The Effects of Oil on Marine Life in the Gulf of Mexico

New Mexico Supercomputing Challenge

Final Report

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Team #13

Aspen Elementary

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Executive Summary

Our project for the New Mexico Supercomputing Challenge was to learn about the effects on the marine life in the Gulf of Mexico during the oil the spill. We used StarLogo TNG to model a region of the Gulf of Mexico. In our model we had agents for fish, micro-organisms and oil. We had two types of fish, one type that was not affected by the oil and one type that was negatively ffected by the oil. We also had two types of micro-organisms one that was not affected by the oil and one that was positively affected by the oil. Oil could be added to the region while the model ran.

We compared two cases, one in which there was no oil in the region and one in which oil was added at a steady rate. In the first case, we observed a predator-prey relationship between the fish and the micro-organisms. There were no significant differences between the two types of fish or the two types of micro-organisms. When we added oil to the region, we noticed that the predator-prey relationship still occurred, but the negatively affected fish population died out.

Introduction

Our project for the New Mexico Supercomputing Challenge was to learn about the oil spill in the Gulf of Mexico that happened during the summer of 2010. We wanted to see the effects of the oil on the marine life during and after the oil the spill. We used agent based modeling to simulate what happens in the Gulf of Mexico between the marine life and the oil. We decided to do this project because the oil spill in the Gulf of Mexico was a major event and its effects on the environment concerned us. We care about disasters that happen in our world and want to learn about them, so perhaps we could help when something like this happens in the future.

Description

We modeled a region of the Gulf of Mexico using StarLogo TNG. In this region, we had agents that represented fish, micro-organisms and oil. In the model the fish eat the micro-organisms to gain energy. They use energy when they move or reproduce and they die when they run out of energy. The micro-organisms gain energy steady rate, reproduce and die when consumed by the fish. Oil drops are added to the model at a regular pace and are removed from the region when they are absorbed by the fish or the micro-organisms.

We have two kinds of fish, one that is not affected by the oil and one that is negatively affected by the oil. We have two kinds of micro-organisms, one that is not affected by the oil and one that is positively affected by the oil.

Spaceland

The region that we modeled is limited to the size of the StarLogo TNG spaceland. Horizontally the spaceland is a square that is 100 units on a side. For our model we allow the agents to move vertically in a region that is 30 units tall. This represents the part of the ocean that we are modeling. There are no other features in our spaceland. FIGURE 1 shows an image of our spaceland after setup.

