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The Sylt-Rømø Bight Ecosystem Model (SRB Model) – an Introduction

(Final report of the project "SWAP: Modeling of abiotic and biotic aspects of the ecosystem 'Sylt-Rømø bight'", BMBF-Förderkennzeichen: 03 F 006 E/F)

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T. Fast, A. Müller, A. Wilhelm

102 pages with 34 figures and 6 tables

Abstract

Based on the Dutch EcoWasp model the Sylt-Rømø bight ecosystem model (SRB Model) has been developed. The SRB Model is available in two versions now: one for the whole bight area, and one for the Königshafen, which has been the main examination area of the SWAP project. The model describes the oxygen balance and the nutrient cycles in the water column as well as in the sediment. In particular the organism groups pelagic diatoms and non-diatoms, benthic diatoms and blue mussels and the seagrasses *Zostera marina* and *Zostera noltii* are taken into account. The local temporary measurements of the varied SWAP subprojects were used as comparison data for simulation results for the years 1989-1993. This comparison shows good agreement for the nutrient cycles, the dynamics of phytoplankton, the development of a blue mussel bed, and the seagrass calculations. This report describes the conception, the structure, and the handling of the model and shows some model results in direct comparison with measurements, if possible.

Das Sylt-Rømø Bucht Ökosystemmodell (SRB-Modell) - eine Einführung

(Abschlußbericht des Vorhabens „SWAP: Modellierung von abiotischen und biotischen Teilaspekten des Ökosystems 'Sylt-Rømø Bucht'", BMBF-Förderkennzeichen: 03 F 0006 E/F)

Zusammenfassung

Ausgehend von dem niederländischen EcoWasp-Modell wurde ein Ökosystemmodell für die Sylt-Rømø Bucht entwickelt (SRB-Modell). Das SRB-Modell ist sowohl als Teilmodell für den Königshafen als auch als Modell für die Gesamtbucht realisiert. Es umfaßt in der vorliegenden Ausbaustufe die Beschreibung des Sauerstoffhaushaltes und der Nährstoffkreisläufe im Wasserkörper und im Sediment und berücksichtigt explizit die Organismengruppen pelagische Diatomeen und Nicht-Diatomeen, benthische Diatomeen, Miesmuscheln und die Seegrasarten *Zostera marina* und *Zostera noltii*. Simuliert und mit den SWAP-Meßergebnissen verglichen wurden die Jahresgänge 1989 bis 1993 (SWAP-Meßzeitraum). Es ergaben sich gute Übereinstimmungen für die Nährstoffkreisläufe, die Phytoplanktondynamik, die Entwicklung einer Miesmuschelbank und die Seegrasmodellierungen. In diesem Bericht werden das Modellkonzept, der Modellaufbau und die Modellhandhabung beschrieben und Modellergebnisse beispielhaft dargestellt, soweit möglich im direkten Vergleich mit Meßwerten.

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Contents

1. Introduction

Since observations and measurements of ecological systems often are not able to answer questions of interest completely, the modelling of ecosystems has been recognized as a helpful additional tool. Within the last years some models for marine ecosystems in the southern North Sea have been described (Baretta & Ruardji, 1988; Brinkman et al., 1991; Ebenhöh & Simoneit, 1994; EON, 1988a & b; ERSEM, 1993; ERSEM, 1995; ERSEM, 1997; Müller et al., 1992; Nienhuis & Smaal, 1994). In view of their use as additional tool for understanding coastal ecosystems most of them have problems due to low data basis. In fact, the availability of system data is a key component in ecosystem modelling. These data should be easy to access and to use and should be accurate and precise enough to obtain the necessary answers for model relevant questions. Improving the reality and possible accuracy of the models used to describe trends, annual cycles, and events in coastal ecotones results in the need of better comprehension of the field data which are used to run, calibrate and verify these models. Therefore for the further development of models the close cooperation of modellers and data collectors is necessary.

In order to learn something about exchange processes and balances within the Wadden Sea and between Wadden Sea (coastal water) and North Sea, the extensive interdisciplinary research project SWAP (Sylter Wattenmeer Austauschprozesse = Sylt Wadden Sea Exchange Processes) started in 1989 and has been finished in 1996. Although there have been done many experiments with a lot of results, some open questions are still existing or not answered satisfactorily. In order to support the concluding evaluation of SWAP, a second project started in summer 1994 and ended in spring 1999: „SWAP: Modelling of abiotic and biotic aspects of the ecosystem Sylt-Rømø bight“. The project is funded by the German Federal Ministry for Education, Science, Research, and Technology (BMBF), too. The aim of this modelling project was to assess or extrapolate some aspects of balances, internal transports and transformations for the Sylt-Rømø bight and its ecological structures. Additionally, the new model could become a useful tool for interested scientists and further applications in Wadden Sea research.

The model developed in the frame of these projects is the ‘SRB Model’ (= Sylt-Rømø bight ecosystem model). It is a general purpose computer simulation model for shallow coastal waters. It contains biological, chemical and physical processes and is an extension and further development of the Dutch EcoWasp Model (Brinkman et al., 1991; Brinkman, 1993b; Brinkman & Smit, 1993; Brinkman, 1995).

The SRB Model has been built for the Sylt-Rømø bight at the Danish-German Wadden Sea and is available in two versions: one for the Königshafen, a small bight at the northern tip of Sylt, and one for the whole bight area. For the simulation the areas have been divided into several spatial and functional compartments. The Königshafen model consists of one spatial compartment divided into six functional compartments: shallow subtidal zone, sand flat, sandy mud flat, mud flat, mussel bed, and seagrass bed. The model version for the whole bight consists of seven spatial compartments, according to the so called SWAP-compartment division (Figure 3.3). Each of these spatial compartments is subdivided into seven functional compartments, they equal the functional compartments in the model release for the Königshafen. Additionally, the deep subtidal zone exists. This means for the Königshafen model six compartments and for the Sylt-Rømø bight model 49 compartments. The vertical structure of each model compartment gives one pelagic and five benthic layers (Figure 3.1). Therefore the Königshafen model has a resolution of 36 boxes, the Sylt-Rømø bight model consists of 294 boxes.

In general, the model is organized in four main directories: data, models, modest, and wave. In the ‘data’ directory are three subdirectories: at_kh, at_srb, and valid. The ‘at_*’ subdirectories contain ASCII files with time series for the input data for water temperature, solar radiation, wind speed, nutrient, phytoplankton and detritus concentrations in the Lister Ley (input for Königshafen model) or the North Sea (input for Sylt Rømø bight model). Additionally some time series for the annual dependent calculation of seagrass dynamics are given. The ‘valid’ directory contains data from measurements which can be used for the graphical comparison of simulation results and measurements with the graphic tool ‘wave’, based on Visual Numerics, Inc., PV-WAVE (see chapter 5).

In the ‘models’ directory the main directories for the Königshafen model (‘kh’) and the Sylt-Rømø bight model (‘srb’) process descriptions are organized (see chapter 3).

The ‘modest’ directory contains all informations for the pre- and postprocessing of in- and output data and the integration routines. It is organized in diverse subdirectories: bin, include, lib, newdriver, scripts, and time. For further descriptions see chapter 4. During one simulation run the ‘si’ command regulates the interactions and connections between the ‘models’ and the ‘modest’ directory.

The ‘wave’ directory contains all routines which are necessary for the graphical representation of models results on the screen (see chapter 5).

The chapters 6 to 11 give descriptions of main processes and organisms which are included in the SRB Model and calculated during a simulation run.