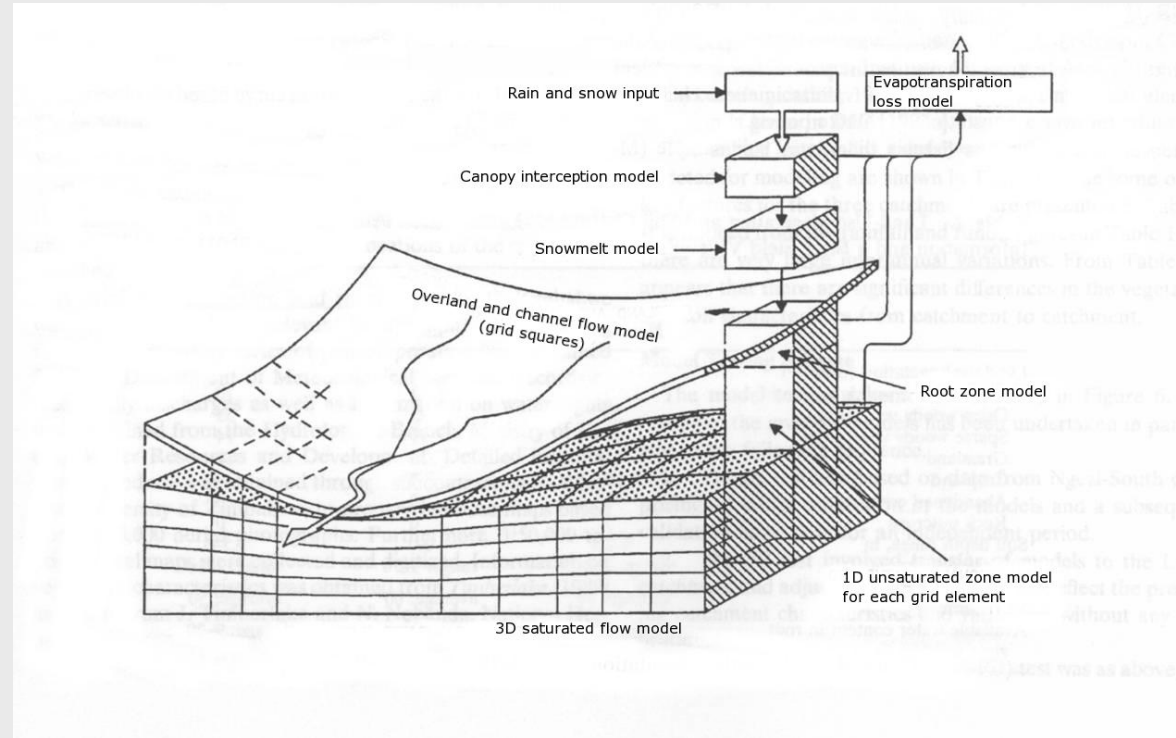
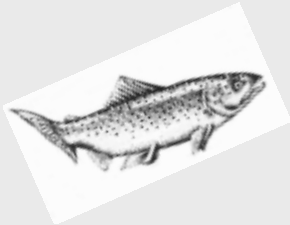


# How to assess groundwater abstraction impact on in-stream physical habitat conditions in small lowland streams



**Martin Olsen<sup>1</sup>, Eva Boegh<sup>1</sup>, John Conallin<sup>1</sup>, Hans Jørgen Henriksen<sup>2</sup>, Jens Christian Refsgaard<sup>2</sup> & Lars Troldborg<sup>2</sup>**

