Resting Behavior

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Relevant Background Information

Term	Definition
Selective Tidal Stream Transport (STST)	A strategy where fish conserve energy by drifting with favorable tidal currents, usually by positioning themselves in slower or deeper water during migration.
Staging	A behavior where fish temporarily stop migrating to recover from low energy or high stress, often staying in one area until conditions improve.
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.

Model Objectives

Purpose: Simulate energy-conserving strategies fish use during migration

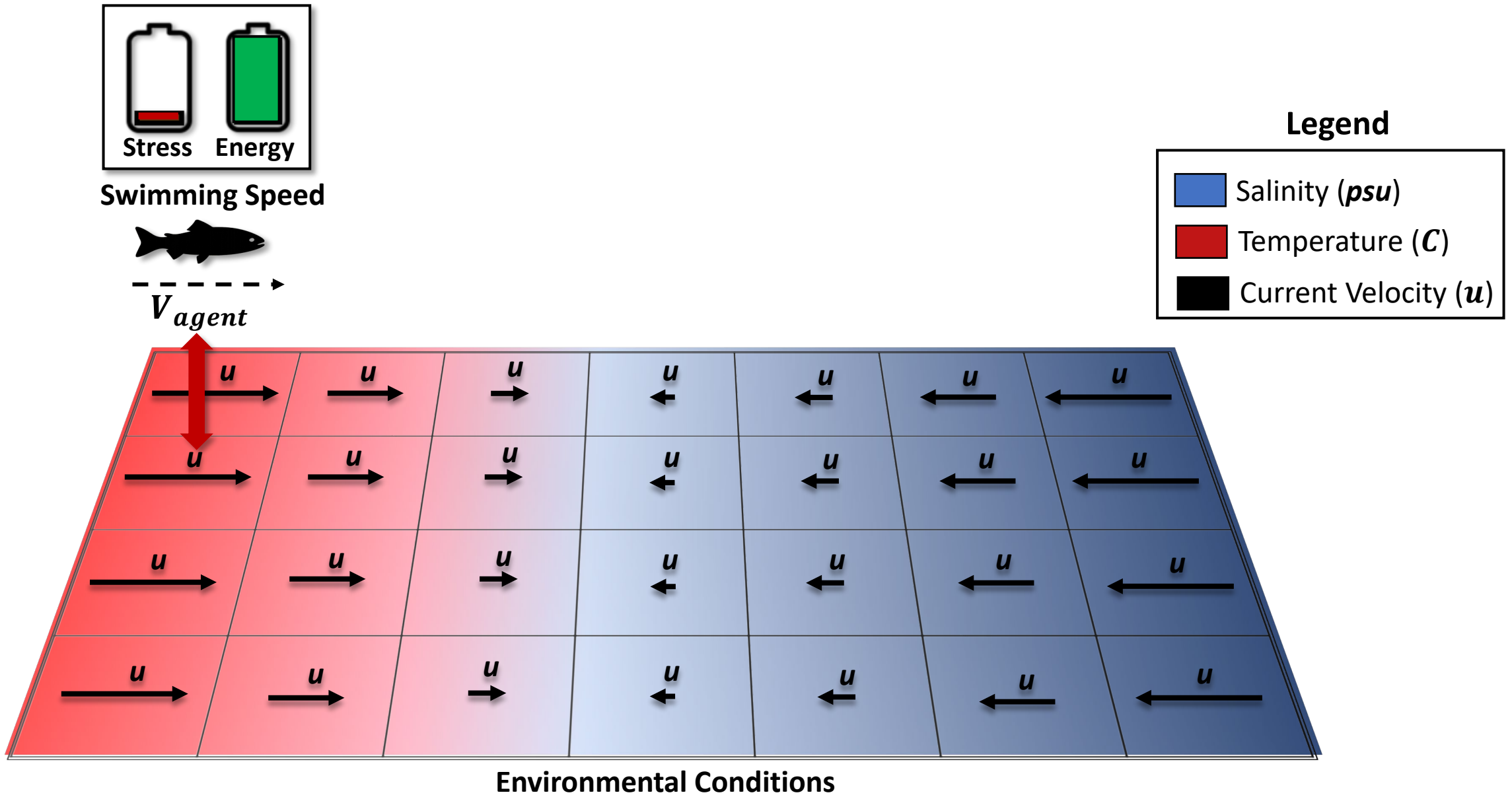
Objectives:

