

Seawall or Sand Dunes? Arguing From Five Winters of Evidence

Learning target: I can write a claim, evidence and reasoning argument that evaluates two competing solutions for protecting a coastal town, using criteria that include keeping ecosystem services and biodiversity.

Claim, evidence, reasoning

About 50 min

Individual

MS-LS2-5 · assesses

MS-ETS1-2 · practice

writing

data analysis

Standards connections

MS-LS2-5 (assesses, evaluating competing design solutions with evidence against agreed criteria): Students evaluate two competing solutions (a concrete seawall and restored native dunes) against criteria that include maintaining ecosystem services (storm protection, a usable beach) and biodiversity (nesting shorebirds), which is the PE as written. The monitoring data are simulated teaching data.

MS-ETS1-2 (practice): Before writing the argument, students score both solutions against each criterion and the cost constraint in a table, a simple systematic comparison.

Purpose: practice · **Time:** about 50 minutes · **Format:** individual

Answers with reasoning

The scenario

Arena Point is a small, made-up town on the central California coast. A two-lane road, Shore Drive, runs along the back of the beach, with about forty homes and the town's only route to the hospital just inland. Winter storms had been washing sand and seawater across the road more often each year. In 2020 the town divided its 2-kilometer beach into two sections to test two solutions. On the North section, engineers built a concrete seawall along the edge of the road. On the South section, crews piled sand into a line of dunes, removed invasive European beachgrass, and planted native dune plants such as beach bur and beach sagewort. A coastal scientist measured both sections every spring for five years. The winter of 2021 to 2022 had the biggest storms of the test.

What the town council agreed on — Criteria: (1) Keep storm water off Shore Drive, with a goal of no more than 1 day per winter. (2) Keep a sandy beach at least 20 meters wide at mid-tide, for visitors and the town's surf and beach businesses. (3) Keep nesting habitat for western snowy plovers, a threatened shorebird that lays its eggs on open sand above the high-tide line. **Constraint:** the total cost over five years must not exceed \$3 million.

How each solution works — A seawall is a hard barrier. It stops waves from reaching what is behind it, but it cuts the beach off from the sand stored behind it, and waves that strike it can scour sand from its base. Over years the beach in front of a seawall often narrows, and with less beach to slow them, waves hit the wall harder and splash over more often. A dune is a store of sand held in place by plants. In a big storm, waves cut into the front of the dune and carry sand offshore, where it can build sandbars that make later waves break farther out. In calmer months, waves bring sand back, wind blows it into the dune, plant stems trap it and roots hold it. Young dune plants are small, so a new dune is weakest in its first years.

Arena Point spring monitoring, 2020-2025 (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Year	North (seawall): beach width (m)	South (dunes): beach width (m)	North: days with water on road	South: days with water on road	North: plover nests	South: plover nests
2020	35	35	-	-	4	4
2021	31	34	0	1	2	5
2022	26	32	0	2	1	7
2023	22	35	1	0	0	9
2024	18	34	2	1	0	10
2025	15	36	3	0	0	11

Simulated data for teaching. 2020 values were measured just after construction, before the first test winter. 'Days with water on the road' counts the days in the winter before each survey.

Five-year costs for each section (teaching dataset)

Simulated teaching dataset: the numbers are invented to be realistic, not measured.

Cost item	North (seawall)	South (dunes)
Building or planting	2.4	0.9
Repairs, replanting, fencing and added sand over five years	0.2	0.6
Total	2.6	1.5

Simulated costs for teaching, in millions of dollars.

Warm-up: organize the evidence

1. For each section, find the change in beach width from 2020 to 2025 in meters and as a percent of the 2020 width. Show the calculation.

Answer: North (seawall): $15 - 35 = -20$ m; $-20 \div 35 \times 100 = -57\%$ (the beach lost more than half its width).
South (dunes): $36 - 35 = +1$ m; $1 \div 35 \times 100 = +3\%$ (about the same, slightly wider).

Why: Percent change uses the 2020 width as the base.

Also acceptable: Accept -57.1% and $+2.9\%$.

2. Add up the days with water on the road over the five winters for each section. In which years did the seawall do better than the dunes, and in which years did the dunes do better?

