Complex eco-evolutionary dynamics of aquatic ecosystems faced with human-induced and environmental stress

Results in Brief

New modelling tools to better understand evolution within ecosystems

How the ecosystem affects evolution is very difficult to establish. But a better understanding of this is important to evaluate the impact of environmental change.

FOOD AND NATURAL RESOURCES

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What drives a species to thrive or decline, and how do the moving parts of a complex interplay between environmental and genetic factors influence survival? The question arises, for example, when we consider the impact of environmental legislation on certain fish populations.

It is largely unknown why some fish species recover from overfishing while others do not, despite reductions in fishing pressure or complete closure.

Understanding how even slight life-history changes can affect population growth could better our understanding of our impact on the natural world.

“There are”, explains Anna Kuparinen, “good reasons to believe that evolution occurs and affects traits that play an ecological role as well, such as body size. Atlantic cod is one famous example, similar to Atlantic and Pacific salmons. In the

lab, such dynamics have been shown, for example in zebra fish."

Kuparinen headed up the COMPLEX-FISH project, which sought to develop a better understanding of the elements at play between the ability of species to be resilient and to recover from environmental shocks, and evolutionary processes.

"I wanted to merge the fields of ecology and evolution into two interfaces of complex biological dynamics," adds Kuparinen, who conducted her work with the support of the European Research Council. The aim was to understand the two sides of the coin of biological dynamics.

"In practice this requires modelling of life-history, population and ecosystem dynamics," says Kuparinen.

Allometric relationships as ways to simplify complex dynamics

COMPLEX-FISH considered what are known as 'allometric trophic networks' (ATNs).

Allometric relationships are used to relate the body mass of species to several of the biological processes driving feeding rates and species dynamics (for instance, clearance rate, handling time and metabolic rates are all a function of species' body mass). The model can also be used to estimate the transfer of energy and nutrients between organisms in a community, the 'trophic interaction'.

"I developed ATN models to include age-body size structure for fish, meaning that different-aged fish have different body sizes and so, different ecological functions," explains Kuparinen.

The project examined the impacts of fishing and species invasions in lake ecosystems and marine ecosystems, analysed data on food web structures the team received from collaborators and ran theoretical simulations using food webs constructed with algorithms they developed.

The result is an evolving ecosystem model which permits the simulation of different fishing pressures, and how they drive the evolution of certain fish species.

"We also studied how ecosystems filter environmental noise and how their stability is affected by food web properties and fishing pressures," Kuparinen notes.

Phenotypic evolution and its relationship with the ecosystem

The team found out that phenotypic evolution, observable traits of an organism, such as body weight or the presence or absence of a disease, does have ecosystem-level effects and needs to be better accounted for.

“We also drew attention to factors affecting ecosystem stability, such as the food web structure itself, human impacts such as fishing and also climate change-related alterations such as invasive species and parasite load.”

Kuparinen believes the most important insight is that species should not be treated in isolation but as part of an ecosystem, and impacts can be seen not only in target species but throughout those ecosystems.

Keywords

COMPLEX-FISH | phenotypic evolution | ecosystems | allometric relationships | environmental stress | environmental change

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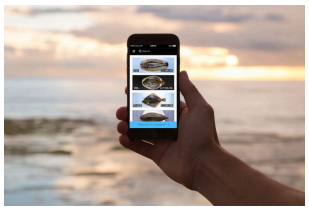

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