Penobscot Estuary Community Modeling Workshop
ABM Draft Foraging Function
August 6th, 2025

Foraging Behavior

Drafted By: Vanessa Quintana

Relevant Background Information

Term	Definition
Optimal Foraging Theory	The idea that animals balance energy gain with effort and risk, choosing to forage only when the benefits outweigh the costs.
Suspended Particulate Matter (SPM)	Tiny particles in the water that influence water clarity, feeding efficiency, and sometimes contamination risk.
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.
Intraspecific Competition	Competition between individuals of the same species, often influenced by density and size differences.
Interspecific Competition	Competition between individuals of different species, often driven by overlapping resource needs or dominance hierarchies.
Staging	A behavior where fish temporarily stop migrating to recover from low energy or high stress, often staying in one area until conditions improve.

Model Objectives

Purpose: Simulate foraging as an opportunistic energy recovery behavior based on local environmental conditions and individual fish needs.

Objectives:

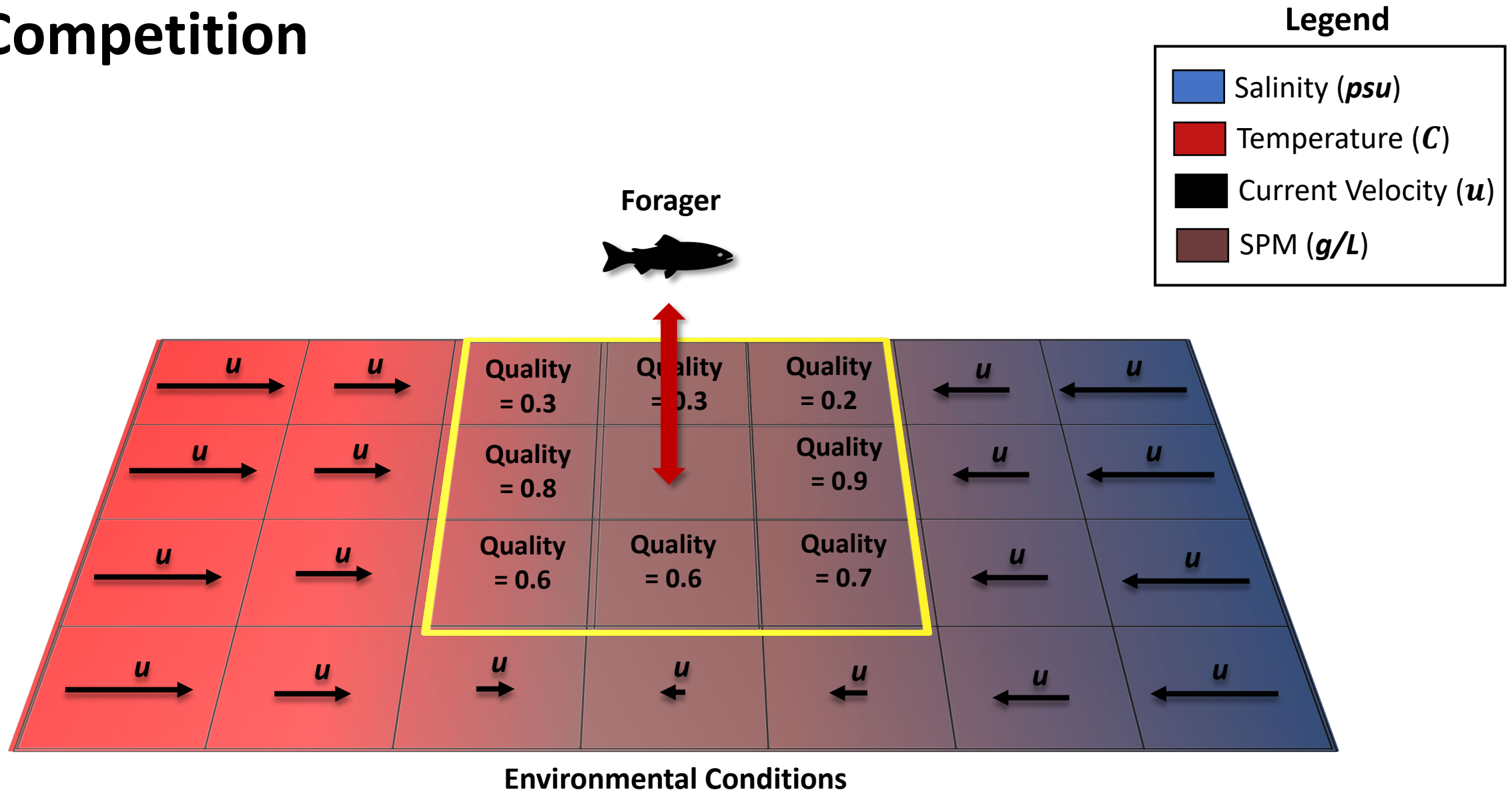
1. **Simulate optimal foraging behavior**
   Allow fish to opportunistically forage when swimming is inefficient or unnecessary, maximizing energy gain during periods of low stress or migratory pause.
2. **Link foraging decisions to environmental conditions and competition**
   Enable fish to evaluate nearby foraging conditions based on salinity, temperature, depth, velocity, and SPM, and forage only when and where conditions are suitable.
3. **Link energy gain to environmental conditions**
   Allow fish to gain more energy in patches with conditions that promote foraging success.