Answer: North total = $0 + 0 + 1 + 2 + 3 = 6$ days. South total = $1 + 2 + 0 + 1 + 0 = 4$ days. The seawall did better in 2021 and 2022 (0 vs 1, 0 vs 2). The dunes did better in 2023, 2024 and 2025 (0 vs 1, 1 vs 2, 0 vs 3).

Why: The totals and the year-by-year pattern both matter: the seawall's performance gets worse over time while the dunes' gets better.

Also acceptable: None.

3. Rate each solution on each criterion and the constraint. Write one number from the data in each cell to back up your rating.

Answer: Criterion 1: North partly meets (met the 1-day goal in 2021 to 2023 but had 2 and 3 days in 2024 and 2025, getting worse); South mostly meets (missed only in 2022 with 2 days, then 0, 1, 0). Criterion 2: North does not meet by the end (18 m in 2024 and 15 m in 2025, below 20 m); South meets (32 to 36 m every year). Criterion 3: North does not meet (nests fell from 4 to 0 by 2023); South meets (nests rose from 4 to 11). Constraint: both meet (\$2.6 million and \$1.5 million, both under \$3 million).

Why: Each rating needs a supporting number. Criterion 1 is the one where the seawall has some real advantage.

Also acceptable: Accept 'meets' for the dunes on criterion 1 if the student explains the 2022 exception, and 'partly' for the seawall on criterion 2 if the student notes it met the goal for the first three years.

- Ratings consistent with the data
- A number backs each rating
- Recognizes both solutions meet the cost constraint

Your argument

Answer: Claim: The restored dunes better meet Arena Point's criteria, protecting the road about as well or better over five years while keeping the beach and the plovers' habitat. Evidence: The dune beach stayed between 32 and 36 m wide and ended 1 m wider than in 2020, while the beach in front of the seawall shrank from 35 m to 15 m (–57%), below the 20 m goal by 2024. Plover nests on the dune section rose from 4 to 11, while the seawall section had none from 2023 on. Over five winters the road flooded 4 days behind the dunes and 6 days behind the seawall, and the seawall's flooding rose each year (1, 2, 3 days from 2023 to 2025). Evidence for the other side: in the big-storm winter of 2022 the seawall kept the road dry while the dunes let water through on 2 days. The dunes also cost less (\$1.5 million vs \$2.6 million). Reasoning: A seawall holds the line but cuts the beach off from its sand supply and scours its base, so the beach in front shrinks; with less beach to absorb wave energy, waves hit the wall harder and overtop it more often, which explains the rising flood days. Dunes are a living store of sand: in the 2022 storms waves took sand from the dune (beach width dipped to 32 m), but calmer months, wind and growing plants rebuilt it (35 m in 2023). The dunes were weakest in the first years because the plants were young and had not yet trapped much sand. The 2022 result shows the seawall is stronger in a single big storm while new, but the five-year trend shows the dunes getting stronger and the seawall getting weaker, and only the dunes keep the beach and plover habitat that the criteria require.

Why: A full-credit argument makes a clear claim, uses at least three numeric pieces of evidence including one counter-piece, and explains the trends with the mechanisms in the box.

Also acceptable: A student may claim the seawall is better only if the argument is grounded in criterion 1 for the early years and honestly addresses the beach-width and plover evidence; such answers can reach level 3 on evidence and reasoning but should lose credit on claim accuracy if they ignore criteria 2 and 3. A combined solution (dunes with a buried barrier) is a strong level-4 answer if supported.

- Claim names a solution and links it to the criteria, services and biodiversity
- Three or more pieces of evidence with years and values
- At least one piece of evidence favoring the other solution
- Reasoning explains beach loss at the seawall and dune recovery using the mechanisms
- Explains the weak early dune results (young plants, storm year)

After the argument

4. At a council meeting the mayor says, 'In the big storms of 2022 the seawall kept the road dry and the dunes let the water through twice. Case closed.' Use the data and the box to respond respectfully.

Answer: Example: 'You're right that the seawall did better in the 2022 storms, when the new dunes let water through on 2 days. But the dunes were only two years old then. After that, the dunes had 0, 1 and 0 days while the seawall had 1, 2 and 3, and the seawall's beach shrank to 15 m. One storm year is not the whole story; over five winters the dunes flooded less and are getting stronger.'

Why: A good response accepts the true part of the mayor's point and uses the trend to answer it.

