Penobscot Estuary Community Modeling Workshop
ABM Draft Predation Function
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Predation Behavior

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Relevant Background Information

Term	Definition
Ectotherm	Swimming, survival, and energy use all depend on environmental temperature.
Optimal Temperature	Each fish has an optimal temperature for performance, and lethal limits for cold and heat.
Thermal Stress	Maximum prey size a predator can consume, based on its own size.
Predator	An agent that detects, selects, and consumes prey to gain energy.
Prey	Agents that avoid predators using fleeing behaviors based on visual detection and social cues.

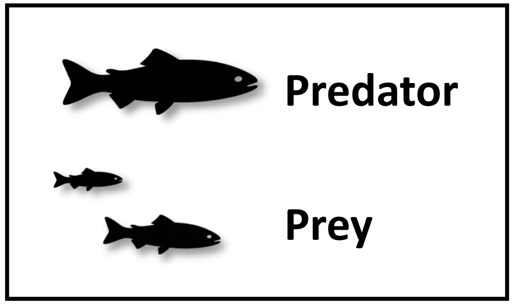
Model Objectives

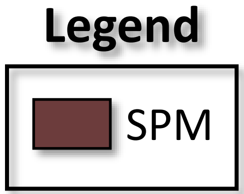
Purpose: This module simulates predator-prey interactions between migratory fish species (predators like striped bass and prey like alewife) during migration.

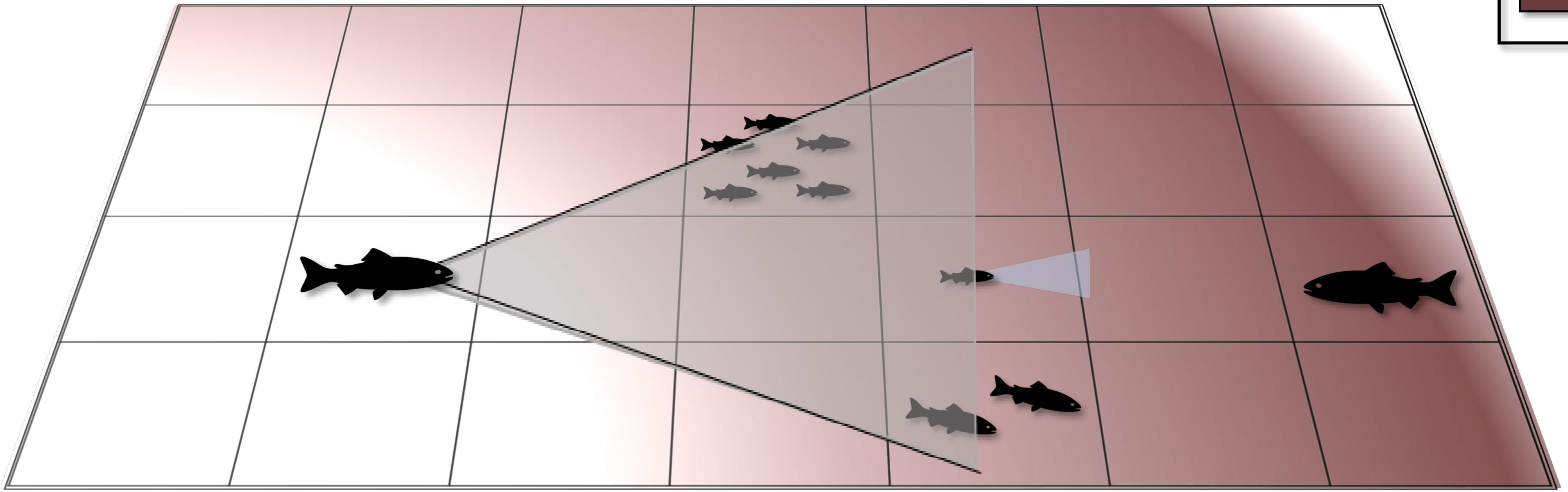
Objectives:

1. **Link predator-prey interactions to environmental conditions**
   Allow predators and prey to evaluate nearby environmental conditions, and adjust their behaviors accordingly.
2. **Simulate optimal predation behavior**
   Enable predators to prey on other agents based on the optimal foraging theory, and prey to flee from predators.
3. **Link energy gain and depletion predator-prey behavior**
   Predators gain energy from consuming prey, while prey lose energy when fleeing.

