Kelp Forest Coevolution: Lesson 4 Teacher Guide & Student Materials
Evaluate

Objective(s):
- Students can predict how climate change might affect kelp forests and evaluate public officials' statements on the topic

Teacher Guide:

[5 minutes] Bellringer: What do you think will happen to kelp if the climate changes? Explain:
Students answer Bellringer question on the handout (first row) or in a notebook.
Teacher can ask for volunteers or cold-call to share answers.

[45 minutes] Kelp in a Changing Climate
Students research how <u>kelp forests</u> might be affected by climate change. The rubric and requirements are on the following page.
Teacher can present the following implications of climate change and increasing atmospheric CO_2 levels for students to choose from:

- **Decreasing ocean oxygen**
  This was discussed in the opening article to this lesson cycle, which students should revisit if they choose this topic. Watch out for misconceptions including that decreasing oxygen will reduce kelp growth OR help kelp growth
  Here is a peer-reviewed scientific article that looks at two species' performance in acute and chronic exposure to low-dissolved-oxygen water in California kelp forests:
  https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.16125
  Here is a peer-reviewed scientific article that looks at four fish species' responses to low-dissolved-oxygen conditions (note these are quite low compared to oceanic levels):
  https://onlinelibrary.wiley.com/doi/abs/10.1111/gcb.15076

- **Increasing ocean temperature** (both average temperature *and* increasing frequency/severity of marine heatwaves)
  This has not been discussed explicitly within the unit so students will be doing more research into this. Watch out for misconceptions including that the ocean is now "hot" (kelp forests are temperate and average temperatures in, for example, California kelp forests are 10-20°C) and that individual heatwaves won't have much impact since they are typically "short."
  Here is a great general introduction video: https://www.youtube.com/watch?v=9bcbNfpu5lg
  Here is a video that's specifically about kelp forests: https://www.youtube.com/watch?v=1jQH6ZG11zU
  Here is a peer-reviewed scientific article on how heatwaves turn kelp forests into urchin barrens: https://www.nature.com/articles/s41598-019-51114-y

- **Decreasing ocean pH (ocean acidification)**
  This is the most difficult topic, as students will need some chemistry knowledge and will have to understand a confusing process. Watch out for misconceptions including that more acidic = a higher pH (it's a lower pH!), and that the greater acidity will "melt" shells or "burn" organisms.
  Here is a great general introduction video: https://www.youtube.com/watch?v=Qdj6z5my58U
  Here is a video that goes into the chemistry: https://www.youtube.com/watch?v=fgBozLCGUHY
  Here is a peer-reviewed scientific source which makes predictions about the effects of ocean acidification on kelp forests: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0236218

Kelp in a Changing Climate Project Instructions

Name: _____

Date: _____ Period: _____

Research Project Instructions

In this project, you will summarize what you have learned about the kelp forest so far in this unit, explain ONE change that the ocean is currently undergoing due to increasing atmospheric CO_2 levels, then predict how that change will impact organisms in the kelp forest. Three possible changes you could choose to focus on are:
- Decreasing ocean oxygen
- Increasing ocean temperature (average *and* increasing frequency/severity of marine heatwaves)
- Decreasing ocean pH = ocean acidification

<u>What to Include</u>
- ☐ Summarize the unique features of the kelp forest ecosystem including keystone and foundation species.
- ☐ Summarize the conditions kelp forests are evolved in, including reference to evidence/sources used in class thus far
- ☐ An explanation of what is changing in the ocean and why
- ☐ Evidence about this change (e.g. a graph of ocean temperatures in an example kelp forest, etc)
- ☐ A prediction of how this will affect <u>at least 3 organisms</u> in the kelp forest. Be specific as to how/why each organism will be affected (e.g. kelp populations will increase because…)
- ☐ Evidence to support your predictions for EACH of the 3 organisms
- ☐ CITATIONS for each piece of evidence. These could be links or APA-style (ask your teacher)

You SHOULD include at least some relevant graphs/data (if doing a podcast, you can verbally explain and say the source information).

<u>Format Options</u>
- ☐ Physical poster
- ☐ Digital poster / flier
- ☐ Picture book
- ☐ Slide presentation / Prezi
- ☐ Podcast
- ☐ Choose your own - CONFIRM permission before starting

Research Project Grading Rubric

	4 - Advanced	3 - Proficient	2 - Basic	1 - Minimal	0 - Not present
Style and formatting	Excellent, detailed, and professionally presented with very few style errors	Detailed and professionally presented with some style errors	Clearly presented with significant style errors	Presented chaotically with major style errors	Poorly and confusingly presented
Informational content	Information is exceptionally well researched and organized and insightfully addresses topic	Information is thoroughly researched, well organized, and directly relevant to topic	Information is somewhat researched, with some lack of organization or relevance	Information is poorly researched and/or organized, with some relevance	Information does not address topic
Scientific predictions	Scientific predictions are detailed, reasonable, and include robust evidence in support	Scientific predictions are reasonable and include some evidence in support	Scientific predictions are reasonable but have no evidence to support	Scientific predictions are not reasonable	No predictions are present
Citation of evidence	Sources are appropriate and fully cited, and include peer-reviewed scientific article(s)	Sources are appropriate and fully cited	Sources are mostly appropriate and mostly cited	Sources are inappropriate and/or poorly cited	No sources are cited