

TEACHER AND STUDENT RESOURCE

Statistical Investigations and Real Data



NC Math 4 • NC.M4.SP.1

Statistics and Probability

Seven instructional sections with 30 multiple-choice and 30 open or performance tasks, teaching scripts, original mathematical visuals, generous workspaces, and worked keys.

Free sample | Contents

NC.M4.SP.1 | NC Math 4 mathematics

This sample contains 22 complete selected pages from the 98-page resource, plus this sample contents page. Original printed page numbers are retained. Gaps are intentional.

Included original pages: 1-18, 33-34, 63, 78

Representative activities

M01: sample PDF page(s) 19; original page(s) 18

M02: sample PDF page(s) 19; original page(s) 18

O01: sample PDF page(s) 20; original page(s) 33

O02: sample PDF page(s) 21; original page(s) 34

Selected teacher prompts and keys: original page(s) 63, 78

Using this sample

Read the preparation and access guidance before using a selected activity.
Keep teacher keys and private preparation pages separate from student copies.
Use the original resource contents to see the scope of the complete packet.

Complete paid download

The complete resource includes the full PDF task bank and teaching materials.
Its required companion lab is included with the complete paid download.
The sample does not include that complete companion archive.

ALIGNMENT

Standard and learning targets

Create statistical investigations to make sense of real world phenomenon.

T1 NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

T2 NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

T3 NC.M4.SP.1.3 Use technology to organize a real data set with more than 200 cases and at least three measures; identify variables, outcomes, questions and summaries.

T4 NC.M4.SP.1.4 Interpret nonstandard visualizations from scientific research, including linked panels and two-direction uncertainty bars.

NC.M4.SP.1.1 Construct statistical questions to guide explorations of data in context.

NC.M4.SP.1.2 Design sample surveys and comparative experiments using sampling methods to collect and analyze data to answer a statistical question.

NC.M4.SP.1.3 Organize large datasets of real world contexts (i.e. datasets that include 3 or more measures and have sample sizes >200) using technology (e.g., spreadsheets, dynamic data analysis tools) to determine: types of variables in the data set, possible outcomes for each variable, statistical questions that could be asked of the data, and types of numerical and graphical summaries could be used to make sense of the data.

NC.M4.SP.1.4 Interpret non-standard data visualizations from the media or scientific papers to make sense of real world phenomenon.

Each item names its own target. The bank supports multiple sessions; do not assign all 60 tasks in one sitting.

NAVIGATION

Choose evidence deliberately

Warm-up: M01-M04 and O01-O04

I Do: M05-M08 and O05-O08

We Do: M09-M13 and O09-O13

Collaborative practice: M14-M18 and O14-O18

Independent practice: M19-M23 and O19-O23

Small-group reteach: M24-M27 and O24-O27

Exit ticket: M28-M30 and O28-O30

T1: M01, M05, M09, M13, M17, M21, M25, M29, O01, O05, O09, O13, O17, O21, O25

T2: M02, M06, M10, M14, M18, M22, M26, M30, O02, O06, O10, O14, O18, O22, O26

T3: M03, M07, M11, M15, M19, M23, M27, O03, O07, O11, O15, O19, O23, O27, O29

T4: M04, M08, M12, M16, M20, M24, M28, O04, O08, O12, O16, O20, O24, O28, O30

DAILY LEARNING TARGETS

A multi-session teaching path

Session 1 Diagnose and model

Learning target: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

Learning target: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Use warm-up evidence to choose explicit I Do models. Collect predictions before revealing the worked solution.

Session 2 Compare and explain

Learning target: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Learning target: NC.M4.SP.1.3 Use technology to organize a real data set with more than 200 cases and at least three measures; identify variables, outcomes, questions and summaries.

Learning target: NC.M4.SP.1.4 Interpret nonstandard visualizations from scientific research, including linked panels and two-direction uncertainty bars.

