accumulate mercury (Hg) and methylmercury (MeHg) across space and time.
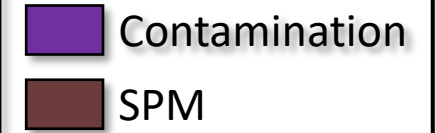
2. **Capture thresholds and exceedance**
   Identify when exposure exceeds health thresholds that may trigger physiological stress or regulatory concern.

3. **Quantify Bioaccumulation Risk**
   Compute cumulative exposure and uptake risk by integrating environmental contamination, stress responses, and suspended particulate matter dynamics.
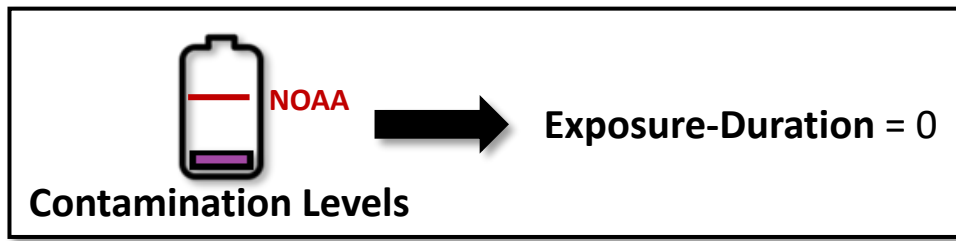
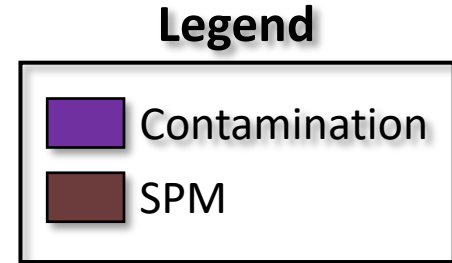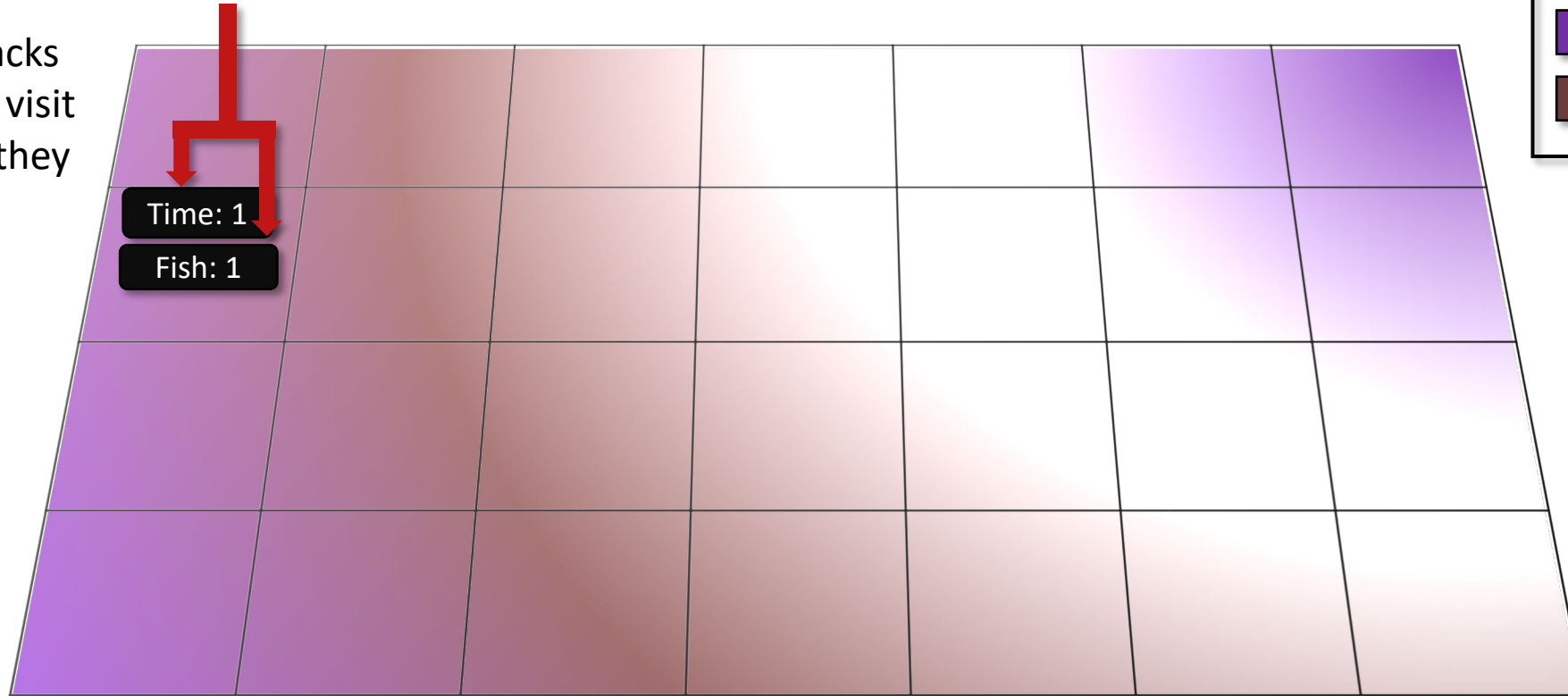Fish Experience and Record Contamination Levels Along Migration.

