

Project Title: An Investigation of Time Series Prediction Methods for Improved Stock Projections: Understanding Variability in Fish Populations (first year of a 2-year project).

Principal Investigator(s): George Sugihara, Roger Hewitt

Goals:

- 1) Understanding the sources of variability in marine fish populations (separating anthropogenic effects from natural causes).
- 2) Investigate the applicability of modern time series forecasting methods

Approach:

- 1) The project objective of understanding sources of variability (both anthropogenic and environmental) was addressed by using historical ichthyoplankton data for the CALCOFI domain. These are unique data that were used to answer one of the classic questions in marine fishery management: whether fishing itself will increase or dampen the population variability of targeted fish species.
- 2) The project objective using nonlinear methods to improve prediction directly addresses the overall NOAA Fisheries mission. It is essential information for setting harvest targets of fished species in the CALCOFI domain. The nonlinear methods developed and used here directly address the mission of *ecosystem-based management*. Demonstrating the applicability of the forecasting technology and refining the methods to apply specifically to data of this kind is of general utility to its future *applications to other fisheries*.

Work Completed:

We have obtained the following results:

- 1) Found fishing increases boom and bust variability of exploited populations. This is a classical question in fisheries science that we were able to answer generally and empirically for the first time. The important implication of this work is that the destabilization of the population is a consequence of common fisheries practices that target the larger older individuals. This work was published in Nature October 2006, and was mentioned as an important finding by VAdm Lautenbacher in a speech at the National Academies of Sciences later that fall.
- 2) Found nonlinear forecast methods are effective for fisheries. These methods work best when the time series composite is constrained by habitat type or region.
- 3) Found low dimensional nonlinearity in the population dynamics of both exploited and unexploited populations.
- 4) Confirmed that fishing results in a truncated age and size structure for the population, and further related this to destabilization of exploited populations.

Applications:

Our results suggest that time series forecasting methods should be deployed at very least as a supplement to existing stock assessment practices.

Publications/Presentations/Webpages:

Journal Articles: (all articles are in reviewed journals)

- 1) Southwood, T.R.E, R.M. May, G. Sugihara (2006) Some observations on related ecological exponents. PNAS USA: 2006;103;6931-6933.
- 2) Hsieh CH, C. Reiss, W. Watson, MJ. Allen, JR. Hunter, RN. Lea, RH. Rosenblatt, PE Smith, G. Sugihara (2005) A comparison of long-term trends and variability in populations of larvae of exploited and unexploited fishes in the Southern California region: A community approach. Prog. Oceanography 67:160-185.
- 3) Hsieh CH, Reiss, C.S., Hunter, J.R., Beddington, J.R., May R.M., Sugihara G (2006) Fishing elevates variability in the abundance of exploited species. NATURE, 443, 859-862.
- 4) Hsieh CH, Glaser SM, Lucas AJ, Sugihara G (2005) Distinguishing random environmental fluctuations from ecological catastrophes for the North Pacific Ocean. NATURE 435: 336-340.
- 5) Maye, A., CH. Hsieh, G. Sugihara, B. Brembs (2007). Order in spontaneous behavior in *Drosophila*. PLOS.

Books/Articles-in-Books:

- 1) May, R.M, Crawley, Sugihara, 2007, Multispecies Patterns, in Theoretical Ecology
- 2) Sala, E. and G. Sugihara 2004. Food-web theory provides guidelines for marine conservation.
In Aquatic Food Webs, ed. J. Cohen, pgs 170-183.

Reports:

(Reviewed and produced by National Academy of Sciences and Board on Mathematical Sciences and its Applications (18 members))

New Directions in Systemic Risk, (NAS Report in Press)

Conference Proceedings/Workshops:

Ph.D. Dissertations:

Chih-Hao Hsieh 2006.

Submitted and In Press:

(several)