Use selected We Do and collaborative tasks. Ask each learner for an initial representation, then compare methods and checks.

Session 3 Transfer independently

Learning target: Apply the objectives with explicit restrictions, checks and contextual interpretations.

Choose independent items across every objective. Use small-group tasks for a documented gap and a fresh exit task to test transfer.

PLANNING

Materials, access and pacing

Materials

A spreadsheet or another data-analysis tool is required for the authentic data tasks. Provide penguins.csv, the companion standard-library Python script penguins_lab.py if desired, and the two reproduced research-figure reference pages. Use a readable color display or enlarged print for Figure 4; a teacher may neutrally identify which marker belongs to each legend group without interpreting its height. No personal identifying information is needed for the invented study designs.

Prerequisites

Percentages, mean and median, reading scales, paired rows, categorical and quantitative variables, and basic scatterplots.

Pacing

Use a short diagnostic warm-up, a model and shared task in one session; collaborative and independent reasoning in later sessions; then targeted reteaching and an exit task. Select two to four tasks at a time based on evidence. Each section's full bank is reusable, not mandatory in one lesson.

Neutral access

Read directions aloud without interpreting the graph, enlarge a page, supply a writing or pointing response method, and allow a learner to dictate an explanation. Keep axes, units, data and mathematical demand unchanged.

Separate instruction from evidence

Keep the learner's first response. Record answer-supplying cues separately from access supports. A completed teacher graph or worked key is for discussion after independent work, never a student construction template.

Review convention

Use the supplied authentic penguins.csv for data tasks. NA means unavailable, never zero. Describe the recorded cases unless a defensible sampling design supports wider inference. Other survey and experiment scenarios are invented. Research-figure readings are approximate; report sensible ranges, not invented exactness. Figure error bars show one standard error, not the range of individual birds.

TECHNOLOGY LABORATORY

The authentic data laboratory

Data source and scope

The simplified Palmer Penguins data contain 344 recorded penguins and eight variables. Data were collected by Kristen Gorman and Palmer Station Antarctica LTER. This file is a teaching-friendly version of the research data, not a random sample of every penguin in the world.

Variables and units

species and island are group labels. bill_length_mm, bill_depth_mm and flipper_length_mm are lengths in millimeters; body_mass_g is mass in grams. sex records the available male/female classification. year is the observation-year code. The data dictionary and study context matter more than whether a spreadsheet stores a field as text or number.

Technology workflow

Import the CSV with one header row and one penguin per row. Preserve the original file. Confirm row and column counts, units and missing-value codes. Create a separate analysis sheet. Filter only the variables needed for the question, record exclusions and denominators, then build summaries and labeled graphs. Sort whole rows, never independent columns.

Reproducible alternative

Run penguins_lab.py with Python 3. It uses only the standard library and reads penguins.csv in the same source folder. It prints an audit and descriptive summaries, then writes penguins_summary.json. Save your own question, filter, graph and interpretation as evidence; a printed number alone is not a statistical investigation.