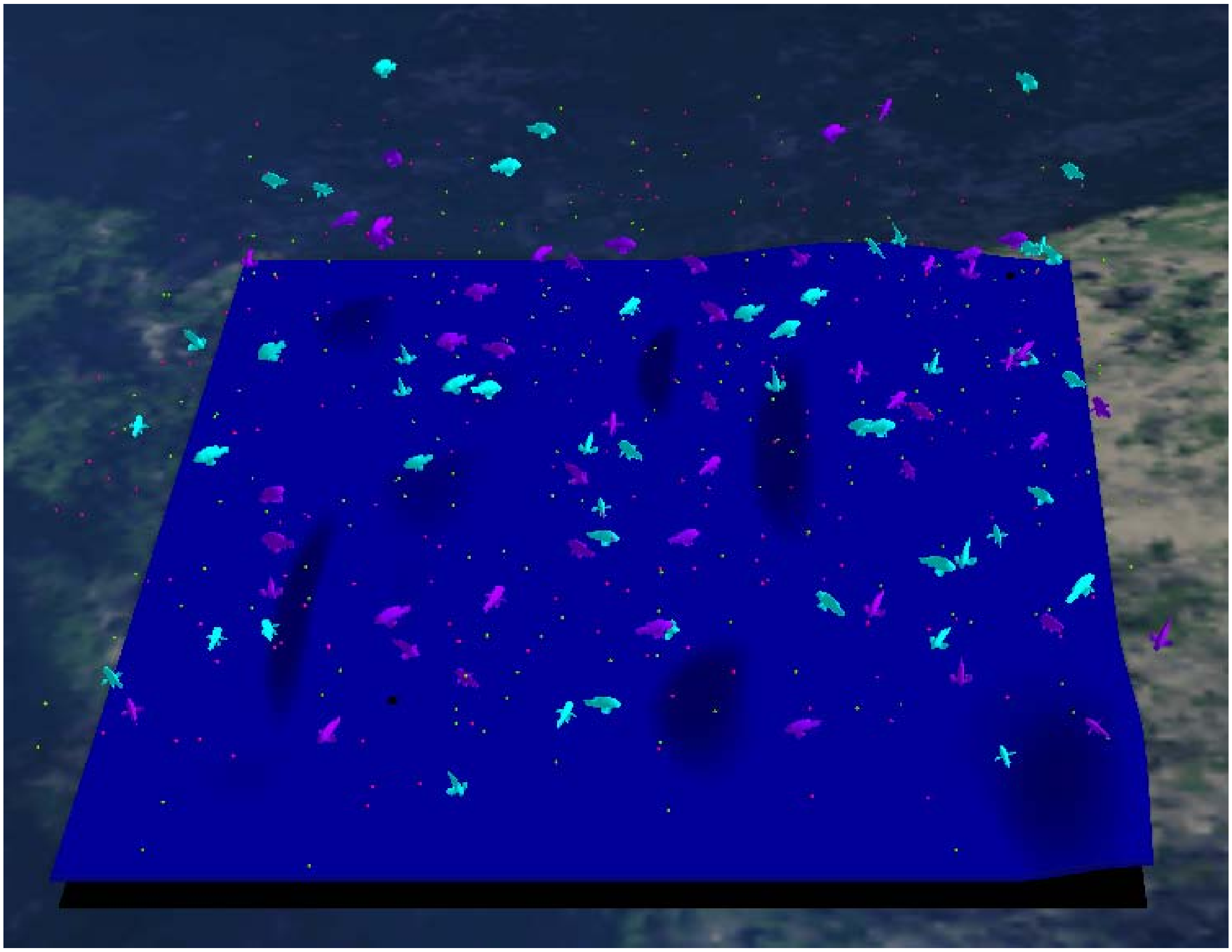


FIGURE 1: An image of the initial spaceland. The micro-organisms show up as colored dots. The oil shows up as black dots.

Fish Life Cycle

We have two populations of fish. One we refer to as the “affected fish”, and one we refer to as the “non-affected fish”. During setup both of the populations of fish are distributed randomly throughout the spaceland. The initial color of the “affected fish” is purple. The initial color of the “non-affected fish” is cyan. When the model runs the fish move both horizontally and vertically within the region and can collide with other agents. The fish lose energy when they move. When the fish collided with the micro-organisms, they “eat” the micro-organisms and gain energy. The consumed micro-organisms are removed from the model. The fish reproduce when they have more than a pre-determined amount of energy. If the fish run out of energy they die and are removed from the model. When the “affected fish” collide with the oil they become contaminated. We change their color from purple to red to indicate this. Also, we remove the oil from the model. Contaminated fish use more energy to move than do uncontaminated fish. When the “non-affected fish” collide with the oil nothing happens. We track the total number of each population of fish while the model is running.

Micro-organism Life Cycle

We have two populations of micro-organisms. One we refer to as the “affected micro-organisms”, and one we refer to as the “non-affected micro-organism”. During setup both of the populations of micro-organisms are distributed randomly throughout the spaceland. The color of the “affected micro-organism” is pink. The initial color of the “non-affected micro-organism” is green. When the model runs the micro-organisms move both horizontally and vertically within the region and can collide with other agents. The micro-organisms gain energy at every time step. They reproduce when they have more than a pre-determined amount of energy. When the “affected micro-organisms” collide with the oil they gain additional energy. Also, we remove the oil from the model. When the “non-affected micro-organisms” collide with the oil nothing happens. We track the total number of each population of micro-organisms while the model is running. To avoid the micro-organisms populations from going to zero, and resulting in the fish having no food, we keep the minimum number of micro-organisms at 100.

Oil Life Cycle

We can set the initial number oil drops in the model. The oil is distributed randomly about the spaceland. We can add a specific number of oil drops to the spaceland every time step. The oil does not move.

Model Parameters

Initial conditions:

Energy for each fish	Randomly set between 1 and 10
Energy for each micro-organisms	Randomly set between 1 and 7
Number of non-affected fish	50
Number of affected fish	50
Number of non-affected micro-organisms	200
Number of affected micro-organisms	200
Number of oil drops	2 (Can be changed by a slider.)

Energy gained or lost during each time step:

Non-affected fish	-0.025
Uncontaminated affected fish	-0.025
Contaminated affected fish	-0.0375
Affected micro-organisms	+0.125
Non-affected micro-organisms	+0.125

Energy level for reproduction:

Fish	7
Micro-organisms	10

Energy lost during reproduction:

Fish	2
Micro-organisms	2

Amount of energy gained during collisions:

Fish colliding with micro-organisms	Fish gain 1
Affected micro-organisms colliding with oil	Affected micro-organisms gain 0.25

Amount of oil added per time unit: 1 (Can be changed by a slider.)

Screen shots of the model code is shown in Appendix A.

Results

We ran the model for two cases one without any oil and one with oil. FIGURE 2 shows the number of agents as the model ran. The population of agents follows a steady cycle. The reason that the population of affected fish and non-affected fish are not exactly the same is because the energy that the fish start with is randomly selected between 1 and 10, and also the fish move about the spaceland randomly. The figure shows a predator-prey relationship between the fish and the micro-organisms. When there are a lot of micro-organisms the fish have a lot to eat, gain energy and reproduce more. As there are more fish they eat more micro-organisms until there are not enough micro-organisms to support the fish population. The number of micro-organisms decreases and then the fish die off because they don't have enough food. To keep the model running we have to keep the number of micro-organisms falling below one hundred. If we don't doe this, the fish will eat all of the micro-organisms and then they won't have any food, and they will die out and the cycle will stop.

