Prey-Predator Ecosystems (Shark-Fish-Algae)

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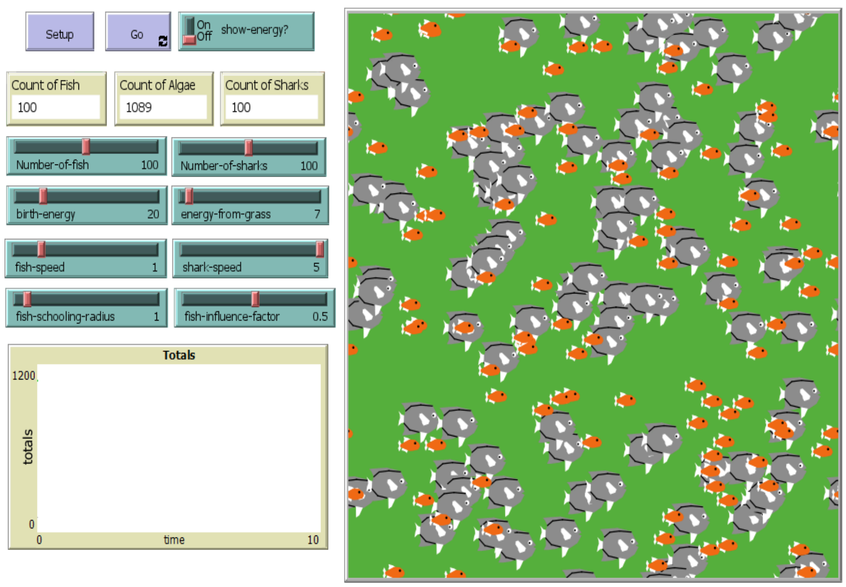
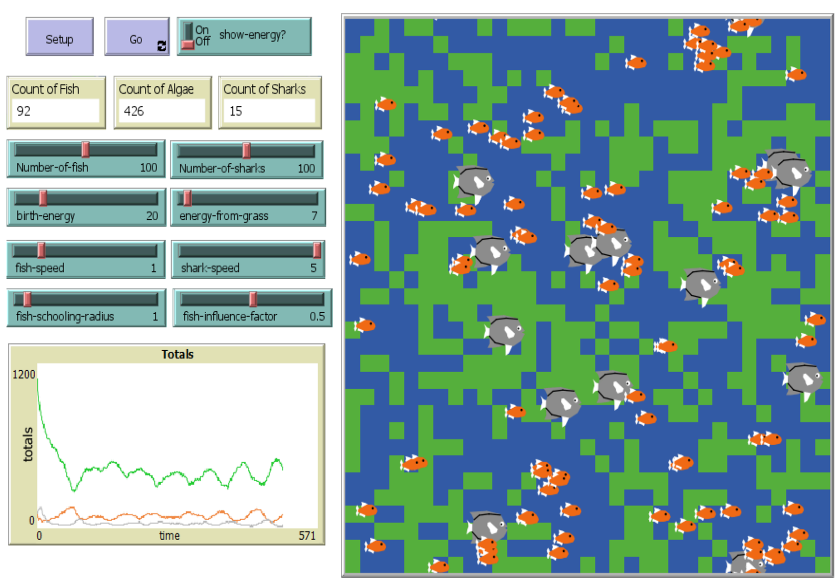
GitHub Link: https://github.com/ruzmishael/pred_prey_eco_cs

Scenario #1: Set the initial population of preys to 100 and predators to 100. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Setup:



After 500 ticks:



Simulation no.	Shark Count	Fish Count	Algae Count
1	15	92	426
2	45	66	353
3	44	118	279
4	0	199	177
5	40	69	379
6	0	206	185
7	2	173	366
8	0	152	355
9	33	51	380
10	0	195	193
Average	**17.90**	**132.10**	**309.30**

1. How would you describe the general behavior of your model up to tick 500?

   Based on the simulations in the table above, sharks seem to maintain a somewhat volatile population, with some simulations having no sharks and others having as many as 45. The fish population seems to decrease when the shark counts are high, due to predation. Inversely, they influence the algae population - more fish lead to less algae and vice versa. Though this does not hold for all simulations, this is a general behavior observed during all the runs and can be considered a classic predator-prey dynamic.

   Also, the populations of the preys and predators, as well as the vegetation, oscillate through time, as shown by the population time series. This means that for each agent, there are multiple periods of population recovery and decline and these periods are usually in tandem with the decline and recovery of the other agent consuming it. Although the prey and predator both have the same count at first, the predator is more susceptible to extinction because it is harder for them to get food compared to the prey, since

2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?

