Run the Model

One update rule. Two management plans. Five years. You are the computer.

NGSS HS-ESS3-3 "Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity."

NAME ______________________ DATE ____________

A coastal community depends on a nearby fishery for food, jobs, and income. Fishery managers must decide whether to take a larger catch now or protect enough fish for future years. Their decision also affects a seabird colony that depends on the fish as food. In this model, the health of the seabird colony is a biodiversity indicator.

WHY THIS IS COMPUTATIONAL

This paper activity is a computational simulation because you apply one fixed update rule step by step to model changes over time. Computers use rules like this too, but they can repeat them millions of times faster and test many possible management choices.

1 THE MODEL RULES

Read before running

Start: 1000 tonnes of fish.
Each year: add growth based on the population at the **start** of the year, then subtract the harvest.
Seabirds: the colony is healthy in any year that **ends** at 800 tonnes or more.

START-OF-YEAR STOCK	GROWTH
800 or more	+200
400 to 799	+100
below 400	+50

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end = start + growth(start) − harvest
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Each year's **end** becomes the next year's **start**.

2 RUN BOTH STRATEGIES

Year 1 of A is done

STRATEGY A · MAX HARVEST quota: 300 tonnes every year

YR	START	+ GROWTH	− HARVEST	END	BIRDS OK?
1	1000	+200	−300	900	✓
2	900		−300		
3			−300		
4			−300		
5			−300		
		TOTAL HARVESTED			

STRATEGY B · STEADY HARVEST quota: 150 tonnes every year

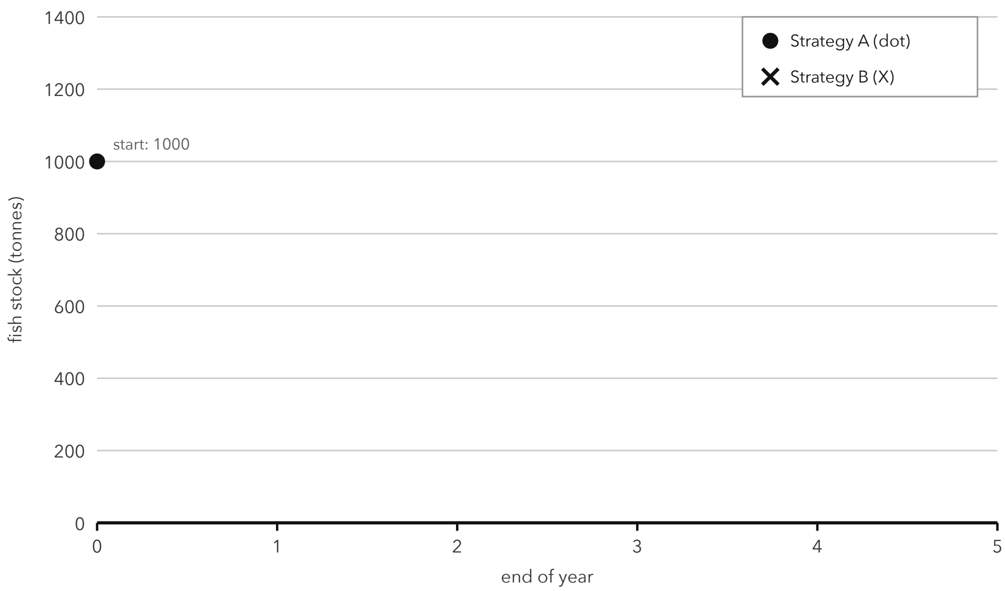
YR	START	+ GROWTH	− HARVEST	END	BIRDS OK?
1	1000		−150		
2			−150		
3			−150		
4			−150		
5			−150		
		TOTAL HARVESTED			

Fill every white cell. Mark Birds OK? with ✓ or ✗. Then add up each TOTAL HARVESTED.

3 PLOT BOTH RUNS

One point per year

Plot each year's **End** value. Use a filled dot for Strategy A and an X for Strategy B, then connect each run with a line.



4 SCORE THE STRATEGIES

Use your tables

CRITERION	STRATEGY A	STRATEGY B	WINNER
Community catch how much fish the community harvests in the short term			**A / B**
Final fish stock how many fish remain at the end of the model run			**A / B**
Seabird health how often the seabird colony has enough fish to stay healthy			**A / B**

SHORT RESPONSE

Use results from both runs to describe how the management rule affects the sustainability of the fishery and the seabird colony. Support your claim with evidence from the harvest totals, final fish populations, and seabird results.