Fish Track Time Exposed to Contamination Above NOAA Limits

SPM   Stress   Contamination   Uptake Risk

NOAA

Time: 1

Fish: 1

Risk: 1.4

Legend

Contamination

SPM

**Environmental Contamination
(Mercury and Methylmercury)**
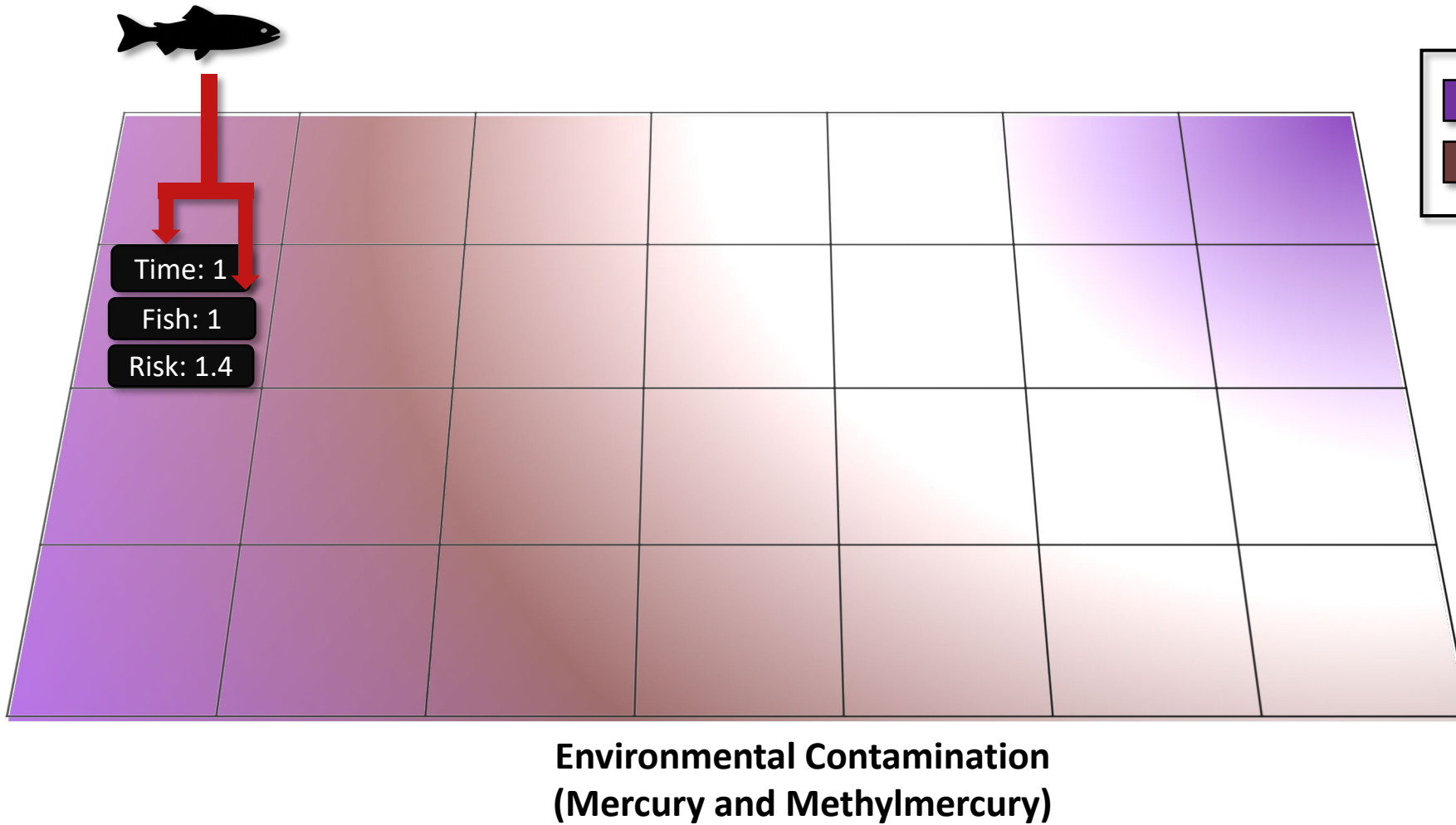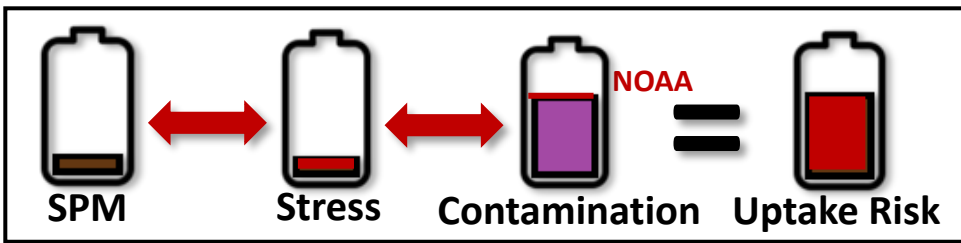
Fish Track Bioaccumulation Uptake Risk