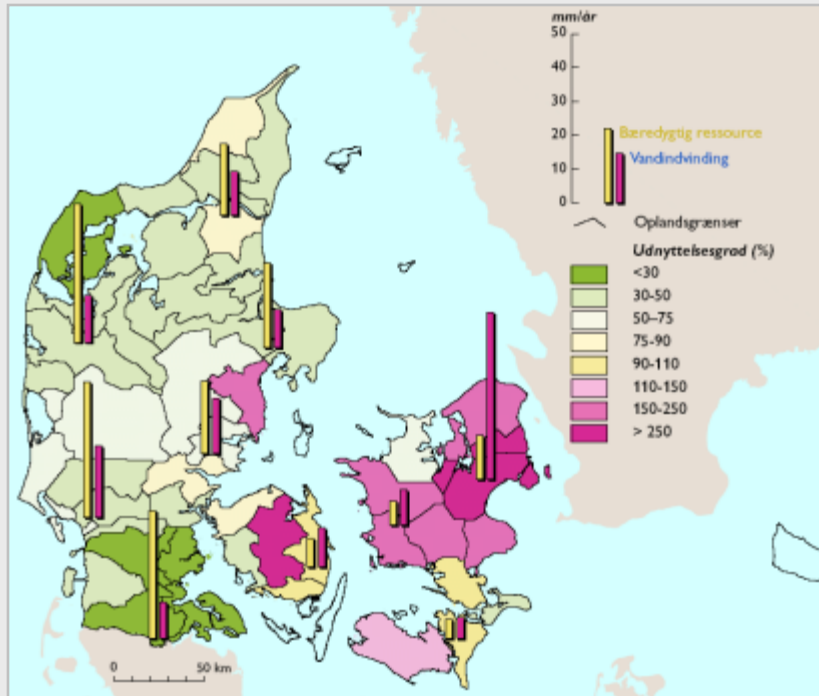
**1) Department of Environmental, Social and Spatial Change (ENSPAC), Roskilde University  
2) Department of Hydrology - Geological Survey of Denmark and Greenland (GEUS)**

**ENSPAC**

**Roskilde University**



# Danish Groundwater Resource



Henriksen & Sonnenborg (2003)

- Overexploited (Henriksen & Sonnenborg 2003; Henriksen et al. 2008)
- Minimum flows most limiting
- Special challenge in relation to groundwater abstraction impact assessment on minimum flows

*”The analysis of critical streamflow depletion-limit values was based on figures from Danish guidelines for water supply planning from 1979. There is a strong need for new and better estimates of threshold values for critical streamflow depletion for both average flow and low flow conditions linked to ecological parameters, e.g. using habitat models”*

Henriksen et al. (2008)

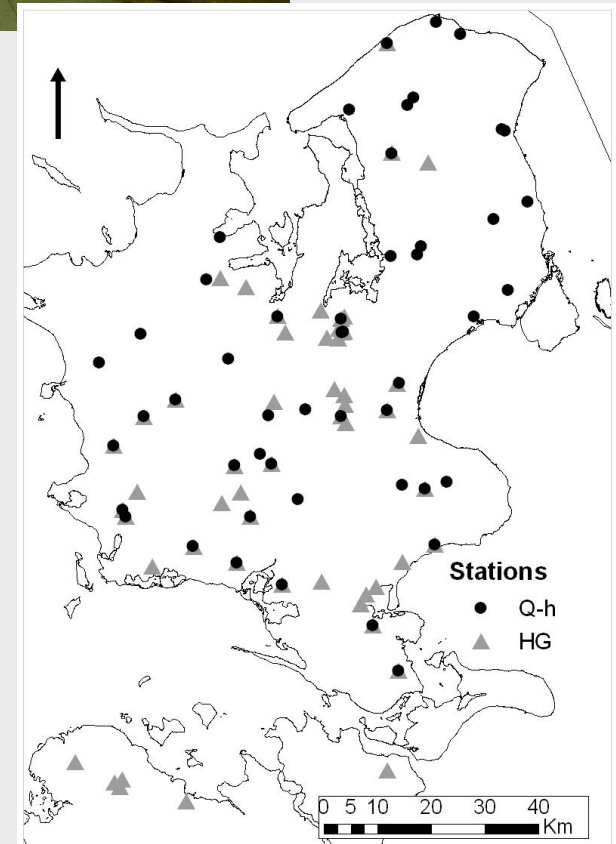
# Objective

- *to assess if it is feasible to combine in-stream environmental flow criteria with an integrated surface-groundwater model to quantify groundwater abstraction impacts on in-stream physical habitat conditions*
- **Outline**
  - Case
  - Habitat Conditions
  - "Eco-relevant-flows"
  - Flow simulations and "Eco-relevant-flows"

