Shellfish and Climate Change Research

How students can act as an effective bridge between science and society in carrying out research

by **Francisco Sóñora Luna** and **Aitor Alonso Méndez**

ANTHROPOGENIC CLIMATE change is one of the greatest challenges facing the world today. For this reason, it is essential to make citizens aware of its urgency, following the premise of "think globally, act locally." Secondary school can act as an effective bridge between science and a local community, so why not carry out field experiences where students can research the local effects of climate change, and then disseminate their conclusions? Following this target, we at *Climántica* have developed a school-based research project in a shellfish bank in Testal, Galicia, Spain, involving a total of 70 students aged 13 to 17 years old. This shellfish bank is an ideal study site as it has a rich congregation of the common cockle (*Cerastoderma edule*). This species is commercially harvested here, meaning that it has both ecological and economic significance in the area. Other mollusk species are also ecologically and economically significant in various parts of Europe, Asia, and America, so similar studies can be carried out at many locations.

Below, we have outlined the steps of our study in Testal with hopes that you can replicate a similar study in your region.

Background

In class on the day prior to carrying out data collection in the shellfish bank, students were instructed on the proposed research method, the biology of the focus animal, and how to use the materials needed to conduct the field work.

Research method

The selected methodology for this type of research is transect sampling, and for this, it is necessary to divide the study area. In this project, we divided into two sections: the *infralittoral* and the low *mesolittoral* (Image 1; see glossary on page 18 for definitions).

Common cockle biology

Cerastoderma edule is a bivalve mollusk with a high reproductive capacity, and it lives in areas visibly affected by tides. Fertilization takes place in the *water column*, and after embryonic development, a free-swimming larva hatches.

Image 1. *The two sections of the study area: infralittoral and low mesolittoral*

After about a month, the larva will fix itself in the sediment of the mesolittoral where it becomes a "*spat*." After fixation and metamorphosis, the spat becomes a juvenile. The process whereby larvae survive settling (fixing to sediment), metamorphosis, and early post-settling mortality is known as *recruitment*, so remaining cockles are known as recruits. This reproductive process takes place between March and July/August, so the first recruits may appear at the end of March.

Materials

The necessary materials for this field study are simple and low-cost. Many are readily found in most schools or education centers. You will require the following: measuring tapes (100 m), wooden stakes, rope, vegetable paper, pencils, calipers, sieves, and rigid boards.

Students can bring the following materials from home: cameras, mobile phones (to obtain GPS coordinates), plastic shovels, and rubber boots.

Connections to climate change

During the previous class, it is important to introduce climate change-related factors which can affect the common cockle. These include ocean acidification and stratification, the reduction of the upwelling period, and the formation of anoxic zones as a consequence of an increase in nutrients, which tends to promote the proliferation of phytoplankton. The main implications of these consequences of climate change on the common cockle are a reduction of the cockle's calcification rate due to acidification, reduced cockle recruitment, changes in growing patterns due to the rise in temperature, and an increase in the frequency and duration of harmful red tides.

Many of these concepts have not been incorporated into the syllabus yet, but their relevance to the common cockle on a local level (as well as to the broader discussion of climate change) make them effective lenses through which students can, from a young age, take control of the concepts, procedures, and attitudes necessary to engage scientifically with the impacts of climate change.

Formulation of the Hypothesis

To situate the students in the context of the scientific method, we presented the intentionally false hypothesis that the cockles are distributed evenly in the shellfish banks regardless of their size and location (infralittoral or low mesolittoral). By using a hypothesis that counters the expected results, students are encouraged to reformulate the hypothesis at the end of the project in order to reflect their research findings.

Field Work

To verify the initial hypothesis, it was necessary to observe the distribution of the different sizes of cockles embedded in the substrate of the infralittoral and low mesolittoral zones in an intertidal shellfish bank. For this, students spent five hours in the shellfish bank divided in 20 groups of three or four students each.

Once on the beach, we extended two metric tapes parallel to the coastline, one in the low mesolittoral and another in the infralittoral. At the beginning of each 25-metre transect, we marked a sampling point with a wooden stake, and recorded its coordinates using a mobile phone or GPS.

Each sampling point of 25 cm x 25 cm was marked with a rope. Here, students collected sand to a depth of five centimeters, and placed it in plastic buckets conveniently marked

Transect	Sampling point Nº	Obtained data
INFRALITTORAL or LOW MESOLITTORAL		**Spats:** equal to or less than 4 mm **Nº:**
		Juveniles group 1: from 5 to 10 mm **Nº:**
		Juveniles group 2: from 11 to 16 mm **Nº:**
		Juveniles group 3: from 17 to 20 mm **Nº:**
		Adults: larger than 20 mm **Nº:**

Table 1. *Table used to write down the data and the results*

with a pencil on tracing paper, which was useful given the rainy weather that day (Image 2).

Students then carried their buckets to the seashore where the content was sifted through a series of meshes — each with different-sized openings — using seawater to eliminate the sediments. After this, the shells were removed so that only live mollusks were left.