Conditions that Trigger Foraging

Condition	What it Means	Why it Matters
Staging? = True	The fish is already paused in its migration.	Foraging only happens during natural rest periods.
Energy < 75%	The fish is low on energy.	Foraging is only worth the effort when the fish needs to refuel.
Stress < 3	The fish has low stress levels.	High stress prevents safe feeding.
SPM < Mean SPM	Water has less suspended sediment.	Clearer water improves feeding success.

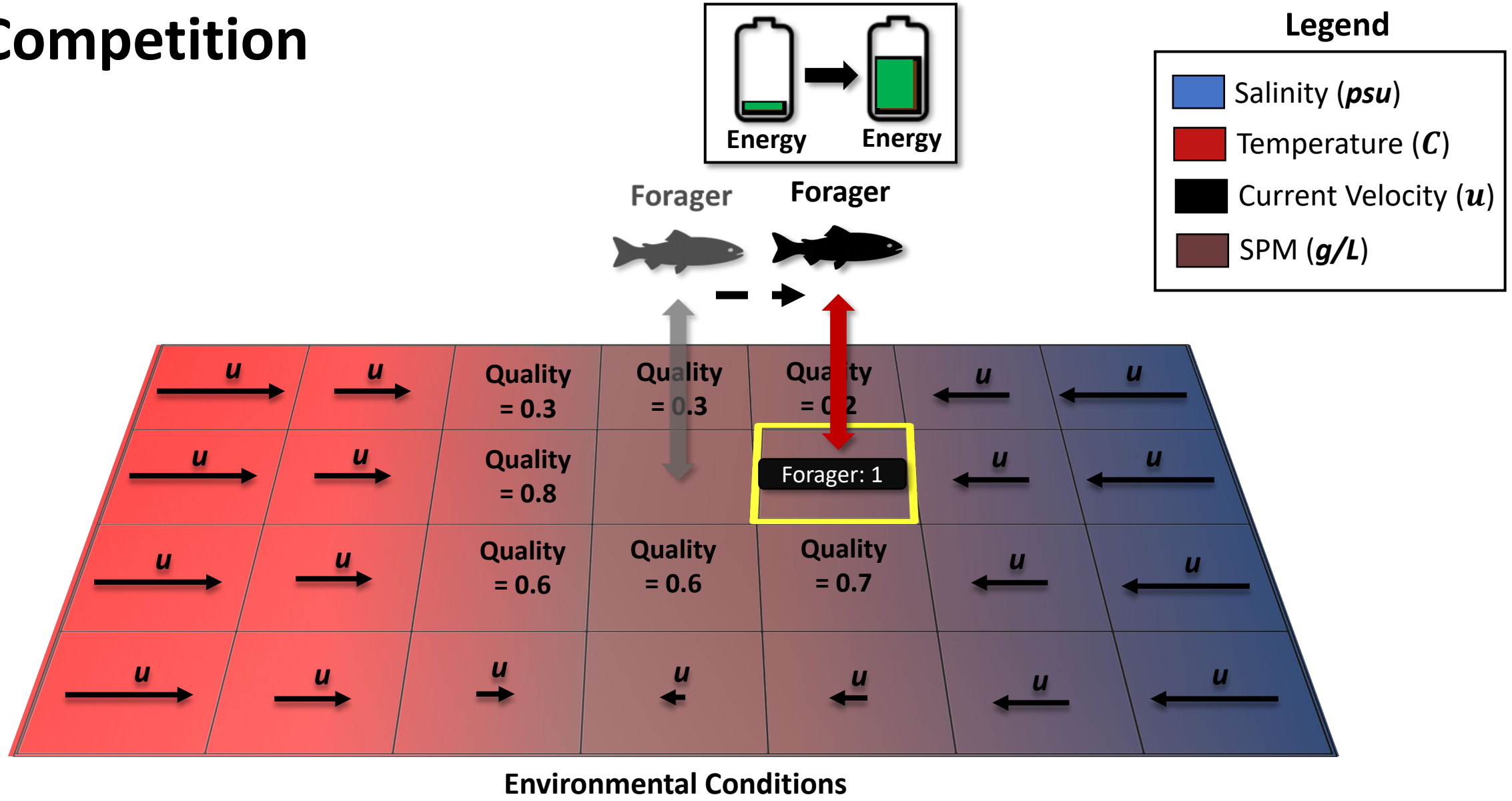
All of these conditions must be true for a fish to forage.

No Competition



Fish scan nearby patches and score them based on salinity, temperature, depth, velocity, and turbidity.