Attribution

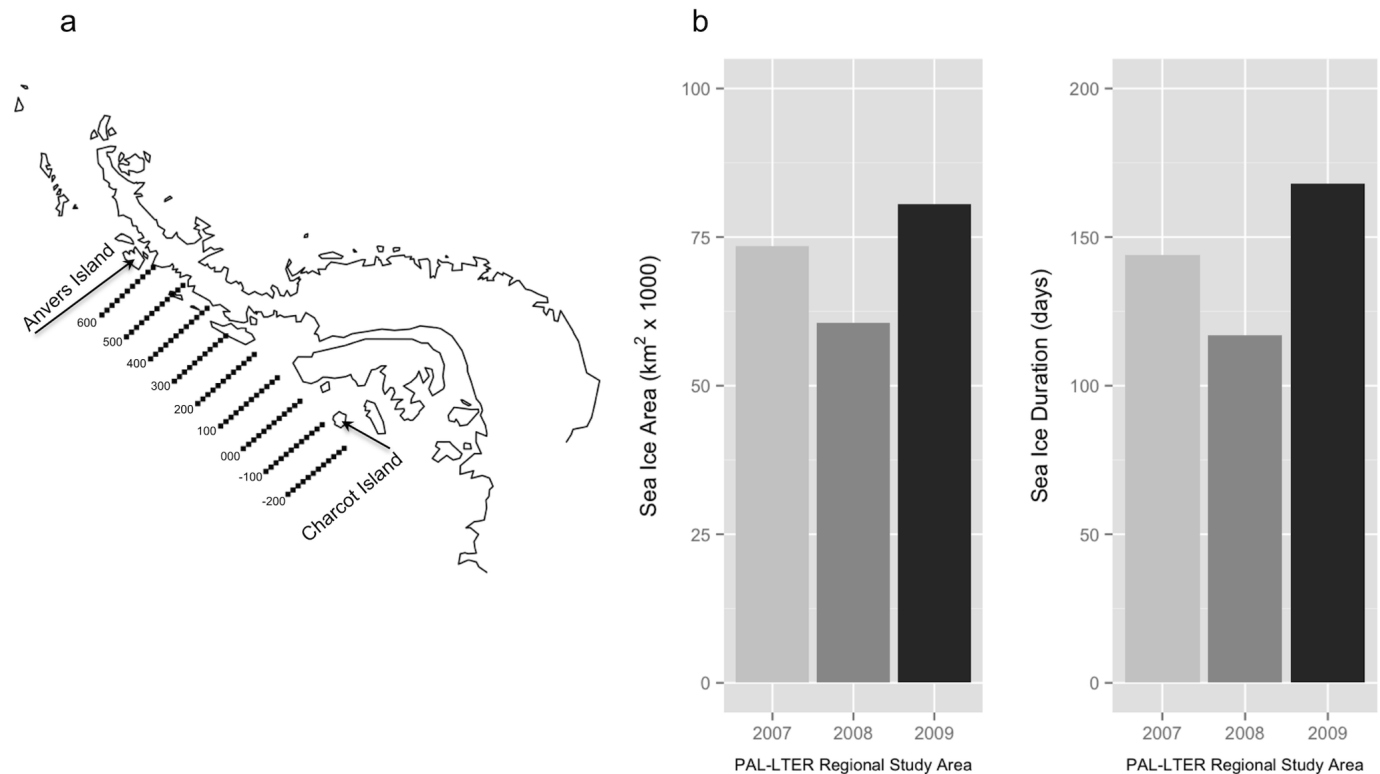
Horst AM, Hill AP, Gorman KB (2020), palmerpenguins, DOI 10.5281/zenodo.3960218. Data are CC0. Source and data dictionary: <https://allisonhorst.github.io/palmerpenguins/>
The original scientific study is Gorman KB, Williams TD, Fraser WR (2014), PLOS ONE 9(3): e90081, <https://doi.org/10.1371/journal.pone.0090081>

SCIENTIFIC FIGURE REFERENCE

Research Figure 2

Read the encodings first

Panel a locates the study grid. Panel b pairs a sea-ice area display with a sea-ice duration display for the same years. Read each vertical scale separately. The area label includes a multiplier; the duration label uses days. These regional summaries are not individual penguin measurements.



Reproduced without alteration from Gorman, Williams and Fraser (2014), Figure 2. PLOS ONE.