1. **Reduce energy cost during high-flow events**
   Enable fish to passively rest when swimming is inefficient, conserving energy for critical behaviors like migration and spawning.
2. **Allow recovery during periods of physiological stress**
   Let fish temporarily stop migrating to restore energy and acclimate to environmental changes such as salinity shifts or elevated flow resistance.
3. **Track when and where resting occurs**
   Identify the spatial and temporal patterns of resting behaviors, including staging hotspots and zones of selective tidal stream transport, to inform habitat quality assessments.

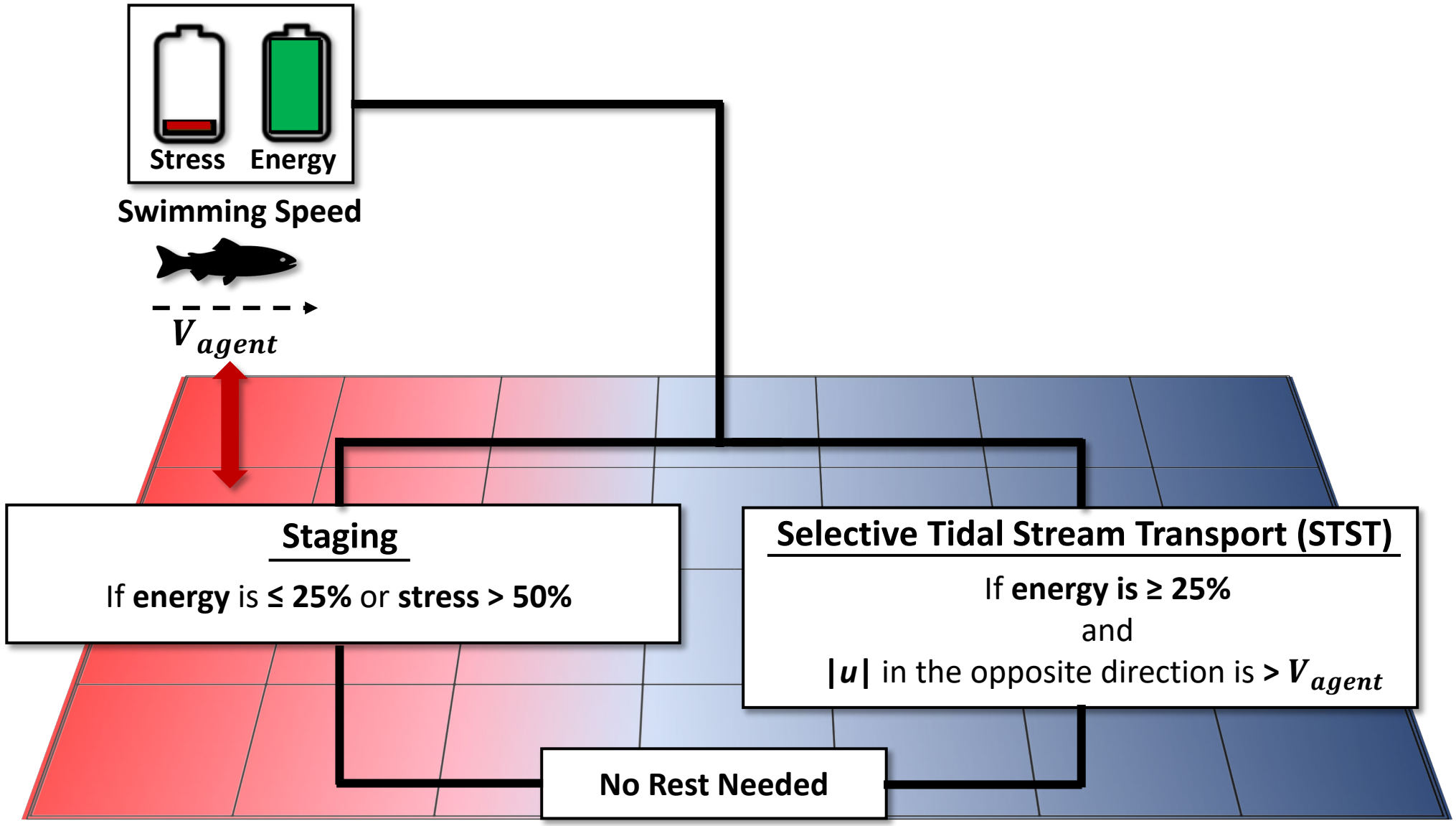
Conditions that Trigger Resting

Condition	Result	Mechanism
Current velocity > swimming speed	Passive resting	Selective Tidal Stream Transport
Energy ≤ 25%	Stop & actively recover	Staging
Stress > 50%	Stop & actively recover	Staging

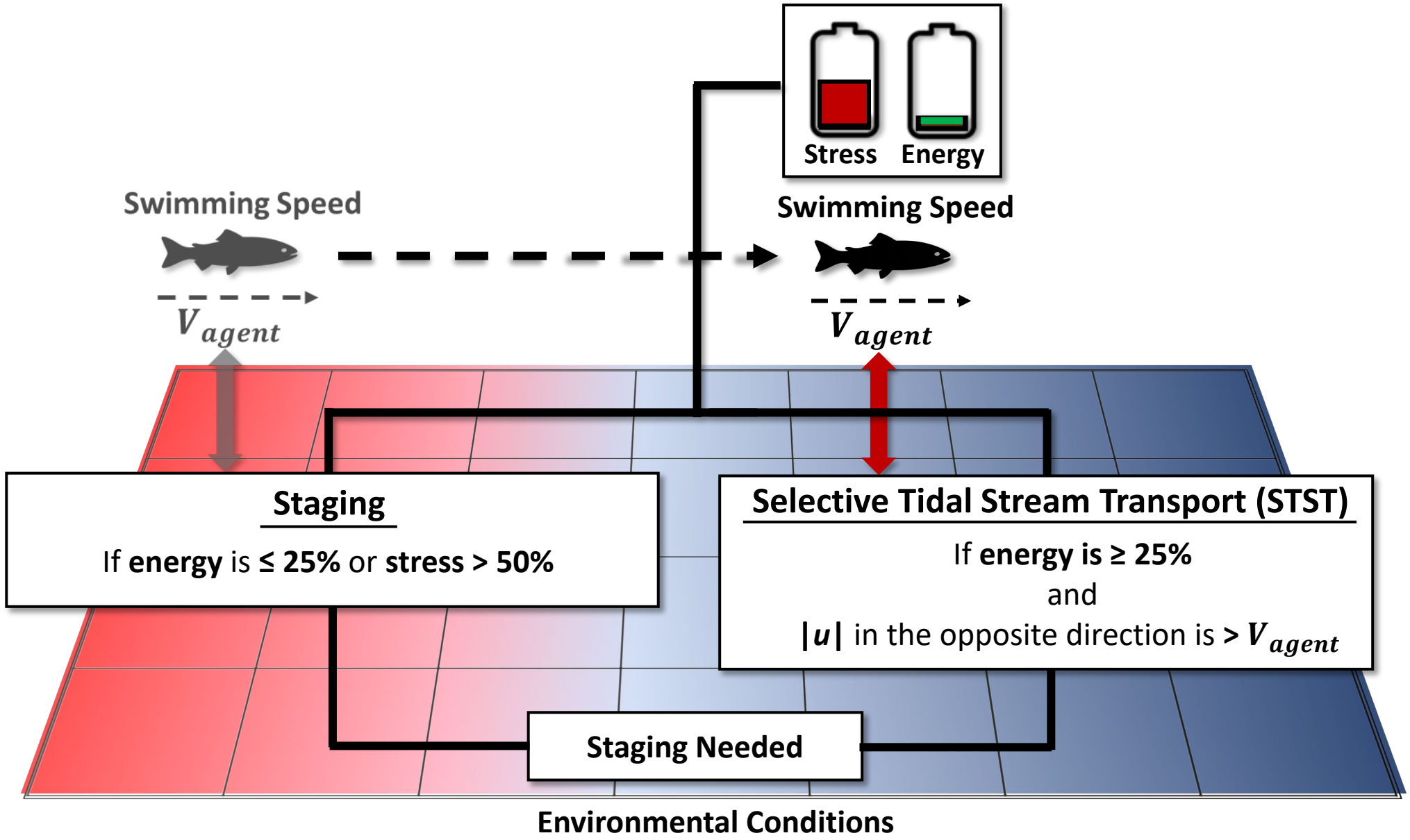
Fish rest when environmental conditions exceed their ability to swim or cope.