Contamination Levels X Stress X SPM = Bioaccumulation Risk

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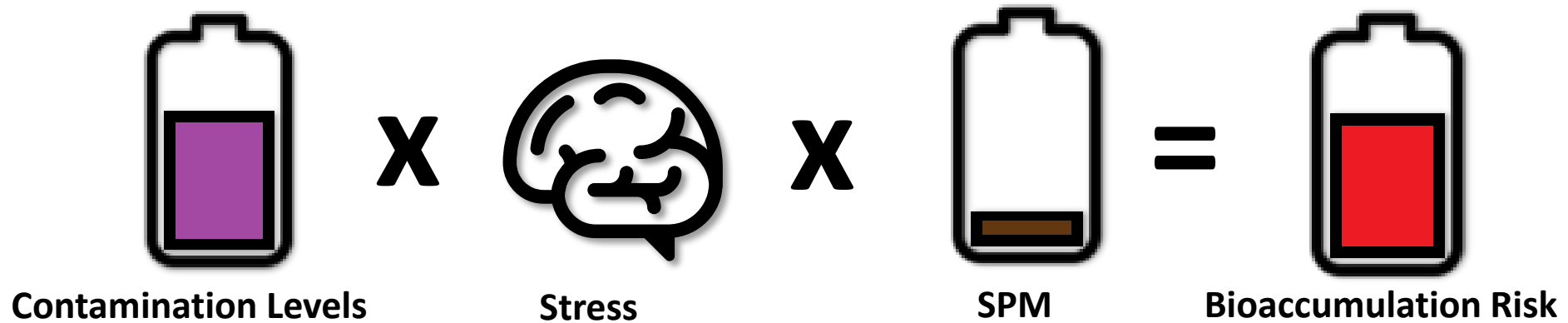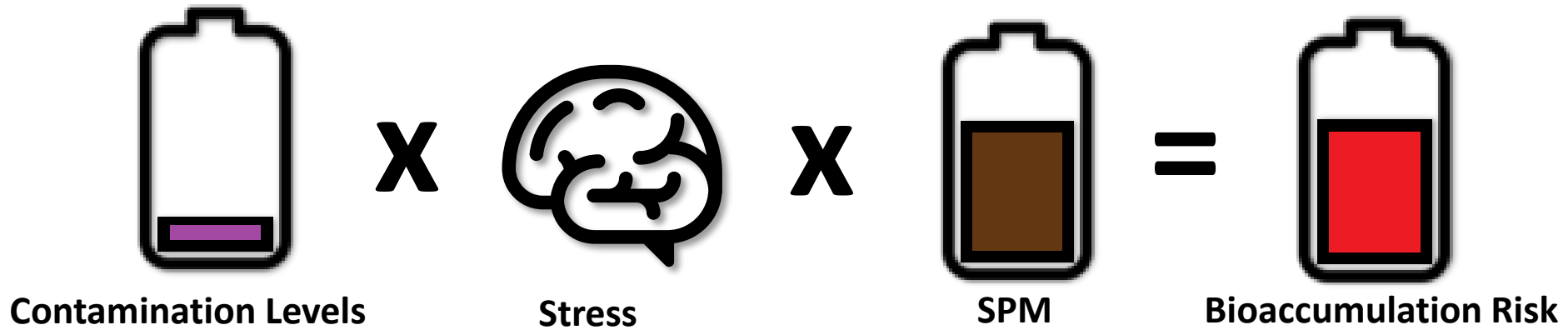