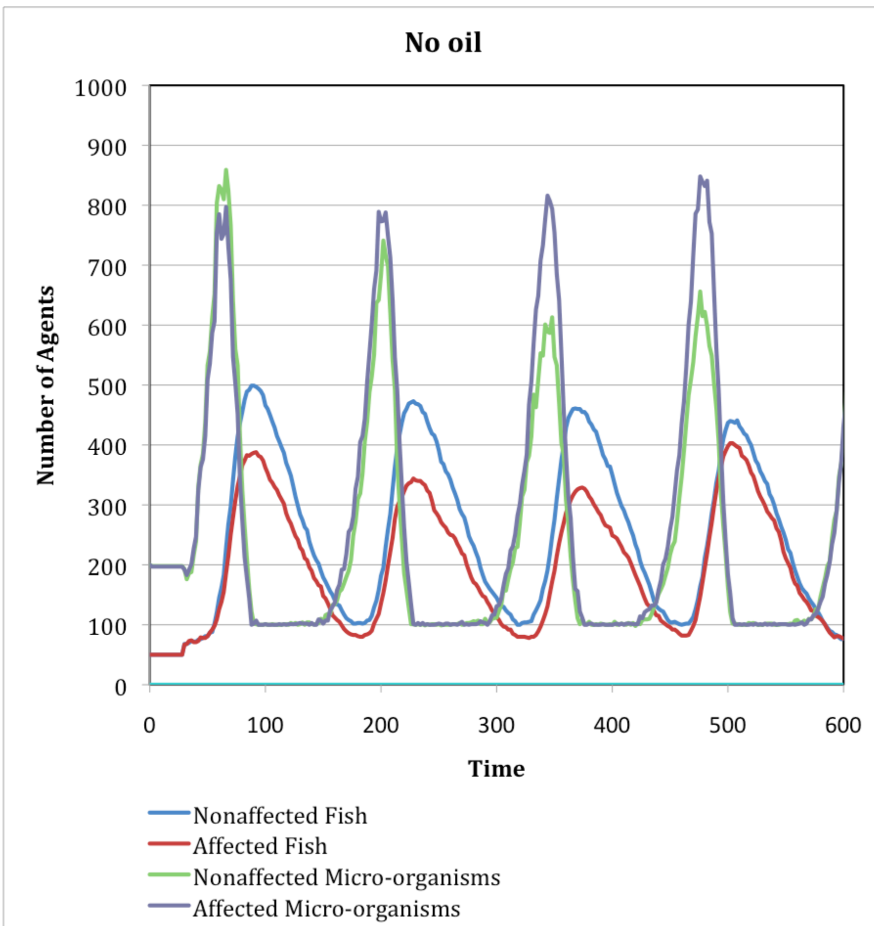


FIGURE 2: Number of agents as a function of time for the case with no oil.

FIGURE 3 shows the case where we start the model with 2 oil drops and add 1 oil drop to the spaceland every time unit. In this case we see the affected fish die off in about three cycles. The peak number of non-affected fish eventually becomes larger because the non-affected fish aren't competing for food with the affected fish. At the beginning when there are still affected fish the amount of oil only increases slowly. After the affected fish die out, they amount of oil increases at a faster rate. We still see fluctuations in amount of oil because the affected micro-organisms still interact with the oil. There isn't an obvious a difference between the affected micro-organisms and non-affected micro-organisms. We think that this is because the minimum number of micro-organisms is forced to be at least 100, so the natural deviation between affected and non-affected micro-organisms is not allowed to evolve.

