

Case File: Two Kelp Coves, One Heat Wave

Investigation question: Two fictional kelp coves on the California coast went through the same sea star die-off and the same marine heat wave. Why did one keep its forest and most of its species while the other became an urchin barren?

Evidence-based mystery

Groups of 4

1 session

Setup 5 · Activity 50 · Cleanup 5 min

MS-LS2-4 · practice

MS-LS2-5 · supports

Name _____

Group _____

Date _____

Your role today

- ☐ **Case lead:** Runs the suspect table, keeps the group on one suspect at a time, and makes sure every verdict has a written reason.
- ☐ **Data analyst:** Computes richness totals, percent change and urchin increase, and reads numbers from the datasets when the group needs them.
- ☐ **Clue reader:** Reads each clue card aloud and asks the group whether it supports, rules out or says nothing about each suspect.
- ☐ **Chain builder:** Draws the causal chain for Driftwood Cove and checks that every arrow is backed by data or a clue.

Safety

- Paper-based activity with no physical hazards; if students cut their own cards, use classroom scissors at their desks.
- Keep the case clearly fictional: the coves and every number are invented teaching data, so students should not quote them as facts about real California places.

Procedure

1. Read the case introduction and both cove datasets. In q1, write your first hunch about the biggest difference between the coves by 2018.
2. Data analyst totals the species for each cove and year in the totals table and computes the percent change from 2012 to 2018 for each cove (q2). The others check the arithmetic.
3. Data analyst computes how many times purple urchin density grew at each cove from 2012 to its highest survey value (q3). Highlight in one color every change that happened at both coves and in the other color every change that happened at only one.
4. Open Round 1 (clue cards 1-4). The Clue reader reads each card aloud; the group decides which suspects it supports and which it rules out or weakens, and records the card number in the suspect table.

- Open Round 2 (cards 5-8) and repeat. Rule a suspect out if its timing is wrong or if it cannot explain why only one cove collapsed.
- Give every suspect a verdict: needed to explain the difference, contributed but cannot explain the difference, or ruled out. Each verdict needs one written reason.
- Chain builder draws the causal chain for Driftwood Cove from the first stressors to the loss of species, labeling each arrow with its evidence, and adds a box showing what was different at Lupine Cove.
- Answer q4 as a group. Then answer the analysis questions individually.

Record your observations

Lab 2 case file: Two Kelp Coves, One Heat Wave

Lupine Cove and Driftwood Cove are **fictional** rocky coves on the California coast, and every number in this file is a **teaching dataset** patterned on real events. Divers surveyed the same underwater transects at both coves every two years from 2012. By 2018, Driftwood Cove's kelp forest was nearly gone and the rock was carpeted with purple sea urchins, a habitat called an **urchin barren**. Lupine Cove still had a forest. Your team must work out why, using the data and the clue cards.

Lupine Cove survey data

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

Year	Kelp canopy (% of area)	Purple urchins per m ²	Sunflower sea stars per 100 m ²	Sea otters seen per km of shore	Red abalone per 100 m ²	Summer water above normal (°C)
2012	55	2.0	3.0	6	3	0.0
2014	50	2.5	0.5	6	3	1.0
2016	34	6.0	0	7	2	2.5
2018	46	3.5	0	7	2	0.5

Teaching dataset for a fictional cove. Kelp canopy is the share of the survey area covered by kelp at the surface.

Driftwood Cove survey data

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

Year	Kelp canopy (% of area)	Purple urchins per m ²	Sunflower sea stars per 100 m ²	Sea otters seen per km of shore	Red abalone per 100 m ²	Summer water above normal (°C)
2012	60	1.0	3.5	0	40	0.0
2014	52	1.5	0.5	0	38	1.0
2016	6	32	0	0	20	2.5
2018	3	48	0	0	7	0.5

Teaching dataset for a fictional cove, surveyed with the same method as Lupine Cove.

Species richness on the survey transects

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

Cove and year	Fish species	Invertebrate species (not counting urchins)	Seaweed species (including kelp)
Lupine 2012	18	26	14
Lupine 2014	18	25	13
Lupine 2016	16	23	11
Lupine 2018	17	24	12
Driftwood 2012	17	25	15
Driftwood 2014	16	24	13
Driftwood 2016	10	15	6
Driftwood 2018	8	12	4

Number of different species recorded on the same transects in each survey (teaching dataset).