Fish are more likely to accumulate contaminants when they are stressed, surrounded by fine suspended particles, or exposed to high contamination levels.
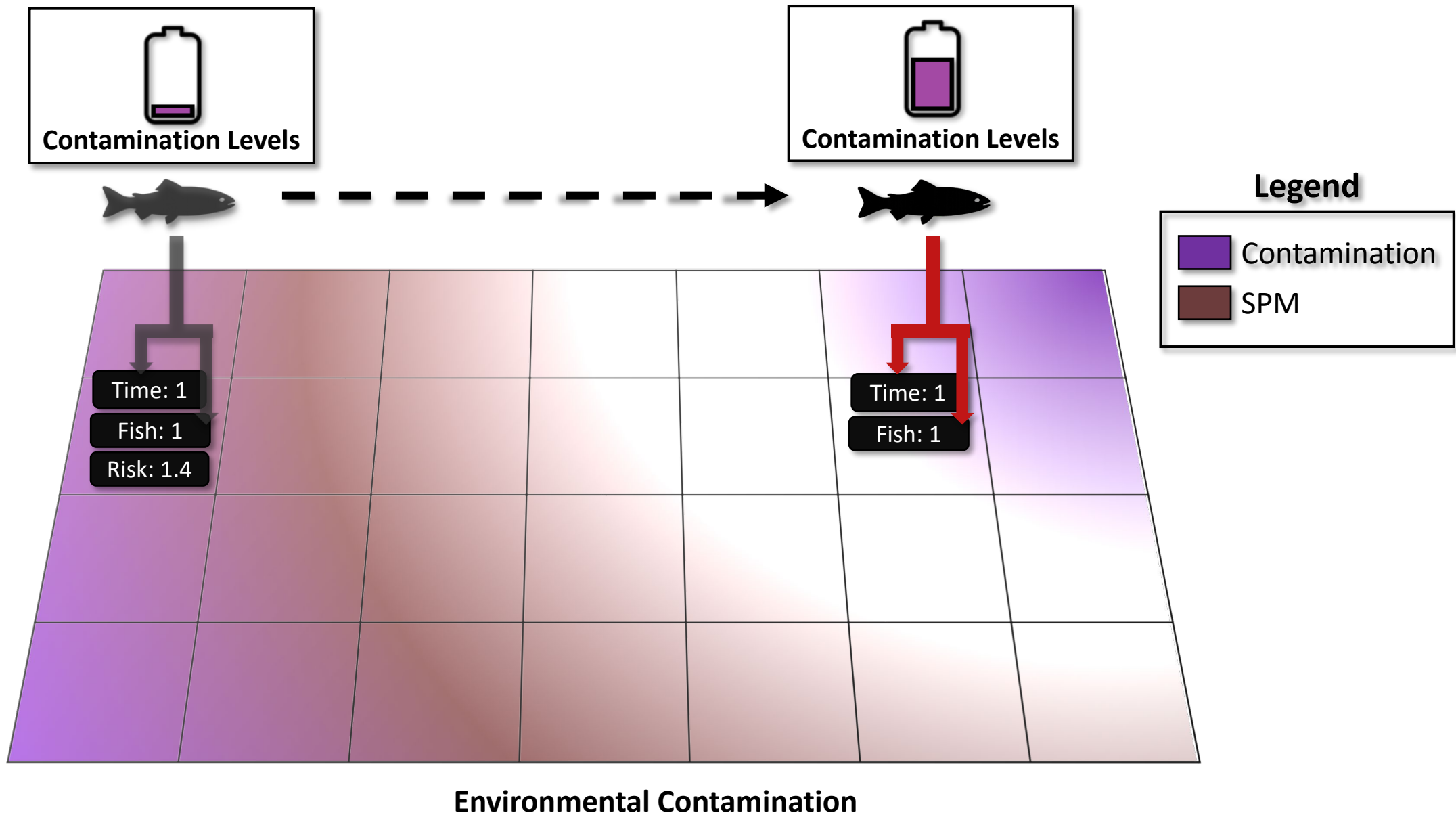