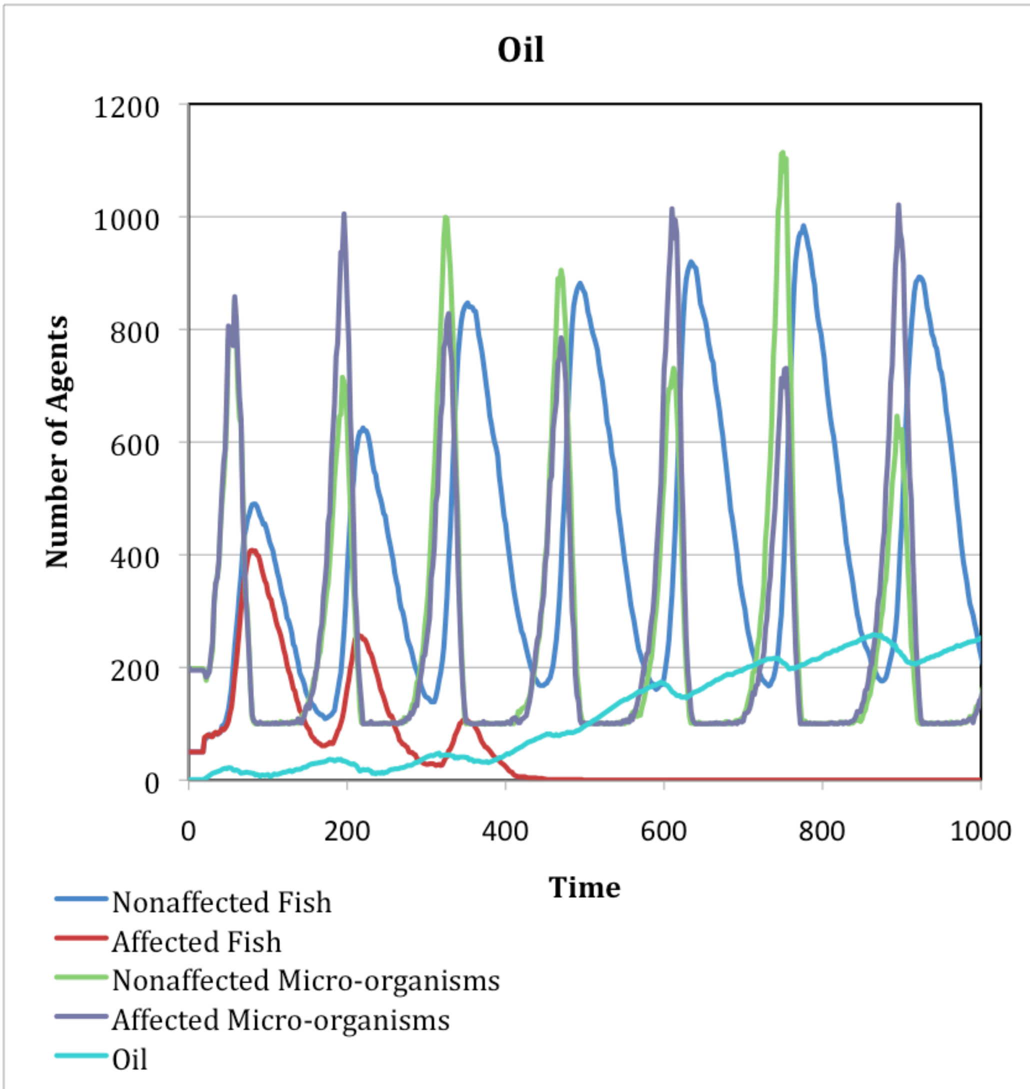


FIGURE 3. Number of agents as a function of time for the case where oil is added 1 drop per time unit.

Conclusions

We were able to model the predator prey relationship for both cases with and without oil. We found that the fish that were affected died out after several life cycles when we added oil to the spaceland. This also caused a change in the balance in the population of unaffected fish. We conclude that adding oil to the marine environment is bad. We found that to make a realistic model is difficult because we were only able to model a very small region of the Gulf of Mexico, with only a very few species.

Recommendations

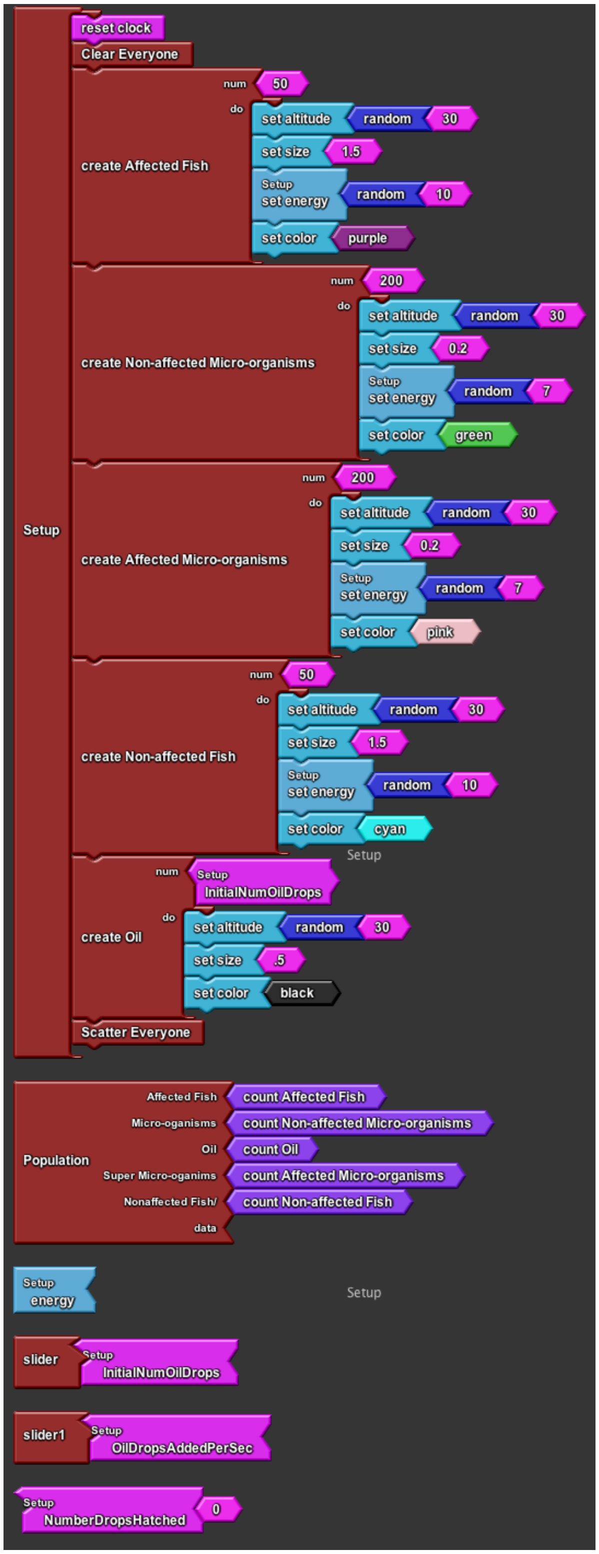
We think that the following changes would be useful for improving the model. One thing that should be done is to look at different parameters to explore the boundaries of the existing model. For example by changing the amount of oil added, or making the amount of energy gained and used more realistic. Also, we would like to find parameters that will allow the model to run without having to artificially set the minimum number of micro-organisms to 100. Also, we think it would be useful to use something other than StarLogo TNG for the model so that we can use a larger spaceland and more total number of agents and species. StarLogo is limited to a maximum number of 4096 agents. We also think it would be useful to add different kinds of animals, including marine mammals and birds. We would want to do this because we want to explore the positive and negative affects on other kinds of marine life in the model.