<https://doi.org/10.1371/journal.pone.0090081.g002>

CC BY 4.0: <https://creativecommons.org/licenses/by/4.0/>

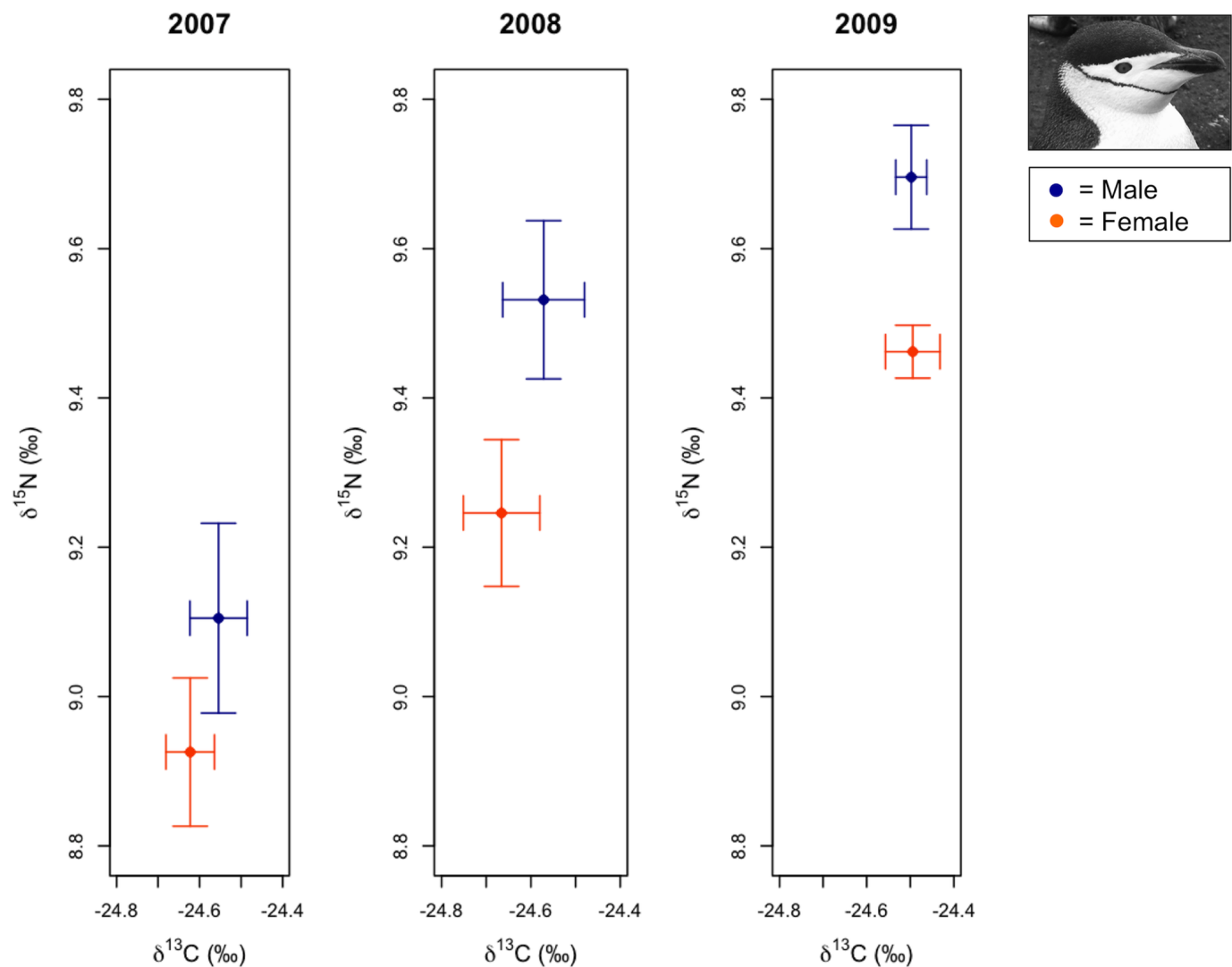
Use this page for items that name Research Figure 2. Numerical readings from bar heights are approximate.