Fish Keep Track of Cumulative Contamination Throughout Migration
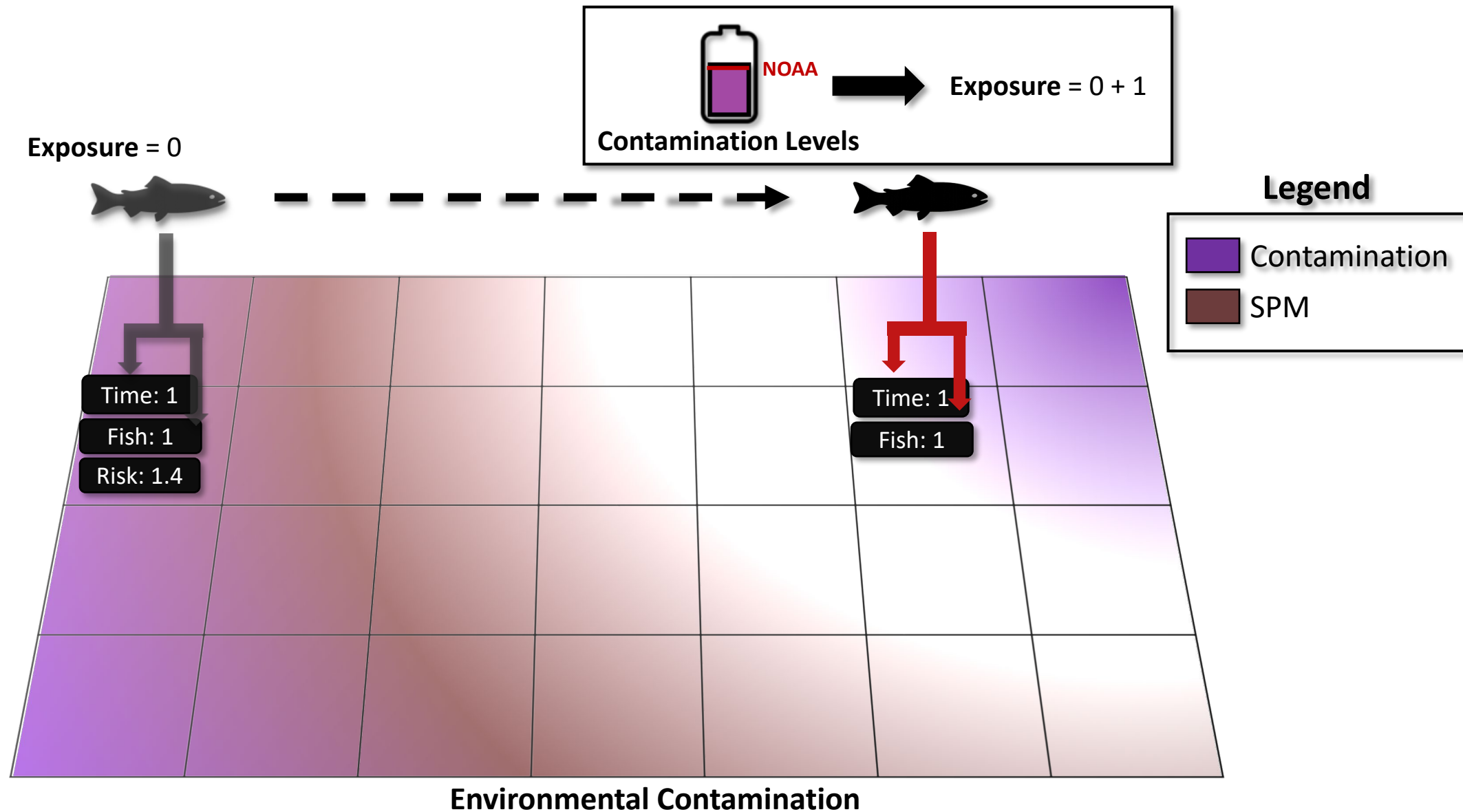
When fish enter a patch with contamination above NOAA limits, exposure time increases and is recorded for that location.
