The Influence of UVR and Climate Conditions on Fish Stocks: A Case Study of the Northeast Arctic Cod (UVAC)

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Project website: http://phaeocystis.nfh.uit.no/uvac/

Objectives

The main of the UVAC was to study the influence of potential geophysical regulators, with an emphasis on UV radiation. On Northeast Arctic cod directly and, where feasible, on its feeding conditions.

In more detail it was planned:

1. To re-analyse historical data sets of cod recruitment and fishery and correlate them with regional UV and meteorological long-term records

2. To perform a more detailed correlation study between UVR and cod and its food web based on satellite-derived UVR maps from the region

3. To perform supporting field and laboratory process studies of the potential impact of UVR on cod, zooplankton and phytoplankton

4. To develop geophysical/biological modelling tools in order to improve the predictability of cod year class strength.

Results

The UVAC project lead to a major progress in deriving a comprehensive data set of UV radiation based on ancillary data from ground-based and satellite measurements:

65-year UV daily dose record for Skrova, Lofoten, Norway
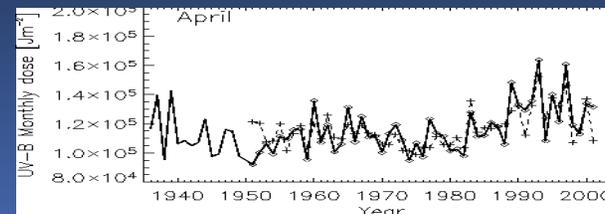
18-year UVB climatology based on METEOSAT cloud and TOMS ozone data
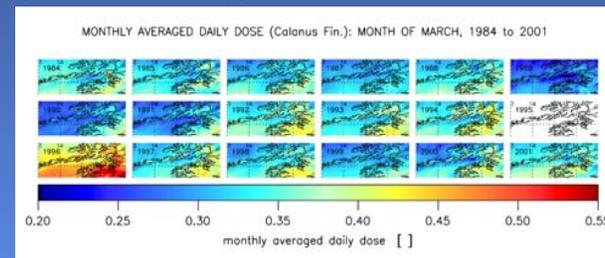
BUT: The main working hypothesis that UVR affects cod eggs and larvae negatively was rather contradicted than supported by correlation studies
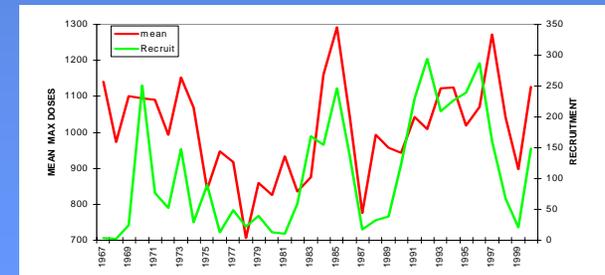
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Results (2)

The field and laboratory studies, on the other hand, rather support earlier studies that UVR has a negative, and, under certain conditions, lethal impact on both cod eggs and larvae as well as on the zooplankton *Calanus finmachicus*, the main feeding of cod larvae.

Hatching success of cod embryos after a six-day exposure to sunlight

Percentage of hatching success andviability of Calanus finmarchicus nauplii after exposure to UVR
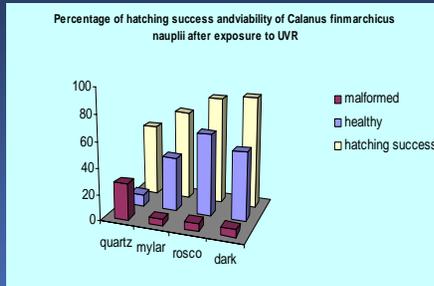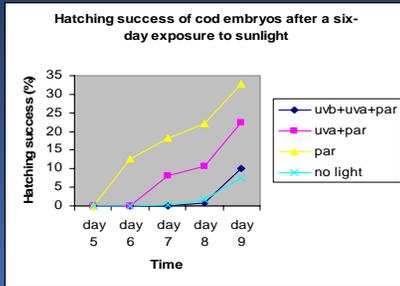
However, field experiments also showed that the UVR effects were much less significant under realistic conditions at sea than under "ideal" laboratory conditions.

Since the main work hypothesis was not confirmed, the development of a biological-geophysical model focusing on UVR was not achieved. However, with a realistic process model including solar irradition, water transparency, turbulence etc. it could be shown that only in few years since 1970, under special geo-physical conditions – few clouds, low ozone, slack wind – radiation levels reached critical levels. In the two years of field investigations, levels were almost a factor 10 lower.

Doses recieved by eggs and larvae as modeled with realistic turbulence model
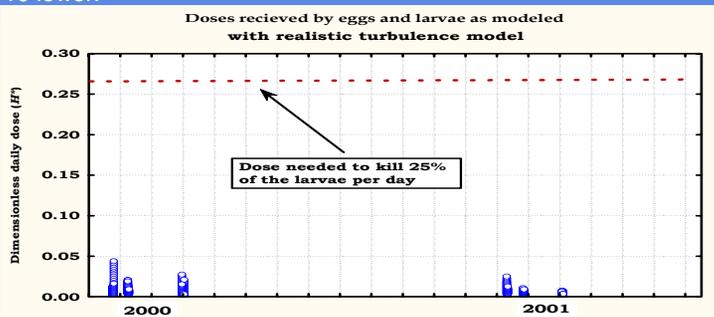
Relevance for Society

Our study has shown that "in the real world of the North Atlantic" UVR is not an important geophysical parameter to be considered for marine ecosystems under present conditions. On the other hand, if climatic conditions change, leading to less cloudy and windy weather, critical levels can be reached even with "normal" ozone/UVR levels.

The UVAC project also showed that other geophysical conditions – sea temperature and turbulence, which are highly correlated with both the NAO and the GSI index – correlate signifcantly with cod 0-year class strength. Hence, these well-known parameters could be used easily for estimates of expected cod recruitment 3 – 5 years in advance, allowing the determination of fishing quota over a longer time frame than the annual base used today.
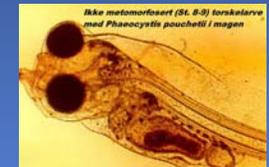
The UVAC project yielded a wealth of new data on the cod – zooplankton – phytoplankton ecosystem in addition to simultaneous radiation and oceanic data in the Vestfjord region which can be used in future studies of this important fishing region.

The project produced the longest UVR data series on a daily basis ever calculated, using a new modelling approach. It also lead to the calculation of a comprehensive UV climatology not only of the study region but the whole of Europe, which can be applied to any kind of UV impact studies.