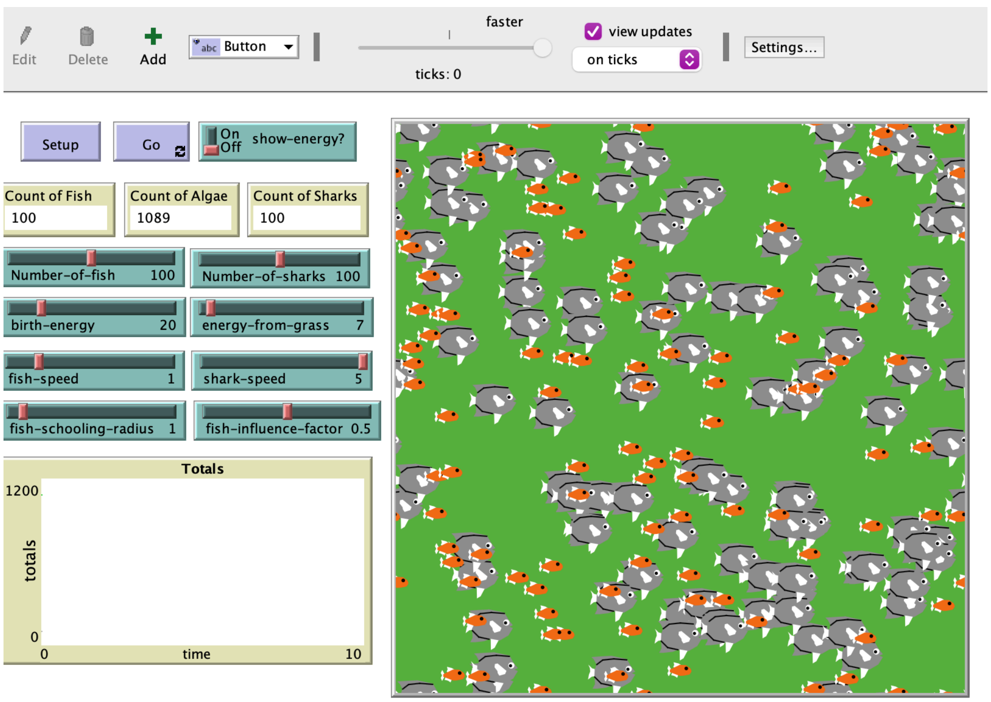
   The average population across all the simulations is:

	Shark Count	Fish Count	Algae Count

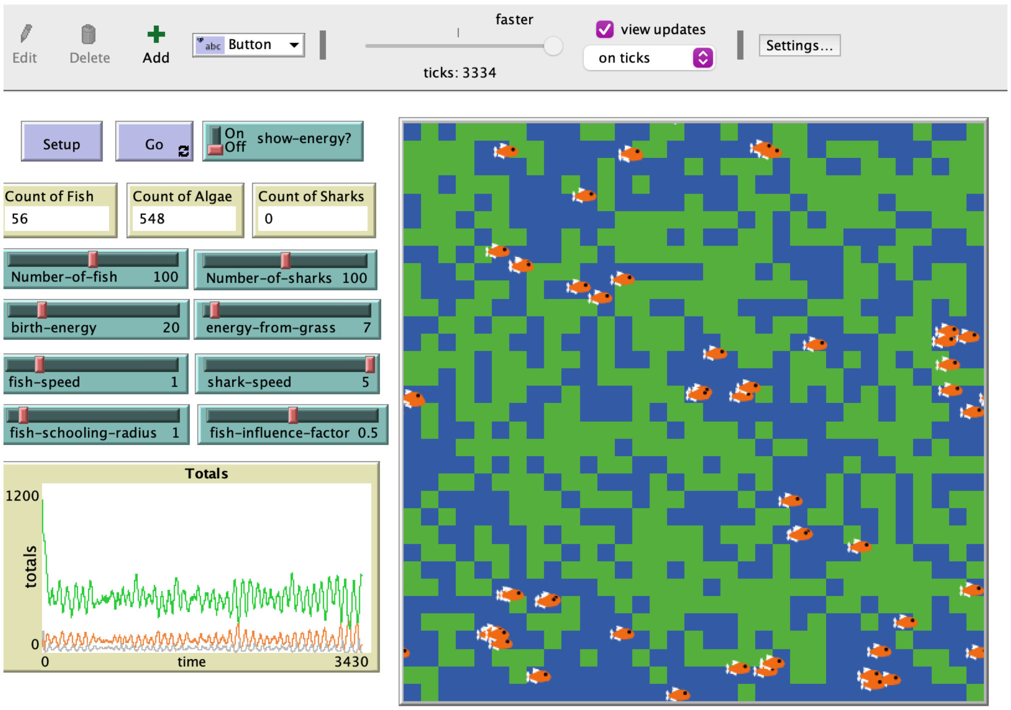
Average	**17.90**	**132.10**	**309.30**

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations goes down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the prey, predators, and food.

Setup:



After Predators Die:



Simulation no.	Shark Count	Fish Count	Algae Count	Ticks
1	0	56	548	3334
2	0	148	385	511
3	0	40	593	892
4	0	77	543	103
5	0	170	331	345
6	0	195	356	329
7	0	35	643	1982
8	0	180	299	207
9	0	94	490	2488
10	0	45	578	860
Average	**0**	**104**	**476.6**	**1105.1**

1. How would you describe the general behavior of your model when it runs indefinitely?

   When the model runs indefinitely, the populations exhibit cyclical fluctuations typical of predator-prey ecosystems (as seen in the volatile totals across ticks of each species in the screenshot). Sharks reach extinction first, leaving fish populations to grow without predators, which in turn leads to a reduction in algae due to overconsumption by the fish. The sharks' extinction likely reflects real-life challenges faced by top predators, such as difficulty in finding sufficient prey and energy.