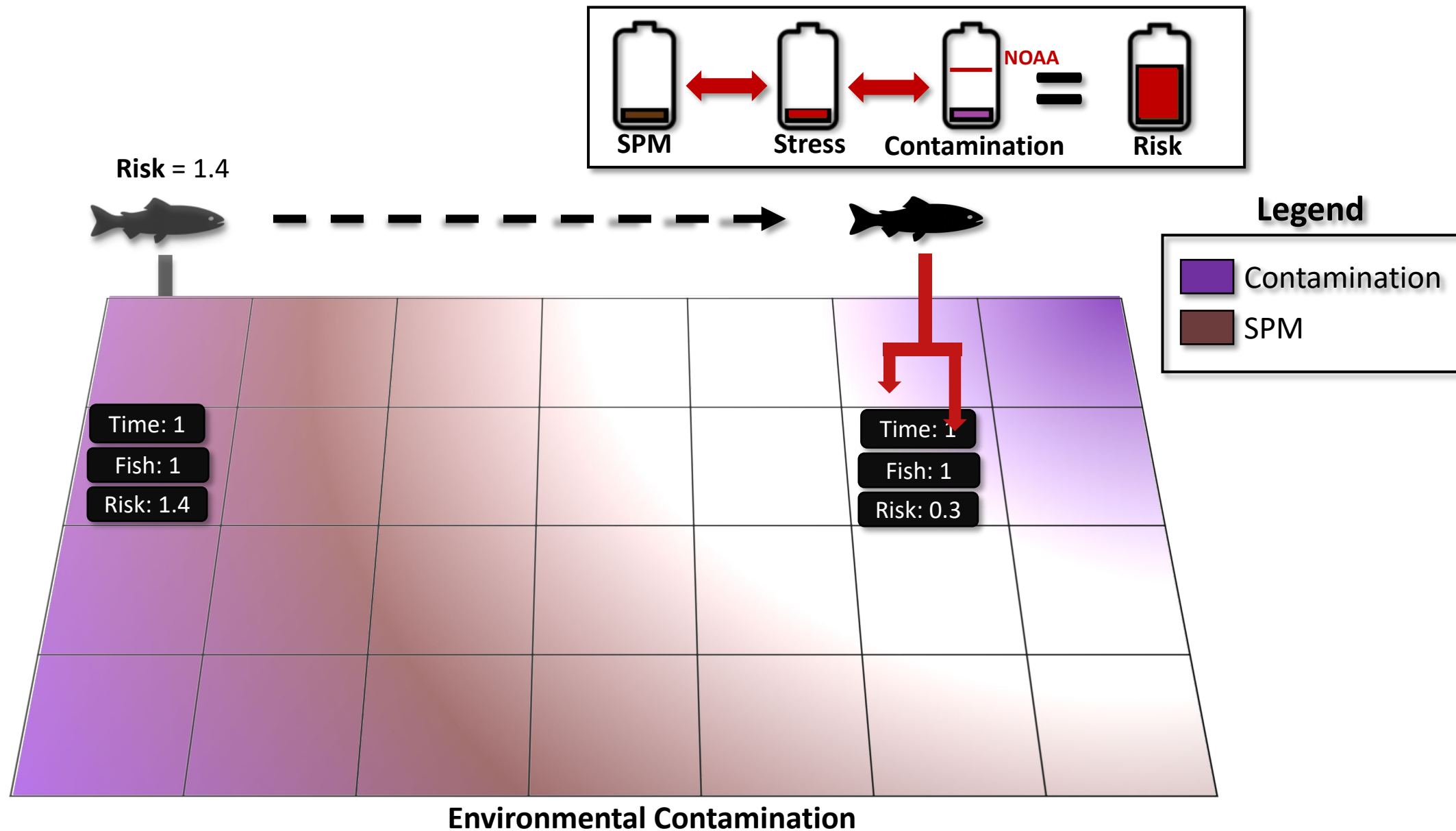
Overlap of salinity shifts, SPM, and contamination in transitional zones raises bioaccumulation risk.
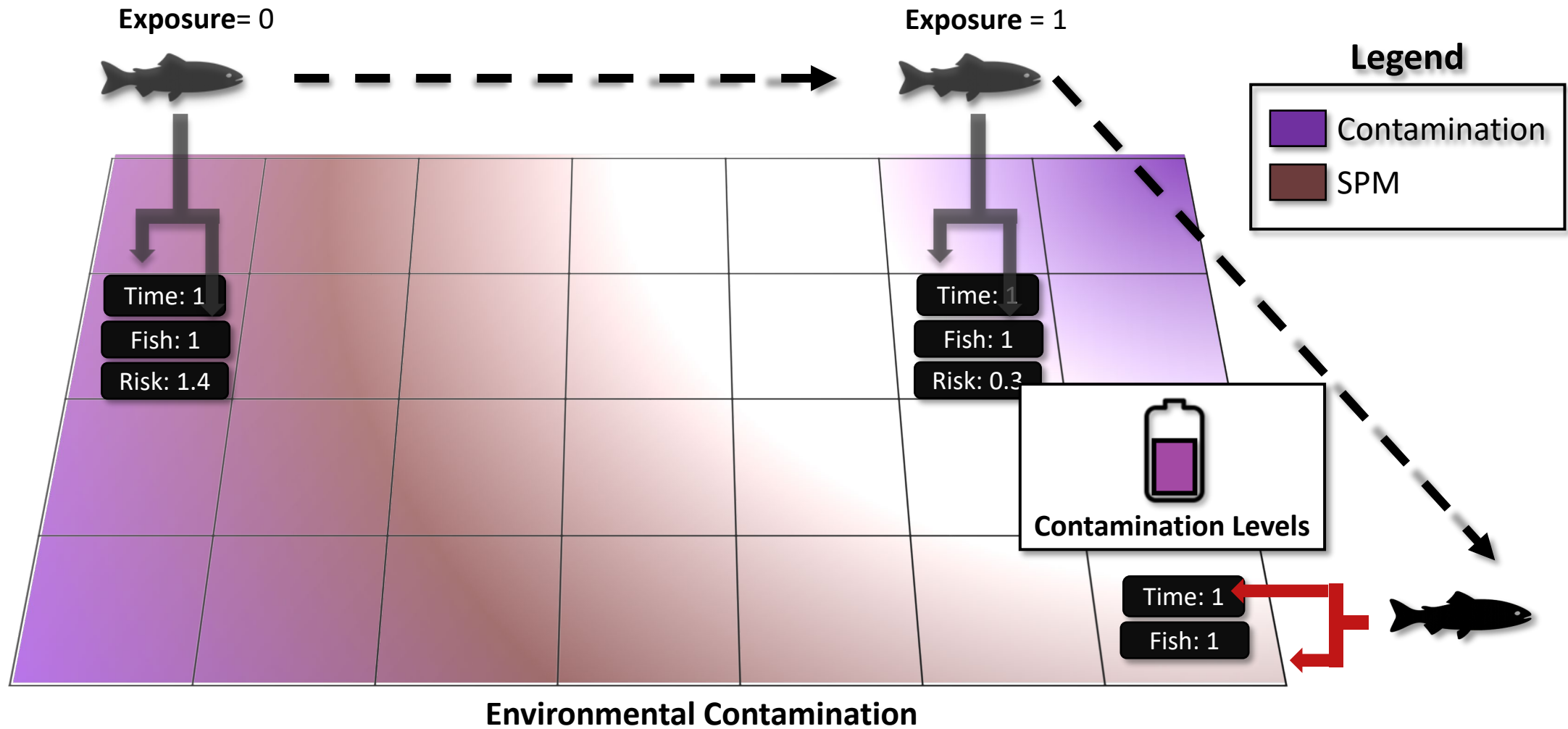