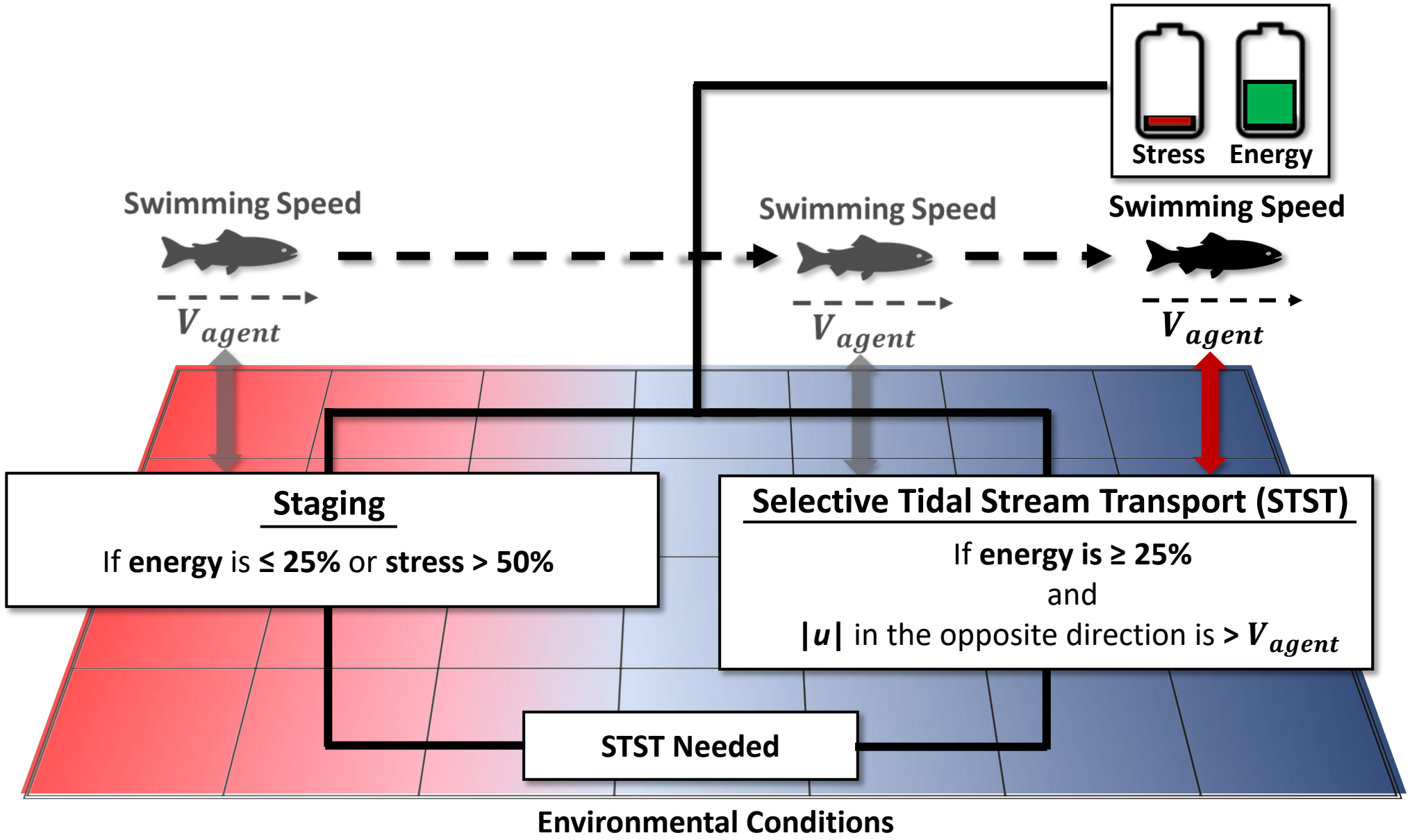
Fish adjust energy and stress based on current speed, salinity, and temperature.