2. How does it compare to the average behavior up to tick 500?

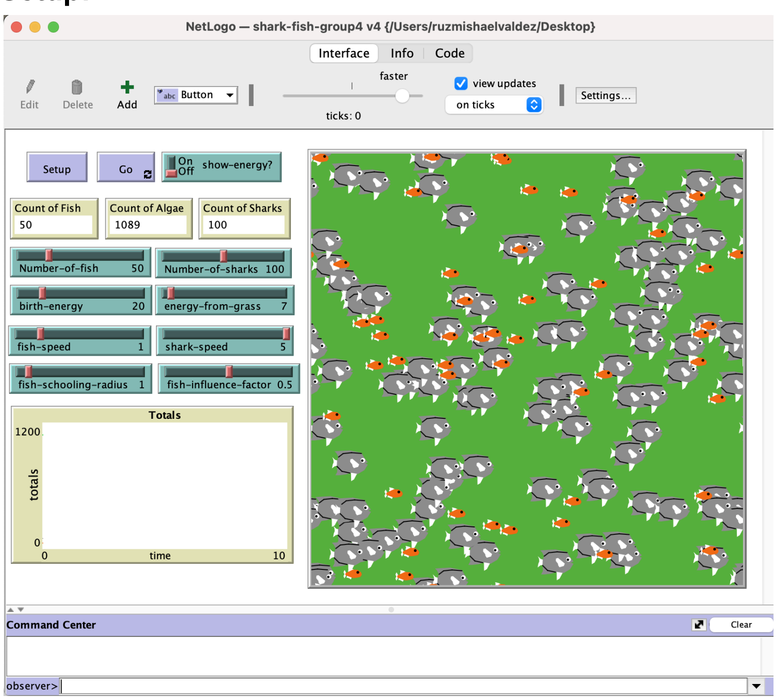
   When comparing the average behavior of the model run indefinitely to its behavior up to tick 500, we observe significant differences in population dynamics. Up to tick 500, fish and shark populations experienced fluctuations due to competitive interactions and resource availability. In contrast, the indefinite runs exhibited a more balanced ecosystem, with the simulations running beyond 1000 ticks before a species would reach extinction.

3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):

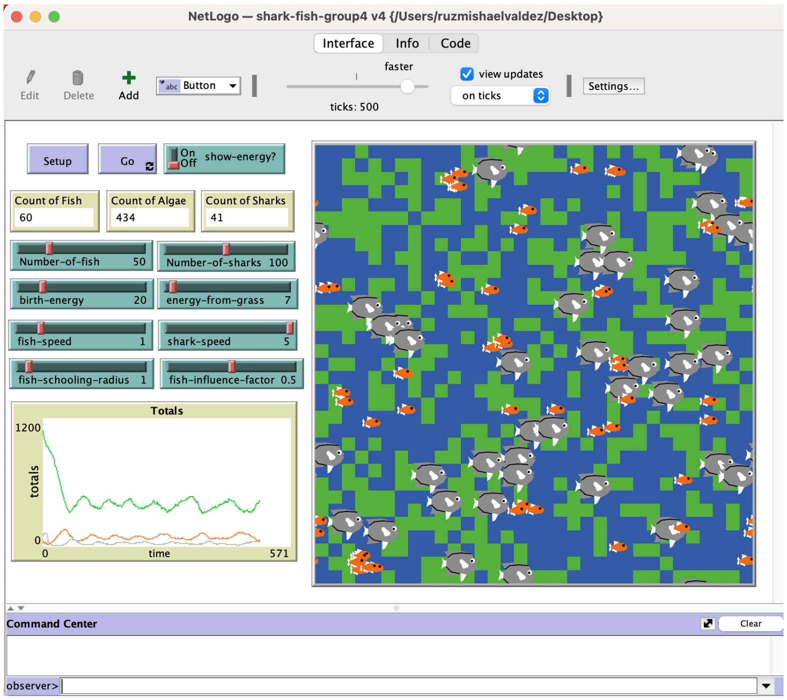
   Out of all the 10 runs, it is always the sharks (predators) that become extinct.

Scenario #2: Set the initial population of preys to 50 and predators to 100. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Setup:



After 500 ticks:



Simulation no.	Shark Count	Fish Count	Algae Count
1	41	60	434
2	23	117	353
3	17	82	440
4	18	130	359
5	11	118	395
6	10	41	491
7	33	51	468
8	16	76	453
9	38	54	424
10	39	67	338
Average	**24.6**	**79.8**	**415.5**

1. How would you describe the general behavior of your model up to tick 500?

Up to tick 500, the model shows a repeating cycle between sharks, fish, and algae. At first, the high number of sharks causes the fish population to drop quickly. As fish become scarce, sharks start dying off, which gives the fish time to recover. With more fish around, the shark population rises again, and this cycle continues. However, by tick 500, the shark population starts to drop more sharply, suggesting that the balance between sharks and fish is becoming unstable, likely due to overhunting or slow fish recovery.

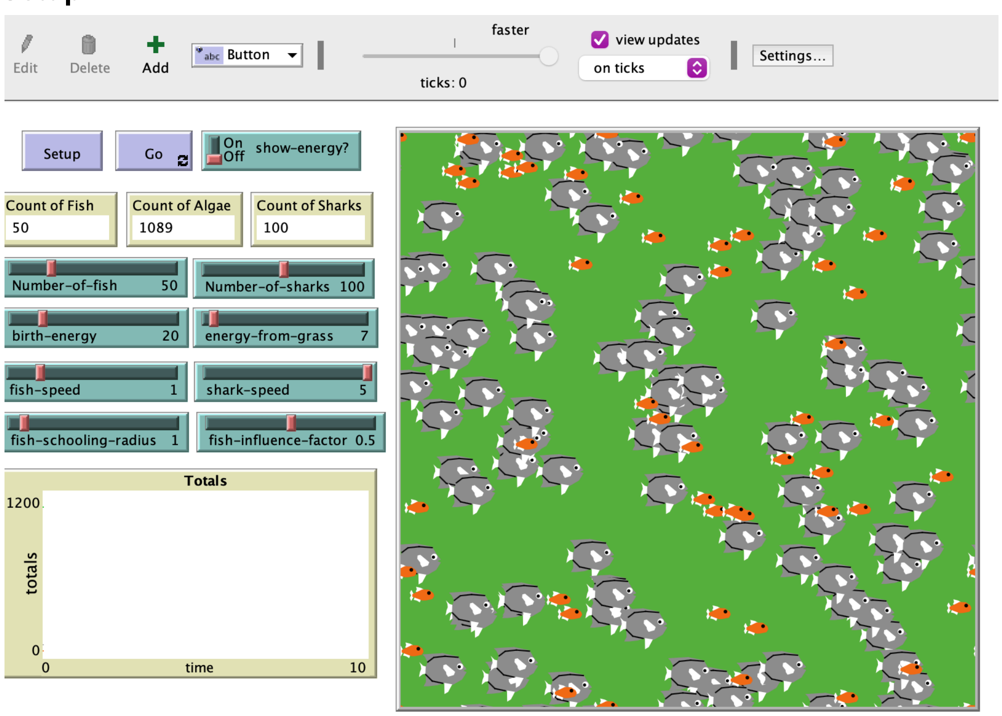
2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?

