Abstract: Exploring questions of biology means characterizing environmental impacts on an individual’s physiology, and how effects combine to produce observed population changes. Individual based modeling (IBM) offers a tool to bridge this physiology-ecology gap, allowing consolidation of current theories regarding environmental impacts on individuals and estimation of our ability to explain variation in populations, species, etc., over space and time. I will present my recent research in this area, which includes development of new IBM tools, as well as efforts to explain climate effects on the physiology and ecology of marine organisms. First, I will present a flexible and conceptually simple approach for building a stochastic IBM that can be used to test hypotheses statistically. Second, I will outline recent efforts to describe environmentally dependent physiology and ecology for such models. This includes describing spatial variability in thermal tolerance limits with an example from a temperate reef fish (banded morwong, *Cheilodactylus spectabilis*) in the Tasman Sea, one of the most rapidly warming areas of the southern hemisphere. In addition, I will demonstrate the use of thermal history metrics (e.g., growing degree-days, °C·day) in disentangling temperature effects on size and life-history, with an example from exploited North Sea Atlantic cod (*Gadus morhua*). Finally, I will demonstrate how these characterizations of environmentally dependent physiology and ecology can be combined with physical oceanography through IBMs to explain observed temporal and spatial changes in population ecology, make predictions regarding population dynamics under future oceanographic conditions, and address general ecological questions concerning resource management, macroecology and adaptation.

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