SCIENTIFIC FIGURE REFERENCE

Research Figure 4

A multivariable uncertainty display

Each year has a panel. Horizontal position is the carbon isotope measure $\delta^{13}\text{C}$; vertical position is the nitrogen isotope measure $\delta^{15}\text{N}$. Both use per-mille units (‰). Colors distinguish the recorded male and female groups. Points are group means; horizontal and vertical bars show ± 1 standard error in their respective variables. The caption reports 53 analyzed chinstrap penguins in total.



Reproduced without alteration from Gorman, Williams and Fraser (2014), Figure 4. PLOS ONE.

<https://doi.org/10.1371/journal.pone.0090081.g004>

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Read approximate coordinates from the printed scales. These isotope variables are not columns in the simplified eight-variable CSV.

TEACHER MODEL

A question must fit the available evidence

The authentic file records species, body mass and flipper length. Construct a statistical question, choose a graph and state one limit of the conclusion.

Ask, “Within each recorded species, how are flipper length and body mass related?” The cases are individual recorded penguins. Use the 342 cases with both measurements, plot mass in grams against flipper length in millimeters, and distinguish species. Describe direction, strength, clusters and unusual observations. Do not turn a positive association into a claim that lengthening a flipper causes mass gain. Save the filter and usable count so another analyst can reproduce the display.

REUSABLE REASONING GUIDE

Represent, justify, interpret

Name: _____ Date: _____

Givens, quantities and restrictions**Representation and calculation****Justification or check****Conclusion, domain and units**

WARM-UP

Teaching script

Core: 001 • T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

Optional bank: M01–M04; O01–O04. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 5–8 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O01, including its graph when present. Invite a first independent response before discussion. Ask, “What do the symbols represent? What evidence supports your claim?”

Core task

A café manager says, “The queue is bad.” Write a statistical question that could guide a one-week investigation. Identify the cases, response variable, unit and source of expected variability.

Teacher solution and discussion

One valid question: “How do waiting times from joining the queue to ordering vary among customers arriving from noon to 1 p.m. on weekdays this week?” Cases are customer visits in that window; response is elapsed waiting time in minutes. Different arrival loads, staffing and order times create variability. This is descriptive unless a separate intervention design is used.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M01 to compare all alternatives after evidence is collected.

I DO

Teaching script

Core: 005 • T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

Optional bank: M05–M08; 005–008. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 10–12 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page 005, including its graph when present. Think aloud through the core task. Say, “I will identify the quantities first, then build a representation and check it against the stated domain.” Hide the worked key until after predictions.

Core task

Using only variables actually present in penguins.csv, write one statistical question involving a numerical response and two grouping or explanatory variables. State a plausible analysis plan and what variation it anticipates.

Teacher solution and discussion

Example: “Within each species, how does recorded body mass differ between the male and female groups?” Response: body_mass_g; grouping variables: species and sex. Filter rows with available values for those fields, report each group count, and compare side-by-side mass distributions within species. Variation is expected among individual birds even within the same group. The analysis is descriptive and does not establish that a group label causes mass.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M05 to compare all alternatives after evidence is collected.

WE DO

Teaching script

Core: 009 • T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

Optional bank: M09–M13; O09–O13. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 10–15 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O09, including its graph when present. Have learners propose the next step, then ask a partner to verify it using the original representation. Record more than one valid explanation.

Core task

A survey asks, “Do you use the park often?” Explain why this is hard to analyze consistently. Rewrite it into a statistical question and a corresponding neutral response item with a defined observation window.

Teacher solution and discussion

“Often” can mean different things to different people. A question could ask, “How does the number of days with at least one park visit during the past seven days vary among adult residents of the service area?” The response item could be, “During the past seven days, on how many days did you visit this park?” with responses 0 through 7 and an optional cannot-recall category. The operational definition is days visited, not total separate visits.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M09 to compare all alternatives after evidence is collected.

COLLABORATIVE PRACTICE

Teaching script

Core: O14 • T2: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Optional bank: M14–M18; O14–O18. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 15–20 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O14, including its graph when present. Assign reader, representer, checker and explainer roles. Each learner first makes a private prediction; compare reasoning and resolve differences with the data.