Visual Ability

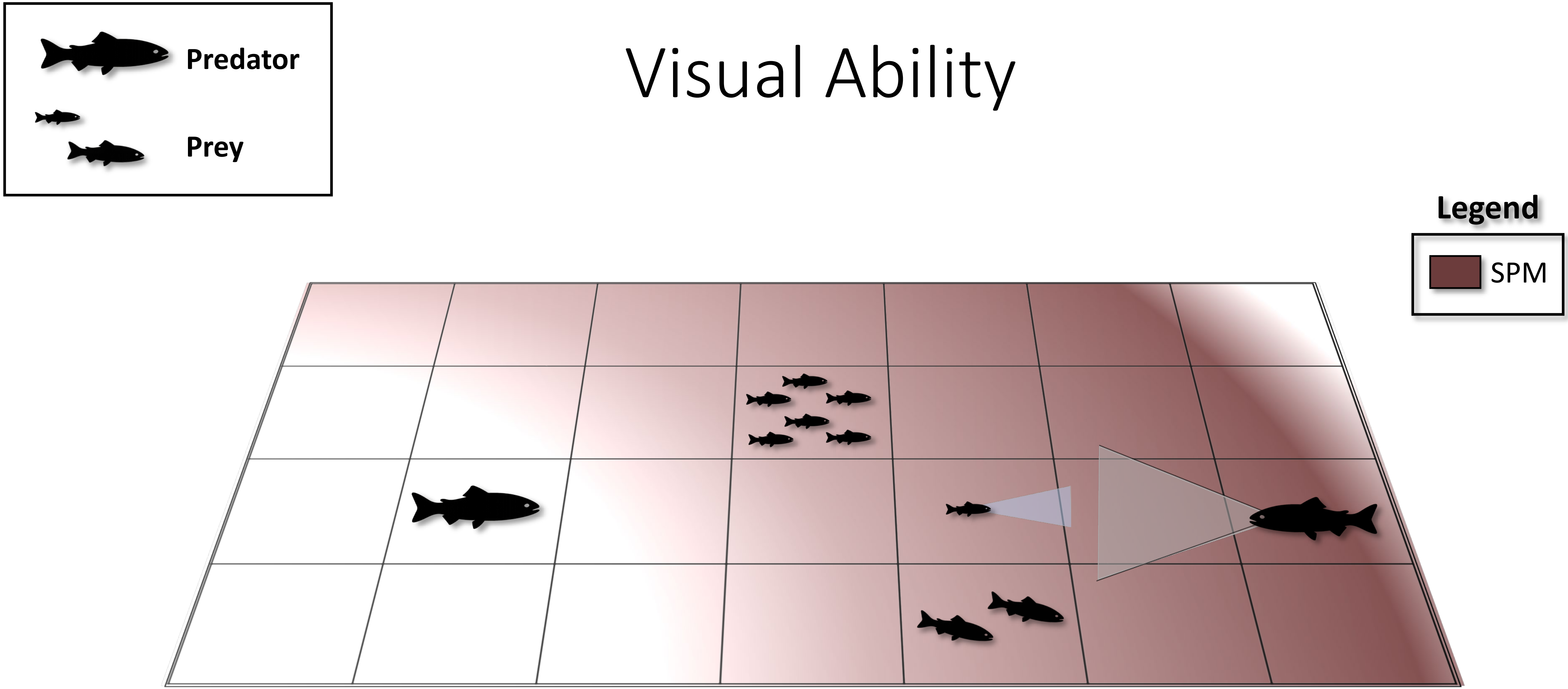






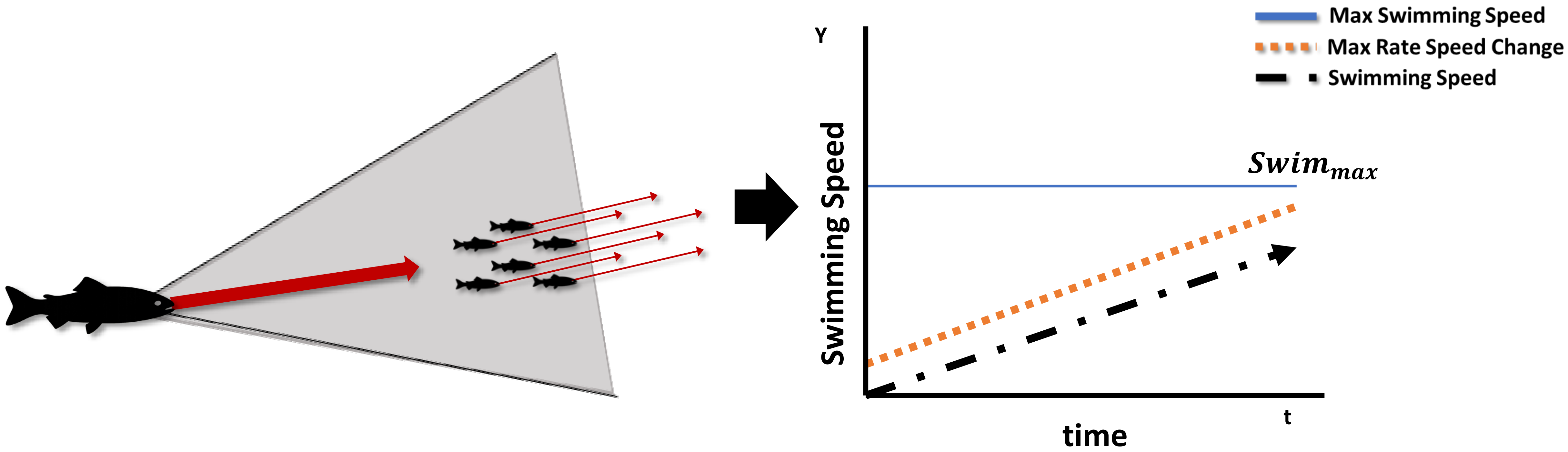
Fish can only see each other if the water is clear enough, the other fish is large enough, and they are close enough.

