Summary

It is generally conceded that the globe is undergoing a period of rapid climate change that includes a substantial warming. A major challenge to ecologists nowadays is to predict possible impacts of such temperature shifts which can only be achieved if there is an understanding of the basic mechanisms underlying climate-driven changes at the individual, population and community levels. One of the key factors that limit predictions is that climate change may not only affect species performances, but also interactions among species, namely predator-prey relationships.

In shallow-water temperate systems, an important interaction is predation on newly-settled bivalve spat by crustaceans. Several studies have highlighted the importance of crustacean predation (mainly by shore crab *Carcinus maenas* and brown shrimp *Crangon crangon*) as an important source of post-settlement mortality and contributing to the year-to-year recruitment variability typically found. Such variability in bivalve stocks affects the predictability of this food source for other species groups like wading birds which use shallow-water areas as an essential chain of re-fuelling stations on their migratory pathways.

Because of the significance of this interaction to the ecological function of shallow-water systems, the aim of this thesis has been on developing a framework to study the impact of temperature changes on epibenthic predation based on first principles of physiology and available ecological data, in order to gain predictive power to anticipate effects of rising temperatures on bivalve survival. Instead of considering the crustacean-bivalve relationship in isolation, this interaction has been analysed as part of an intricate predator-prey system where crustaceans are simultaneously predators but also prey for other abundant components of shallow-water habitats, including several flatfish, gobies and larger demersal fish.

Such a complex of epibenthic predators is present from the cold-water Norwegian systems to relatively warmer Portuguese estuaries experiencing a wide range of temperature conditions. Assuming that latitude is a good surrogate for temperature, a latitudinal perspective was adopted to examine the impact of temperature on epibenthic predation on a large geographic scale and to capture the main patterns.

The starting hypothesis was that the temperature effect on size-dependent interactions boils down to physiological principles since both growth performance of prey and crustacean predation are temperature-related. In this respect, not only temperature but also food conditions are key factors, since temperature influences the time prey take to escape predation by reaching a size refuge, and food conditions ultimately determine if prey growth potential can be achieved, reducing the predation window. In addition, temperature directly affects metabolic demands influencing predator’s ingestion rates.

The specific temperature responses (tolerance range, sensitivity) of prey in relation to predators were determined based on experimental data reported in literature. Clear differences
were found between species, with crustaceans showing higher temperature sensitivity and tolerance ranges compared to their potential fish predators and bivalve prey. The overall picture arising pointed out that crustaceans may benefit from temperature increases leading to a higher predation pressure upon bivalves under such a global warming scenario. Nevertheless, because predictions are based on the differential growth responses of prey and predators, and growth is strongly determined by food availability, elucidation of prevailing food situation in the field still needed to be addressed.

In order to tackle questions concerning food conditions in the field, we used the Dynamic Energy Budget (DEB) theory and its modelling tools. The major advantage of this approach was the possibility of describing growth in relation to food and temperature in a consistent way, using a single model for the various species (predators and prey), whereby differences between species are reflected in the values of model parameters only. A major component of this thesis dealt with the estimation of model parameters which is still the most challenging aspect of the theory application. In this respect, several improvements have been made throughout time, which are naturally reflected in this thesis. Since data from different areas was taken, several assumptions had to be made which could potentially create unforeseen pitfalls. These are discussed in the final chapter and provide opportunities for future research.

The DEB-based approach revealed that in bivalves, growth is far below maximum possible irrespectively of latitude, suggesting food limitation. On the other hand, in crustaceans, feeding conditions seem to be optimal and hence, growth appears to be largely determined by prevailing water temperature conditions. These contrasting growth conditions of bivalves as prey and crustaceans as predators point to a disadvantageous position of bivalves which is expected to intensify under a warming climate scenario: increased predation intensity by crustaceans will not be compensated by a parallel increase in bivalve growth therefore resulting in enlarged size-selective predation window and overall mortality. If future temperature shifts approach upper thermal limits of some of the bivalve species, possible extinctions may occur. This seems to be the case of the baltic clam *Macoma balthica* which in the last decades has progressively declined in the Wadden Sea.

The impact of temperature changes on the epibenthic complex preying upon crustaceans is less clear. Using the same framework as the one applied for analysing crustaceans-bivalve interactions requires that information on thermal responses and food conditions is accessible, which is not the case for most potential predators. For some predators (gobies and flatfish), the fact that flatfish have narrower tolerance ranges and seem to suffer from food restrictions in part of the summer, seem to fit with the observations of recent extensive periods of increase of sand gobies in the Dutch coastal zone as well as drastic reductions in plaice in the shallow intertidal area. Shifts in species composition and abundance within the epibenthic species complex (replacement of cold-water by warm-water species) as well as cannibalistic interactions, common among crustaceans, might make the outcome of these interactions even more difficult to predict.
Has this thesis contributed to increase our understanding on the potential effects of climate change on bivalve recruitment? Although only part of the problem has been tackled, we advocate that physiological-based studies are a cornerstone for assessing climate change impacts on species interactions. The DEB-approach as a tool to analyse growth conditions in the field, including food reconstructions, is promising instrument and although it has been applied for each species individually it could be used to model predator-prey interactions in a more systematic way. However, we still have to deal with complicating and largely unexplored factors like intraspecific variability in model parameters and population-specific adaptations.