   The average population across all the simulations is:

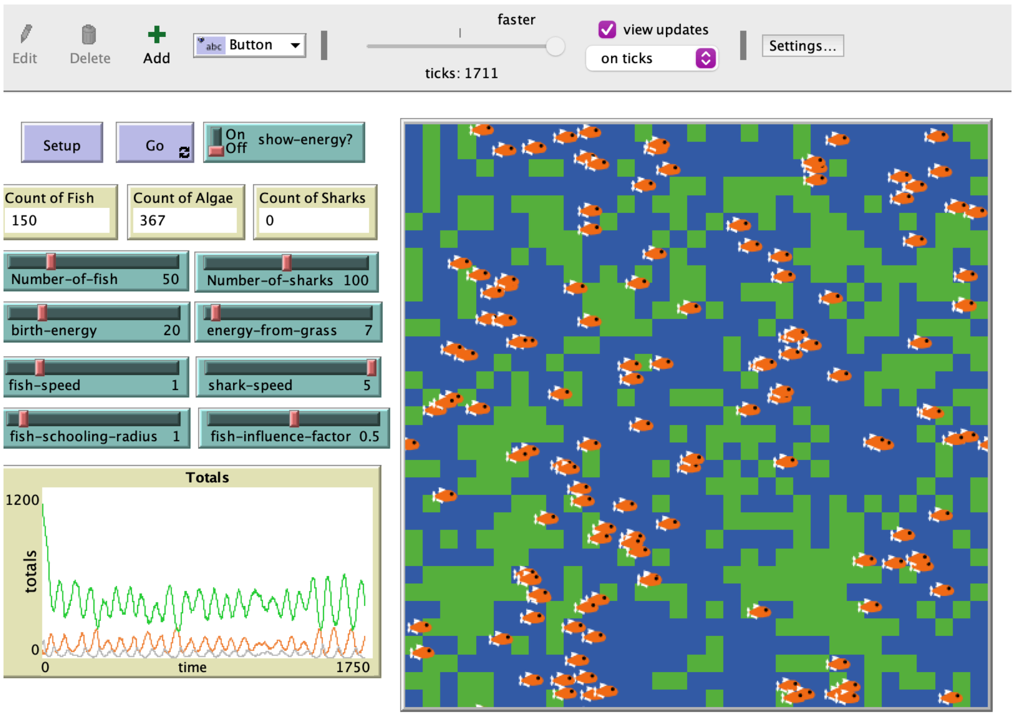
	Shark Count	Fish Count	Algae Count
Average	**24.6**	**79.8**	**415.5**

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

Setup:



After Predators Die:



Simulation no.	Shark Count	Fish Count	Algae Count	Ticks
1	0	150	367	1711
2	0	78	533	6563
3	0	85	481	2876
4	0	122	464	4338
5	0	55	550	775
6	0	202	277	799
7	0	163	362	325
8	0	65	591	1081
9	0	129	438	1050
10	0	92	480	2210
Average	**0**	**114.1**	**454.3**	**2172.8**

1. How would you describe the general behavior of your model when it runs indefinitely?

Similar to the first scenario when the model was run indefinitely, the sharks also become extinct first, but on average, **they become extinct at a slower pace (takes more ticks),** when the initial population of prey is smaller rather than when they both started at 100. This could be because with fewer prey initially, there's less immediate food competition, allowing the sharks to consume prey more gradually. When both populations start at 100, the sharks may consume prey too quickly, leading to rapid depletion of their food source, and thus faster extinction. The slower extinction pace in the smaller-prey scenario reflects a more balanced predator-prey interaction over time.

