THERMAL PERFORMANCE OF THE PURPLE SEA URCHIN *PARACENTROTUS LIVIDUS* (LAMARCK, 1816)

Giacoletti A.[1,2]* and Sarà G.[1,2]

[1]Dipartimento di Scienze della Terra e del Mare, Università degli Studi di Palermo, viale delle Scienze ed. 16, 90128 Palermo, Italia.

[2]National Biodiversity Future Center (NBFC), Piazza Marina 61, 90133 Palermo, Italia.

* e-mail: antonio.giacoletti@unipa.it

The concept of **climate change** refers to a change in the climatic state that can be identified by variations in the mean or variability of its properties persisting for a prolonged time, typically decades or more, due to natural or anthropogenic processes. Climate change includes all those processes that generate a series of secondary effects, including **ocean acidification**, **alien species**, and **sea-level raising**. The interaction between direct and indirect effects with those deriving from other anthropogenic activities are often the cause of specific compositional shifts at local scale known as **regime shifts**, that are often difficult to anticipate and costly to reverse. These are defined as large, persistent changes in the structure and function of social-ecological systems, with substantive impacts on the suite of **ecosystem services** provided by natural systems on which human societies depend, with relevant impacts on human economies, societies and health.

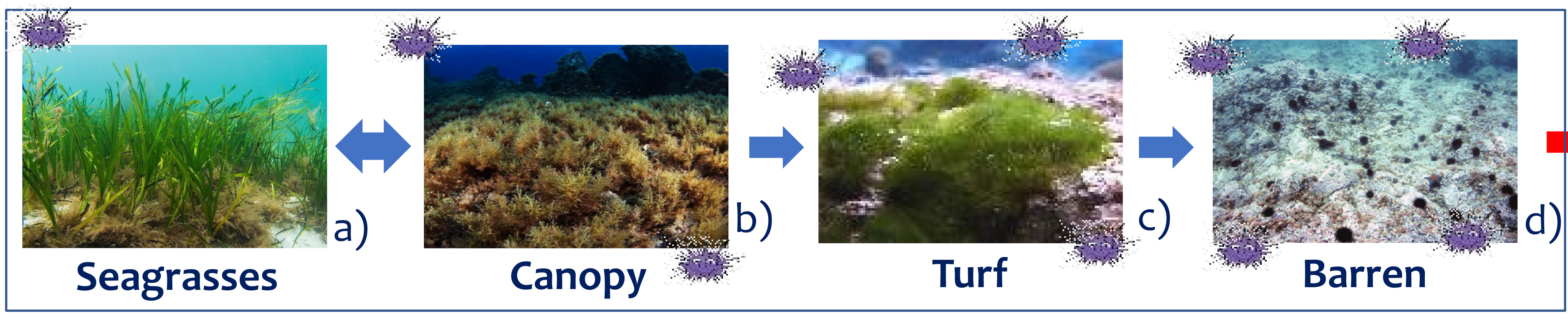

Fig.1: Example of different regime shifts.

Not so simple, as natural systems are regulated by several key feedback loops regulating complex dynamics.

