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System Modeling of Biological time series in Mediterranean

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Abstract

The main scope and objectives in this workshop are testing ecological theories making short and medium term forecasting. The paper describe how to start this process by a system modeling approach.

Introduction

"Mediterranean participants are strongly encouraged to provide/ present a summary / review of available biological time series for their geographical area / country of expertise."

This participant has his experience from modeling the climate influence on the biomass dynamics in the the Barents Sea. Since the time series from the Barents Sea have little or none value for an analysis of the Mediterranean situation, he has chosen to focus on the to methods to analyze the Mediterranean biomass by a system approach.

Conference Scope and Objectives

The accumulation of information on different marine food-web components at regular time intervals is important for:

(a) testing ecological theories, thus deepening our understanding of the structure and function of marine ecosystems;
(b) applying recent approaches in identifying and quantifying the effects of human impacts on marine ecosystems; and
(c) practical purposes, such as short- and medium-term forecasting, and thus largely relevant to management.

Biological time series are available for many areas of the world ocean. In contrast the

Mediterranean Sea, despite its long history of human exploitation, is generally considered as lacking biological time series (as distinct from proxies) longer than about a century. Such a lack seriously hampers the realization of the above mentioned aspects as well as the development of a general framework underlying ecosystem-oriented studies.

This workshop will bring together a small group of active researchers, who through invited talks and group discussions, will tackle the following issues, among others:

(a) Mediterranean biological time series: availability, scales (up to secular scale), and gaps;
(b) Available main statistical (i.e., empirical time series and regression techniques), biological (i.e., based on sound biological/ecological theories/processes) and other (i.e., simulation) techniques, varying in complexity and developed from diverse disciplines, that can be used for analyzing time series in order to extract and identify trends and inter-relationships;
(c) How to use biological time series in Mediterranean ecosystem studies and in the management of living resources.

Materials and Methods

Some fundamental questions

A first step in an analysis is to ask some fundamental questions.

1. Is this a deterministic system?
2. If it is deterministic, what is the fundamental drive behind the deterministic process?
3. What is the reasonable time scale of a fundamental dynamic process?
4. Is the biomass a stochastic stationary process?
5. Is the biomass a time variant process?
6. If it is a time variant process, what is a reasonable time of useful history data?
7. Are fluctuations in data noise or a fluctuating biomass?
8. Is there a correlation between cause and effect in the food chain?
9. What are the available data series?
10. Is there a relation between a set of indicators?

Answers from some of these questions may get ideas to start modeling the biomass in the Mediterranean Sea.

General System theory

General Systems theory is an holistic approach of modeling biomass systems. A *System Architecture* is a set of mutual related subsystems. A system S(t) may be represented by

$$S(t) = \{B(t),\{S_1(t), S_2(t),,,S_n(t)\}\} \in w \qquad (1)$$

where $S_n(t)$ represents the n-te subsystem, B(t) represents the mutual binding between the subsystems and w is the purpose. A system element $S_i(t)$ may represent an organization from nature, a man made system, a substance, and any type of abstract organizations. The chosen system elements in the system S(t) are dependent on the system model purpose w. The binding B(t) may represents a force, a flux, and any type of relation that influences related system elements. A time variant binding B(t) will introduce a time variant and structural unstable system. Equation (1) indicates that *science is dealing with concepts*.

So, when "*testing ecological theories,*", the ecological theories are dependent on the chosen elements in a system. Incomplete models introduces noise or disturbance from an unknown source.

A *subsystem* $S_i(t)$ may be modeled by a new set of subsystems represented by the simplified architecture

$$S_i(t) = \{B_i(t),\{S_{i1}(t), S_{i2}(t),,,, S_{im}(t)\}\} \in w \qquad (2)$$

where $S_{im}(t)$ represents the im-te subsystem and $B_i(t)$ represents the mutual binding between the subsystems. The sub system $S_{im}(t)$ may be modeled by a new set of subsystems. A system model thus is dependent on the model system abstraction level. This means that the explanations of dynamics in nature are dependent on the integration of events in a system level. Equation (2) indicates that *concept models are dependent on the abstraction level.*

So, when "*testing ecological theories,*" The ecological theories are dependent on the chosen abstraction level in a system.

The system dynamics

According to (1) and (2) we may expect a time variant binding B(t) between the system elements. This indicates we may expect

1. A time variant stochastic system
2. Time variant parameters in all models
3. No mean values in the system
4. No stationary biomass safe limits

In a time variant system, the phase of dominant cycles are of most importance. The phase of dominant cycles may be studied by

1. A wavelet spectrum analysis of time series
2. The relation between wavelet cycles in a mutual related system

If there is estimated a driving force in the wavelet analysis, there is a possibility of long-term forecasting.

