Levant rocky-shore biodiversity: testing ecological impacts of climate change and bioinvasions on a unique ecosystem

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Diversity of life on a vermetid reef

This project was set to initiate a research program on the ecology of a unique marine ecosystem on the Israeli Levant shores, the biogenic rocky-intertidal *vermetid reefs*, as part of the capacity building of the new Marine Community Ecology lab at IOLR led by Dr. Gil Rilov. The main focus of the work was to establish a pilot biodiversity monitoring program along the coast, and to jumpstart the research on the potential effects of climate change and bioinvasions on the ecosystem. The resulting monitoring program is extensive and included 11 sites along the shore from north-to-south that Dr. Rilov's lab members monitor annually, and 4 sites that are monitored seasonally for both biodiversity and monthly for biophysical factors. This program has been running now for 4 years, and as a result, last year IOLR managed to get long-term funding commitment from the Ministry of Environmental Protection for continuous supporting of this monitoring program – indicating the success of the pilot project funded by the Marie Curie program. The original modest work on climate change has evolved into two major cutting-edge projects using state-of-the art mesocosm technologies. Rilov's lab now consists of 5 technicians and 10 graduate students, and works on 5 (nationally and internationally) funded projects.

The major findings from the project and related ones that sprung from it are: (1) high variability in community structure along the coast that slightly related to biogeography but is mostly driven by local reef characteristics (height, size, etc.) and nearshore oceanography, (2) high seasonal variability in community structure, where the highest diversity occurs during winter and spring, (3) major differences in community structure and diversity among different areas on the reef (e.g., water edge and platform center), (4) near-complete extirpation of the reef building vermetid gastropod *Dendropoma petraeum* with potential dire consequences to the structural integrity of the ecosystem and the conditions on it, (5) near extirpation of the once-abundant predatory snail *Stramonita haemastoma* and possibly a few algal species, (6) sea surface temperatures that are higher by 1.5-2.5 ^{0}C than those measured two decades ago, a possible sign of climate change, (7) high sensitivity of most tested reef species to current and future peak summer seawater temperatures, which indicated that many species on this coast are already under stress due to climate

A macroalgal forest in a shallow tide pool on a vermetid reef

change and will be at risk of population collapse in the further, and (8) the Red Sea invasive mussel *Brachidontes pharaonis* is very abundant on the reefs in some sites and its population is highly dynamic. This species has a very seasonal recruitment pattern (highest in the summer), and it is successful despite high predation rates on it.

As a result of these findings, the pilot monitory program has turned into a long-term national monitoring program funded by the government, and the results are presented in annual reports to the Ministry of Environmental Protection. Furthermore, climate change issues have become a major focus of research in the Rilov Marine Community Ecology lab. The project's findings have led to the successful recruitment of a range of research grants on similar topics to supplement the basic funding from the Marie Curie program. These include the Israeli Science Foundation (ISF), the German-Israel Marine Sciences Program (BMBF-MOST), and several smaller government grants. With this funding, the lab had set up innovative laboratory systems to test climate change effects (ocean acidification and increased temperature) on the reef substrate, on ecologically-important species, and on communities and their functions. These include a "minicosm" (to test effects of temperature or acidification on individual species), a "tidal-cosm" (to test the effect of sea level rise on communities), and a highly sophisticated, computer-controlled, "mesocosm" system to test the individual and combined effects of temperature and acidification on communities and their functions.

With the Marie Curie grant and the other funding that stemmed from it we now have a much better understating of the structure and dynamics of rocky shore communities on the Israeli shore and we are starting to also understand some of the processes and mechanisms that drive these patterns. Knowing how biodiversity patterns of this ecosystem naturally vary in space and time, and developing tools to monitor climate change and bioinvasions and test their ecological impacts are highly important for better conservation planning and ecosystem management. This information can also be useful on a much broader scale because it can be connected to similar investigations by other European researchers, and merged to large ecological databases that are currently being developed for the Mediterranean as part of an effort to reach Good Environmental Statue, an important goal of the Marine Strategy Framework Directive (MSFD). Collaborative work on a basin scale can improve our understanding of biophysical patterns and processes in the region, of directional changes in these patterns (such as those caused by climate change), and lead to more effective conservation on a Mediterranean scale (using for example a network of marine reserves). These connections are already being established through EU projects that Dr. Rilov is involved with (VECTORS and PERSEUS), as well as other less formal interactions. One recent example is a new initiative led by Dr. Rilov to develop a Global Rocky Intertidal Ecology Network (GRIEN) of intertidal researchers worldwide aimed to investigate the generality vs. context dependency of community structure, diversity and function in a macro-ecological context in the context of global climate change.