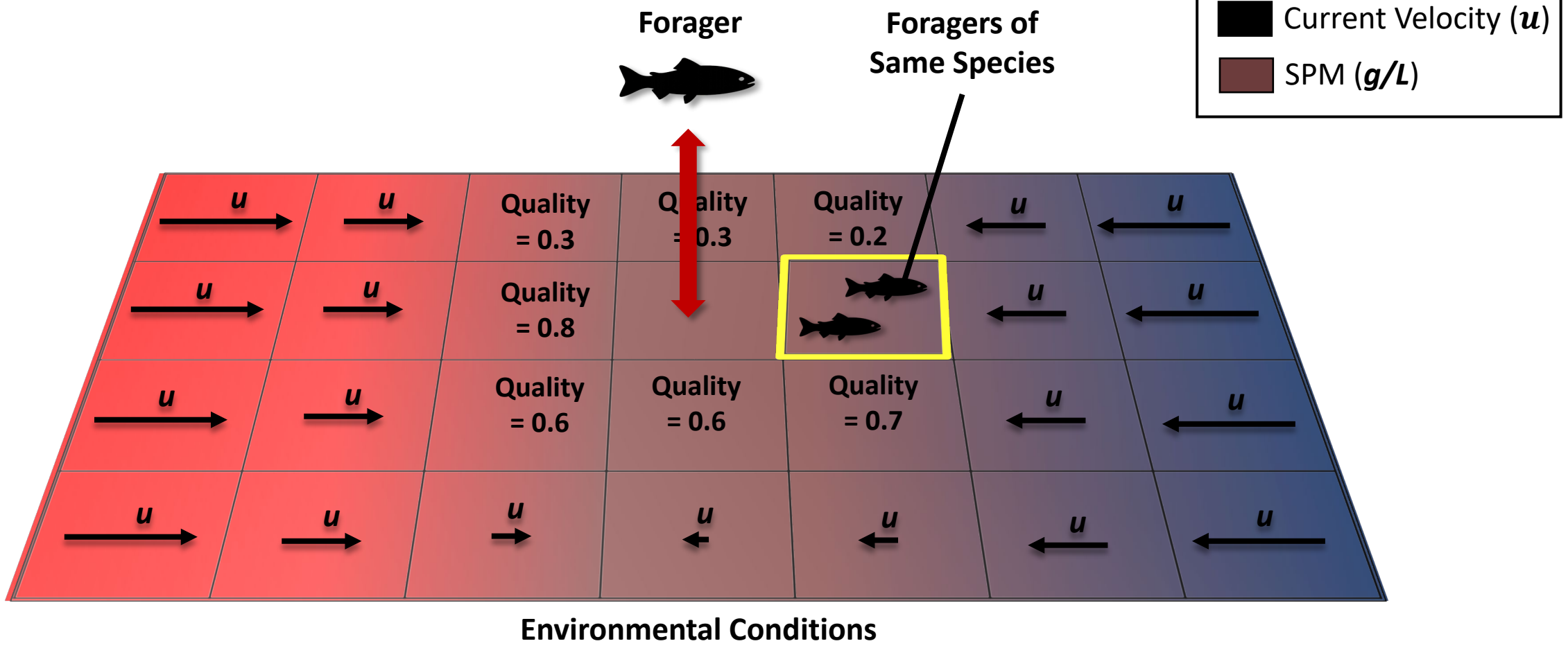
No Competition



Fish move to the best nearby patch and gain more energy when environmental conditions match their foraging preferences.

Intraspecific Competition

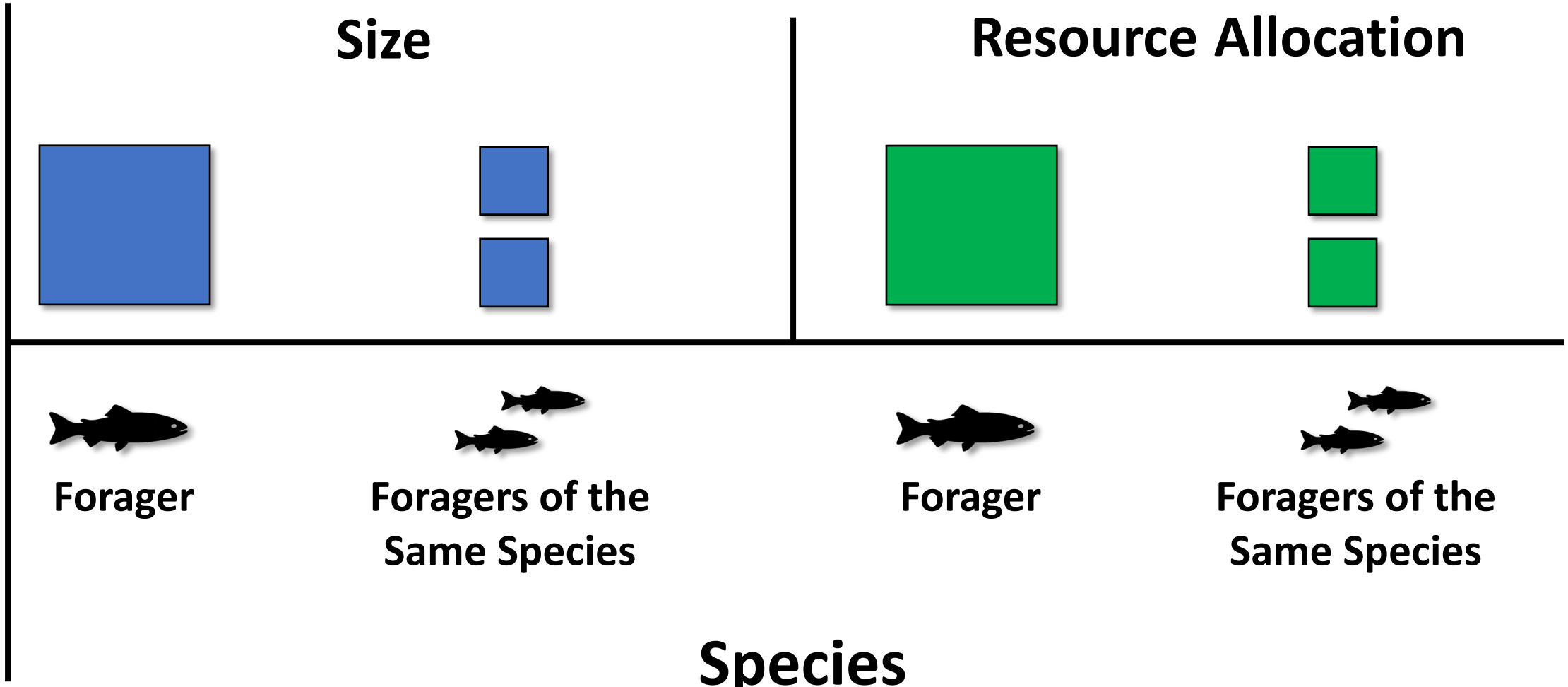
(same species)