Modeling Mediterranean Sea

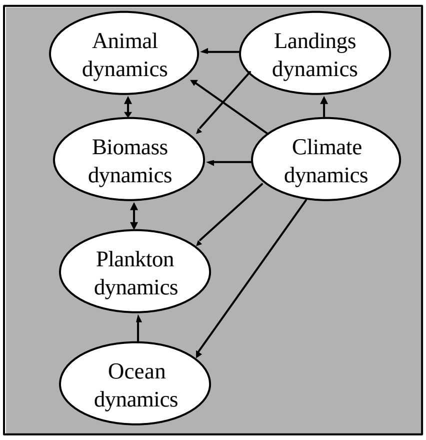

Figure 1. A simple Mediterranean system model

The Mediterranean system may be represented by a simplified system model as shown on Figure 1. This system may be represented by the system elements

$S_{Med}(t) = \{B_{Med}(t),\{S_{Climate}(t),S_{Ocean}(t),S_{Plankton}(t),S_{Biomass}(t),S_{Animal}(t),S_{Landings}(t),S_v(t)\}\} \in w$ (3)

Where $S_{Climate}(t)$ represents the climate system, $S_{Ocean}(t)$ represents the ocean system, $S_{Plankton}(t)$ represents the plankton system, $S_{Biomass}(t)$ represents the plankton system, $S_{Animal}(t)$ represents the animal system, $S_{Landing}(t)$ represents the landing system, $S_v(t)$ represents disturbance from an unknown source and $B_{Med}(t)$ represents the mutual binding between the systems.

The objectives of the work shop is

a) *testing ecological theories, thus deepening our understanding of the structure and function of marine ecosystems;*
b) *applying recent approaches in identifying and quantifying the effects of human impacts on marine ecosystems; and*
c) *practical purposes, such as short- and medium-term forecasting, and thus largely relevant to management.*

Testing ecological theories need a holistic approach as described in Eq. (3). This implies we need to understand the dynamics of each system element in the system model (3), and we need to understand the mutual dynamics controlled by the time variant binding $B_{Med}(t)$.

Short- and medium-term forecasting is dependent on

1. the eigen dynamics in the system element
2. how the system is controlled by external system
3. the model abstraction level
4. sampling in time and space

This means we have a complex system, and we have to make some choices.

What are we looking fore?
What are we looking for when we have a complex time variant system?
The answer is, we are looking for something deterministic in a time variant process.

More questions

When we are looking for something deterministic, it may be a good start to ask new questions about the system elements.

The climate dynamics:

1. Do we have some long climate indicator time series?
2. Are there deterministic cycles in the climate indicator time series?

Ocean dynamics:

1. What are the Large-scale circulation patters, cycle time and cycle phase?
2. What are the Sub-basin Scale Circulation patters, cycle time and cycle phase?
3. What are the Mesoscale Circulation patters, cycle time and cycle phase?
4. What are the tide cycle time and cycle phase?
5. Is there a vertical tide in the oceans?

Plankton dynamics:

1. What are the relation between Plankton dynamics and Ocean dynamics?
2. What are the relation between Plankton dynamics and climate indicators?
3. What are the relation between Plankton dynamics and seasons?

Biomass dynamics:

1. Why are there so many different spices in the Mediterranean Sea?
2. Why have the spices a short life cycle time?
3. Have most spices the same spawning cycle time?
4. Is there a relation between the spices life cycle time and an ocean circulation cycle time?

Animal dynamics:

1. What are the relation between Animal dynamics and Biomass dynamics?
2. What are the relation between Animal dynamics and Climate dynamics?

Landings dynamics

1. What are the long history records of catch?
2. What are the relation between long history records and Climate dynamics?
3. What are the official landin g dynamics?
4. What are the expected la ding dynamics?
5. What are the relation between Landing dynamics and Population dynamics?
6. What are the indirect indicators of biomass catsh?

When we have some answers to these questions, the time has come to make integrated model. The poem "Computers: the Irish Sea" by *Stafford Beer*, say something about this problem.

"Computers: the Irish Sea"

"That green computer sea
with all its molecular logic
to the system's square inch,
a bigger brain than mine,
writes out foamy equations from the bow
across the bland blackboard water.

Accounting for variables
which navigators cannot even list,
a bigger sum than theirs,
getting the answer continuously right
without fail and without anguish
integrals white on green.

Cursively writes recursively computes
that green computer sea
on a scale so shocking
that all people sit dumbfounded
throwing indigestible peel at seagulls
not uttering an equation between them.

All this liquid diophantine stuff
of order umpteen million
is its own analogue. Take a turn
around the deck and understand
the mystery by which what happens
writes out its explanation as it goes."

Stafford Beer, 1964, from Transit