2. How does it compare to the average behavior up to tick 500?

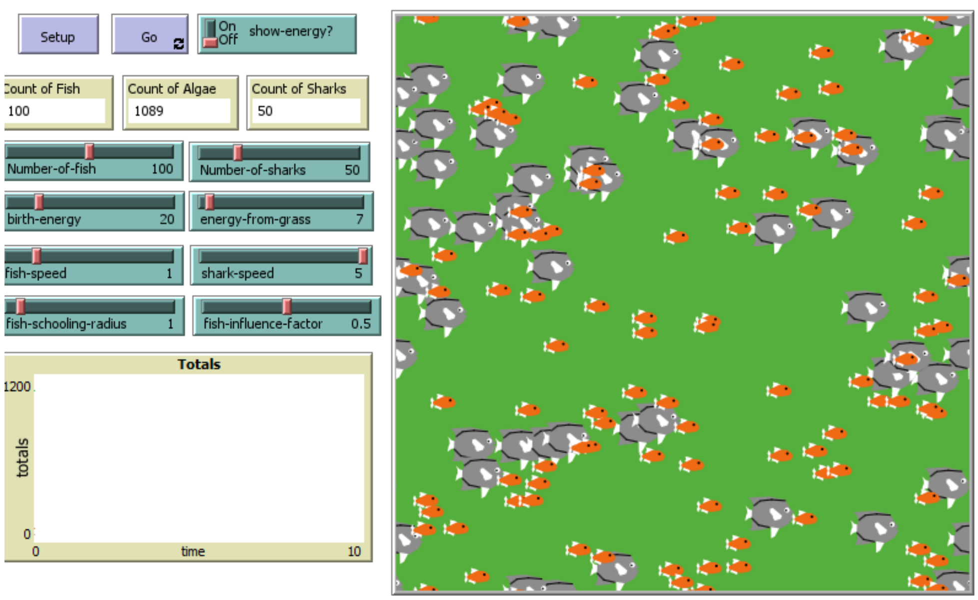
   When the model is run indefinitely, we get to see longer simulations of the ecosystem and can observe more closely how the agents interact, as opposed to the behavior until tick 500 which was more unstable.

3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):

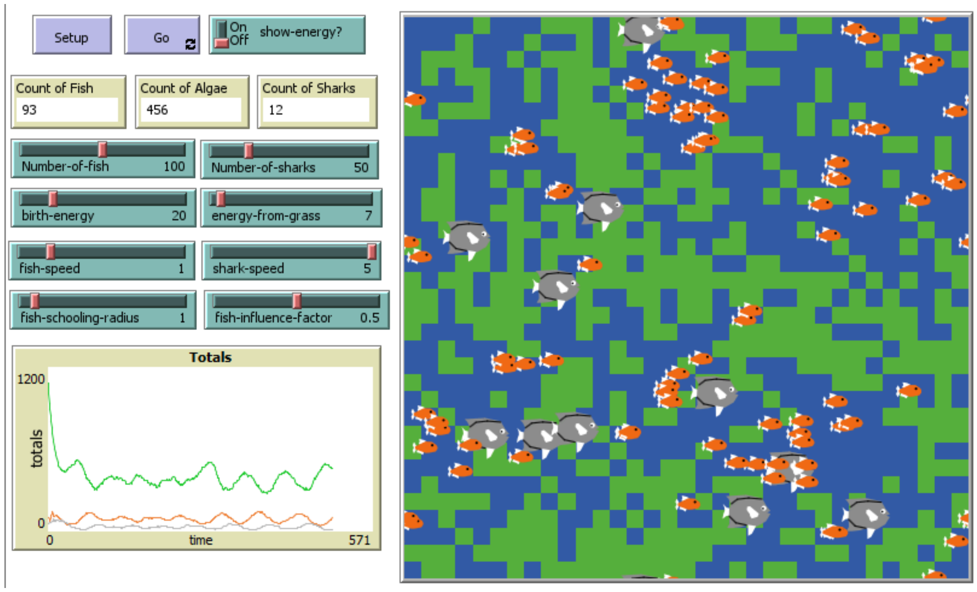
   Out of all the 10 runs, it is always the sharks (predators) that become extinct.

Scenario #3: Set the initial population of preys to 100 and predators to 50. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Setup:



After 500 ticks:



Simulation no.	Shark Count	Fish Count	Algae Count
1	22	52	427
2	38	96	369
3	5	70	470
4	0	191	217
5	63	36	368
6	0	211	189
7	43	38	382
8	21	83	401
9	20	136	356
10	54	42	391
Average	**26**	**96**	**357**

1. How would you describe the general behavior of your model up to tick 500?

This scenario still represents a classic predator-prey dynamic, with sharks as predators controlling the fish population, and fish acting as consumers of algae. For the scenario of having 50 predators, 100 prey, and 500 ticks, the highest predator count recorded after 10 runs was 63, which was higher than the highest count of 39 from scenario 2. Same result was also observed with the fish count. This may mean that scenario 3 is more sustainable than scenario 2.

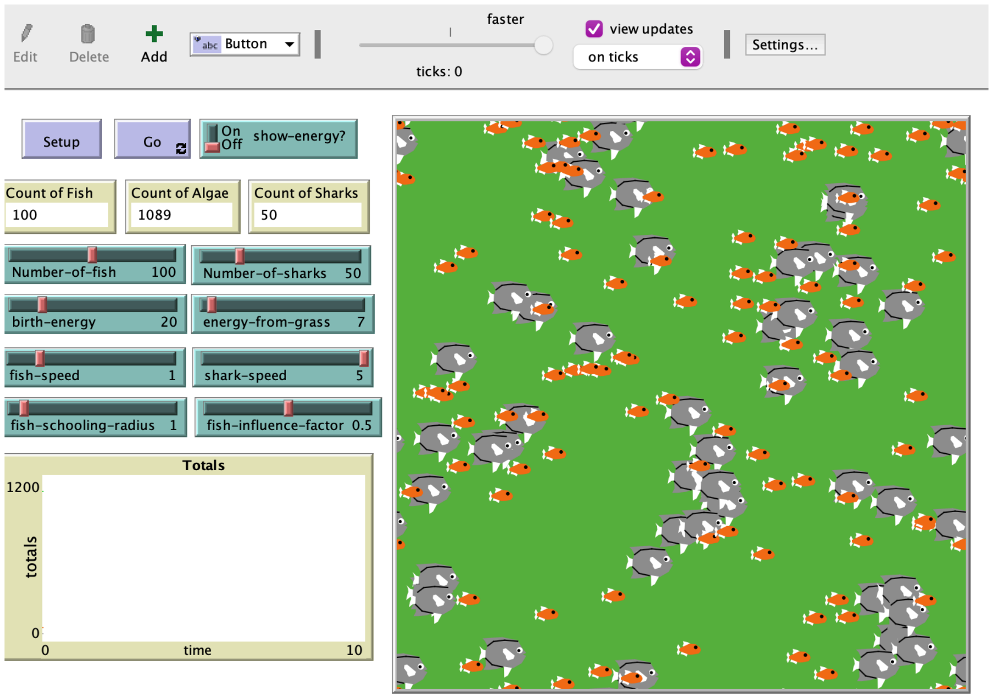
2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?