Cumulative Contamination builds up as fish move through polluted areas.
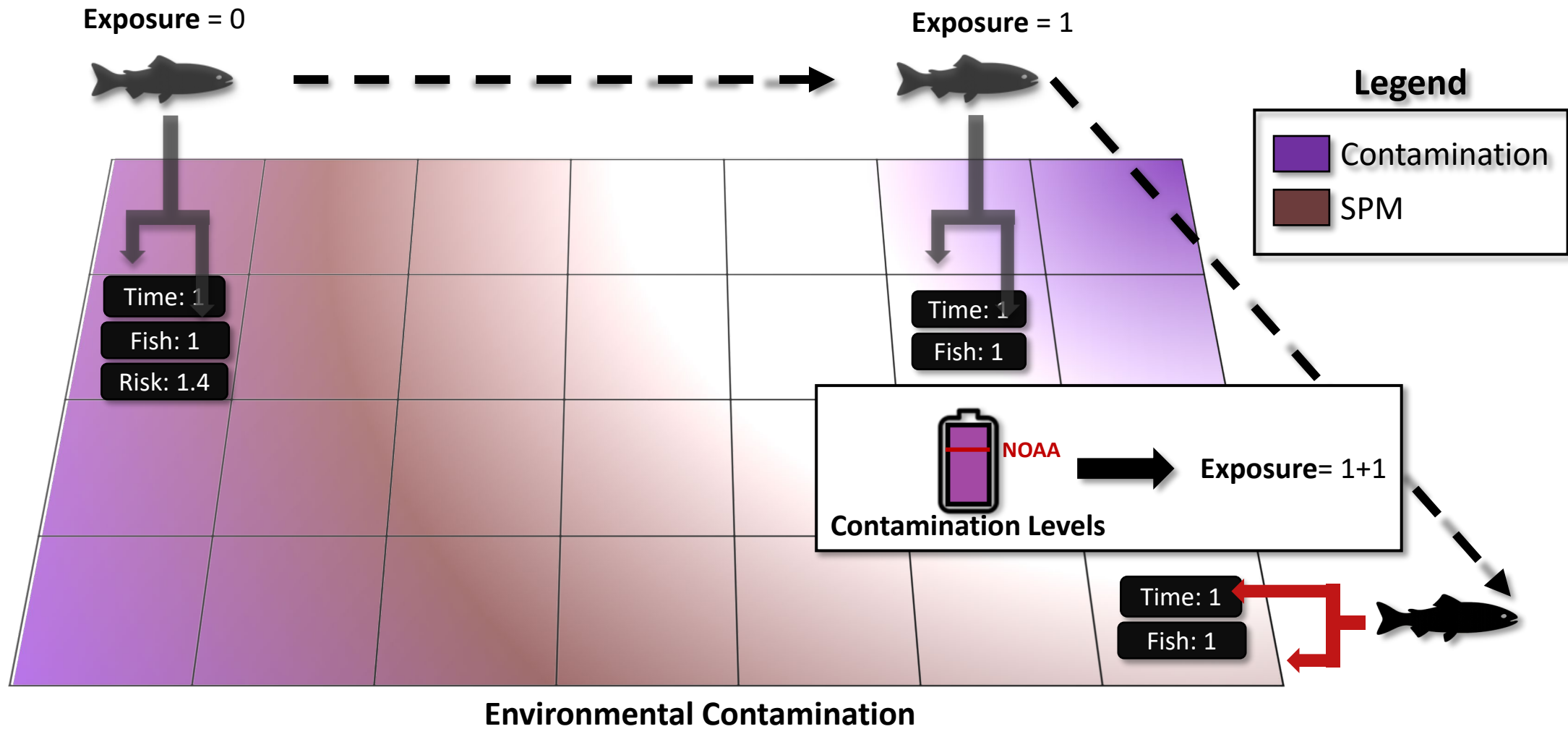
Exposure time increases as fish move through highly polluted areas.