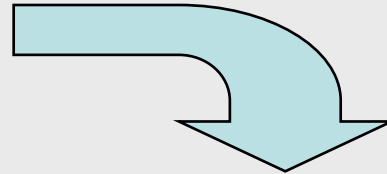
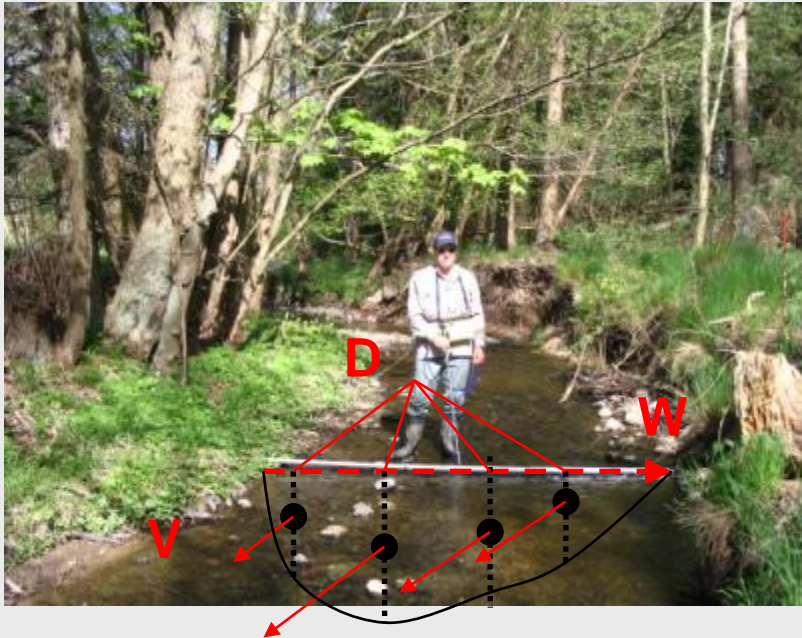


# Case

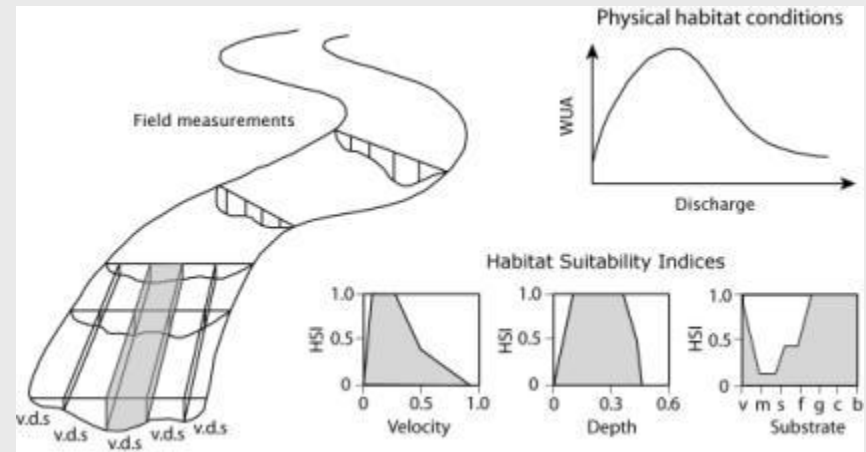
- Zealand
- Groundwater abstraction
- Impact on stream flow
  - Majority <2.5 m wide
  - Physical habitat
- Brown trout
  - Well studied ecological indicator species
  - Spawning streams



# Physical Habitat Conditions



How does physical characteristics change with flow? Often depth, velocity, substrate and wetted area.



# Ecologically relevant flow

- When?

## Expert Opinion Critical Flow-type Calendar

Life stage \ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fry (<7 cm)				H	H	H	L	L	L	L		
Juvenile (7-20 cm)	N	N	N	N/L	N/L	N/L	L	L	L	L	N	N

- What?