   The average population across all the simulations is:

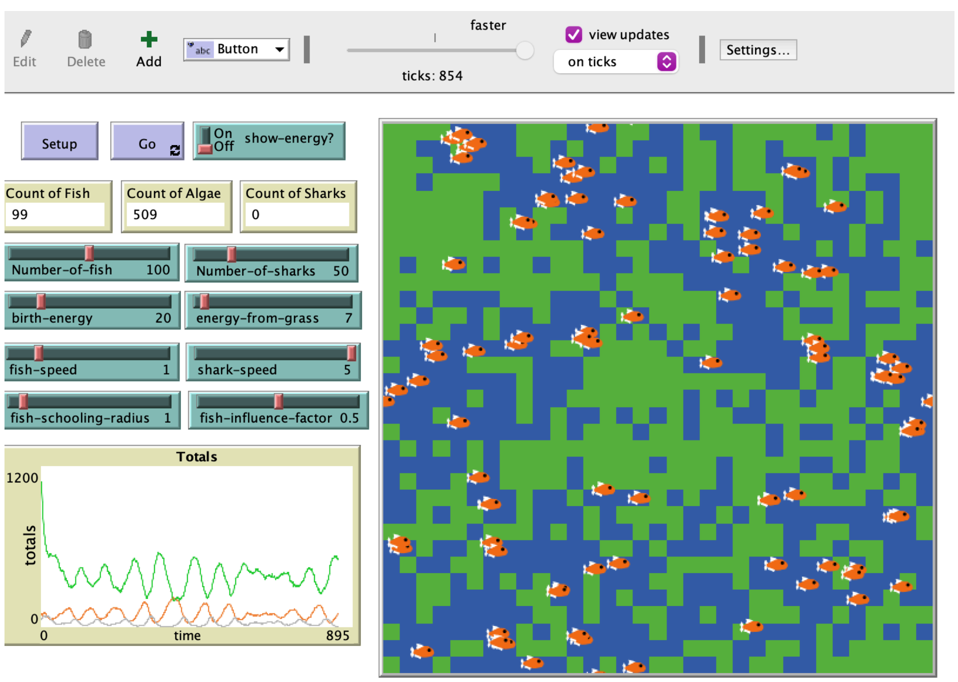
	Shark Count	**Fish Count**	**Algae Count**
Average	**26**	**96**	**357**

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations go down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

Setup:



After Predators Die:



Simulation no.	Shark Count	Fish Count	Algae Count	Ticks
1	0	99	509	854
2	0	199	252	221

3	0	102	471	3003
4	0	119	437	2000
5	0	91	485	903
6	0	38	616	257
7	0	72	514	421
8	0	46	633	2017
9	0	155	350	1002
10	0	151	365	298
Average	**0**	**107.2**	**463.2**	**1097.6**

1. How would you describe the general behavior of your model when it runs indefinitely?
   Similar to the first two scenarios when the model was run indefinitely, the sharks also become extinct first, but on average, **this scenario is where they become extinct at a faster pace (takes less ticks on average).** This is likely because the higher initial fish population provides an abundant food supply for the sharks early on, allowing them to consume prey rapidly. However, as the sharks deplete the fish population quickly, their food source runs out, leading to a sharp decline in shark numbers and eventual extinction. This scenario highlights how an imbalance in initial populations can create a boom-and-bust cycle, accelerating predator extinction.

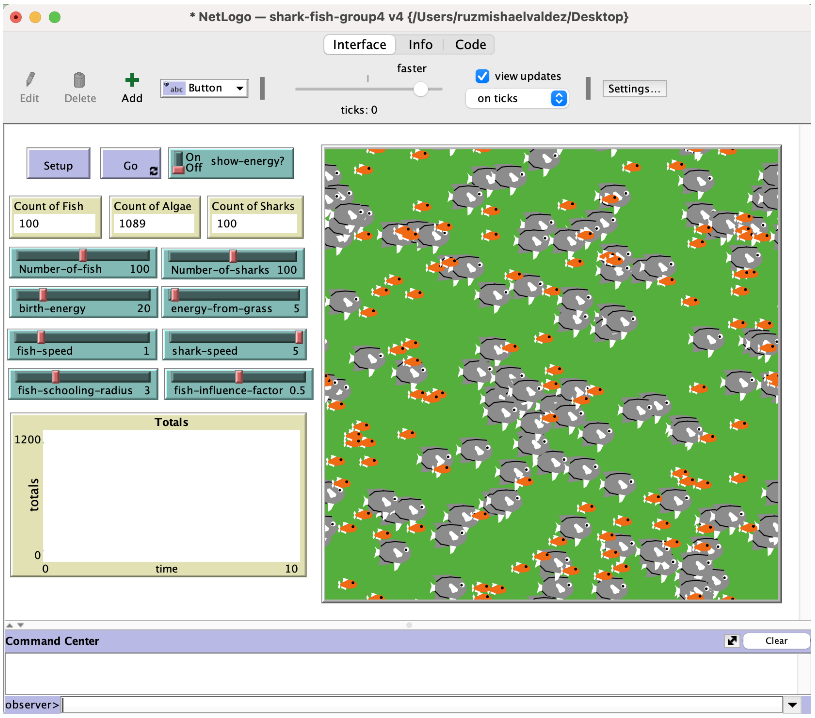
2. How does it compare to the average behavior up to tick 500?
   Compared to the average behavior up to tick 500, when the model runs indefinitely, we observe more extreme outcomes, such as faster extinction of the sharks, particularly in scenarios where the initial populations are imbalanced. Up to tick 500, the populations tend to fluctuate, reflecting the predator-prey dynamics, but the ecosystem remains relatively stable. However, when the model runs without a time limit, the depletion of one species, especially predators like sharks, becomes more likely as food sources diminish or population imbalances intensify.