Same-species fish can share a patch, but larger individuals benefit more.

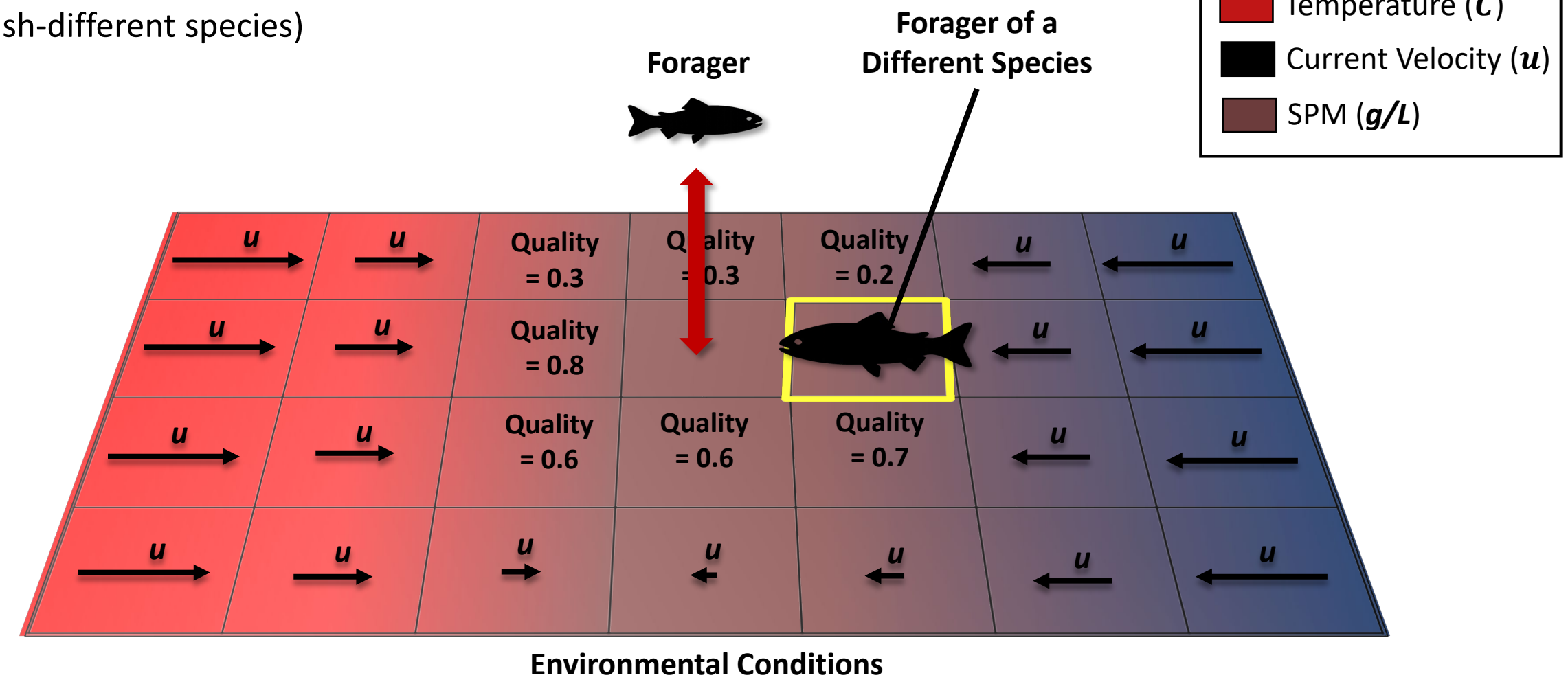
Intraspecific Competition

(same species)



