Chalk, Coral, and an Acid Ocean Lab: NYSSLS Alignment

Teacher guide for the student worksheet at mrsajdak.com/acidocean (two pages, 16 questions; a low-write version has the same numbering). Environmental Science, Chapter 6 Case Study: The Importance of Coral Reefs (SE p. 160), with Lesson 6.3. Plan-book objective ES.2.6.3: use the chapter case study to frame a question about climate and ecosystems. It is the virtual version of the hands-on day, "Test Your Own Question": Tab 1 is the chalk-in-acid test with the same four menu questions, Tab 2 is the real Hawaii record the lesson reads, and Tab 3 is where students frame and test their own question.

Objectives

The three statements printed at the top of the worksheet, each with a box to tick.

I can	Questions
run a fair test: one change, one measurement, the rest kept the same.	1 to 4, 6
use real ocean data to explain how CO2 is changing seawater.	7 to 11
turn a question about reefs and climate into a testable question and test it in a model.	12 to 16

Performance expectations

The district unit doc lists these for Chapter 6, and the lesson plan cites both. The lab gives evidence toward them; it does not fully assess either.

> **HS-ESS2-5**
> *"Plan and conduct an investigation of the properties of water and its effects on earth materials and surface processes."* Worksheet link: Part 1 is a planned fair test of how acidic water dissolves calcium carbonate (Q1 to Q4, Q6); Part 2 shows seawater taking up CO2 and its pH falling.

> **HS-ESS2-7**
> *"Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth."* Worksheet link: Q11 and Q16 argue from real and model evidence about how a changing ocean affects whether a reef can keep building.

DCI ESS2.D Weather and Climate: *"Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate."* DCI LS2.C Ecosystem Dynamics, Functioning, and Resilience (the reef as an ecosystem that persists only while building outpaces breakdown).

Opening: pick a phenomenon

The slideshow opens with a menu. Pick one opener per class, or run two back to back. All three end at the same Observe, Wonder, Predict slide and the driving question, *"Can a more acidic ocean hurt a coral reef?"*, and the revisit at the end works with any of them.

Option	What happens
A. Video A Coral Grows, 1 to 3 min	1. "Time lapse of staghorn hard coral growing, close up of polyps", Peter Kragh, 0:00 to 0:42 (youtube.com/watch?v=dU6KmDP0qhw); 2. "The awakening of the coral", Meerwasser Aquaristik Kanal, 0:00 to 1:30 (youtube.com/watch?v=h-REE6AsC2o). Both embed (checked). Mute the sound. Watch for: is a coral a rock, a plant or an animal; what is changing at the branch tips; what is it building with. Preview both first: they were chosen by title and length.
B. Try it Breath Makes Acid, 4 min	About 100 mL of water with 3 to 5 drops of bromothymol blue (blue). One student, goggles on, blows out through a straw for about 2 minutes; call the color at 1 and 2 minutes (green, then yellow). Never sip; BTB stains, wipe spills. This is the plan's Engage demo.

C. Photos One Shell, 45 Days, 3 min	The same pteropod shell at the start and 45 days later, in seawater adjusted to the chemistry projected for 2100 (NOAA, public domain). A quiet minute to look, then Observe, Wonder, Predict.

Part by part

Part	Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts	What students do
1. The chalk test Q1 to 6	SEP 3 Planning and carrying out investigations SEP 5 Using mathematics (% lost)	ESS2.C (water and earth materials)	Cause and Effect	Explore Q1 to 3: pick menu question A to D (vinegar strength, temperature, crushed chalk, seltzer), check that only one thing changes, soak 10 minutes, copy before, after, lost and % lost, then soak chalk in seawater (0.0%). Learn It 1: coral as an animal with a calcium carbonate skeleton, acid and CO2 bubbles, independent and dependent variable and control, seawater is basic. Apply Q4 to 6.
2. The ocean near Hawaii Q7 to 11	SEP 4 Analyzing and interpreting data SEP 7 Engaging in argument from evidence	ESS2.D; ESS3.C (human impacts)	Stability and Change; Scale, Proportion, and Quantity	Explore Q7 and 8: record 1990, 2024 and a year of their own from 35 years of real Station ALOHA data (air CO2, seawater CO2, pH, aragonite saturation as "building material"), and describe the bumpy but one-way pattern. Learn It 2: ocean acidification, the pH scale (about 20% more acidic since 1990; vinegar about 400,000 times), carbonate as the building block, slow steady change. Apply Q9 to 11.
3. Test a reef question Q12 to 15	SEP 1 Asking questions SEP 3 Planning investigations SEP 2 Developing and using models	LS2.C; ESS2.D	Cause and Effect	Explore Q12 and 13: build a testable question from three boxes (a change the model cannot test is refused, with the reason), set three tanks under different air (280, 354, 425, 538 or 936 ppm), tick a control and run one year. Learn It 3: a testable question, what the model does, the One Tree Reef test (about 34% less), slow change adds up. Apply Q14 (model check) and Q15 (model against a real reef).
Wrap it up Q16	SEP 7 Engaging in argument from evidence	ESS2.D; LS2.C	Stability and Change	Argue against "the chalk in seawater lost nothing, so CO2 is harmless to reefs" with one real number and one model number.