Fish compare their energy, stress, and swimming capacity to the environment to decide whether to pause and recover (staging) or drift passively (STST).

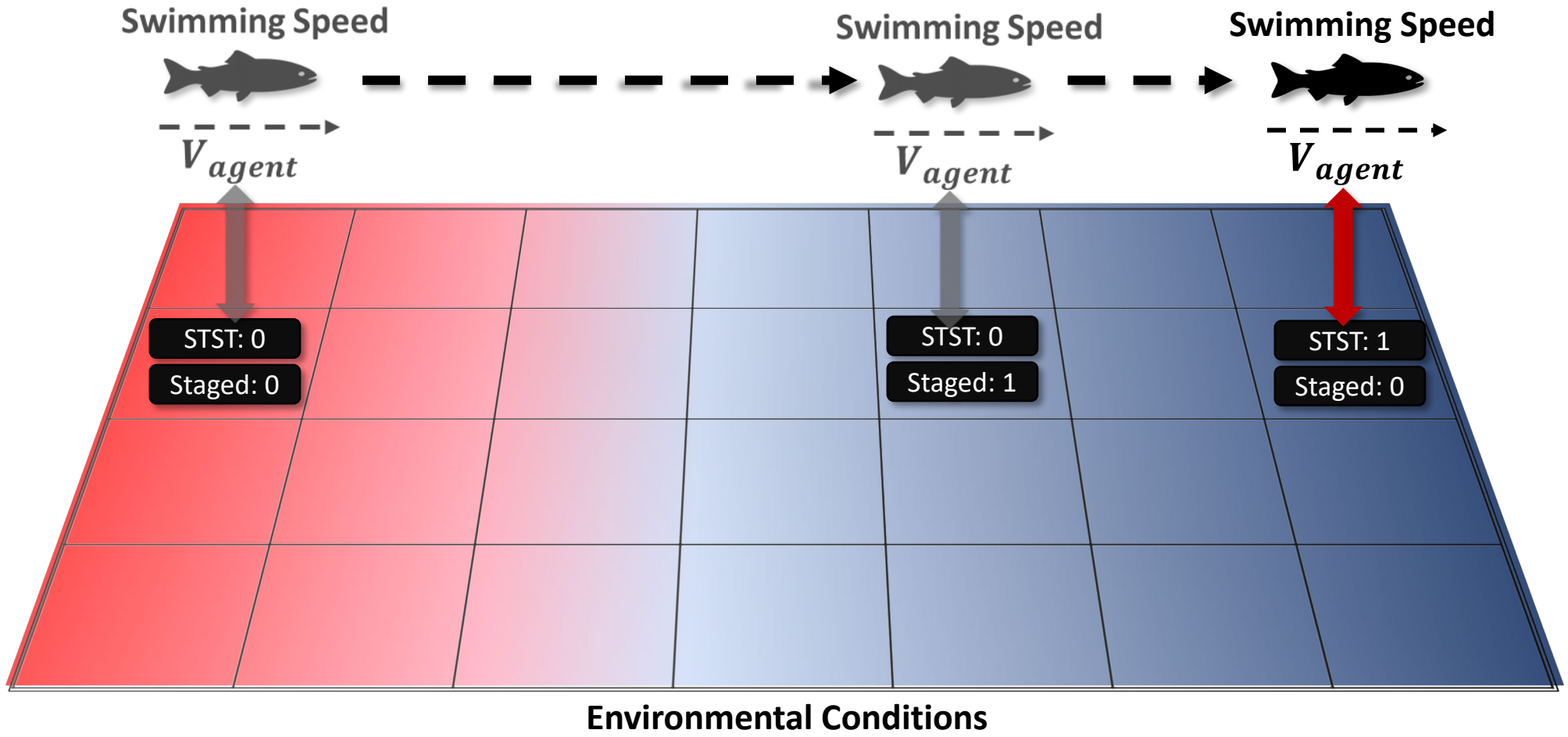


When conditions exceed a fish's limits, it enters staging or STST mode depending on whether it needs to actively recover or passively drift.