Visual Ability

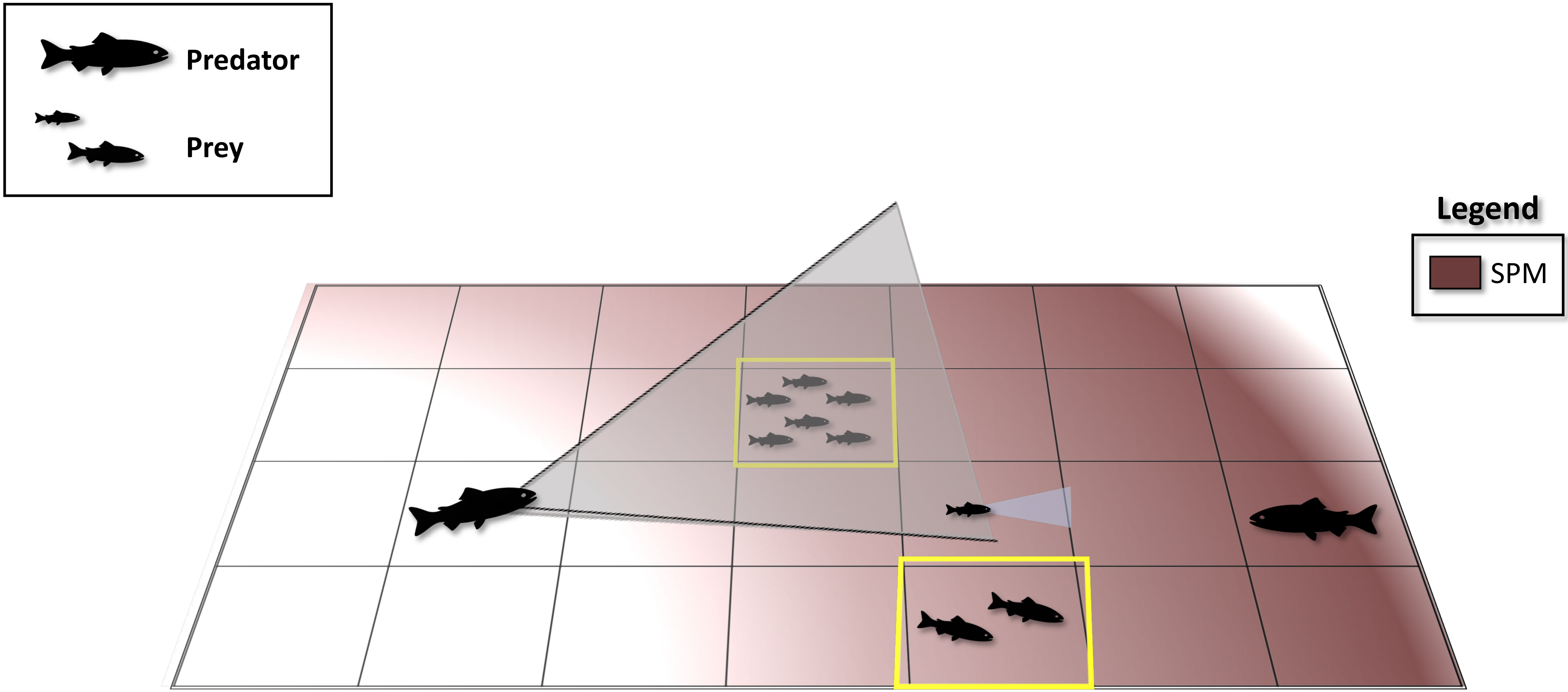


High SPM levels can decrease vision and make prey harder to find, and predators harder to recognize

Fleeing and Pursuit Limits



- Fish can't instantly speed up. They have a natural limit to how fast they can accelerate, and each burst of speed uses energy.