Also in play

- **Explore, then explain, then apply:** each part opens with data questions; a READ FIRST line sends students to the green Learn It box, which opens once they have the data (Tab 1: a fair-test soak and a seawater soak; Tab 2: 1990 and 2024 recorded and all three graphs viewed; Tab 3: a testable question built and three tanks run).
- **The district section and what is added:** the BPS Unit 2 doc lists for the Case Study the Science Talk "Ideas about Coral Reefs", Interpret Visuals "Effect of Dead Coral", Connect to the Case Study and Read With Purpose. This lab is an addition, built on Lesson 6.3's acidification checkpoint and design-an-experiment item, as the hands-on chalk test is.

- **With the hands-on day:** use Tab 1 after the real chalk test as a check, or in its place when there are no supplies, for absent students and for make-up work. The model was set to match the plan's expected class results (full-strength vinegar about 5% in 10 minutes; warm about half again more; seltzer under 1%).
- **Misconceptions:** "chalk in seawater (or seltzer) lost nothing, so acidification is harmless" (Q11, Q16: the harm is building less, not dissolving); "the ocean is turning into vinegar" (Q9: pH 8.0 against 2.5); changing two things at once (Q6; the lab's green and red fair-test box).
- **Nature of models:** Tab 1 rates are a model calibrated to classroom chalk, not measurements. Tab 3 chemistry is the standard seawater carbonate system (it reproduces Station ALOHA's pH within 0.01); the growth rule is an average from many lab experiments with a wide spread, measured between building material 2 and 4, so 936 ppm (1.84) is an extrapolation. The model leaves out heat and bleaching, light, food and the reef community, and its tank water matches its air exactly, which the real sea near Hawaii does not (Q14, Q15).
- **Builds on:** the Explorers at Work lesson (heat waves and bleaching). **Leads into:** Lesson 6.1 and later 6.3 on ocean chemistry.

Standards text quoted from the New York State P-12 Science Learning Standards (NYSED). Data: NOAA Global Monitoring Laboratory, Mauna Loa annual mean CO2 (co2_annmean_mlo.csv); Hawaii Ocean Time-series surface CO2 system data product (HOT_surface_CO2.txt, J.E. Dore, University of Hawaii, updated 1 January 2026), yearly means of pCO2calc_insitu, pHcalc_insitu and aragsatcalc_insitu; Dore, J.E., Lukas, R., Sadler, D.W., Church, M.J. and Karl, D.M. (2009), Physical and biogeochemical modulation of ocean acidification in the central North Pacific, PNAS 106: 12235-12240. Chemistry: Weiss (1974) Marine Chemistry 2: 203; Lueker, Dickson and Keeling (2000) Marine Chemistry 70: 105; Dickson (1990) Deep-Sea Research 37: 755; Millero (1995) Geochimica et Cosmochimica Acta 59: 661; Mucci (1983) American Journal of Science 283: 780. Growth rule: Chan, N.C.S. and Connolly, S.R. (2013), Sensitivity of coral calcification to ocean acidification: a meta-analysis, Global Change Biology 19: 282-290. Real reef: Albright, R. and others (2018), Carbon dioxide addition to coral reef waters suppresses net community calcification, Nature 555: 516-519. Future air: IPCC AR5 concentration pathways for 2100, RCP4.5 538 ppm and RCP8.5 936 ppm (NASA Scientific Visualization Studio). Ocean uptake about a third of CO2 and pH: NOAA Ocean Acidification Program and NOAA Education. Photos via Wikimedia Commons: NOAA EVL pteropod (public domain), Muminur Rahman coral skeleton (CC BY-SA 4.0), ESA Sentinel-2 One Tree Reef (CC BY-SA 3.0 IGO), U.S. Navy Kilo Moana (public domain), and others credited on each slide. The answer key is a separate teacher file, kept off the public site.