BIOLOGY 30 | NATURAL SELECTION | INDIGENOUS WAYS OF KNOWING

Walleye Watch

Investigating change in Mistassini Lake

A fish can become smaller for several reasons. In this investigation, you will examine a real research case, test a model of inheritance and selection, and decide what evidence would help distinguish competing explanations.

Name: ____

Class: ____________________ Date: ____________________

How to use

Open the website provided by your teacher. Follow the seven numbered chapters. The question numbers in this workbook match the website notebook exactly. You may write here or in the website, then download your notebook. Keep graph files and run records with your answers.

Begin with a prediction. Make fair comparisons. Save evidence before starting a new trial. Explain your reasoning even when a result differs from your prediction.

Three labels to watch for

Label	What it means
Evidence from the study	Published observations and analyses, with their limitations.
Later monitoring	Findings reported after the original research.
Teaching model	Invented fish, genes, and parameters used to explore a mechanism.

Your assessment is based on observations, comparisons, explanations, and revisions. You are not expected to reach a predetermined conclusion about the cause of change in the lake.

EVIDENCE FROM THE STUDY

1 Listen to the question

Mistassini Lake is in Eeyou Istchee, northern Quebec. Mistissini is the Cree community; Mistassini is the lake. Walleye matter as food and as part of relationships with the water and across generations.

Cree Elders and fishers raised concerns about smaller walleye and fewer fish being caught. These observations motivated the study by Bowles, Marin, Mogensen, MacLeod and Fraser (2020). Community members helped with sampling, and Pamela MacLeod, a Cree Nation of Mistissini coauthor, explained the importance of respecting local knowledge in research and decisions.

The question was: are walleye changing, and could fishing help explain the change? The researchers brought together three kinds of evidence: Cree knowledge of the fishery, measurements of fish bodies, and comparisons of DNA. Each could reveal something the others could miss.

What did people observe? The study reports that Cree Elders and fishers had noticed smaller walleye and fewer fish being caught in three southern tributaries close to Mistissini: Chalifour, Icon, and Perch. Community members wanted to understand the changes and whether action to care for the fishery might be needed. These reports helped shape the research question; the study did not have historical catch-per-effort measurements to test the catch trend directly.

Community members helped collect fish samples. The team compared fish sampled in 2002–2003 with fish sampled in 2015–2017, measuring length and mass and estimating age for a smaller group. DNA comparisons used samples from 2003 and 2015. These were different samples of fish from the same rivers, not the same individual fish followed for 15 years.

In 2018, the team interviewed 17 experienced Cree Elders and fishers about changes they had noticed over time, including catches, fish sizes, and fishing pressure. Participants were chosen for their knowledge of the fishery, not at random. Their observations helped interpret the measurements as well as identify concerns worth investigating.

In the next part of your investigation, you will compare walleye sampled in four tributaries, rivers that flow into Mistassini Lake where fish gather to spawn. Chalifour, Icon, and Perch are in the south; Takwa is at the northeast end and had less reported fishing pressure. Start by looking for patterns in body size. As you continue, ask what else you would need to know before explaining why the fish changed.

FIELD NOTEBOOK

1 Knowledge and a first explanation

“The Cree skills gained have been passed on from one generation to another”

Pamela MacLeod, in Bowles et al. (2020), Box 1, p. 1141. Read the full account with the website’s **Read Box 1** button.

1.1 What two changes did Cree Elders and fishers report? Explain how their observations shaped the research question.

1.2 How does Pamela MacLeod’s statement connect knowledge, relationships with the environment, and future generations? Use the reading; you are not being asked to speak for the community.

1.3 Write an initial explanation for smaller fish. Name one observation that would make you reconsider it.

Optional viewing

Stanley Mianscum and his son Conrad reflect on their family’s fishing heritage in Episode Six – Fish, from James Bay Cree Communications. Their conversation connects fishing with family and knowledge shared across generations, themes that also appear in Pamela MacLeod’s account of the Mistissini research.

EVIDENCE FROM THE STUDY

2 Read the river evidence

The study compared body measurements from 2002/03 with samples from 2015–2017. The southern rivers were Chalifour, Icon, and Perch; Takwa in the north was used as a lower-harvest reference. Genetic comparisons used 2003 and 2015 samples.