### Critical flow

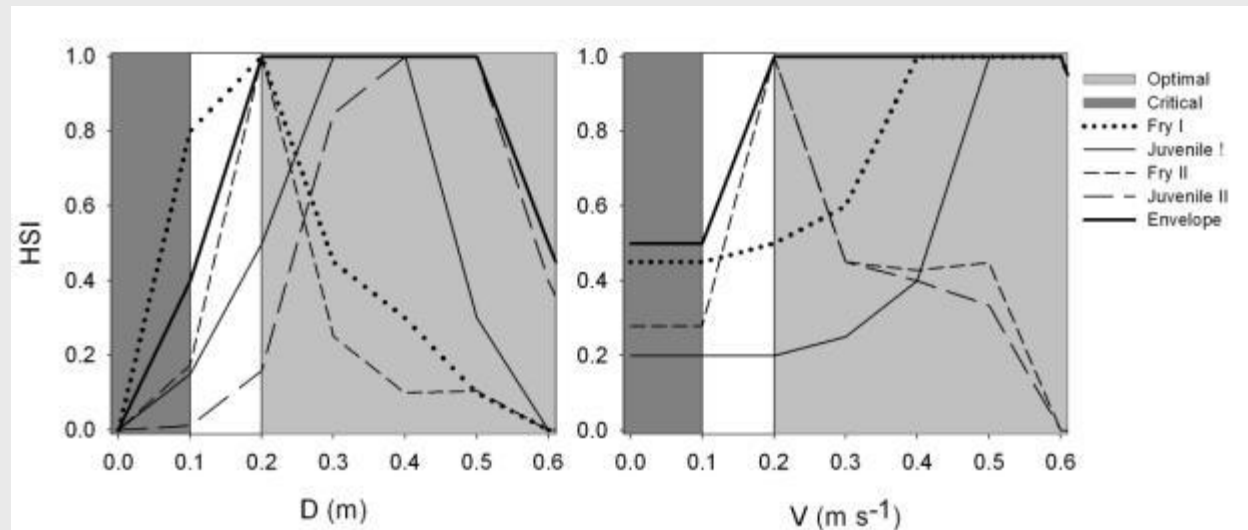
$$D < 0.1 \text{ m}$$

$$V < 0.1 \text{ m s}^{-1}$$

### Optimum flow

$$D > 0.2 \text{ m}$$

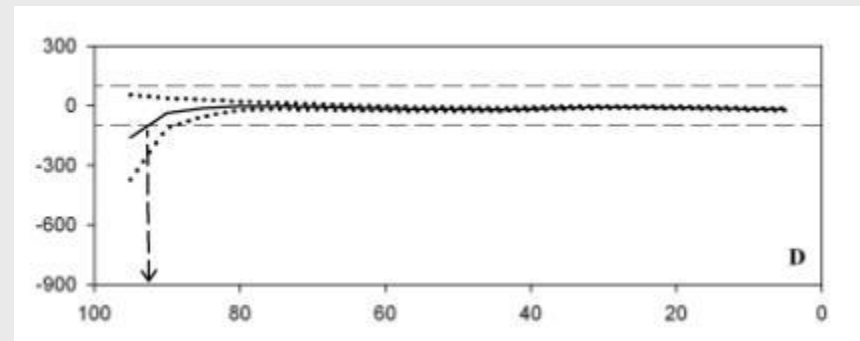
$$V > 0.2 \text{ m s}^{-1}$$



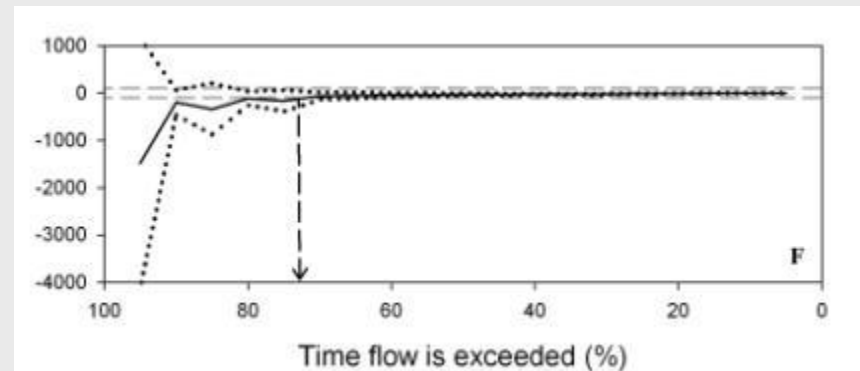
# Flow simulation bias

- Groundwater surface water model covering Zealand (DK-model) ~7000 km<sup>2</sup> (MIKE SHE and MIKE 11 based)
  - New calibration with improved simulations of low flows
  - 49 discharge stations
- Annual flows
  - ~8% of time flow >100% overestimated
- Summer flows
  - ~28% of time flow >100% overestimated