- Once a fish runs out of energy, it can't keep fleeing or chasing.



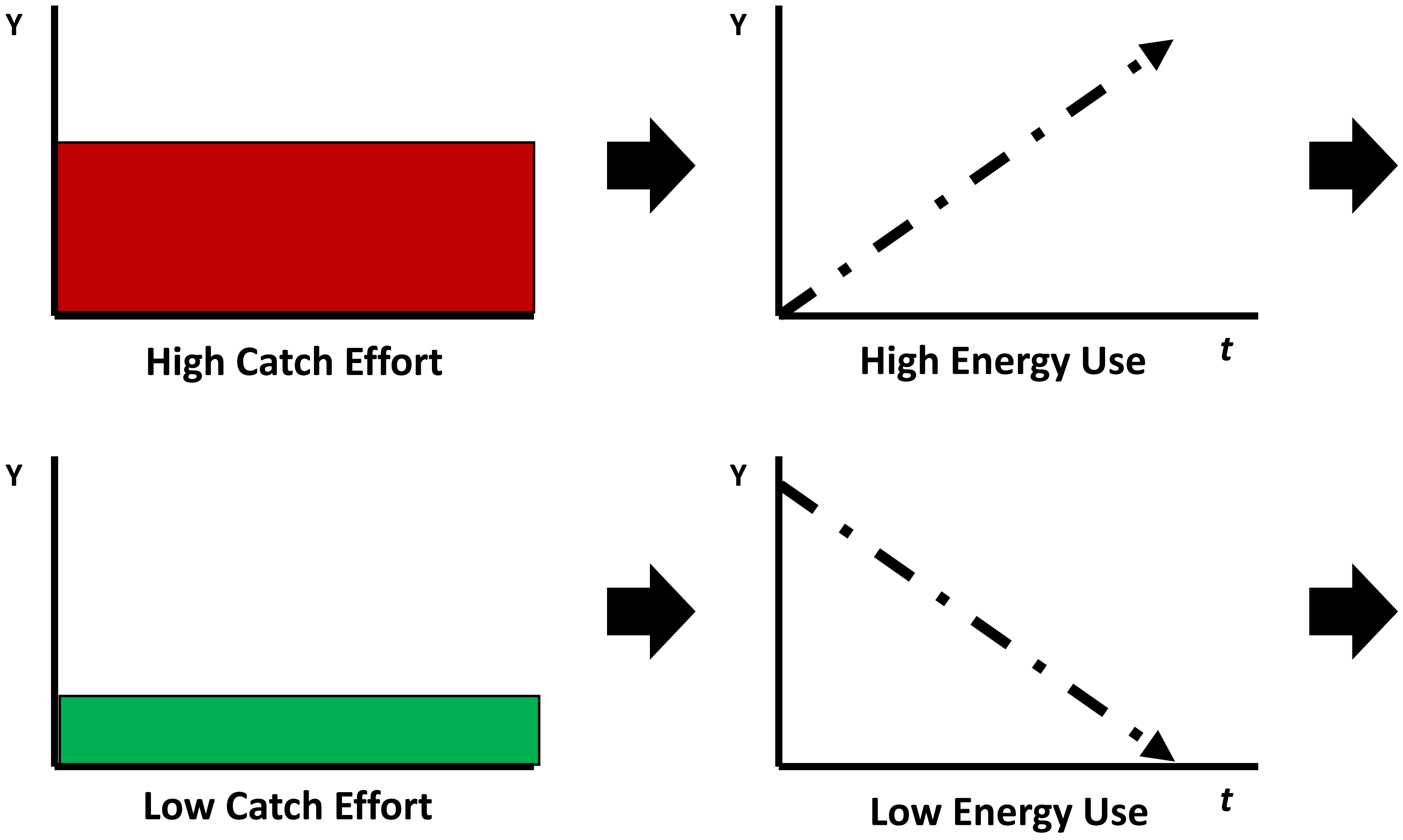
Predators weigh how hard it will be to catch and eat a fish. They prefer prey that are nearby, smaller than their mouth can handle, and part of a group.