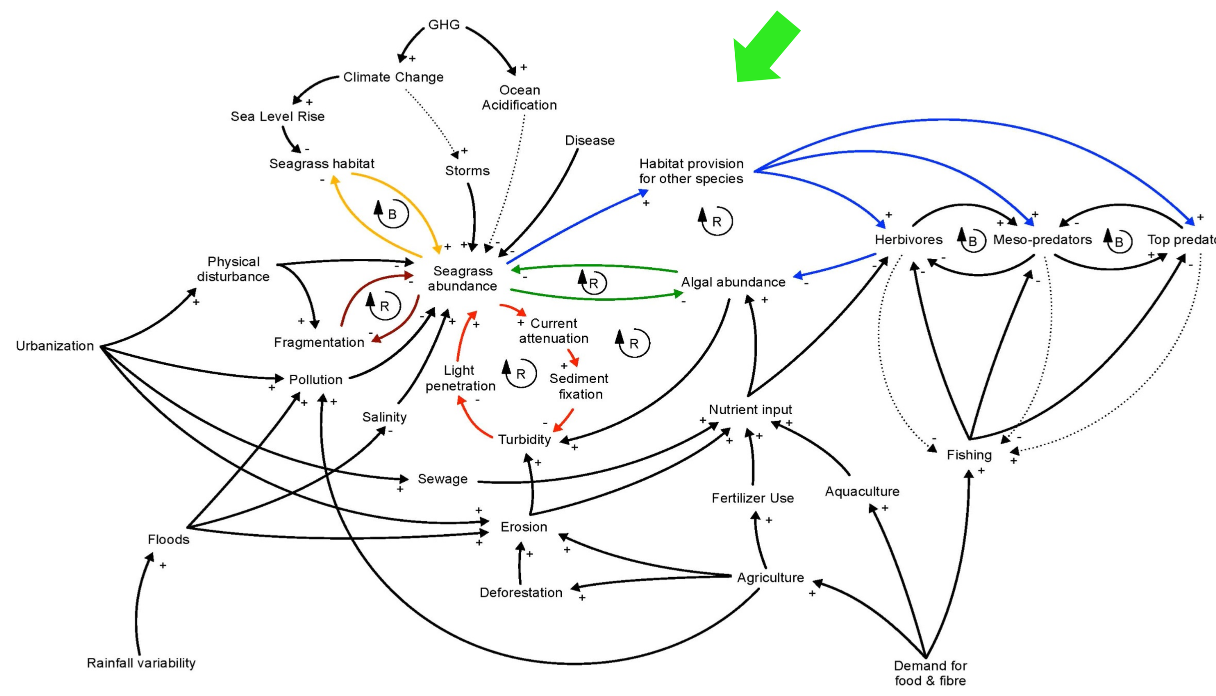

Fig.2 Causal loop diagram for the seagrass transitions regime shift.

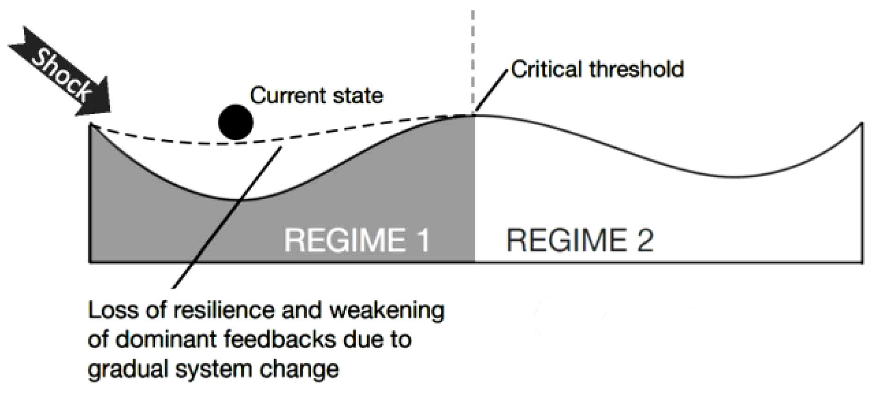

Fig.3: Stylized representation of a generic regime shift.

A well-known case is represented by the shift from a **seagrass-dominated state** to an **algae-dominated** one (Fig.1 a to b), with both competing for the availability of substrate and nutrients in the environment. Seagrasses represent and important habitat provider to herbivores, that in-turn regulate algal density through their grazing activity (Fig.2). A high **grazing pressure** however, such as that exerted by high densities of sea urchins, caused by conservation policies or human alteration of natural food-webs determine a series of events that lead to the removal of erect macroalgae shifting the ecosystem to the so-called **barren** (Fig.1 b to d), whose state can persist until their density declines. **Global warming**, however, is one of the major driver of climate change exerting a direct effect on marine ectotherms, through direct effects of temperature on distribution, physiology, morphology and behaviour. Among the main effects of **temperature** on grazer's metabolism, that on oxygen consumption and food intake should be highlighted, whose alteration can cause alteration on natural communities' equilibria.

METHODS

To investigate the effect of temperature on individual performances a **trait-based approach**, based on the use of oxygen consumption as a **proxy of individual metabolism**, was adopted. Consequently, specimens of the purple sea urchin *Paracentrotus lividus* were sampled near the town of Punta Raisi (Sicily, Italy). Individuals of similar size (35 ± 4 mm) were sampled in a depth range between 0 and 10 meters and 19 different temperatures, in a window between 8°C and 37°C, were tested to investigate their **thermal performance** curve (TPC) and estimate the **Arrhenius temperature** (T_A). Accordingly, oxygen consumption was standardized on individual dry weights. 24 different TPC models were fitted using nonlinear least squares regression through the *rTPC* and *nls.multistart* R packages.