Interspecific Competition

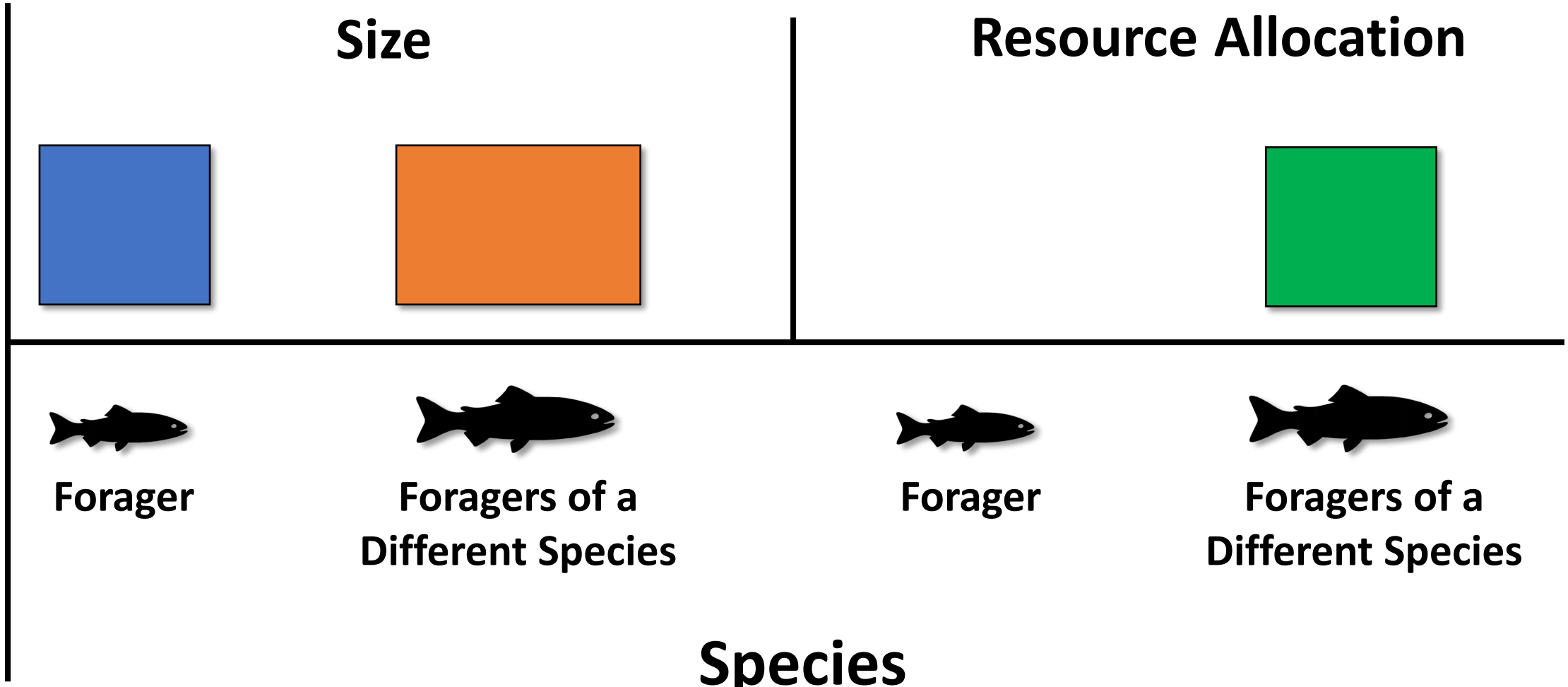
(single fish-different species)



Fish avoid patches with larger individuals from other species.