Calculate Catch Effort

$$\text{Catch Effort} = \text{Distance} \cdot \left(1 + \frac{1}{\text{Prey Density}}\right)$$

- Available prey for consumption is filtered out by an agent’s gape limit.
- Higher density of prey decreases the catch effort in predators.
- Closer prey require less energy to pursue and capture.

Predator Energy Use



Ecological Implication

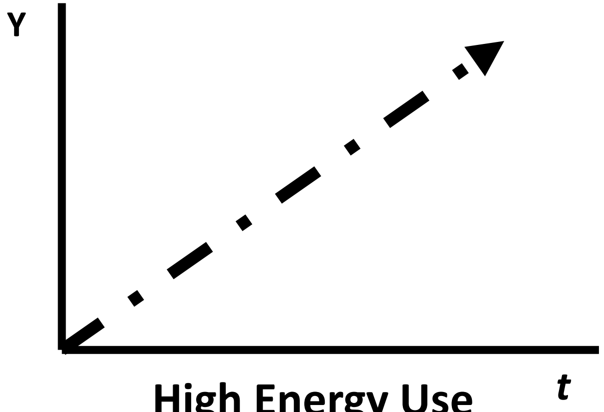
Greater catch effort forces fish to use more energy to successfully capture prey.

Lower catch effort requires less energy to successfully capture prey.

Every pursuit costs energy. Predators must choose wisely to avoid wasting energy on prey they can't catch.

Prey Energy Use

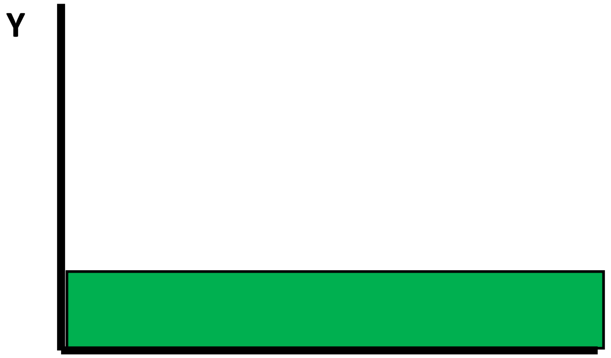
High Fleeing Effort



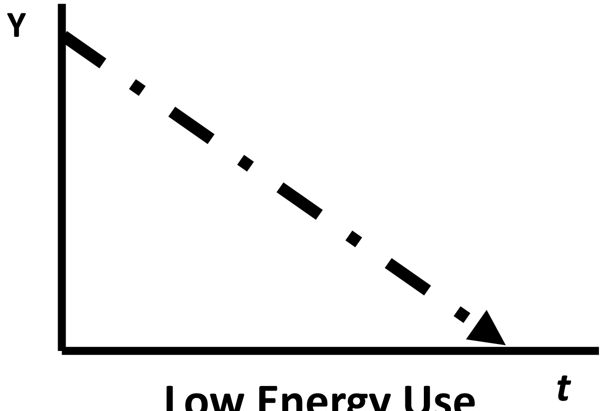
High Energy Use

Ecological Implication

Greater fleeing effort forces prey to use more energy to successfully evade predators.