Select each river to see a summary in words of the 2020 study’s body-size results. “Qualitative” means that the summary describes a pattern instead of giving exact measurements. It compares earlier and later samples within a river, keeping males and females separate where needed. Open Figure 2 to see the measured lengths, masses, and uncertainty around the estimates.

Takwa provides a reference: if the southern fish changed more than fish in a less-harvested river, that could support investigating fishing as an explanation. But rivers also differ in habitat, food, the numbers of young fish joining the population, and sampling. Fishing was not experimentally assigned. Takwa became easier to reach around 2015; less harvest does not mean no harvest.

Chalifour River

Fish were generally shorter and lighter in 2015–2017 than in 2002–2003. The pattern was clearer for some comparisons than others. Some female comparisons were not statistically significant: the evidence was not strong enough to distinguish those differences confidently from variation in the samples. Small female samples made some estimates less precise.

Icon River

The available comparisons showed clear decreases in both length and mass from the earlier to the later sampling years. However, too few females were sampled in 2017 to analyse female body size for that year. A missing comparison means there is not enough evidence for that group; it does not mean no change occurred.

EVIDENCE FROM THE STUDY

2 Complete the river comparison

Perch River

Females were shorter and lighter in the later samples where comparisons were possible. The male results were less consistent: some comparisons did not show the same decrease. No females were available for the 2017 body-size analysis, so that year cannot tell us whether the female pattern continued.

Takwa River

In the original 2020 body-size analysis, average length and mass were comparatively stable across the sampled years. Takwa had less reported fishing pressure than the southern rivers. This makes it a useful comparison, but not an identical control or an unfished river. Later analyses and monitoring add qualifications that you will explore in chapter 6.