Total species and change

Cove	2012 total	2014 total	2016 total	2018 total	Change 2012 to 2018 (%)
Lupine Cove					
Driftwood Cove					

1. First hunch: from the two cove datasets alone, what is the biggest difference between the coves by 2018, and what do you think caused it?

2. Compute the percent change in total species from 2012 to 2018 for each cove. Show the calculation.

3. How many times larger was the purple urchin density at its highest survey value than in 2012, at each cove? Show the calculation.

Clue cards (Round 1: cards 1-4; Round 2: cards 5-8)

1 Clue 1. Water temperature log

Summer water at both coves ran 1 to 2.5 °C above normal from 2014 to 2016. Warm surface water along this coast carries fewer nutrients, and divers at both coves reported thinner, shorter kelp in the hottest summer.

2 Clue 2. Sea star die-off

A wasting disease spread along the Pacific coast starting in 2013. Sunflower sea stars at both coves developed sores and fell apart; after 2015 none were seen at either cove. Sunflower sea stars are fast-moving predators that eat purple urchins.

3 Clue 3. Diver's notebook, Driftwood Cove, 2015

The purple urchins have left their cracks. They are crawling across open rock in dense fronts, chewing through kelp stalks near the bottom so whole plants break loose and drift away. Behind the front there is only bare rock and urchins.

4 Clue 4. Otter watch, Lupine Cove

Volunteers recorded what sea otters brought up from their dives. In 2012 about 1 in 10 prey items was a purple urchin; in 2016 about 4 in 10 were. Most were plump urchins taken at the edges of the remaining kelp; otters mostly ignored the thin, starved urchins on bare rock. (Teaching data.)

5 Clue 5. Abalone condition report, 2017

Many red abalone at Driftwood Cove had shrunken bodies and were losing their grip on the rock, and empty shells were common. Abalone feed mainly on drifting pieces of kelp. At Lupine Cove the few abalone found were tucked deep in cracks and looked well fed.

6 Clue 6. Harvest records

Recreational divers took about the same number of red abalone from Driftwood Cove each year from 2008 to 2017, including the years when the forest was healthy; none were taken in 2018 after the fishery closed. No one harvests abalone at Lupine Cove, where they are scarce and hidden in cracks.

7 Clue 7. Creek water tests

A small creek enters the sea between the two coves. Monthly tests from 2012 to 2018 showed no change in mud, nutrients or chemical pollutants, and the creek's plume reaches both coves about equally.

8 Clue 8. Young kelp and a fenced plot

Each spring, young kelp appeared on the rock at both coves. At Lupine Cove many grew into adult kelp by late summer. At Driftwood Cove, young kelp vanished within weeks wherever urchins were present, but grew tall inside a small mesh-fenced test plot that kept urchins out, even in the warm year of 2016.

Suspect table

Suspect	Clues and data that support it	Clues and data that rule it out or weaken it	Verdict (needed / contributed / ruled out)
S1. The heat wave killed the kelp.			
S2. The sea star die-off let the urchins take over.			
S3. Driftwood Cove had no sea otters to eat urchins.			
S4. Abalone divers overharvested and damaged the forest.			
S5. Pollution from the creek.			

-  Causal chain for Driftwood Cove: start with the stressors and end with the loss of species. Write the evidence (a data value or clue number) on every arrow. Add a box showing what was different at Lupine Cove and where it breaks the chain.

4. Group explanation: which suspects were needed to explain the collapse, and why did only Driftwood Cove become an urchin barren? Use at least three numbers or clues.

Analysis questions

5. Why is Lupine Cove so useful to this investigation? Explain how having a comparison site let you rule suspects in or out.

6. Lupine Cove had far fewer red abalone than Driftwood Cove even in 2012. Use the clue cards to explain why. Does this mean sea otters are bad for the kelp forest ecosystem? Explain.

7. Sea otters are far less numerous than urchins at Lupine Cove. Use the data to explain why the otter still counts as a keystone species.

8. Which single condition would most likely have protected Driftwood Cove's forest, and what is your strongest piece of evidence? Give one reason your answer could still be wrong.

9. Use the richness table to explain how the kelp collapse spread from a few species to the whole community, and why kelp-forest biodiversity is a useful measure of the cove's health.

- 10.** This case is fictional but patterned on real events. What can a case like this teach you, and what can it not prove?