Low Fleeing Effort

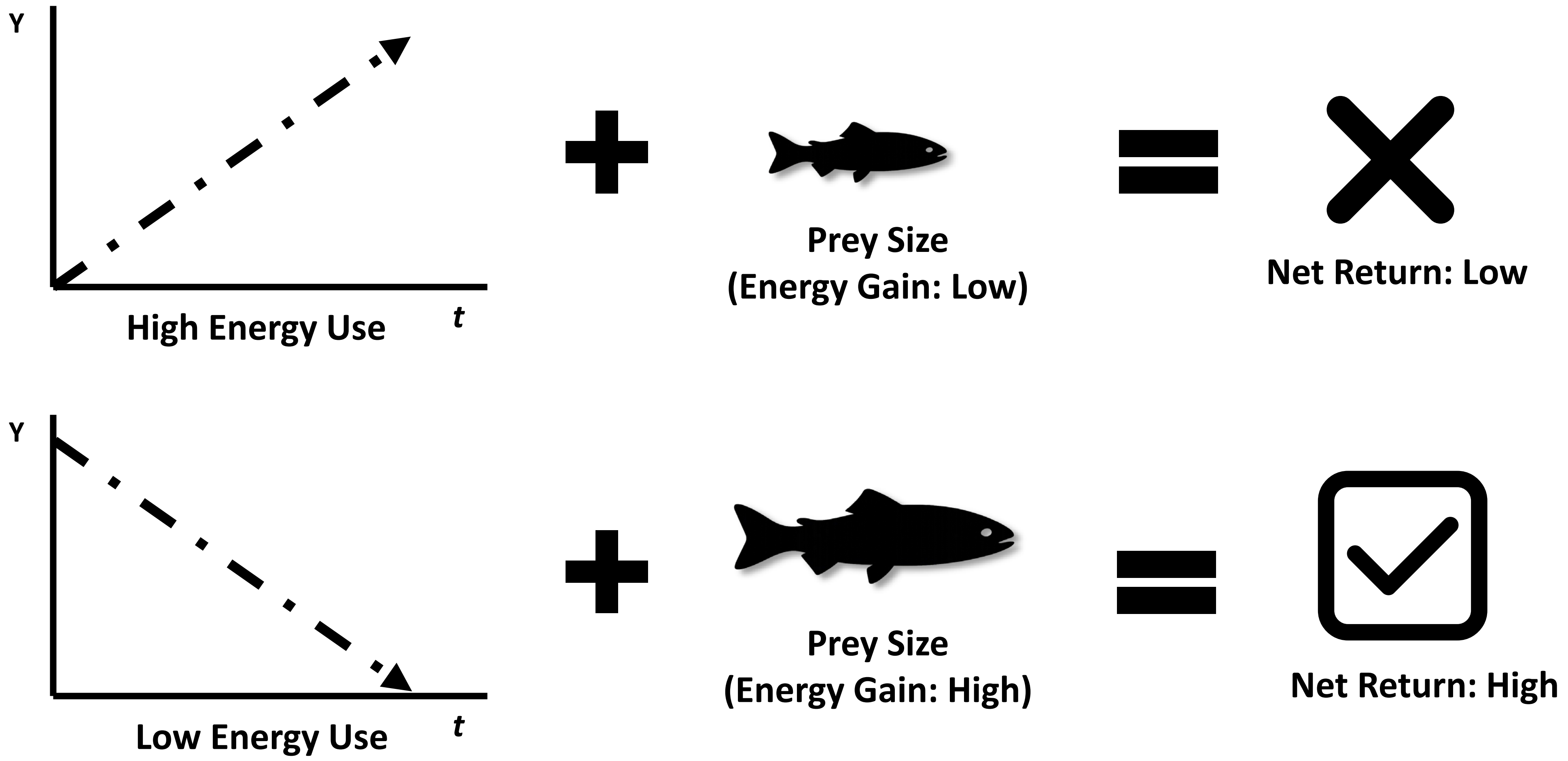


Low Energy Use

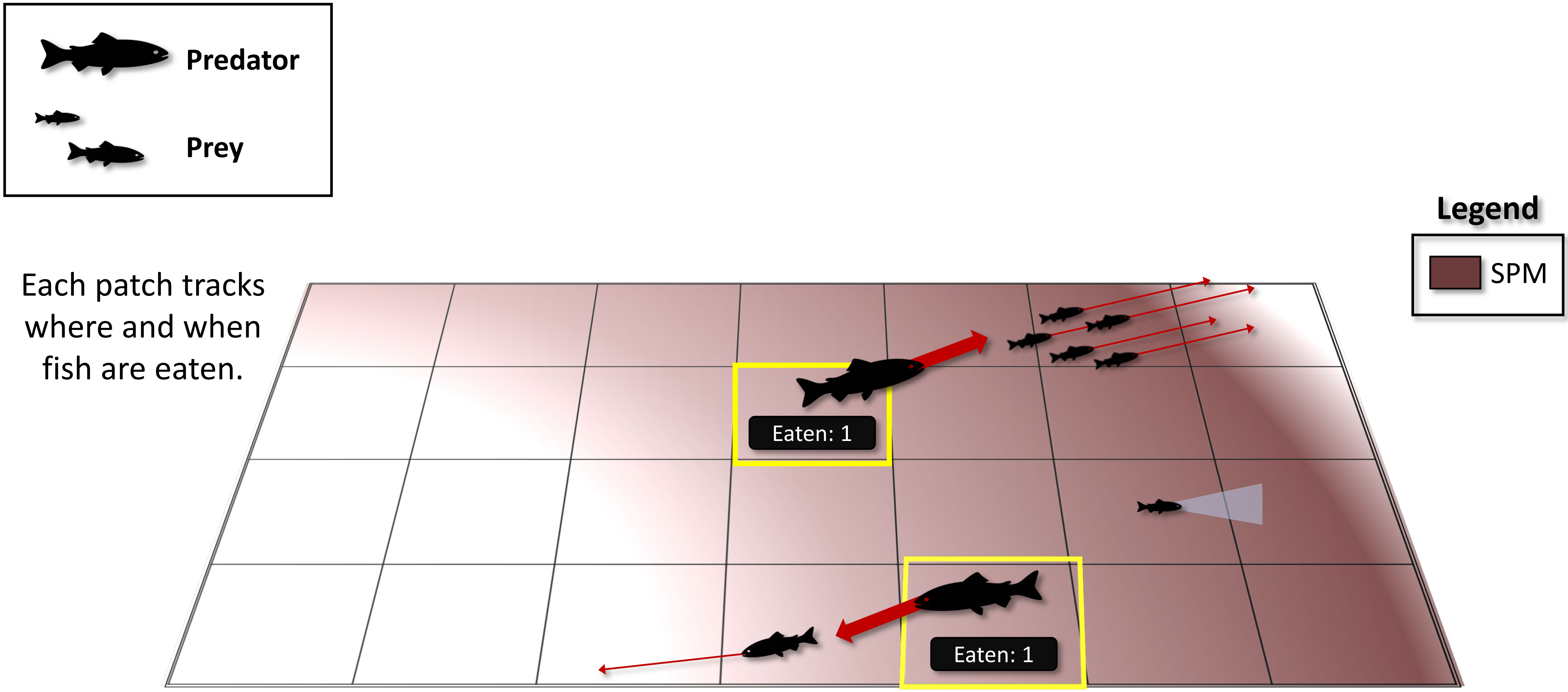
Lower fleeing effort requires less energy to successfully evade predators.

Escaping predators burns energy, and prey that run out of energy become easy targets.

Optimal Foraging Theory



Predators choose prey that give them the most energy for the least effort.



When one prey detects a predator, it triggers an alarm that causes the entire school to flee, reflecting how fish use group behavior to avoid predators.

Individual-Specific Traits

Trait Type	Generalization
Energy	Determines if predators can pursue or prey can escape.
Hunger Level	Determines if a predator is hungry or not.
Predation Ability	Determines reaction time to prey based on age and experience.
Fleeing Ability	Determines reaction time to predators based on age and experience.

Traits like energy and experience determine if and how fast a fish reacts, whether it can escape or chase, and how well it survives.

Outputs of Interest

Type	Variable	What It Tells Us
Temporal	Prey Consumed	Tracks when fish are consuming prey.
	Prey Species	Tracks what type of prey fish are consuming.
Spatial	Predation Events	Areas where predation is concentrated.
	Escape Events	Areas where predation is constantly avoided successfully.

These outputs help us understand where and when predator–prey interactions happen, and may point to habitat features that increase risk or provide refuge.

Discussion Prompts

1. **Accuracy & Realism**

- Do predators always prioritize predation during migration, or are there situations when they are more likely to ignore nearby prey?
- Does limiting predator pursuit by gape size, hunger levels, or energy availability reflect real-world behavior?

2. **Missing Variables, Traits, or Parameters**

- Are there time-of-day, tidal phase, or species constraints that influence when predation is more likely or more successful?
- What environmental (e.g., turbidity, salinity, visibility) or structural barriers (e.g., dams, culverts, entrainment zones) might inhibit predation or fleeing behavior?

3. **Outputs of Interest**

- Should the model prioritize where predation and escape attempts happen or how often they occur?
- Are there ways we could use these outputs to support habitat restoration or passage design?