5 CRASH TEST

Strategy A, extended

Keep Strategy A running past year 5 with the same rules. The harvest can never take more fish than the water holds.

YR	START	+ GROWTH	– HARVEST	END
6				
7				

The fishery hits zero in year ______

6 DESIGN A BETTER RULE

Beat Strategy B

YOUR RULE

Write a new harvest rule that could harvest more than Strategy B over five years while keeping the fishery stable and the seabird colony healthy. Explain how you would test your rule by using the model.

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Test it like a computer would. Run your rule for five years.

YR	START	+ GROWTH	– HARVEST	END	BIRDS OK?
1	1000				
2					
3					
4					
5					

☐ Total harvest beats Strategy B's 750 tonnes ☐ Seabird colony healthy all 5 years

MODEL LIMITS

What is one factor in a real fishery or ecosystem that this model leaves out, and how could that factor change the results?

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Run the Model

PART 2 · COMPLETED RUNS

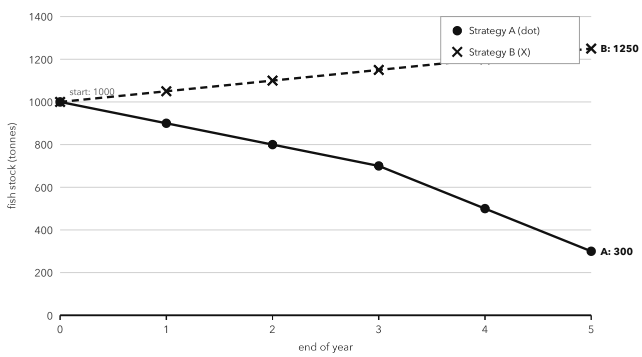
STRATEGY A quota: 300

YR	START	+ GROWTH	− HARVEST	END	BIRDS OK?
1	1000	+200	−300	**900**	✓
2	900	+200	−300	**800**	✓
3	800	+200	−300	**700**	✗
4	700	+100	−300	**500**	✗
5	500	+100	−300	**300**	✗
		TOTAL HARVESTED	**1500 tonnes**		

STRATEGY B quota: 150

YR	START	+ GROWTH	− HARVEST	END	BIRDS OK?
1	1000	+200	−150	**1050**	✓
2	1050	+200	−150	**1100**	✓
3	1100	+200	−150	**1150**	✓
4	1150	+200	−150	**1200**	✓
5	1200	+200	−150	**1250**	✓
		TOTAL HARVESTED	**750 tonnes**		

PART 3 · PLOTTED RUNS · PART 4 · MATRIX



Community catch: A 1500 vs B 750 tonnes. Winner: **A**.
Final fish stock: A 300 vs B 1250 tonnes. Winner: **B**.
Seabird health: A healthy 2 of 5 years vs B 5 of 5. Winner: **B**.

Crash test: Year 6: 300 + 50 − 300 = 50. Year 7: 50 + 50 = 100, harvest takes all 100. The fishery hits zero in **year 7**.

SHORT RESPONSE (SAMPLE)

Strategy A provides more fish for the community in the short term, harvesting 1500 tonnes compared with 750 tonnes for Strategy B. However, Strategy A ends with only 300 tonnes of fish, while Strategy B ends with 1250 tonnes. The seabird colony stays healthy for only 2 of 5 years under Strategy A, compared with 5 of 5 years under Strategy B. Therefore, Strategy B is more sustainable for both the fishery and the seabird colony.

DESIGN A BETTER RULE (ONE STRONG ANSWER) · MODEL LIMITS

One possible rule is to harvest 200 tonnes whenever the fish population at the start of the year is 800 tonnes or more. Because the population gains 200 tonnes in that band, this rule keeps the stock at 1000 tonnes, keeps seabirds healthy, and harvests 1000 tonnes over five years. Test it by running the update rule year by year, as in Parts 1 and 2.

- The model leaves out changes in ocean temperature. A marine heat wave could reduce fish growth, so a harvest level that seems safe in the model might cause the population to decline.
- The model treats the seabird colony as healthy or unhealthy based only on fish population. In reality, seabirds also need nesting habitat and may compete with other predators for food.

Check that students apply growth from the population at the start of each year before subtracting the harvest, including the zero-floor result in the extension. In the evaluation matrix and short response, accept evidence-based comparisons that identify Strategy B as more sustainable, while recognizing that Strategy A produces the larger short-term harvest.