Acknowledgements

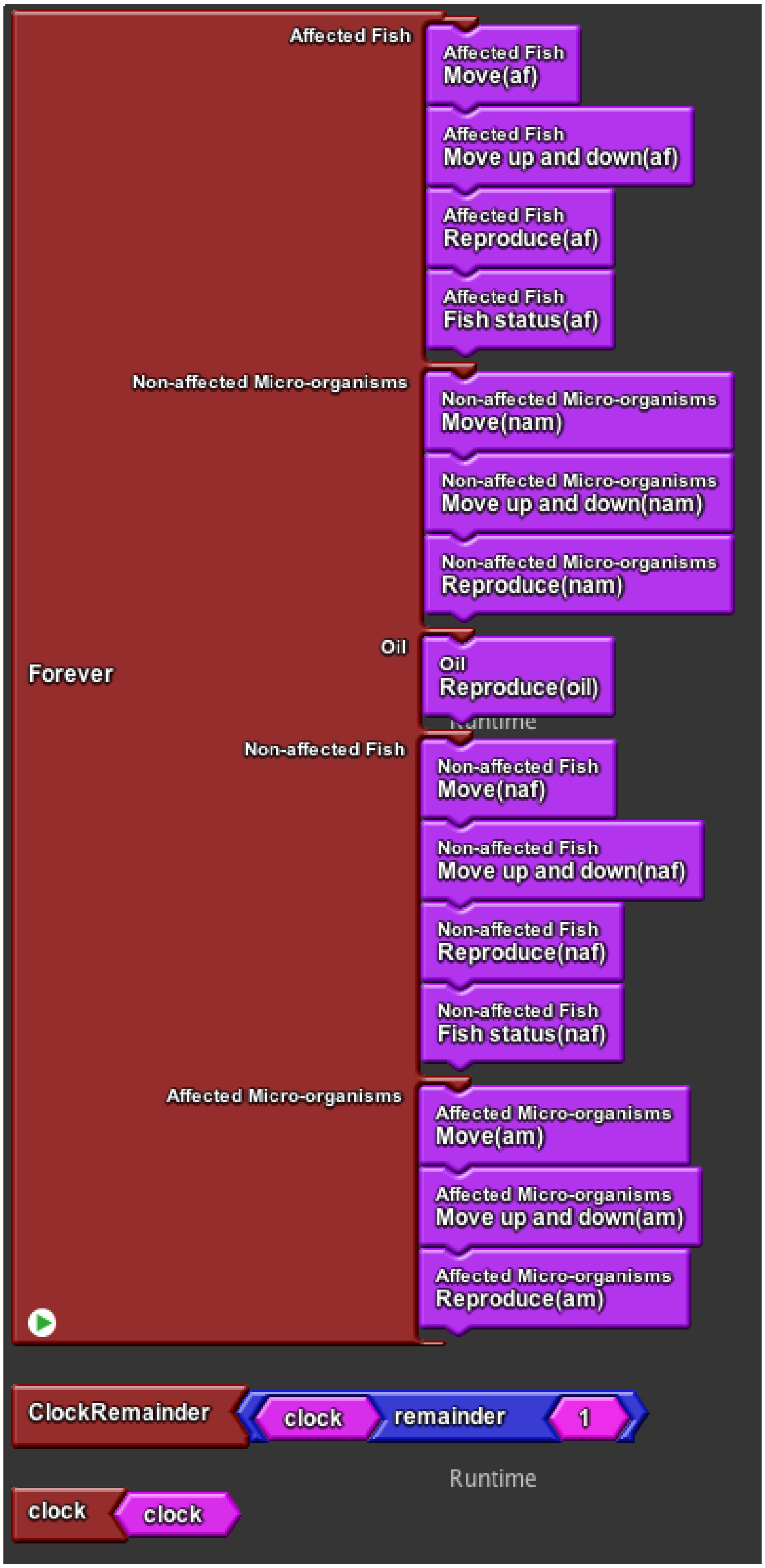
We would like to thank the following people for helping us and giving us support: David Oro (mentor), Mrs. Zeynep Unal, and our parents.