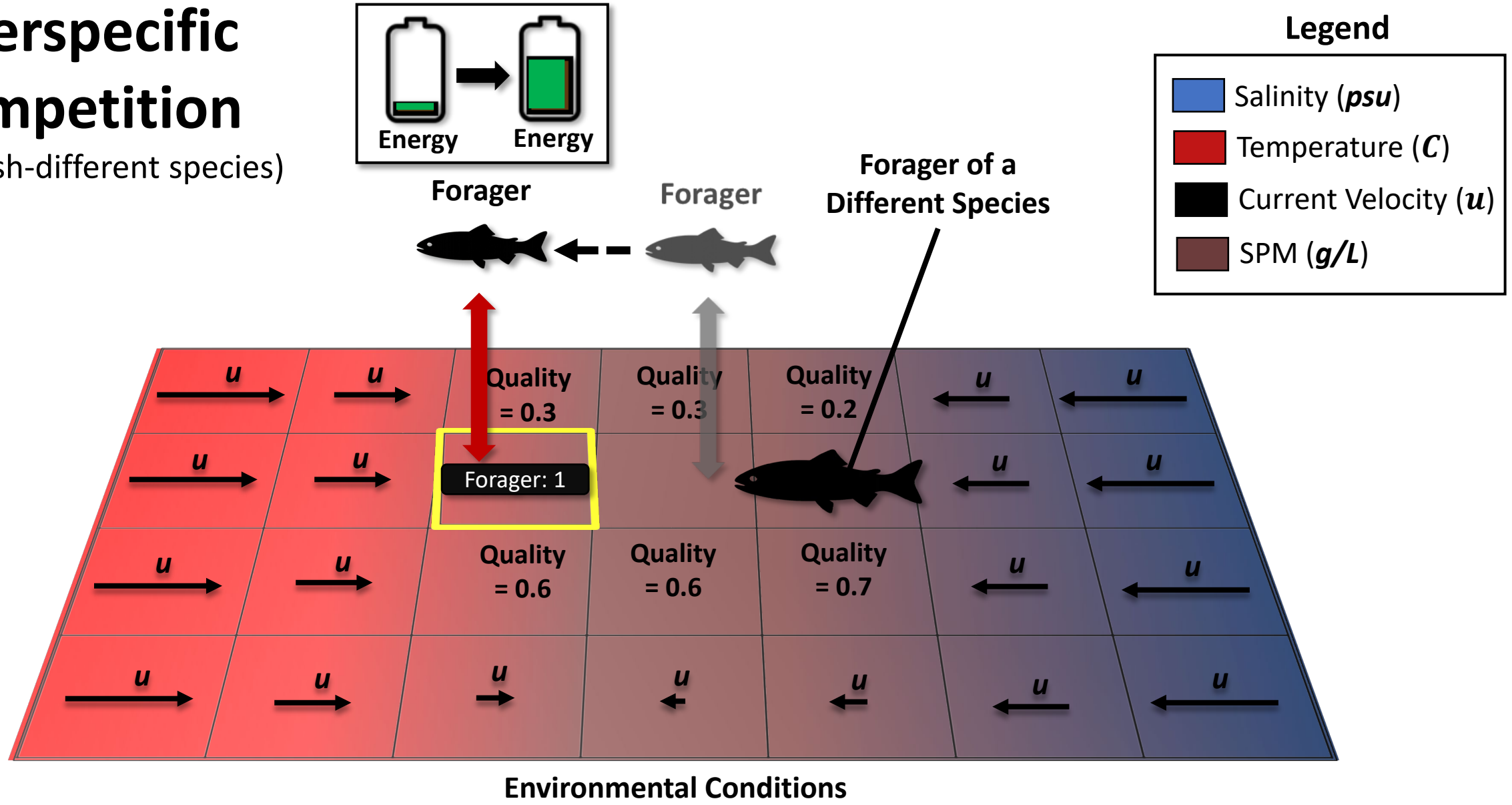
Interspecific Competition

(different species)



Interspecific Competition

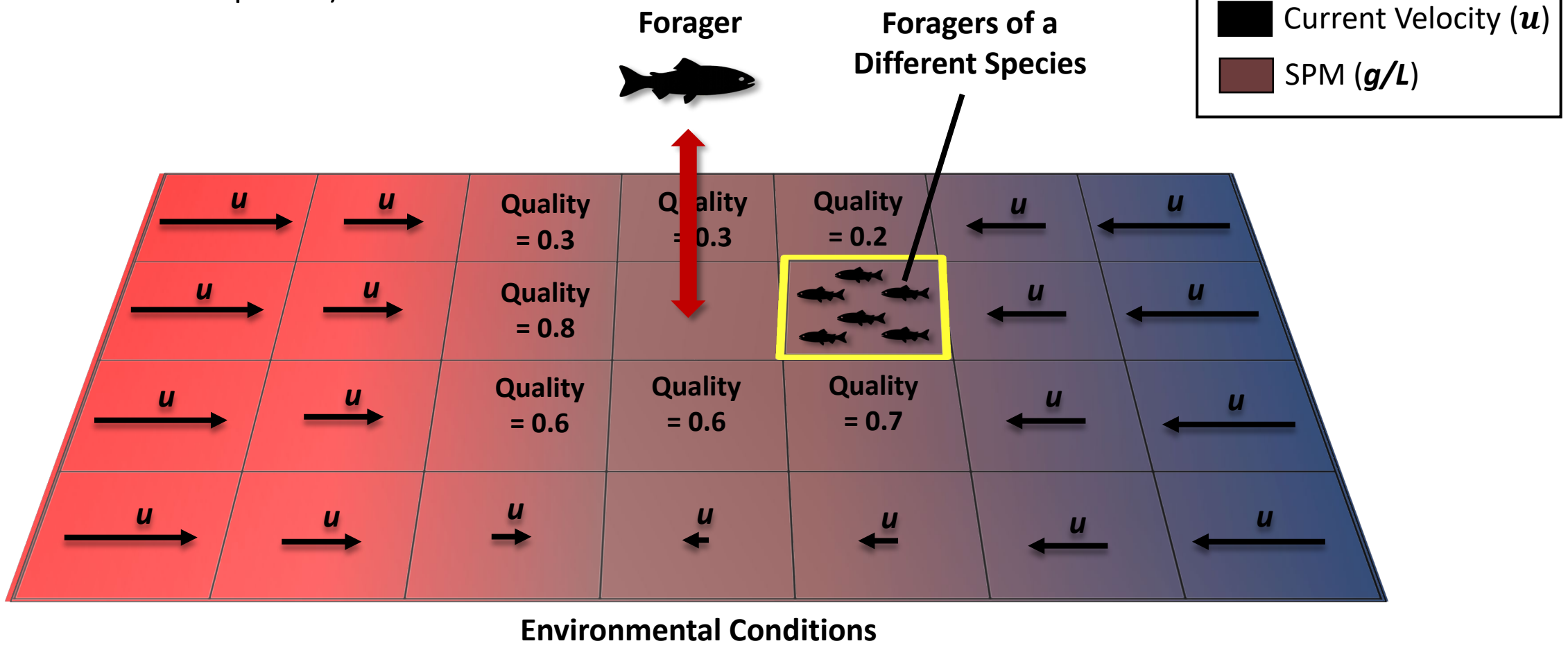
(single fish-different species)