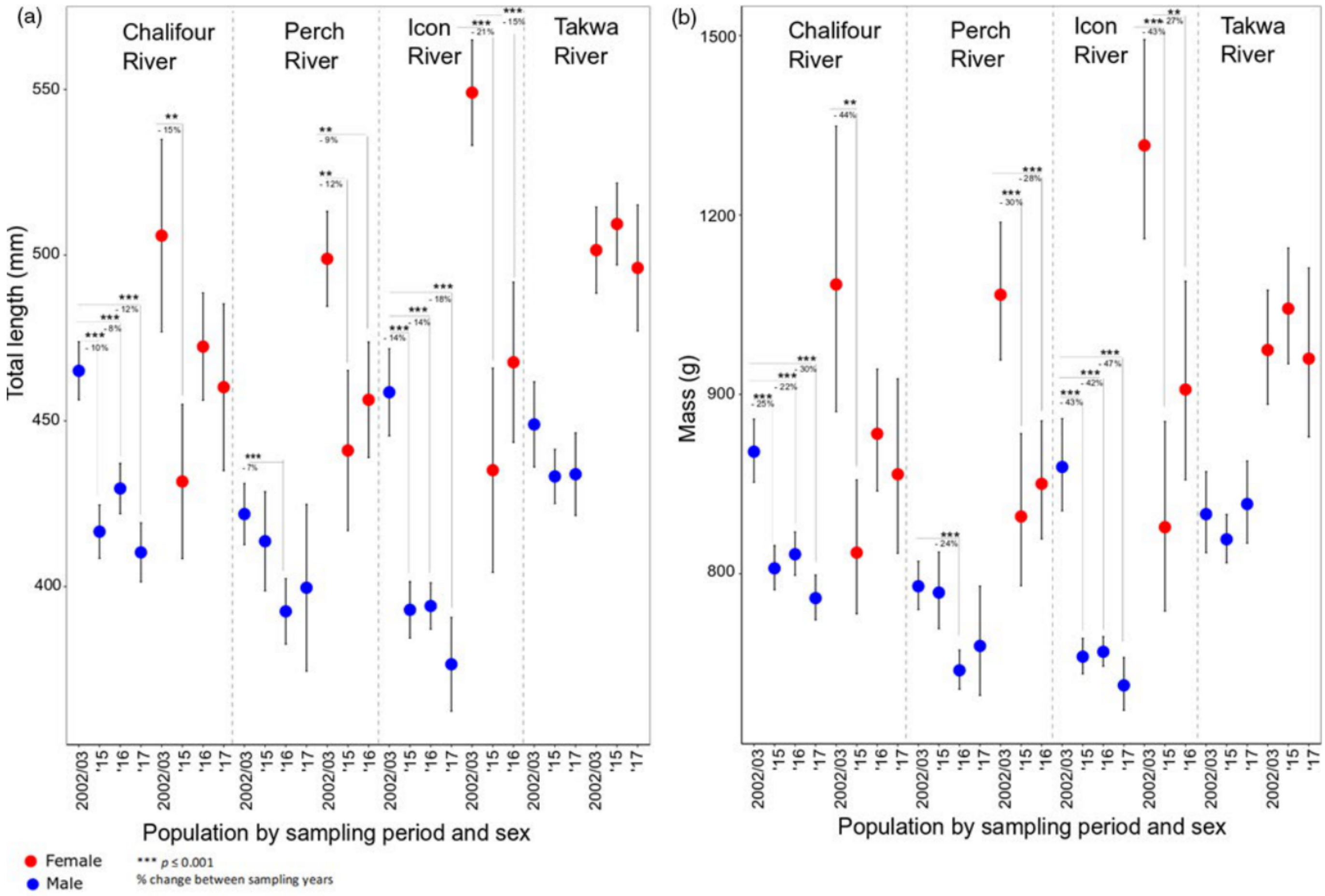
Use the original graph on the next page

Compare earlier and later samples within the same river and sex. Blue points represent males; red points represent females. Total length is measured in millimetres, and mass is measured in grams. The vertical bars show uncertainty around the estimated averages.

A gap in the available data is a limit to the comparison. It does not mean the population stayed the same. In question 2.1, describe both the overall pattern and any exceptions or missing groups.

EVIDENCE FROM THE STUDY | ORIGINAL FIGURE 2

2 Inspect the published graph



Bowles et al. (2020), Figure 2, p. 1137. © The Authors, CC BY. Cropped, otherwise unaltered. Left: total length (mm). Right: mass (g). Blue: males; red: females. Vertical bars: 95% confidence intervals. Open the image on the website for a larger view.

2.1 Record the body-size pattern for each of the four rivers. Where are there exceptions or limits to the comparison?

FIELD NOTEBOOK

2 What can the comparison tell us?

2.2 What does comparing the southern rivers with Takwa add to the investigation? Give two reasons this comparison does not establish causation.

2.3 Would a decrease in average length alone show that inherited traits changed? Explain using age, growth conditions, or sampling.

Useful distinction: a distribution describes the fish sampled. An explanation must account for how that distribution arose.

TEACHING MODEL

3 Meet the model population

Open the stream laboratory below. Set Harvest to No harvest, Food to Normal, and Seed to 42. Click Start new trial. Inspect at least three fish by clicking them or choosing their IDs from the list.

A seed is a number that starts the computer's repeatable sequence of chance events. The same seed and settings reproduce the same trial. Keep the seed the same when comparing treatments, then try other seeds to see whether a pattern holds. It is not a biological trait or a measure of fishing pressure.

Each fish carries two alleles at each of three fictional gene locations. A G copy contributes to growth in this model. Lower-case g contributes less. Offspring receive one allele at each location from each parent. These are invented teaching genes, not genes identified in Mistassini walleye.

All adults are age 6 model years. A model cycle has three steps: Apply harvest, Reproduce, and Grow to adults. After reproduction, juveniles appear at age 1. Surviving adults are replaced by the next cohort. Real walleye have overlapping generations; this model deliberately separates cohorts.

Try one full cycle. Inspect an offspring in the nursery and read its parents' genotypes. At Grow to adults, the same juveniles become larger without changing their alleles. The population contains 60 young fish per successful reproduction, so this model cannot predict fishery yield or abundance.

Keep the sequence visible

Adults → Apply harvest: inspect the current lengths and allele frequencies.
Survivors → Reproduce: inspect which fish remain and can pass on alleles.
Juveniles → Grow to adults: compare offspring genotypes, parents, and growth.