Appendix A

StarLogo TNG Code

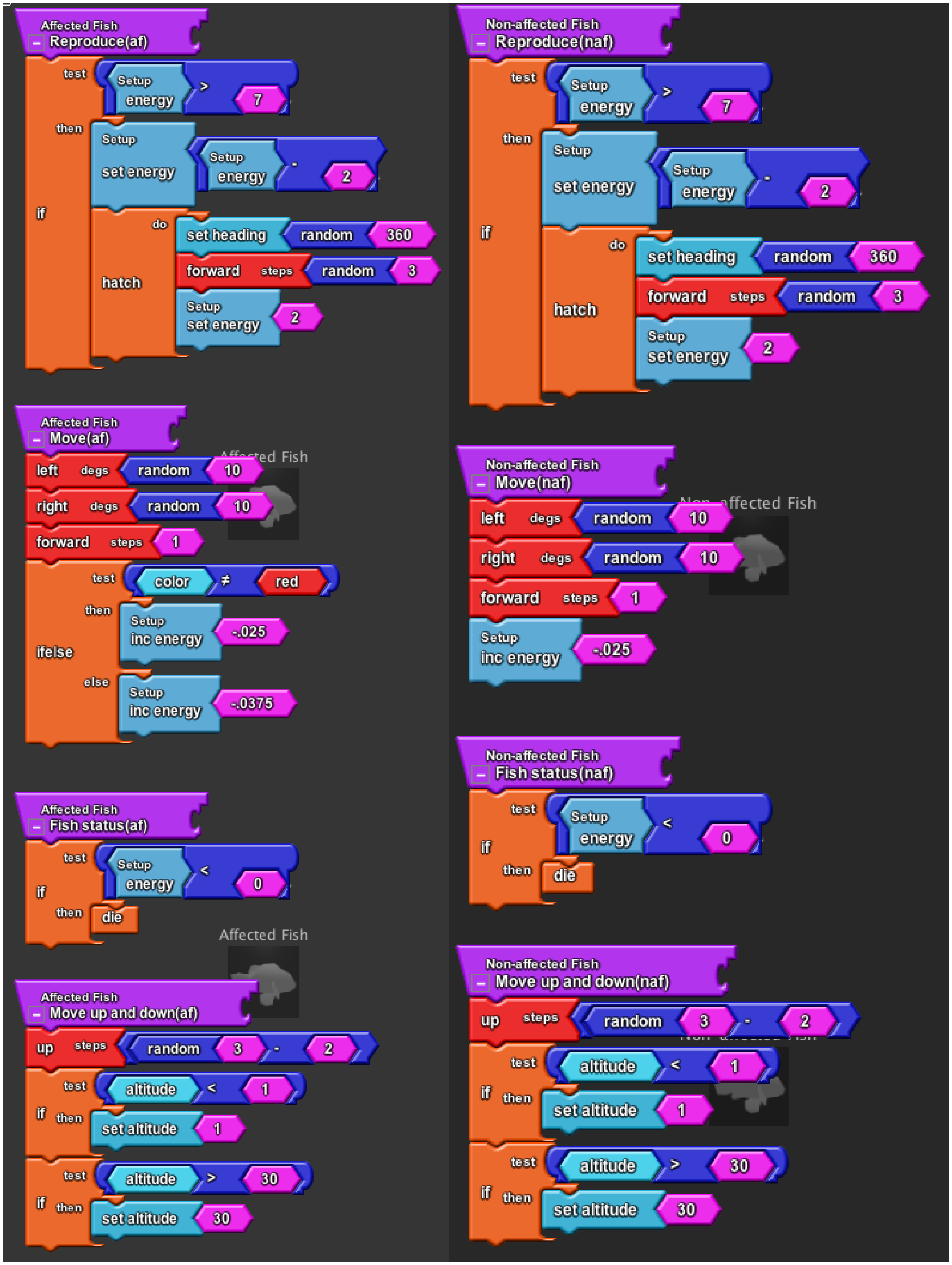


Setup

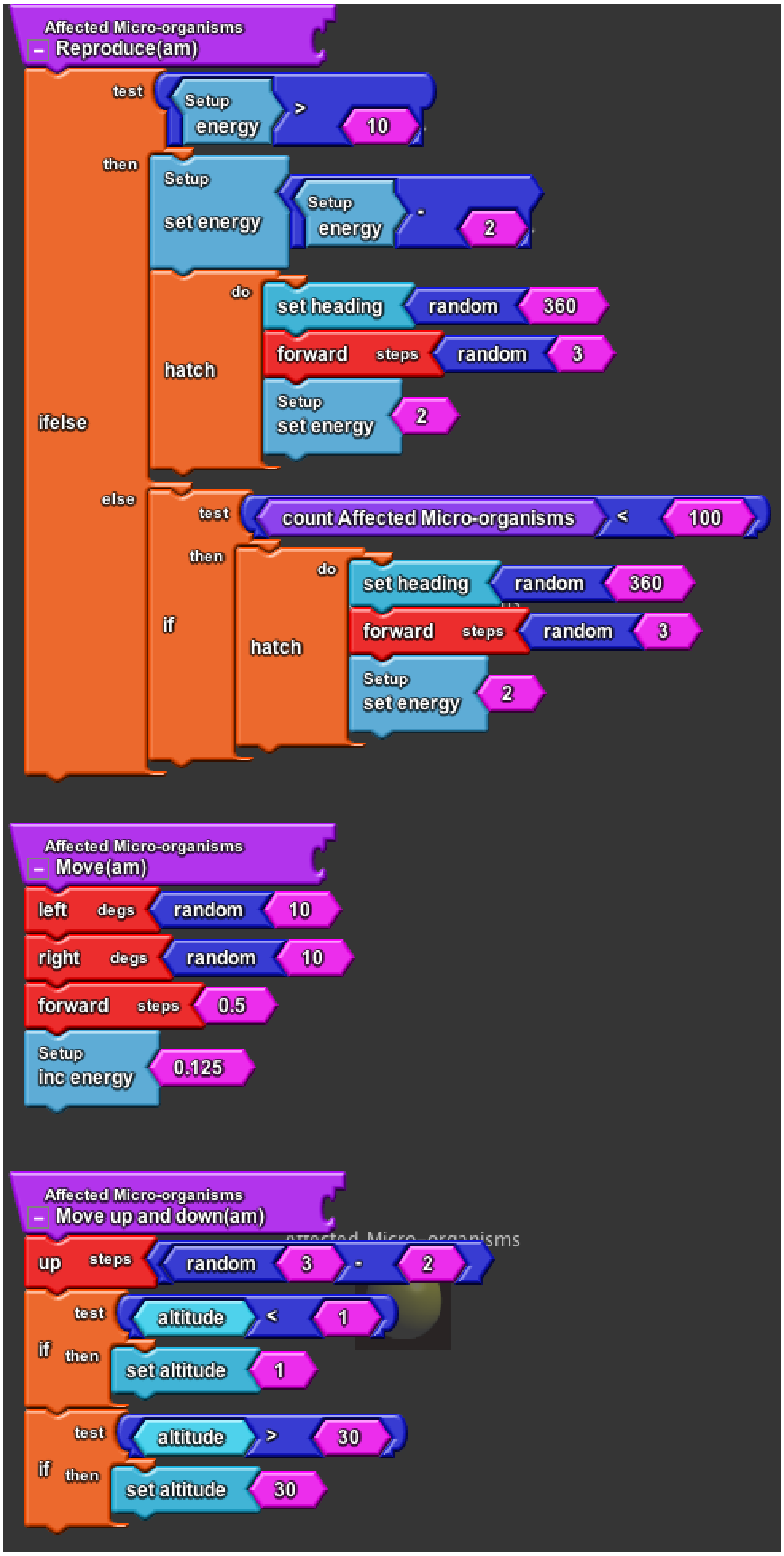

Forever
Affected Fish
Affected Fish
Move(af)
Affected Fish
Move up and down(af)
Affected Fish
Reproduce(af)
Affected Fish
Fish status(af)
Non-affected Micro-organisms
Non-affected Micro-organisms
Move(nam)
Non-affected Micro-organisms
Move up and down(nam)
Non-affected Micro-organisms
Reproduce(nam)
Oil
Oil
Reproduce(oil)
Non-affected Fish
Non-affected Fish
Move(naf)
Non-affected Fish
Move up and down(naf)
Non-affected Fish
Reproduce(naf)
Non-affected Fish
Fish status(naf)
Affected Micro-organisms
Affected Micro-organisms
Move(am)
Affected Micro-organisms
Move up and down(am)
Affected Micro-organisms
Reproduce(am)
ClockRemainder
clock
remainder
1
Runtime
clock
clock