Also acceptable: Accept responses that propose combining the solutions if supported by data.

- Acknowledges the 2022 result
- Uses later years or totals as counter-evidence
- Explains why the early dunes were weaker or why one year is not enough

5. Name one limitation of this evidence (think about the length of the test, the two sections or the storms) and one more piece of data that would make you more confident in your claim.

Answer: Limitations: five years is short compared with the life of a seawall or dune; there was only one section of each, so differences in the shape of the coast, currents or sand supply between North and South could explain some results; each winter had different storms. More data: several more years of monitoring; a third section with no protection as a comparison; measurements of wave height and sand supply in both sections; results from other towns that tried each solution.

Why: Recognizing limits of evidence is part of evaluating solutions honestly.

Also acceptable: Accept 'the data are simulated' only if the student also names a limitation of the study design.

- One real limitation
- One specific additional piece of data that addresses a limitation

6. Name one ecosystem service, other than protection from storms, that the dunes provide and the seawall does not. Which category of service is it?

Answer: Examples: habitat for plovers and other wildlife, which maintains biodiversity (supporting, or habitat); a wide beach for recreation and surfing (cultural); a store of sand that rebuilds the beach (regulating, erosion control); native plants for pollinating insects.

Why: The dunes provide services beyond storm protection that the seawall does not.

Also acceptable: Accept 'habitat' as supporting or as biodiversity.

- A service other than storm protection
- A sensible category with a reason

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	Clear claim naming one solution (or a supported combination) and linking it to the criteria, ecosystem services and biodiversity.	Clear claim naming a solution, linked to the criteria but not to services or biodiversity.	A claim that names a solution without any link to the criteria, or a vague claim ('both are good').	No claim, or a claim unrelated to the scenario.
Evidence	Three or more specific pieces with years and values, including at least one piece that favors the other solution.	Three pieces with numbers, but no evidence for the other side.	One or two pieces, or evidence described without numbers.	Evidence missing, invented or contradicting the tables.
Reasoning	Explains the trend in both sections with the seawall and dune mechanisms, explains the weak early dune results, and explains why the counter-evidence does not overturn the claim.	Explains the trends with the mechanisms but omits the early-years explanation or the counter-evidence.	Restates the evidence without explaining why it happened.	No reasoning, or reasoning that contradicts the box.
Weighing trade-offs and accuracy	Weighs all three criteria and the constraint, distinguishes a single year from a trend, and makes no scientific errors.	Weighs most criteria; one minor error or one criterion ignored.	Judges on one criterion only, or confuses a single year with the trend.	No weighing of criteria; several errors.

Teacher notes

Arena Point and all its numbers are invented; the mechanisms are real. Seawalls fix the shoreline in place and beaches in front of them commonly narrow over time (coastal squeeze and scour at the base), while dunes erode in big storms and rebuild in calmer seasons. The textbook says coastal ecosystems 'absorb water'; the more accurate idea, used here, is that dunes and marshes act as barriers that take up wave energy, slow water and store sand. California dune restoration typically removes invasive European beachgrass, which was once planted to hold sand but builds steep, unnatural foredunes and crowds out native plants, and replants natives such as beach bur, beach sagewort and, on the northern and central coast, American dunegrass; the lesson's general advice to plant beach grass should be read with that in mind. Western snowy plovers (Pacific coast population) are federally listed as threatened and nest on open sand. Expect some students to claim the seawall wins because of 2022; q4 and the rubric's trade-off row address that.

Scaffold offered to students: Sentence frames for the argument

Claim: 'The ___ solution better meets the town's criteria because it ___ while also ___.' Evidence: 'From 2020 to 2025, the beach in front of the ___ changed from ___ m to ___ m.' 'In ___, the ___ had ___ days with water on the road.' 'One result that favors the other solution is ___.' Reasoning: 'This happened because a ___ ___. The early results were weaker because ___. Even though ___, the trend shows ___.'

Extension: Plan the next ten years

Sea level along the California coast is expected to keep rising over the coming decades, so storm waves will reach farther inland. Write a ten-year plan for Arena Point that uses what you learned. You may combine solutions (for example, dunes in front of a buried rock barrier, or moving part of Shore Drive inland). For each part of your plan, say which criterion it serves, what it would cost relative to the test sections, and what the town should measure each spring to know whether the plan is still working.