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Trans-life cycle impacts of ocean acidification on the green sea urchin *Strongylocentrotus droebachiensis*

Narimane Dorey
Institutionen för biologi och miljövetenskap
Naturvetenskapliga fakulteten

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Abstract

This thesis studies the impacts of ocean acidification on an ecologically and economically important invertebrate of the Nordic waters: the green sea urchin *Strongylocentrotus droebachiensis*. Acidification affects the different life stages and transitions composing the life-cycle.

Paper I establishes the robustness of the larval stage to a broad range of acidification (-1.5 pH_T units) covering present, projected near-future variability and beyond. Development of normal, although showing morphological plasticity, swimming larvae was possible as low as $pH_T \geq 7.0$. Acidification increased mortality and respiration and decreased growth rate.

Paper II focuses on the impacts of a decreased pH (-0.4 and -0.8 units) on the transitions phases between the larval and juvenile stages and on juveniles' survival. Lowered pH induced both direct effects of (e.g. juvenile spine amount) and carry-over effects (e.g. increased settlement rates).

Paper III deals with juvenile and adult stages. While adult fecundity was reduced after a 4-months exposure to low pH (-0.4 units), it was not affected anymore after 16-months. On the other hand, juveniles experienced a 95% mortality when grown at low pH since fertilization.

Paper IV is a meta-analysis based on the available experimental data available on echinoderms in 2010 revealing differing sensitivities of the stages and processes studied to near-future predictions.

Paper V reveals, from *in vivo* measurements on *S. droebachiensis* pluteus larvae, that the extracellular compartment surrounding the calcifying cells conforms to the surrounding seawater with respect to pH. Under ocean acidification, maintaining constant intracellular pH for calcium precipitation probably causes enhanced metabolic costs.

Keywords: Ocean acidification, Anthropogenic CO_2, Seawater pH, *Strongylocentrotus droebachiensis*, life-cycle, larvae, juvenile