Bioaccumulation risk varies by patch as fish encounter different combinations of contamination, stress, and suspended particles during migration.

Individual-Specific Traits

Trait Type	Generalization
Stress	Related to an fish's ability to mitigate salinity and temperature stress.

Individual traits such as size, age, and species influence individual stress levels in fish.

Outputs of Interest

Type	Variable	What It Tells Us
Temporal	Hg-Exposure MeHg-Exposure	When during migration fish are in the most contaminated areas.
	Hg-Exposure-Total MeHg-Exposure-Total	How much contamination fish have built up over their whole migration.
	Hg-Exposure-Duration MeHg-Exposure-Duration	How long fish are exposed to harmful levels of contamination.
	Hg-Uptake-Risk MeHg-Uptake-Risk	How much risk of mercury entering the body fish face at each moment.
Spatial	Time-Spent	Where in the environment fish spend the most time.
	Hg-Patch-Risk MeHg-Patch-Risk	Where fish are most likely to absorb mercury based on stress and conditions

Outputs highlight contamination hotspots and periods of exposure that may increase fish toxicity and guide restoration priorities.

Discussion Prompts

1. Accuracy & Realism

- Do the steps feel realistic based on your knowledge or experience?
- Does it make sense that fish would be more at risk in certain areas or times based on conditions like salinity or pollution levels?

2. Missing Variables, Traits, or Parameters

- Are there other traits (like predation, spawning condition, or foraging behavior) that could influence exposure or risk?
- Are there environmental conditions missing that affect mercury exposure or stress (e.g., salinity, temperature, turbidity)?

3. Outputs of Interest

- Which outputs would help us understand risk to fish or guide management decisions (e.g., exposure maps, stress zones)?
- Are time-based outputs (like how long fish are exposed) more useful, or location-based outputs (like where risk is highest)?