Outcompeted fish search again for the next best nearby patch.

Interspecific Competition

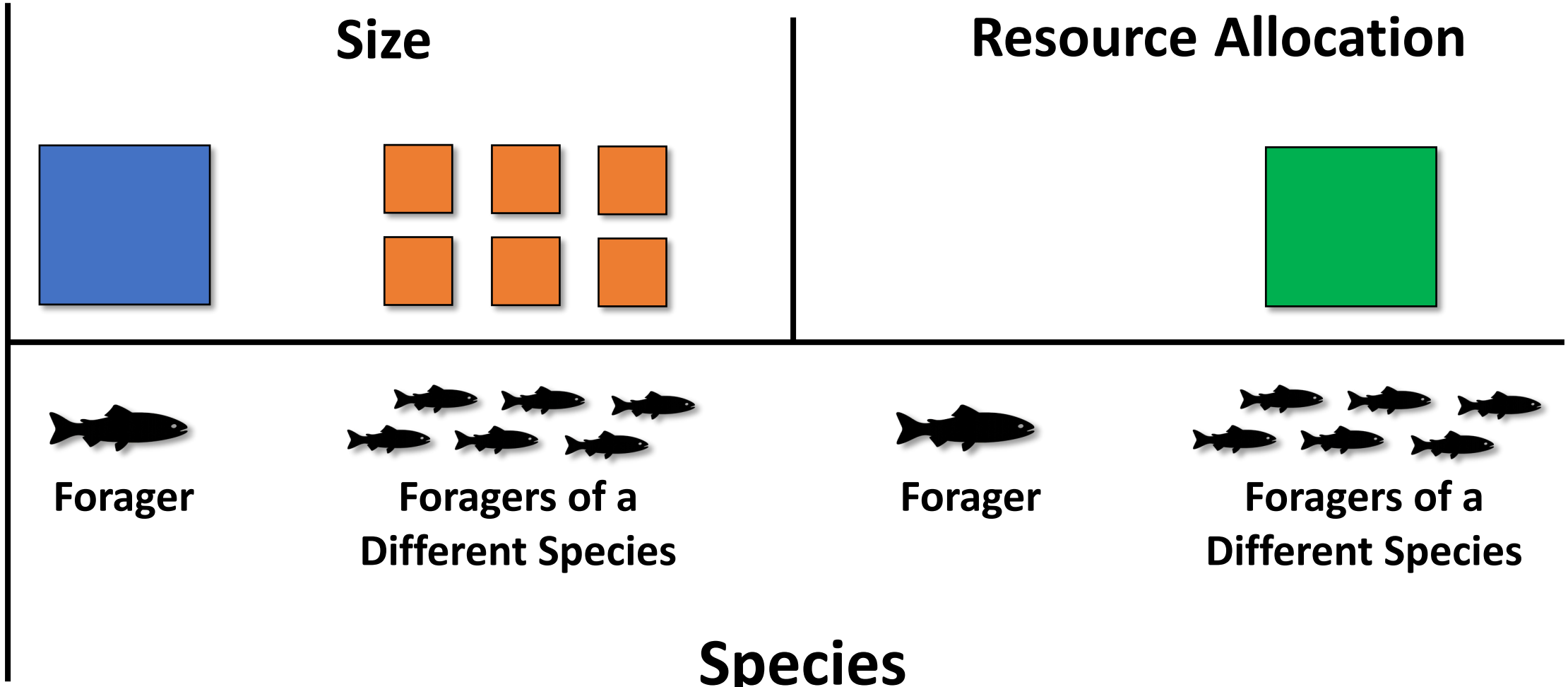
(multiple fish - different species)



Fish avoid patches where the combined size of other species is greater than their own.