Core task

Compare two plans for surveying residents about transit: Plan S samples 10 residents randomly in every neighborhood; Plan C randomly chooses four neighborhoods and surveys all residents in those selected neighborhoods. Identify the designs and give one tradeoff for each.

Teacher solution and discussion

S is stratified sampling because each neighborhood contributes a random sample. It ensures neighborhood coverage but requires access to lists throughout the town. C is cluster sampling because whole randomly selected neighborhoods are surveyed. It may reduce travel costs, but residents within a neighborhood may be similar, limiting effective diversity. Neither plan guarantees freedom from nonresponse or a perfect estimate.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M14 to compare all alternatives after evidence is collected.

INDEPENDENT PRACTICE

Teaching script

Core: O19 • T3: NC.M4.SP.1.3 Use technology to organize a real data set with more than 200 cases and at least three measures; identify variables, outcomes, questions and summaries.

Optional bank: M19–M23; O19–O23. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 15–20 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O19, including its graph when present. Provide the printed task and neutral access supports. Preserve the first independent response; do not point to the requested answer or select a method for the learner.

Core task

Use technology to count male, female and unavailable sex classifications in penguins.csv. Calculate the female percentage among known classifications and among all recorded cases. State clearly what each percentage describes.

Teacher solution and discussion

Counts are male 168, female 165 and unavailable 11. Among known classifications, female percentage = $165/333 \times 100 \approx 49.55\%$. Among all 344 records, the fraction recorded female is $165/344 \times 100 \approx 47.97\%$. The second is not an estimate that the 11 unavailable cases are nonfemale; it only describes the recorded-category share.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M19 to compare all alternatives after evidence is collected.

SMALL-GROUP RETEACH

Teaching script

Core: O24 • T4: NC.M4.SP.1.4 Interpret nonstandard visualizations from scientific research, including linked panels and two-direction uncertainty bars.

Optional bank: M24–M27; O24–O27. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 10–15 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O24, including its graph when present. Start with the learner’s prior evidence. Rebuild one representation with explicit terms and operations, then use a fresh item to check transfer without the prior cue.

Core task

A reader says, “The male and female error bars overlap in Research Figure 4, so the populations are exactly the same.” Explain two problems with that interpretation and state a more careful visual conclusion.

Teacher solution and discussion

The bars are ± 1 standard error, not a predefined test of equality, and sample uncertainty does not establish exact population equality. Also, overlap must be interpreted for the relevant axis and year rather than as one blanket statement about both variables. A careful conclusion describes the plotted mean positions and their displayed uncertainty, reserving a formal difference claim for an appropriate analysis.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M24 to compare all alternatives after evidence is collected.

EXIT TICKET

Teaching script

Core: O28 • T4: NC.M4.SP.1.4 Interpret nonstandard visualizations from scientific research, including linked panels and two-direction uncertainty bars.

Optional bank: M28–M30; O28–O30. Select tasks across more than one meeting if needed.

Suggested discussion/work time: 5–8 minutes. Adjust for access and evidence; this is not a speed criterion.

Display student page O28, including its graph when present. Ask for a concise claim supported by the representation. Collect the response before sharing a solution; use it to choose the next instructional step.

Core task

Write an accessible text summary of Research Figure 4 for a reader who cannot see the image. Include the layout, variable encodings, groups, uncertainty meaning and one carefully limited trend. Do not claim the dots are individual birds.

Teacher solution and discussion

The figure has panels for 2007, 2008 and 2009. Each panel plots carbon-isotope group mean horizontally and nitrogen-isotope group mean vertically, both in per-mille units, for the recorded male and female groups. Horizontal and vertical bars show one standard error in each variable. The plotted nitrogen means rise across the three years for both groups. This describes the displayed sample summaries, not a causal effect or a guaranteed long-term trend.