RESULTS

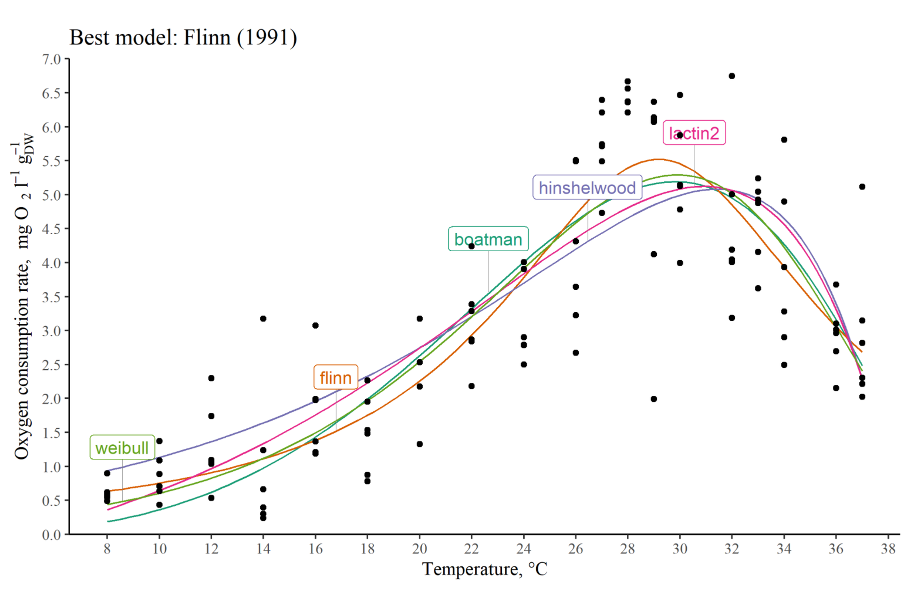

Fig.4: Choice of the best model.

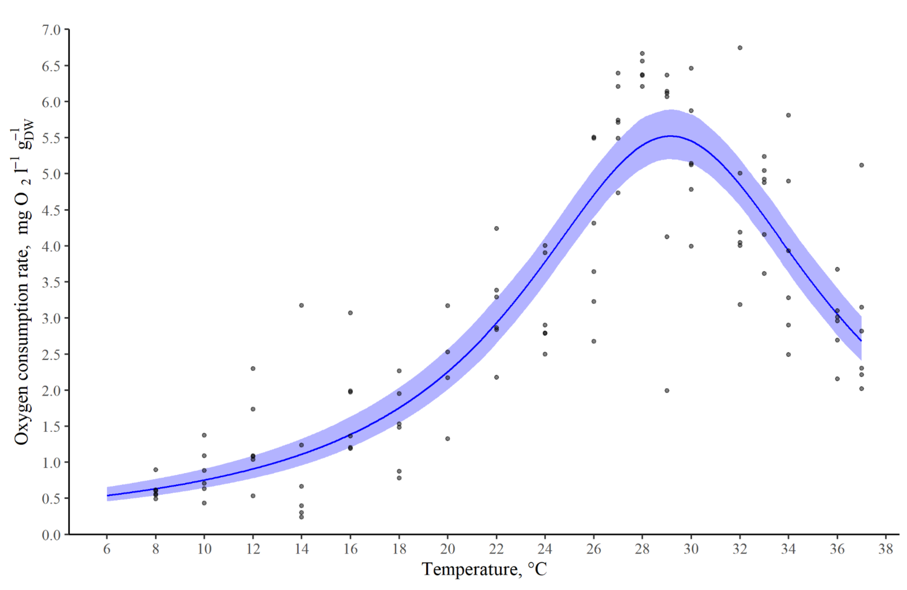

Fig.5: Fit of *P. lividus* TPC with CI.

Fitted models (Fig.4) were compared on the base of Akaike's information criterion, and the best model was selected by the lowest AIC. Experimental results and modelling identified a left-skewed curve (Fig. 5), with the **thermal optimum** (T_{opt}) corresponding to **29.16 °C**. The **Arrhenius temperature** was **11880 K**. Our results classify *P. lividus* as a thermo-tolerant species, living in the Mediterranean Sea near-to or below its thermal optimum. Such a high T_A is typical of species with a wide biogeographical range.

CONCLUSIONS

The investigation of species-specific **thermal tolerance** is useful to quantify how ectotherm's body temperature can affects individual **performance** and their **ultimate fitness**, predicting responses to a changing environment. Specially in a context of climate change, information on thermal thresholds may result as essential to parameterise species within mechanistic models (e.g. **DEB models**) aimed at evaluating how climate change can affect the ecological role and **the future persistence of key-species** in the natural environment.

REFERENCES

- Biggs, R., Peterson, G., & Rocha, J. C. (2015). The Regime Shifts Database: a framework for analyzing regime shifts in social-ecological systems. bioRxiv, 018473.
- Sinclair, B. J., Marshall, K. E., Sewell, M. A., Levesque, D. L., Willett, C. S., Slotsbo, S., ... & Huey, R. B. (2016). Can we predict ectotherm responses to climate change using thermal performance curves and body temperatures?. Ecology letters, 19(11), 1372-1385.
- Padfield, D., O'Sullivan, H., & Pawar, S. (2021). rTPC and nls. multstart: a new pipeline to fit thermal performance curves in R. Methods in Ecology and Evolution, 12(6), 1138-1143.

S.It.E. Società Italiana di Ecologia · Università degli Studi di Catania · Università degli Studi di Palermo · e-lab · National Biodiversity Future Center