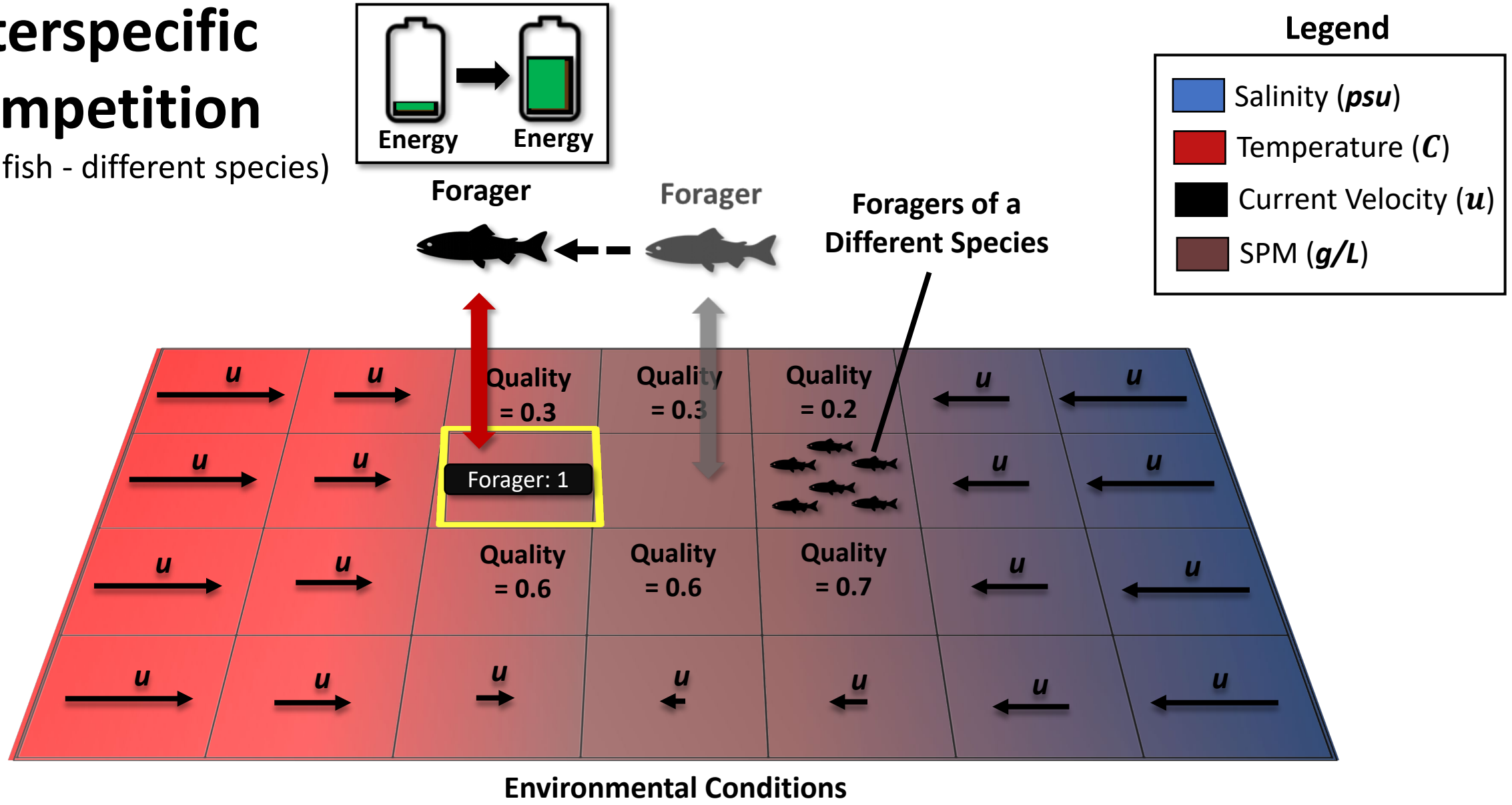
Interspecific Competition

(different species)



Interspecific Competition

(multiple fish - different species)



Outcompeted fish search again for the next best nearby patch.

Individual-Specific Traits

Trait Type	Generalization
Stress	Sensitivity to salinity and temperature changes.
Energy	Internal reserves used for movement and recovery.
Foraging Quality	Depends on preferences of fish (benthic vs bottom feeding)

Each fish's species, size, energy, stress levels, and foraging preferences shape its foraging behavior.

Outputs of Interest

Type	Variable	What It Tells Us
Temporal	Foraging?	Tracks when fish are foraging.
	Time-Foraging	Tracks the amount of time fish spend foraging throughout migration.
Spatial	Forage-Visits	Location of patches repeatedly used for foraging.
	Forager-Count	Local density of foraging fish.
	Forager-Species	Which species have used the patch.

The model tracks where, when, and how fish forage to map resource areas and competition zones.

Discussion Prompts

1. **Accuracy & Realism**

- Do the triggers for foraging (e.g., low energy, low stress, low turbidity) reflect real fish behavior?
- Does the assumption that fish only forage during recovery periods (rather than interrupting migration to seek food) reflect observed migratory behavior?

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

- Should species, size, foraging preferences (benthic vs pelagic), or group behavior influence foraging access and success?
- Are there other environmental stressors (e.g., turbidity, contaminants, predation risk) that should influence patch selection or energy gain?

3. **Outputs of Interest**

- Are metrics like forage visits or forager species helpful for identifying feeding hotspots or competition within the system?
- Should we prioritize tracking total time spent foraging, number of foraging events, or competition intensity in each patch?