Stage records contain every stage. The trend graph uses adults only; the histogram shows the fish at the current stage.

TEACHING MODEL | FIELD NOTEBOOK

3 From individuals to a gene pool

3.1 Record the ID, age, length, sex, genotype, and G-copy count of three adults. Identify two sources of variation in this model.

ID	Age	Length cm	Sex	Genotype at three loci	G copies

3.2 Inspect an offspring after Reproduce. Record its ID and parents. At one gene location, show how its alleles could come from those parents.

3.3 Compare the nursery and adult stages of the same generation. What changes during growth, and what remains the same? Explain why individual growth is not evolution.

3.4 What does the length histogram show? What additional information does the model allele-frequency display provide?

TEACHING MODEL

4 Test a selection pressure

Before running trials, predict what will happen under No harvest, Random capture, and Larger fish more likely. Keep Food at Normal and Seed at 42. Use 40% harvest for both capture treatments. This percentage is a classroom scenario, not a measured harvest rate.

For each treatment, click Start new trial, record generation 1, then Run to generation 6. Watch the adult, survivor, and nursery phases. The run stops automatically at generation 6 adults. Save each run with a clear name. Saved runs appear in the comparison table; download graphs and data for your evidence.

Repeat Random capture and Larger fish more likely with seeds 43 and 44. Using the same seed gives the same starting population; different treatments can still lead to different random paths. Compare patterns across trials rather than treating one run as a universal result.

Larger fish are more likely to be removed in the selective treatment, but capture is still probabilistic. Surviving fish reproduce by passing on existing alleles. The model has no mutation, migration, or directed change in genes.

4.1 Predict the changes in adult mean length and G-allele frequency under each treatment. Give a reason for each prediction.

Treatment	Predicted adult mean length	Predicted G frequency and reason
No harvest		
Random capture		
Larger fish more likely		

TEACHING MODEL | SEED 42 | NORMAL FOOD

4 Save a fair comparison

4.2 Record the generation 1 and generation 6 results for all three treatments at seed 42. Attach or sketch the graphs for two contrasting runs.

Treatment	G1 mean cm	G6 mean cm	G1 G %	G6 G %
No harvest				
Random, 40%				
Larger fish, 40%				

Graph evidence

Attach your downloaded graphs or sketch two contrasting results here. Label treatment, seed, generation, stage, axes, and units. Explain the main difference below.

TEACHING MODEL | NORMAL FOOD | 40% CAPTURE

4 Repeat the experiment

4.4 Compare seeds 42, 43, and 44. Which changes are consistent, and which vary? Explain why allele frequencies can change even under random capture or no harvest.

Treatment / seed	G1 mean cm	G6 mean cm	G1 G %	G6 G %
Random / 43				
Random / 44				
Larger fish / 43				
Larger fish / 44				

4.3 Use adult, survivor, and offspring observations to explain how heritable variation and differential survival can change allele frequencies across generations.

TEACHING MODEL | EVIDENCE REASONING

4 A mechanism and its limits

4.5 Does a successful model experiment show that fishing caused the changes in Mistassini Lake? State precisely what your model can and cannot establish.

Build your mechanism explanation

Use this optional organizer to link your evidence. Include a specific observation at each step; avoid saying that individual fish changed their genes because they needed to survive.

Link	Observation from your experiment
Variation before harvest	
Differences in survival	
Alleles passed to offspring	
Population change across generations	

TEACHING MODEL

5 Try another explanation

Use the matched-growth comparison. It shows the same generation-1 fish from your chosen seed raised under Low, Normal, or High food. IDs, genes, age, and individual growth differences are held constant. Only food during development changes.

These are alternative developmental histories, not an instruction to shrink living adults. Compare adult lengths and allele frequencies. Then run No harvest with Low food and Normal food at the same seed to generation 6 and save both runs.

Food affects growth only in this model. With no harvest, it does not affect survival or which fish reproduce, so those paired runs have identical genetic histories. In nature, food can also affect survival and reproduction. Real fish can show genetic and environmental influences at the same time.