Once sifted, students placed individual mollusks into labelled clear bags, indicating the transect and the sampling point, before measuring the maximum length of each individual cockle using a gauge. These data were transcribed onto a record sheet.

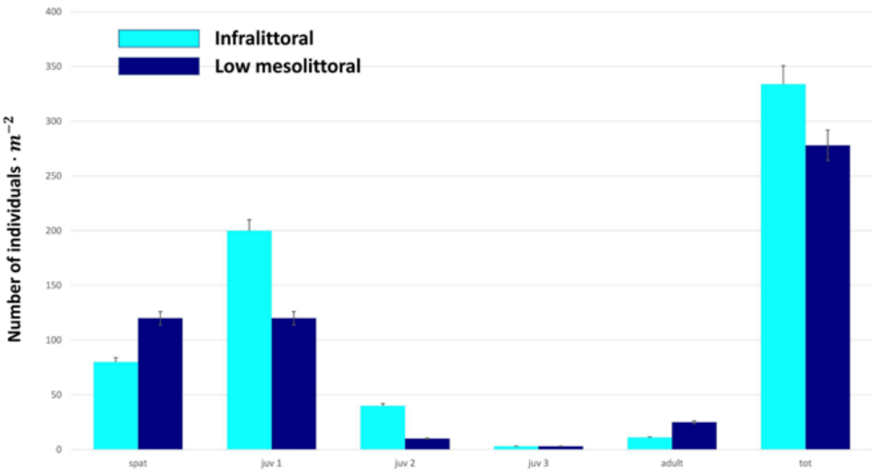
Data Analysis

Once the field work was over, the students went to the computer room at school to input the obtained data into a collaborative Excel document. Each school or education center can obtain these collaborative tools for free from Google, included in their G suite for education, which includes collaborative documents, presentations, and class management tools, among other programs.

Each group ended up with two data tables, one for the infralittoral zone and another one for the low mesolittoral zone. In each table (Table 1, above), the common cockles were classified according to their size in five categories.

With data from the Excel file, we represented the results in a simple graph which the *Ecocoast Project* (from the Coastal Research Group of the Department of Ecology of the University of Vigo) uses to express their data. Graph 1 represents the graphic model that is used to show the abundance of the different size classes in the two zones: infralittoral (light blue) and low mesolittoral (dark blue).

Image 2. *A team sieving the volume of sand with the bivalves from a sampling point*



Graph 1. *Representation of the abundance of the different size classes in the two zones*

The students noted the appearance of larger cockles in remarkably superior frequencies as shown in Graph 2. The students deduced that this occurred because those larger cockles had been recruited the previous year and thus had time to grow. They also deduced that the major frequency of adults (20+ mm) is related to the fact that 20+ mm is the most frequent size of one-year-old cockles (those recruited at the end of the previous year's reproductive season).

The most discussed aspect of the graphs had to do with the fact that the adult cockles were more frequent in the low mesolittoral than in the infralittoral. Cockles typically descend towards the infralittoral as they grow. Given that most of the adult cockles found in the low mesolittoral were of the normal size for one-year-old cockles, the students inferred that one-year-old cockles had not descended to the infralittoral yet. This led them to decide to measure different sizes of adults during the next sampling.

Discussion

Once each group loaded its data into the collaborative Excel document, we discussed the hypothesis using Graph 2 (see next page), which shows that there are significant congregations in only the three largest size classes. In addition, there are significant differences between the two transects in only the adult class, which are more abundant in the low mesolittoral.

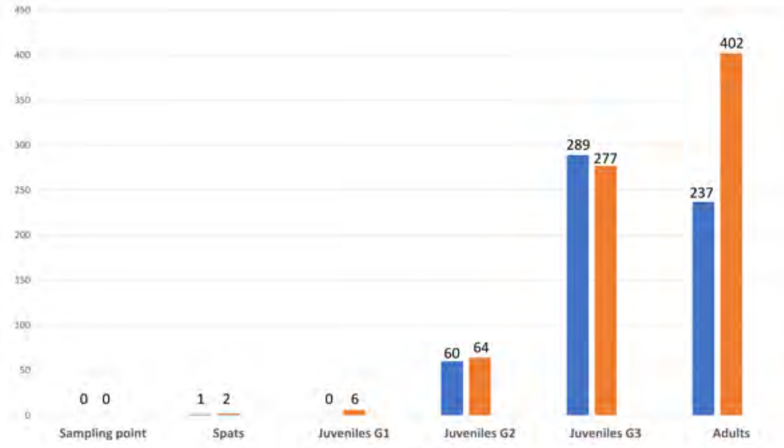
During the discussion of the results, we reiterated that cockle recruitment occurs in the low mesolittoral, and as individuals increase in size, they move towards the infralittoral. It was also mentioned that recruitment does not usually occur until the end of March, which is why commercial shellfish gathering is suspended at that time each year.