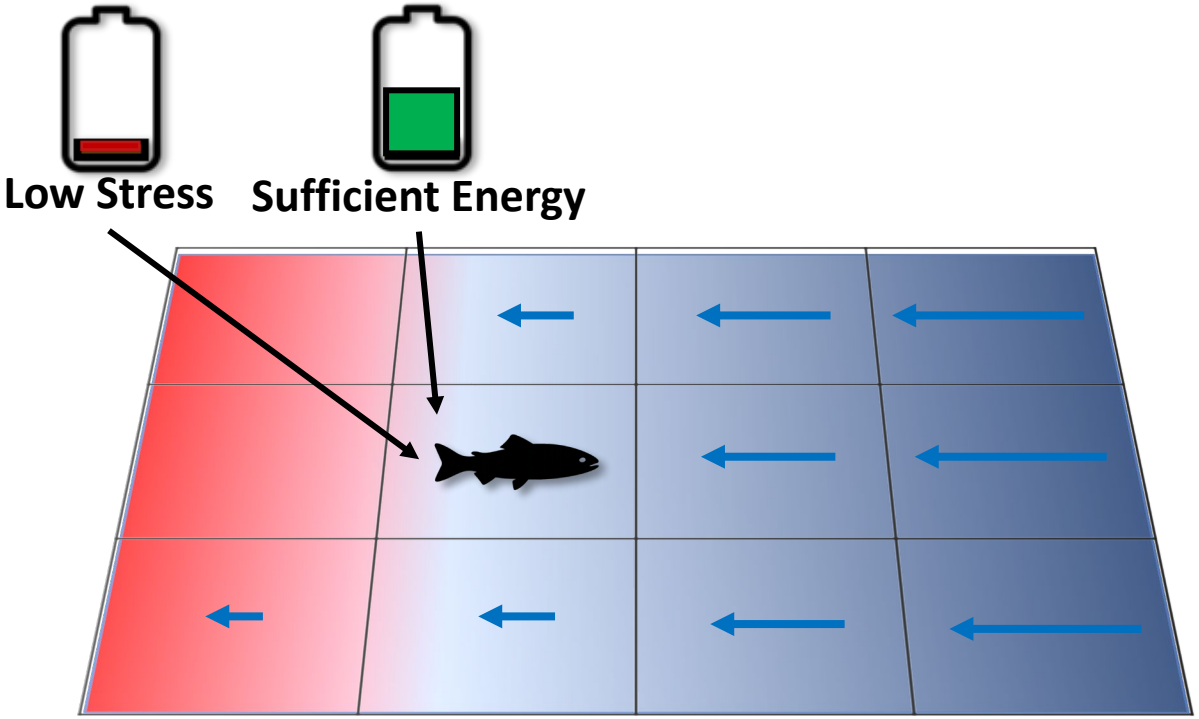


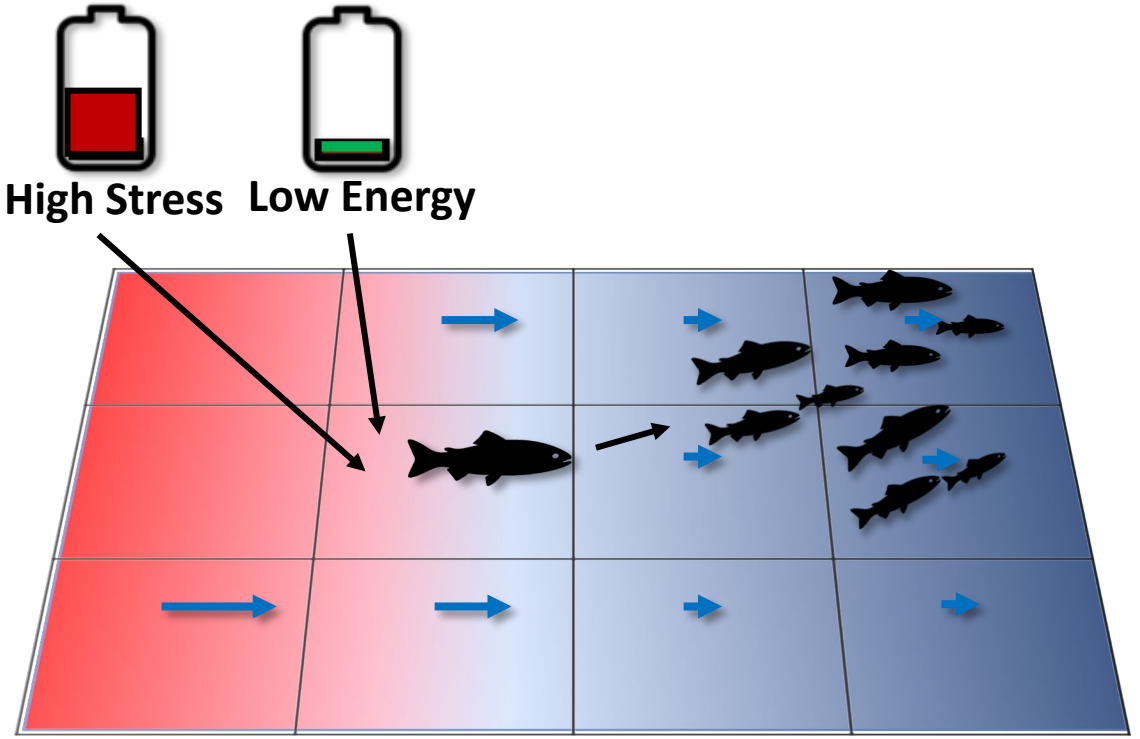
Environmental conditions affect how much stress a fish is experiencing and how much energy is available to the fish.

Each Patch Tracks if Fish are Resting in that Location



Resting patterns help identify areas that may limit progress or increase contamination exposure risk.





Selective Tidal Stream Transport (STST)

Fish attempt to remain in place, move lower in the water column, and drift passively with the current to conserve energy use.

Staging

Fish identify and move to the most energy-efficient neighboring patches to rest

where:

$$|u| < V_{agent}$$

While in Rest: Fish Check for Better Conditions

Fish remain in **STST** until $|u|$ in the **opposite direction** is **<** V_{agent}

Fish remain **Staging** until **Stress** is **<= 10%** and **Energy >= 75%**

Why it Matters:

- Identifies critical recovery thresholds for migratory fish behavior.
- Pinpoints locations where currents or temperature and salinity fluctuations impose energetic stress.
- Supports fisheries management by revealing when and where fish pause most often, and assessing whether these resting zones overlap with areas of high contamination.

Individual-Specific Traits

Trait Type	Generalization
Stress	Sensitivity to salinity and temperature changes.
Energy	Internal reserves used for movement and recovery.
Swimming Speed	How fast a fish can move and if they can overcome current velocity.

Each fish rests differently based on its own energy reserves, swimming speed, and ability to handle stress. These traits shape when, where, and how long it pauses during migration.

