{rokbox title=| Changes in the abundance and stability of the North Sea cod population over time :: Image: Authors|
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Hsiao-Hang Tao, Chih-hao Hsieh, **Manuel Hidalgo**, Vasilis Dakos, 2025. **Tracking changes in stability of North Sea Atlantic cod over 40 years**
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Abstract: Tracking changes in the stability of low-abundance populations is crucial for effective conservation. While population stability is often evaluated using linear models, many natural populations exhibit state-dependent dynamics, such as the iconic Atlantic cod (Gadus morhua) in the North Sea. This population experienced an abrupt decline around year 2000 and has not shown a clear sign of recovery, despite a reduction in fishing pressure. To investigate the mechanisms underlying its recovery dynamics, we applied a dynamical systems approach to reconstruct the population's state space using yearly abundance data of different age groups between 1982 and 2021. We estimated yearly interaction matrices of age groups and derived a measure of population dynamical stability, defined as the rate at which the population recovers to or departs from its current state following small perturbations to the matrix. Our analysis revealed that the North Sea cod shifted from a disequilibrium state to a stable, low-abundance state in 2003. During this stable phase, some age groups exhibited weaker self-regulation, and age-1 group became more sensitive to fluctuations in the abundance of older groups and showed weakened growth to the next age. These changes likely contributed to the population’s failure to recover, even under decreased fishing pressure. The analytical framework used in this study is broadly applicable to assess the stability of structured non-equilibrium populations across different taxa and ecosystems.

Keywords:age-specific abundance,non-linear dynamics,empirical dynamical modelling,interaction Jacobians,population stability,recovery dynamics.