Annual flows

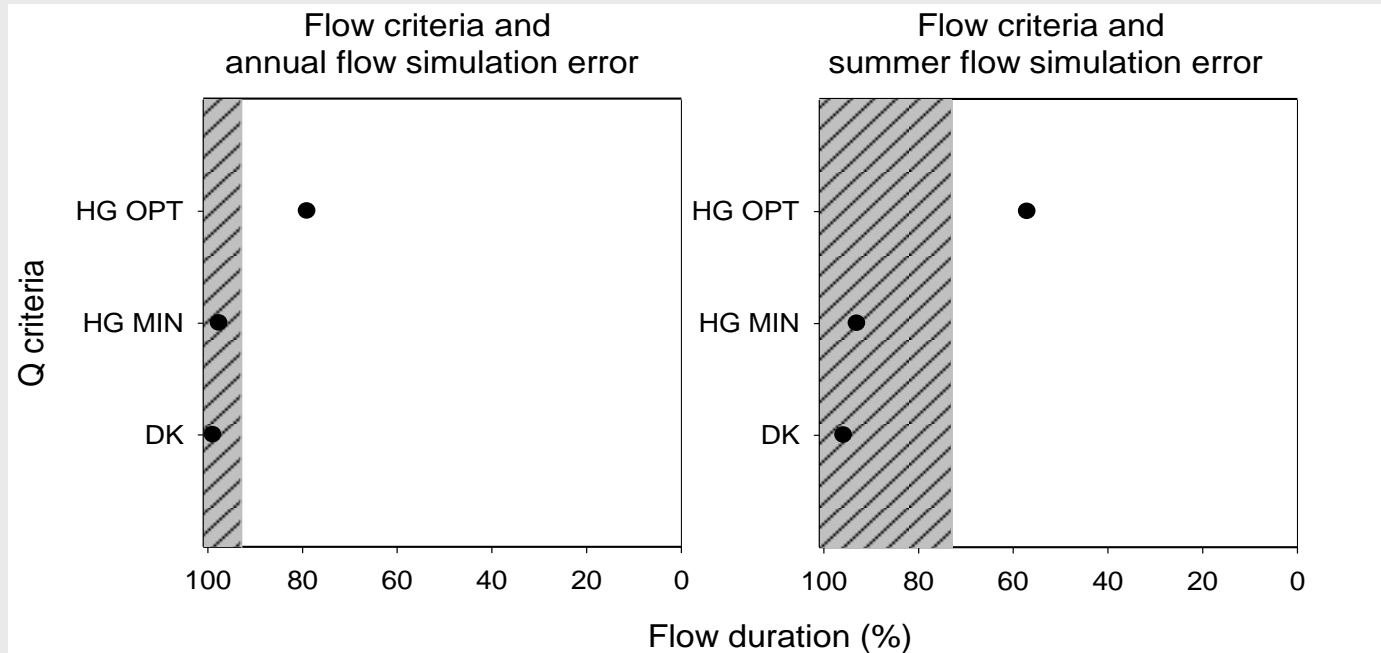


Summer flows



Arrow = 100% bias

# Flow criteria and seasonal Q simulation

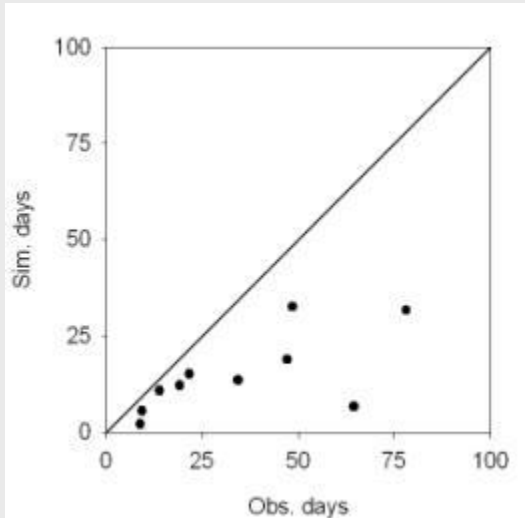


- Low flow criteria are in flow range with  $>100\%$  simulation error
- Optimum flow criteria are in flow range with  $<100\%$  simulation error



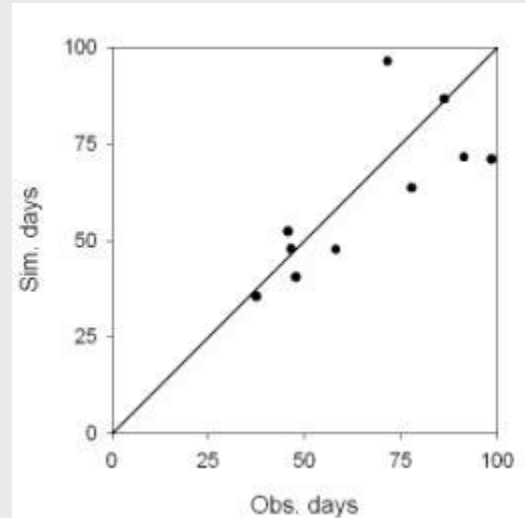
# Flow simulations

Low Flow



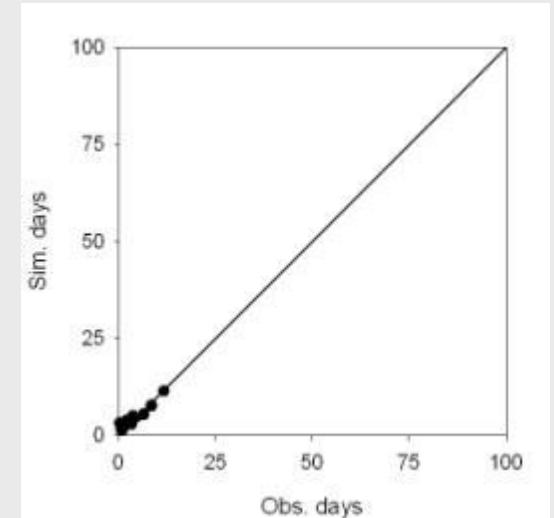
Lower than  $Q_{low}$

Optimum Flow



Lower than  $Q_{opt}$

High Flow



Higher than  $Q_{high}$

- Low flows = largest simulation error
- High flows = lowest simulation error

# Take home message I

## Low flow criteria

- ***It is NOT feasible to combine low flow criteria and large scale integrated surface-groundwater models***
  - *Low flow; depth = 0.1 m and velocity = 0.1 m s<sup>-1</sup>*
- ***Solutions***
  - *Sample low flows and sample at smaller scale*
  - *Set up more detailed hydrological models at smaller spatial scale*
    - *bridge the spatial gap between ecology and hydrology*
  - *Focus (weight) on low flows in set up, calibration and evaluation*

# Take home message II

## Optimum flow criteria

- ***It is feasible*** to combine optimum flow criteria and large scale integrated surface-groundwater model
  - Optimum flow;  $D = 0.2 \text{ m}$  and  $V = 0.2 \text{ m s}^{-1}$
- **Challenge**
  - How much and for how long time can optimum conditions be reduced before it is critical?
  - What is relation between optimum and critical flows?

# Groundwater abstraction and climate change impact on ecological conditions in streams Research project 2007-2009

Funded by the National Research Council for Technology and  
Production

## **Research Team Members**

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Roskilde University

Thanks for  
listening

Next  
Challenge?

