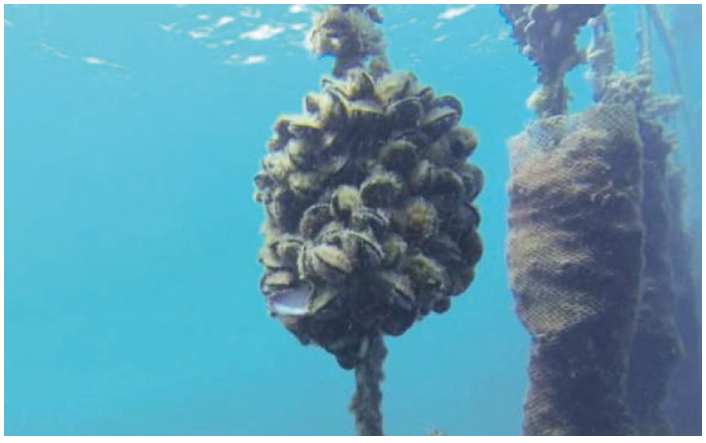
Factsheet No. 9, July 2017

CERES storyline - mussels in the Mediterranean

What do we expect under climate change?

The Mediterranean Sea has been considered a "hotspot" for climate change. The following trends are expected in the Mediterranean basin during the 21st century: an increase in air temperatures between 2.2 and 5.1°C; a decrease in rainfall between 4 and 27%; longer periods of drought, related to an increased frequency of days with temperatures above 30°C; and sea level rise of around 35 cm. The Mediterranean is also becoming saltier and more acidic. Therefore, organisms inhabiting coastal and estuarine waters, i.e. bivalves, will be naturally exposed to greater environmental variations.. Considering the importance of bivalve aquaculture and artisanal fisheries in the Mediterranean region, a strong potential for significant socioeconomic impact of climate change is beyond doubt.

Bivalve culture on the Spanish Mediterranean coast is carried out mainly in the two Ebro Delta bays, Fangar and Alfacs. These semi-enclosed bays present distinctive characteristics, including a wide annual range of temperature (from 6°C to 31°C), salinity (between 13.22 and 37.40 psu) and total particulate matter between 2.70 mg l^{-1} and 14.95 mg l^{-1}. Mussels (*Mytilus galloprovincialis*) are cultured in rafts that occupy a surface area of 1.8% and 6.5% of the total bay surface for Alfacs and Fangar, respectively. Mussel seed is collected using ropes hung from the culture rafts. These seed reaches adult commercial size within 18 months. However, persistence of high seawater temperatures for several consecutive days during some summers caused seed partial or total mortality, which must be then, imported from areas such Italy and France to continue the culture cycle.



How vulnerable are mussels?

The first time that total mussel mortality was observed in Fangar Bay was in August 2003. All mussels cultivated in the bay perished due to high summer temperatures, which surpassed 28°C during a period of 2 weeks. Since then, several mortality episodes have been occurring in summer, affecting mainly the mussel seed.

A reduction of clearance, ingestion and absorption rates obtained in summer highlights the negative influence of high water temperatures upon the feeding and digestive processes of mussels.

What is the economic value of this species?

Mollusc aquaculture represents the 65% of the total aquaculture production in Catalonia, being the mussel the 92% of the molluscan production of about 3000-4000 t $year^{-1}$.

What are the challenges?

Environmental stressors can have simple (additive) or interactive (synergistic or antagonistic) effects on marine organisms and ecosystems. The biological impacts of ocean acidification have been largely considered in isolation. Interactive effects with other climate change stressors, such as temperature or salinity, are still poorly understood. A study on combined effects of ocean acidification and warming on *Mytilus galloprovincialis* in a laboratory experiment and concluded that mussels

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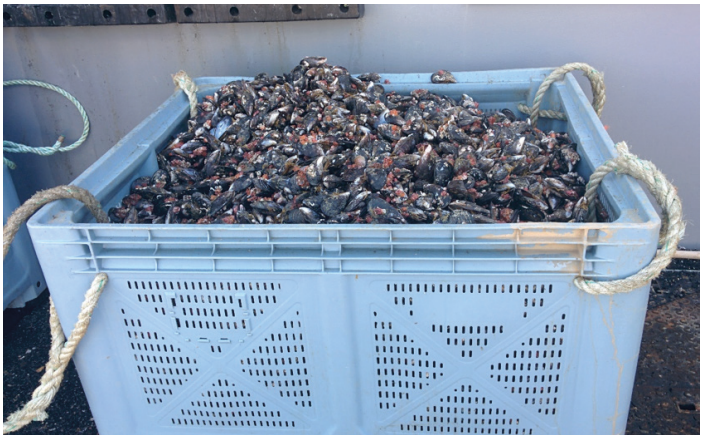

were highly sensitive to warming, with 100% mortality observed under elevated temperature (25°C), although survival was not affected by a pH decrease of 0.3 units. It remains unclear whether the somatic and shell decreases in growth found after summer under low pH were a consequence pH levels or a consequence of a combined effect of acidification and warming. Another study found that the adverse effects of global warming were exacerbated when high temperatures coincided with acidification. Thus, bivalves' production in the Mediterranean is expected to be at risk because of this kind of interactions.

What is the working program in CERES?

Accordingly, in this proposal we plan to set up a series of experiments to investigate the effects of different levels and patterns of variability in pH and temperature on the physiology of *M. galloprovincialis*. Experimental laboratory conditions will be set to simulate natural conditions in the Ebro Delta bays, which is where the most important bivalve aquaculture in the Spanish Mediterranean coast are located. Regarding the experimental set up, we will follow the methods already in use at the ICM-CSIC for pH and temperature manipulation. Three levels of pH (8.1, 7.7 and 7.3), two temperatures (control following Ebro delta bays temperature, and control+3ºC), and one salinity (following the variable Ebro Delta bay salinity) will be tested. Regarding bivalve performance, several indicators will be followed and analyzed, both at cellular and organism level, including mortality counts of dead individuals, shell growth, buoyant weight, ash percentage, calcification (alkalinity anomaly in incubations), feeding behavior (i.e., clearance rate, ingestion rate, and absorption efficiency), reproductive activity, burrowing activity, histopathological lesions (foot, gills, digestive and gonads) and tolerance to desiccation to assess their resilience during low sea level events or during transportation to the market. Regarding feeding behavior, two filter feeding devices with 10 mini-flume tanks each (45×180×60 mm, length×width×height respectively) will be used. These devices have been designed for the purpose and successfully used in the field.

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