

Climate-related changes in recruitment of marine bivalves

Population dynamics of common intertidal bivalves (*Cerastoderma edule*, *Macoma balthica*, *Mya arenaria*, *Mytilus edulis*) are strongly related to seawater temperatures. In north-western European estuaries, series of mild winters followed by low bivalve recruit densities lead to small adult stocks.

Long-term field observations made it possible to examine temperature-induced effects on reproductive output (eggs m⁻²), onset of spawning (day of the year) and the juvenile instantaneous mortality rate (d⁻¹) of *Macoma balthica*. Data analysis was based on an extensive data set (1973-2001) originating from the western Wadden Sea, including water temperature, phytoplankton biomass, bivalve recruitment and crustacean densities.

The results strongly suggest that rising seawater temperatures affect recruitment by a decrease in reproductive output and by spring advancement of bivalve spawning. Apparently, global warming upsets the evolved reproductive strategy of this marine bivalve to tune its reproduction to the most optimal environmental conditions for the first vulnerable life stages, most importantly the match/mismatch of time of spawning with that of the phytoplankton bloom and the settlement of juvenile shrimps on the tidal flats (see Fig. 1).

It is hypothesised that the observed density-dependent mortality of juvenile bivalves may act via competition for food, a behavioural response of shrimp to low spat densities, or be the result of the response of age and size at metamorphosis of marine bivalves to resource variability. It is to be expected that prolonged periods of lowered bivalve recruitment and stocks will lead to a reformulation of estuarine food webs and possibly a reduction of the resilience of the system to additional disturbances, such as the depletion and disturbance by shellfish fisheries.

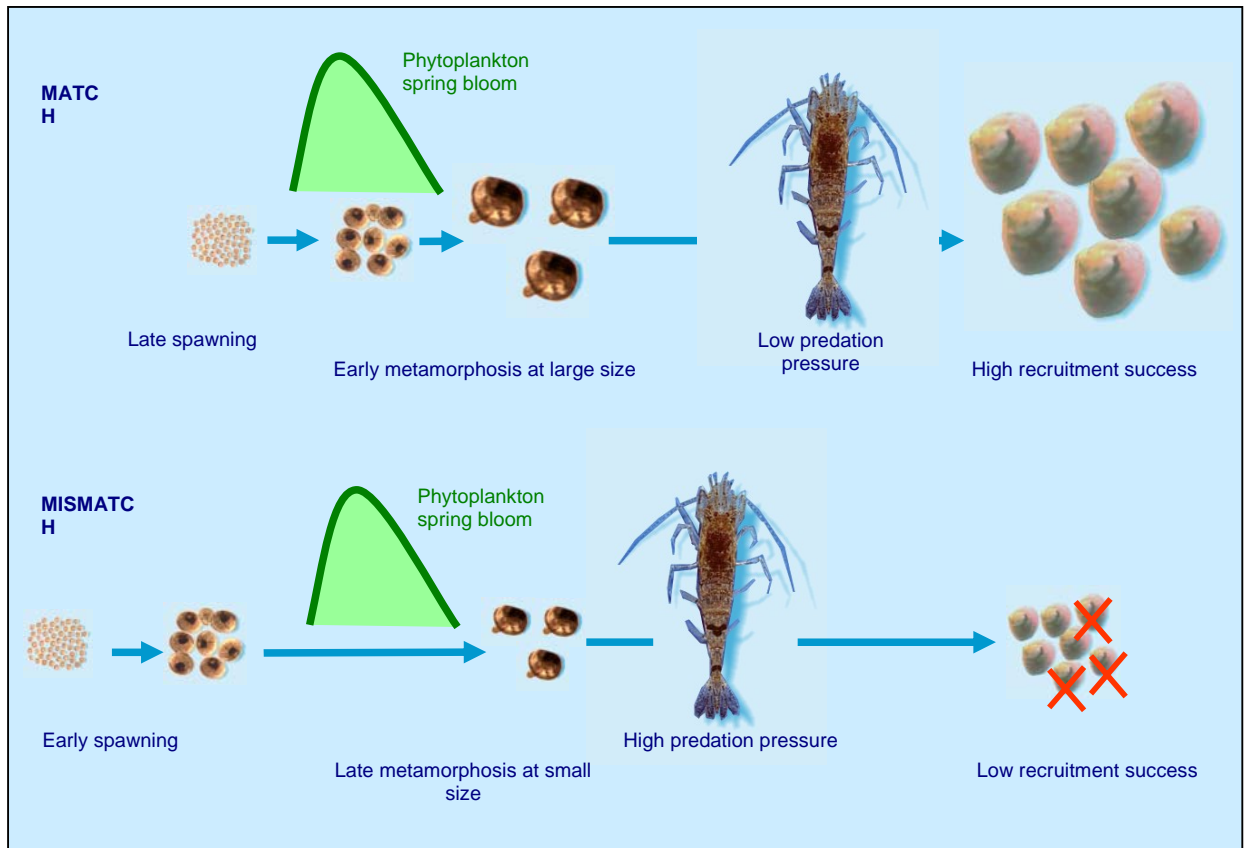


Figure 1.

High temperatures in late winter (an average increase of 2.5 °C within the past 15 years) result in spring advancement of bivalve spawning (8 days per °C). The resulting mismatch with the phytoplankton bloom is considered to effect a reduction of the *per capita* food availability during the pelagic phase, c.f. the match/mismatch hypothesis (see Cushing 1974, 1990). Subsequent reduction of the growth rate results in an extended pelagic phase and a decrease of the size at metamorphosis. Delay of metamorphosis is considered to enhance larval mortality due to increased advection and pelagic predation, and the decrease of the size at metamorphosis is thought to decrease post-larval survival, as predation during that stage is size-dependent. In addition, the predation pressure increased by a temperature-induced advancement of migration of juvenile shrimp into the estuary (16 days per °C). Adapted from Philippart et al., *Limnol. Oceanogr.* 48(6), 2171-2185, 2003.