Evidence and response

Ask what varies, who or what is observed, and how the data were obtained. Require a reproducible filter and denominator for every numerical summary. Distinguish random sampling from random assignment. For published figures, read the axes, grouping, units and uncertainty definition before stating a finding. Keep descriptions separate from causal claims.

Closure: Ask learners to state one feature they verified and one check they used. Use the worked key for M28 to compare all alternatives after evidence is collected.

MULTIPLE-CHOICE BANK

M01 / M02 • Select and justify**M01 | Warm-up | T1**

Which question anticipates variation and can guide a statistical investigation?

- A. How do waiting times vary among customers arriving at a café between noon and 1 p.m.?
- B. What is the café's posted closing time today?
- C. What is 12 multiplied by 5?
- D. What is the name printed above the entrance?

Reasoning: _____

M02 | Warm-up | T2

A library randomly selects 80 names from a complete current adult-member list and invites those people to a survey. What is the selection design?

- A. A simple random sample of members, before considering nonresponse
- B. A voluntary-response sample from an open website link
- C. Random assignment to treatments
- D. A census of all members

Reasoning: _____

WARM-UP

001 • Show your reasoning

T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

A café manager says, “The queue is bad.” Write a statistical question that could guide a one-week investigation. Identify the cases, response variable, unit and source of expected variability.

Representation / calculation

Explanation / check

WARM-UP

002 • Show your reasoning

T2: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Design a survey estimating adult library members' satisfaction with weekend hours. Specify the target population, sampling frame, random selection procedure, neutral question, response scale and handling of nonresponse. Do not collect identifying data for this exercise.

Representation / calculation

Explanation / check

WORKED TEACHER KEYS

M01 / M02

M01 • T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.

Answer: A. How do waiting times vary among customers arriving at a café between noon and 1 p.m.?

The waiting-time question specifies cases, a variable and a time window, and expects different responses.

Check each alternative

- A. Correct. The waiting-time question specifies cases, a variable and a time window, and expects different responses.
- B. This asks for a single fixed schedule fact rather than a distribution of responses.
- C. This is a calculation, not a question about variable observations.
- D. This seeks one fixed label rather than variation across cases.

M02 • T2: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Answer: A. A simple random sample of members, before considering nonresponse

Random selection from the frame is distinct from who later responds. Nonresponse can still affect the completed survey.

Check each alternative

- A. Correct. Random selection from the frame is distinct from who later responds. Nonresponse can still affect the completed survey.
- B. Selection was from a list, not self-enrollment through an unrestricted link.
- C. No treatments were assigned.
- D. Only 80 members were selected.

WORKED TEACHER KEYS

001 / 002**001 • T1: NC.M4.SP.1.1 Construct statistical questions with a population, measurable variables and anticipated variation.**

One valid question: “How do waiting times from joining the queue to ordering vary among customers arriving from noon to 1 p.m. on weekdays this week?” Cases are customer visits in that window; response is elapsed waiting time in minutes. Different arrival loads, staffing and order times create variability. This is descriptive unless a separate intervention design is used.

Full evidence: A measurable question, population/time scope, cases, units and anticipated variation. Partial credit: preserve and score a valid intermediate representation or justified step separately from the final accuracy.

002 • T2: NC.M4.SP.1.2 Design sample surveys and comparative experiments with appropriate sampling, assignment and analysis.

Target current adult members. Use the current membership roster, not only visitors already present on a weekend. Select a simple random sample with a random-number tool. Ask, “How satisfied are you with the current weekend opening hours?” with balanced 1 through 5 response choices and an unable-to-assess option. Use the same invitation and reminder procedure, report invited/responding counts, and examine available nonsensitive frame characteristics for nonresponse differences.

Full evidence: Coherent population/frame, reproducible selection, neutral instrument and disclosed nonresponse plan. Partial credit: preserve and score a valid intermediate representation or justified step separately from the final accuracy.