3. Out of the 10 runs, how many times did the following populations become extinct (population == 0):

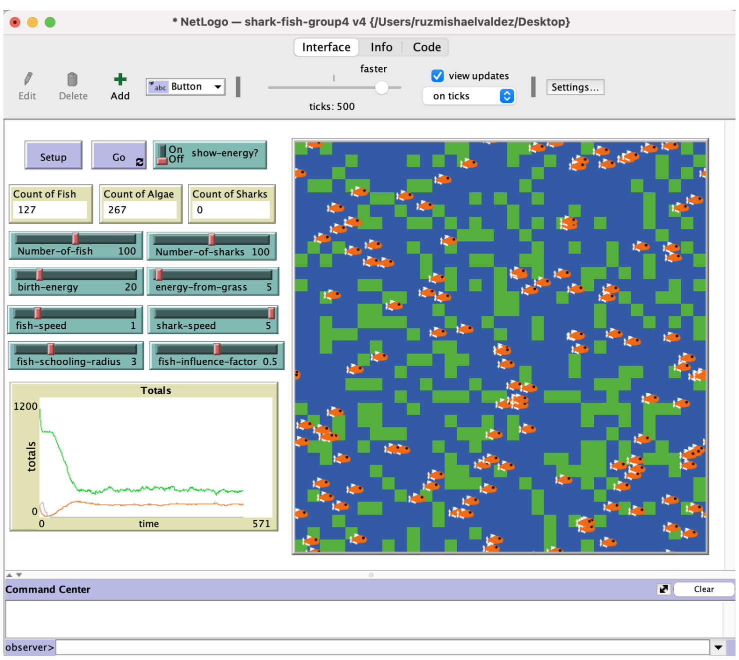
   Out of all the 10 runs, it is always the sharks (predators) that become extinct.

Scenario #4: Come up with your scenario(s) with different initial configurations. You can also play around with your other variables if you hypothesize that they can change the behavior of your prey-predator ecosystem. Run your model 10 times. In each run, stop the simulation at tick 500 and log the total population of your preys, predators, and food.

Setup:



After 500 ticks:



Simulation no.	Shark Count	Fish Count	Algae Count
1	0	127	267
2	0	120	292

3	0	113	287
4	0	134	257
5	0	124	279
6	0	134	273
7	0	126	266
8	0	132	267
9	0	117	304
10	0	121	300
Average	**0**	**124.9**	**279.2**

1. How would you describe the general behavior of your model up to tick 500?

   In scenario 4, 2 variables were tweaked. The “fish-schooling-radius” was increased and the “energy-from-grass” was decreased. The population of predators was consistently wiped throughout all the simulations. This was expected mainly due to the decrease in the energy that both the prey and predators receive when they eat the algae and the fish, respectively. In hindsight, this type of scenario does not sustain the ecosystem.

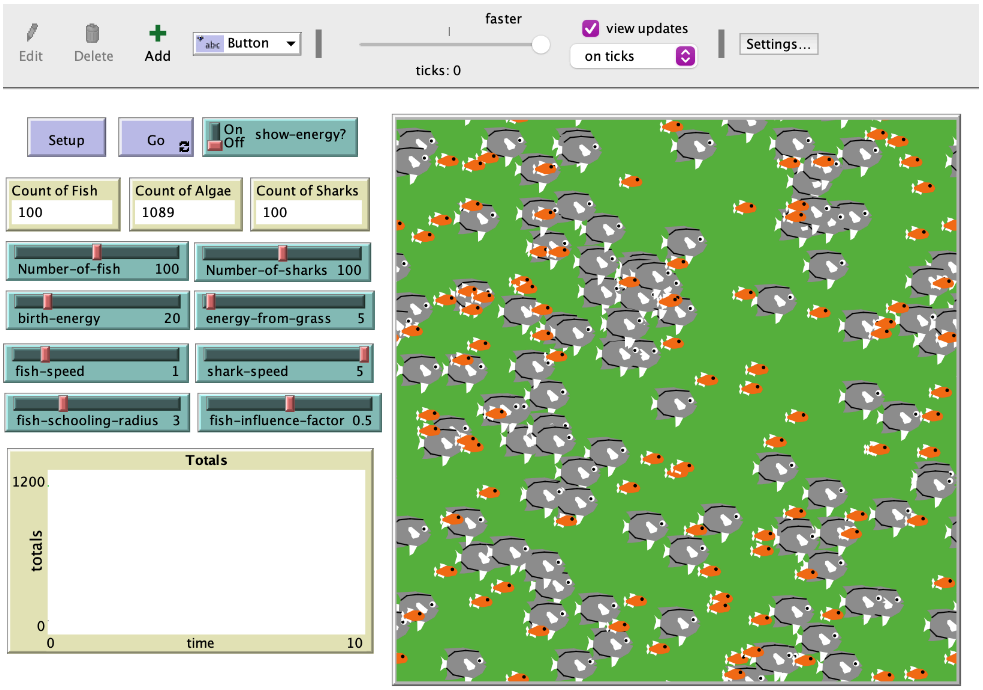
2. What is the average total population of your preys, predators, and food at tick 500 for all 10 runs of your model?