Our study was conducted on September 27, 2017, and at that time of the year the cockle larvae should still have been in the *water column*. However, as shown in Graph 2, there were some spats and juveniles in the low mesolittoral. Since this area corresponds to recruitment, this could indicate the recruitment of premature individuals, which may be due to a rise in water temperature — a consequence of climate change. The oceanic water of this region has experienced an increase in temperature of 0.8 ºC, and it is predicted that it will keep rising more than 0.04 ºC each successive decade (Spanish Institute of Oceanography from Coruña), which could also make recruitment occur earlier. If this is the case, it may necessitate adjusting the no-harvesting period. This implication led to the class's decision to continue sampling in successive years to measure trends within a larger sample size and thus have enough data to effectively inform potential decisions about the timing of the no-harvesting period.

For the purpose of stimulating analytical thinking, we encouraged the students to explain the possible reasons for what they discovered about the distribution of the cockles.

In order to give an explanation to this observed distribution, the students remembered that while they were sampling in the low mesolittoral, they met shellfish catchers who were working in the infralittoral. Students thought about the possibility that the activity of the shellfish catchers contributed to why the adult cockles were more frequently found in the low mesolittoral rather than the infralittoral: There could be a bigger extraction of adults at low tide because the water that is present could help to clean the sediments off of the cockles. Therefore, shellfish catchers may carry out this activity near the infralittoral because the shellfish are easier to see here. This could then justify why, as seen in Graph 2, only 37% of adult cockles in the water at low tide were in the infralittoral, while 63% were located in the low mesolittoral. Due to this comparison, it was proposed to take samples before and after the shellfish collection period.

The results showed that the hypothesis given to the students (that cockles are distributed evenly regardless of



Graph 2. *Representation of the frequency of each age class in the two zones*

the level of the tide and the size of the animal) was incorrect because the size does have an influence on the position of the cockles in relation to the tide. The resulting reformulation of the hypothesis was the basis for the statement of their conclusions: that recruitment occurs in the low mesolittoral, and as cockle individuals increase in size, they move towards the infralittoral.

Recommendations about Student Involvement

To carry out this kind of investigation in the framework of research science, you need motivated students who are eager to take part in relevant investigations in order to increase their training in the scientific fields and others related to raising awareness about climate change. Students of various ages can participate, and it could be useful to form groups of students from different ages with 16- and 17-year-olds completing graph analysis, and younger students taking part in different roles of the investigation such as data collection, the reaching of conclusions, or the dissemination of their results.

It can be interesting to collaborate with other education communities in order to share experiences and results, such as in this investigation where a total of four scholarly communities carried out different research projects.

Communication of the Results

Finally, once the results and the conclusions have been obtained, it is necessary for students to transmit their results to society. For our students, scholar symposiums have been developed where students are able to carry out awareness-raising, wherein they collectively act as an effective bridge between science and the public in alerting their communities about the urgency of climate change and its consequences at local and global levels.

Francisco Sóñora Luna is the Project Director of Climántica and **Aitor Alonso Méndez** is the Social Media Coordinator of Climántica, in Galicia, Spain. Contact them at climantica@climantica.org. Support for Climántica is part of the strategic alliance EduCO2cean (STS Education Models to Transmit to Society the Challenge of Global Change in the Ocean), approved and financed by the European Union as part of Erasmus 2016 (Project Reference: 2016-1-PT01-KA201-022952). See the following links for more information: http://ecocost.webs.uvigo.es, http://tv.climantica.org/entradas/455, www.climantica.org, www.educo2cean.org.

Glossary of Key Terms

- Anoxic zones: areas in oceans and lakes depleted of dissolved oxygen or with a very low concentration, which can occur naturally but also because of the excessive nutrient pollution from human activities. The input of nutrients causes the overgrowth of algae, which finally sinks and decomposes in the water, consuming the dissolved oxygen.
- Biogenic marine calcification: the process during which certain marine organisms such as the common cockle form calcium carbonate in order to build different structures such as shells.
- Infralittoral: a lower part of the seashore next to the mesolittoral which is almost always covered by seawater.
- Mesolittoral: a higher part of the seashore which is covered and uncovered by seawater, thus allowing for some exposure to the air.
- Ocean acidification: a decrease in the pH of the ocean due to the uptake of the carbon dioxide from the atmosphere
- Ocean stratification: process caused because of the surface water heating and ice melting which leads to a difference between the density of the surface water and the bottom water. This difference prevents mineral salts from reaching the surface water, leading to a decrease in the productivity of the ecosystems in the tropics and intermediate latitudes.
- Phytoplankton: photosynthesizing organisms which inhabit the surface waters of oceans and bodies of fresh water in the Earth. These represent the basis of primary production of energy.
- Recruitment: the result of subtracting settling and metamorphosing larvae, and early post-settling mortality of larvae.
- Red tides (harmful algal blooms): episodes where algae grow out of control and decolor the water. In some cases, this produces toxins which, if consumed by humans, can cause harmful effects such as diarrhea.
- Spat: larva of a bivalve which has metamorphosed and settled by attaching to a surface.
- Upwelling currents: an oceanographic phenomenon that consists of the vertical movement of water masses from deep levels towards the surface, causing the upwelling of nutrients from the ocean floor.
- Water column: conceptual column of water from the surface water (which is in contact with the atmosphere) to the bottom sediments.