Outputs of Interest

Type	Variable	What It Tells Us
Temporal	STST?	When fish switch into passive drift due to unfavorable flow conditions.
	Staging?	When fish stop active migration to recover from low energy or high stress.
	Time-in-STST	Cumulative time fish spend utilizing STST throughout migration.
	Time-in-Staging	Cumulative time fish spend staging throughout migration.
Spatial	STST-in-Patch	Where in the environment fish most frequently rely on STST behavior.
	Staging-in-Patch	Where fish most often stop to recover based on flow and stress conditions.
	STST-time	Which locations accumulate the most total time in passive drift.
	Staging-time	Which locations accumulate the most total time spent resting or recovering.

Identifies where and when resting occurs during migration.

Discussion Prompts

1. **Accuracy & Realism**

- Do the triggers for STST or Staging (e.g., high current velocity, low energy, high stress) feel biologically reasonable?
- Does it make sense that fish might rest more in certain areas or times due to hydrodynamics or salinity mismatch?

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

- Should a fish's species, age, or size affect resting behavior?
- Are there missing environmental stressors (e.g., predation, poor habitat quality in resting areas) that could influence resting?

3. **Outputs of Interest**

- Which outputs are most useful for identifying critical habitat or management actions (e.g., resting hotspot maps, resting duration, overlap of these spots with contamination)?
- Is it more helpful to track where fish rest or how long they remain in those states?