   The average population across all the simulations is:

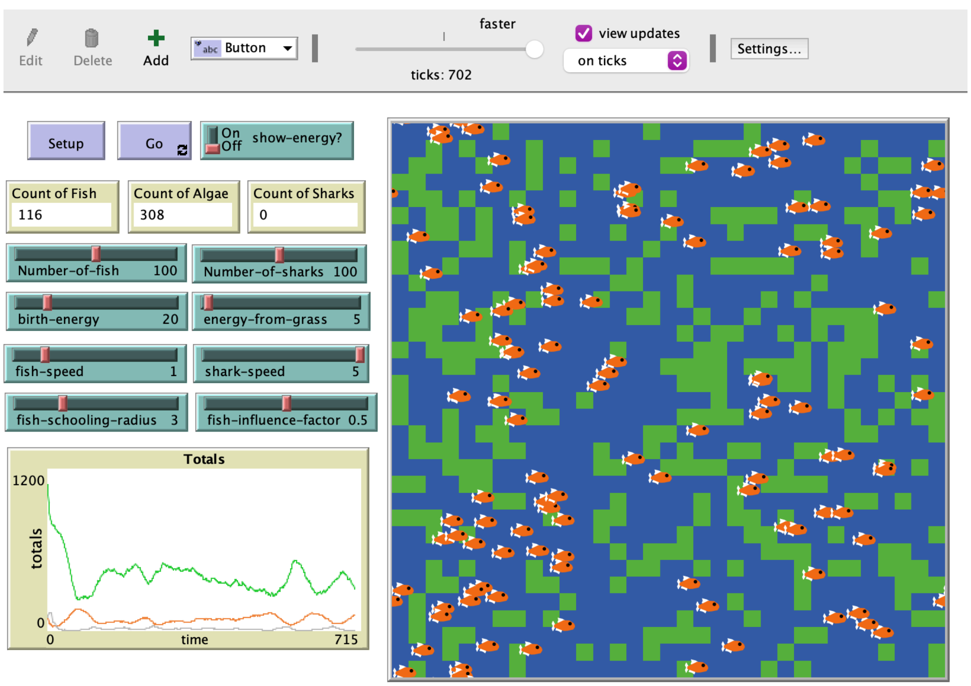
	Shark Count	Fish Count	Algae Count
Average	**0**	**124.9**	**279.2**

Now, run your model 10 times again. Let them run until either one of the prey, predator, or food populations goes down to 0 (e.g. all predators died). Log the tick when that happened and the total population of the preys, predators, and food.

Setup:



After Predators Die:



Simulation no.	Shark Count	Fish Count	Algae Count	Ticks
1	0	107	534	41
2	0	83	476	1522

3	0	116	308	702
4	0	148	353	69
5	0	103	366	664
6	0	76	427	2604
7	0	105	408	1185
8	0	119	354	261
9	0	140	268	487
10	0	107	508	47
Average	**0**	**110.4**	**400.2**	**758.2**

How would you describe the general behavior of your model when it runs indefinitely?

When the model runs indefinitely, the shark population still drops to zero in all simulations. This is because of the changes in parameters on the fish schooling radius and energy from grass. However, we noticed that this is the scenario where the sharks become extinct the fastest. By increasing the fish schooling radius and lowering the energy fish gain from grass, fish become more efficient at avoiding predators and are less likely to be eaten. This, in turn, starves the sharks and accelerates their extinction, as they struggle to sustain their energy without enough prey to feed on.

1. How does it compare to the average behavior up to tick 500?

   The changes in the parameters create a scenario where both the fish and shark populations are unsustainable. he sharks cannot obtain enough energy from the fish, and as fish populations decline due to lower energy from algae, the sharks face starvation, ultimately leading to their extinction in the simulations.

2. Out of the 10 runs, how many times did the following populations become extinct (population == 0):

   Out of all the 10 runs, it is always the sharks (predators) that become extinct.

What are your key findings about the prey-predator ecosystem that you modeled?

Sharks often reach zero in the simulation due to their higher energy requirements and lower reproductive rates compared to fish. As sharks hunt and deplete the fish population, their inability to find enough prey leads to energy depletion and eventual death. Moreover, the growth of new algae far outweighs the fish reproduction since the algae (patches) can randomly grow anywhere within the environment and doesn't require any energy. This implies a better survival for the fish rather than the sharks in the long-term (longer simulation). This dynamic mirrors real-life scenarios where predator species face extinction or near extinction, often resulting from overfishing, habitat loss, and changes in prey availability.

How confident is your group with your model, and why? Take this opportunity to reflect on the limitations of your approach.

Our group is moderately confident in our model, as it effectively simulates the interactions between predator and prey while allowing for adjustments in key parameters like energy acquisition and resource regrowth. However, we acknowledge several limitations. First, the simplified representation of complex ecological interactions may not fully capture real-world dynamics, such as the effects of environmental changes, competition among predators, and varying reproductive strategies. Additionally, the model assumes constant energy values and growth rates, which can fluctuate in natural ecosystems. Lastly, the visual representation may not accurately convey the nuanced behaviors observed in actual underwater ecosystems.