Runtime

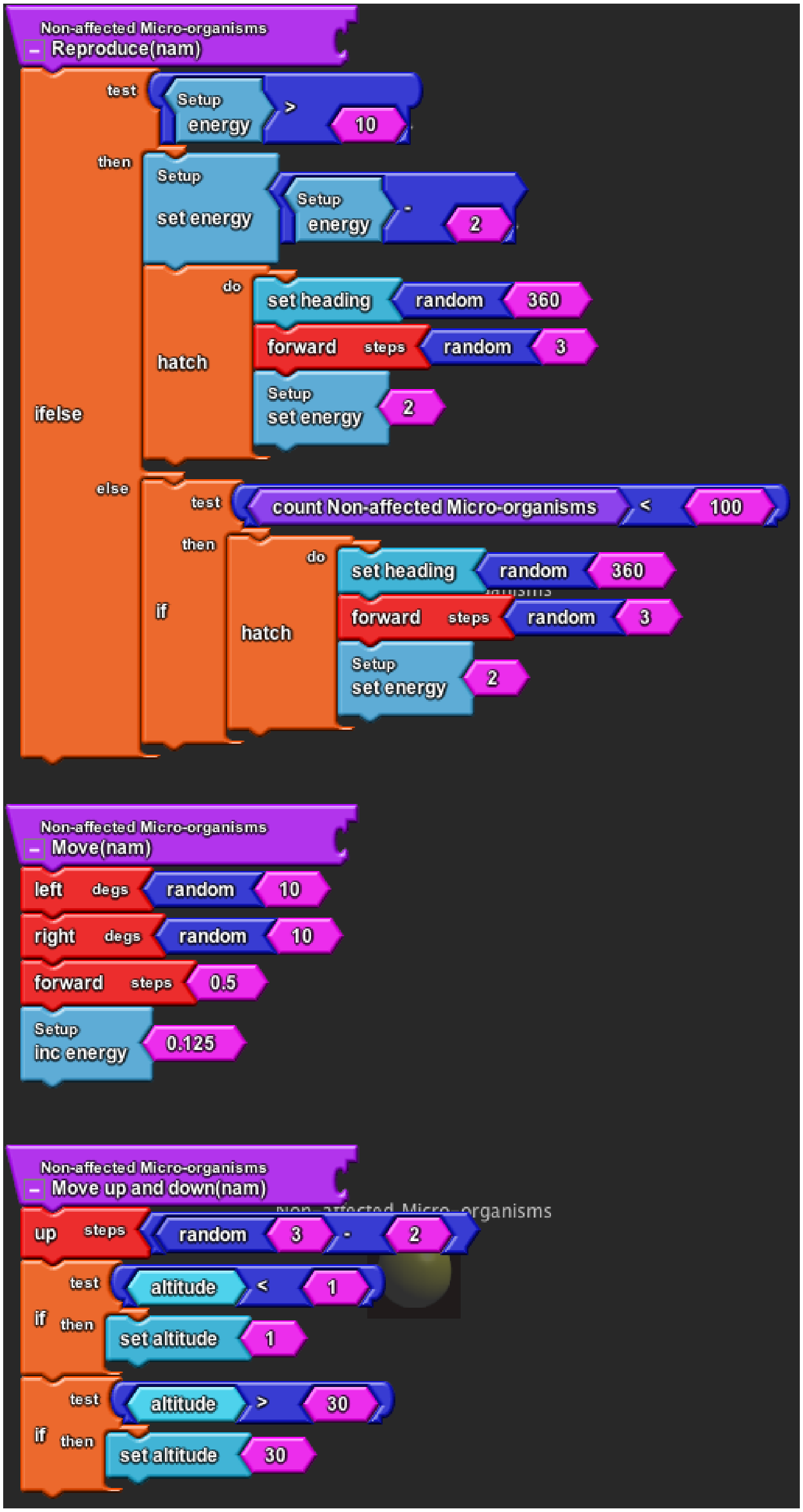
Collision Blocks



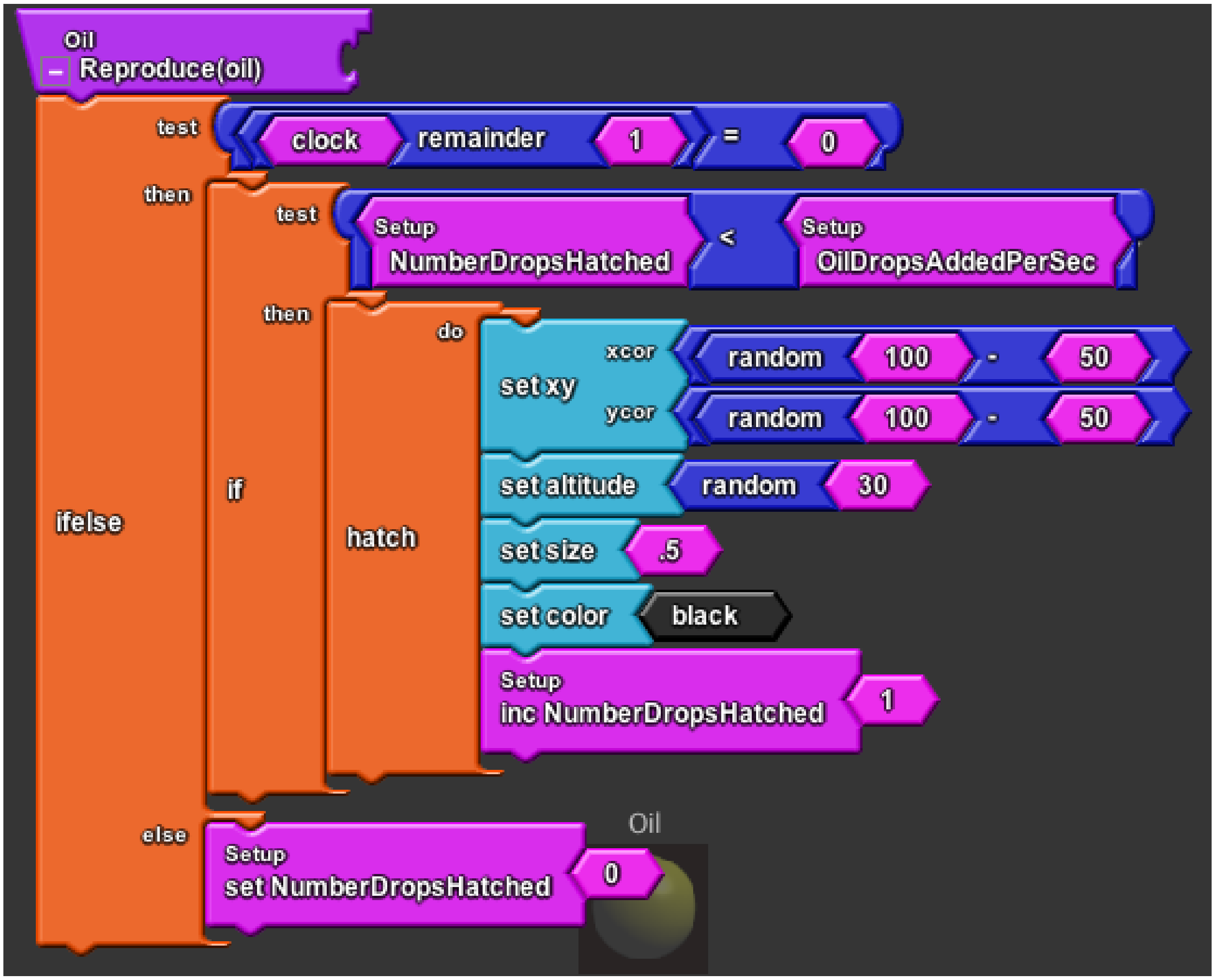
Affected fish and non-affected fish routines.



Affected micro-organisms routines



Non-affected micro-organisms routines.



Oil routines.