5.1 Record the mean adult length and G-allele frequency in the Low, Normal, and High food matched-growth views. What causes their differences?

Food history	Mean adult length (cm)	G frequency (%)
Low		
Normal		
High		

TEACHING MODEL | FIELD NOTEBOOK

5 Compare growth and inheritance

5.2 Compare the two no-harvest runs after six generations. Can a smaller average body size occur without a difference in their allele frequencies? Explain.

No-harvest run, same seed	Generation 6 mean cm	Generation 6 G %
Low food		
Normal food		

5.3 Design a comparison that could help distinguish inherited differences from environmental growth effects in real fish. Identify a control, a measurement, and a practical or ethical consideration.

EVIDENCE FROM THE STUDY

6 Revisit the research

Now return to the lake. Your simulation shows how selection could work under its rules. The real study asks a harder question: what explains the changes in these wild fish? The researchers considered Indigenous knowledge, body measurements, and DNA together.

Bowles et al. analysed approximately 9,000 genetic markers: places in DNA that can be compared among fish. They reported changes in population structure and possible signals of selection in southern populations. Predicted declines in genetic diversity and effective population size were not supported. The authors saw evidence consistent with harvest-associated change, but did not establish that fishing caused genetic evolution.

What did the critics question?

Larson, Isermann, and Feiner questioned whether the data could isolate fishing as the cause. Some age samples were small, and size could also change with food, age structure, or the number of young fish entering the population. Their reanalysis suggested that fish of a given age became shorter in the northern reference river as well as the south. They also argued that missing DNA data and filtering problems could create misleading genetic patterns.

The critics did acknowledge that Indigenous knowledge supported a connection between harvest and fish-size structure. They argued that demonstrating selective removal of particular inherited traits required stronger, more consistent measurements. They did not establish a single alternative cause.

6.1 What did the genetic analyses add beyond length measurements? Name one prediction the 2020 study did not support.

EVIDENCE FROM THE STUDY

6 Knowledge and the response

The response: consider all three kinds of evidence

Bowles, Marin, MacLeod, and Fraser replied that their interpretation was tentative, not proof of causation. They accepted concerns about missing DNA data and acknowledged a filtering problem, but disputed parts of the reanalysis and its filtering choices.

They also argued that the critique gave too little weight to Indigenous knowledge. Experienced Cree fishers had described changes in size, catches, and fishing pressure over time. In a region with limited long-term measurement records, the authors considered this knowledge essential to interpreting the combined evidence. They argued that conservation decisions still have to be considered when measurements are incomplete.

What is at stake for this investigation?

This debate involves both the reliability of particular analyses and the weight given to different contributions. A useful reading keeps both questions open: take Cree knowledge seriously and examine the technical evidence carefully. Knowledge of a changing fishery can guide questions and monitoring even while the exact evolutionary mechanism remains unresolved. The response itself combines Indigenous knowledge with Western scientific methods; these are not two uniform, opposing teams.

6.2 Compare one concern raised by Larson and colleagues with the authors' response. Why did Bowles and colleagues argue that Indigenous knowledge deserved more weight? Explain what that knowledge contributes and what remains uncertain about harvest-driven evolution.

Sources: Larson, Isermann & Feiner (2021), doi:10.1111/eva.13122; Bowles, Marin, MacLeod & Fraser (2021), doi:10.1111/eva.13146. Full links are in the website's Sources & design notes.

6 Follow the later monitoring

Why return to the rivers?

Collaborative monitoring continued after community concerns prompted the original work. The 2022 report compared three periods: 2002–2003 (the early baseline), 2015–2017, and 2020–2022. Fish were sampled during spring spawning. Grouping years helped researchers compare periods despite unequal sample sizes.

What changed in the longer record?

Some body sizes stabilized or increased after 2015–2017, although many remained below the early baseline. Results differed by river, sex, and whether length or mass was measured. For example, Icon fish remained smaller than the early samples, while female mass in Perch continued to decline. The pattern was not a uniform recovery or a steady decline everywhere.

Why does sampling matter?

Some donated Chalifour fish in 2022 were caught in gillnets and included larger females. Including them raised the average female mass. A shift in which fish are sampled can therefore change the average even without a matching population-wide change. This report measured body size; it did not show that genetic evolution had reversed. Continued, comparable observations are needed.

6.3 How does the later monitoring strengthen, weaken, or complicate your earlier explanation? Include one sampling concern.

Source: Marin & Fraser (2022), A twenty-year assessment of Mistassini Lake spawning walleye body size, pp. 1–7. Full report linked in Sources & design notes.

FIELD NOTEBOOK

6 Revise your explanation

6.4 Return to your answer to 1.3. Write a revised claim using community observations, the research debate, and your model. Distinguish what was observed from what is inferred. Explain how Cree knowledge holders could help shape the next investigation.

Check your reasoning

Name the observation or evidence behind each part of your claim. State the limits of your model. Identify a useful contribution Cree knowledge holders could make to the next question, its interpretation, or the monitoring plan.

EVIDENCE FROM THE STUDY

7 Plan for those who follow

Return to Pamela MacLeod's account in Box 1: relationships with land and water support knowledge passed between generations, and that knowledge should be respected in research and environmental decisions. In this case, observations from experienced land users began the inquiry and remain relevant as it continues.

Build a monitoring plan below. Select at least three kinds of evidence and explain how each addresses an uncertainty. Include how researchers could work with community priorities, consent, and decisions about sharing knowledge. This is a student proposal for learning, not a management prescription for the Cree Nation of Mistissini.

Consider what people in future generations would need to know about the fishery, and how useful observations and knowledge could be passed on. Connect your plan to MacLeod's account of relationships with land and water and the continued sharing of Cree knowledge.

Monitoring choices on the website

Community observations: Priorities, places, histories, and changes noticed over time.

Length and mass: Body-size distributions using comparable samples.

Age and growth: Age structure and length at the same age.

Water, food, and habitat: Environmental influences on growth.

Harvest information: Fishing exposure, methods, and effort.

Genetic samples: Gene-pool change with reliable sampling and filtering.

FIELD NOTEBOOK

7 Build a continuing investigation

7.1 Select at least three evidence types in the monitoring planner. For each, state the question it addresses and how you would make future observations comparable.

Evidence type	Question addressed	How to make it comparable

7.2 How could continuing research respect Cree knowledge holders’ priorities, consent, and decisions about sharing knowledge? Explain a role for local expertise beyond an introductory quotation.

FIELD NOTEBOOK

7 Future generations and reflection

7.3 What might people in future generations need to know about this fishery? Connect your answer to MacLeod’s account without speaking on behalf of the Nation.

7.4 Which part of your explanation changed most? Identify the observation, experiment, or reading that changed it and one question you still have.

Before submitting: include your recorded settings, results from repeated trials, graph evidence, monitoring plan, and revised explanation. Download your website notebook if you used it.

KEEP THIS PAGE WITH YOUR EVIDENCE

Sources and quick reference

Research and community contribution

Bowles, E., Marin, K., Mogensen, S., MacLeod, P., & Fraser, D. J. (2020). Size reductions and genomic changes within two generations in wild walleye populations: associated with harvest? *Evolutionary Applications, 13*, 1128–1144. doi.org/10.1111/eva.12987. Box 1 includes MacLeod's account; Figure 2 provides the graphs used here.

Larson, W. A., Isermann, D. A., & Feiner, Z. S. (2021). Published critique. doi.org/10.1111/eva.13122.

Bowles, E., Marin, K., MacLeod, P., & Fraser, D. J. (2021). A three-pronged approach that leans on Indigenous knowledge for northern fish monitoring and conservation. doi.org/10.1111/eva.13146.

The 2022 monitoring report and optional James Bay Cree Communications video are linked in the website's Sources & design notes. All required tasks can be completed using the written material.

Model vocabulary

Term	Meaning in this activity
Phenotype	A measured characteristic, such as fish length.
Genotype	The alleles an individual carries.
Allele frequency	A variant's share of the gene copies in a population.
Natural selection	Differences in survival or reproduction associated with traits.
Genetic drift	Chance changes in allele frequencies in finite populations.
Environmental growth effect	A change in growth associated with conditions, without requiring a change in genotype.