INSTITUTE OF MARINE RESEARCH

Towards a generic zooplankton IBM module in NORWECOM.E2E

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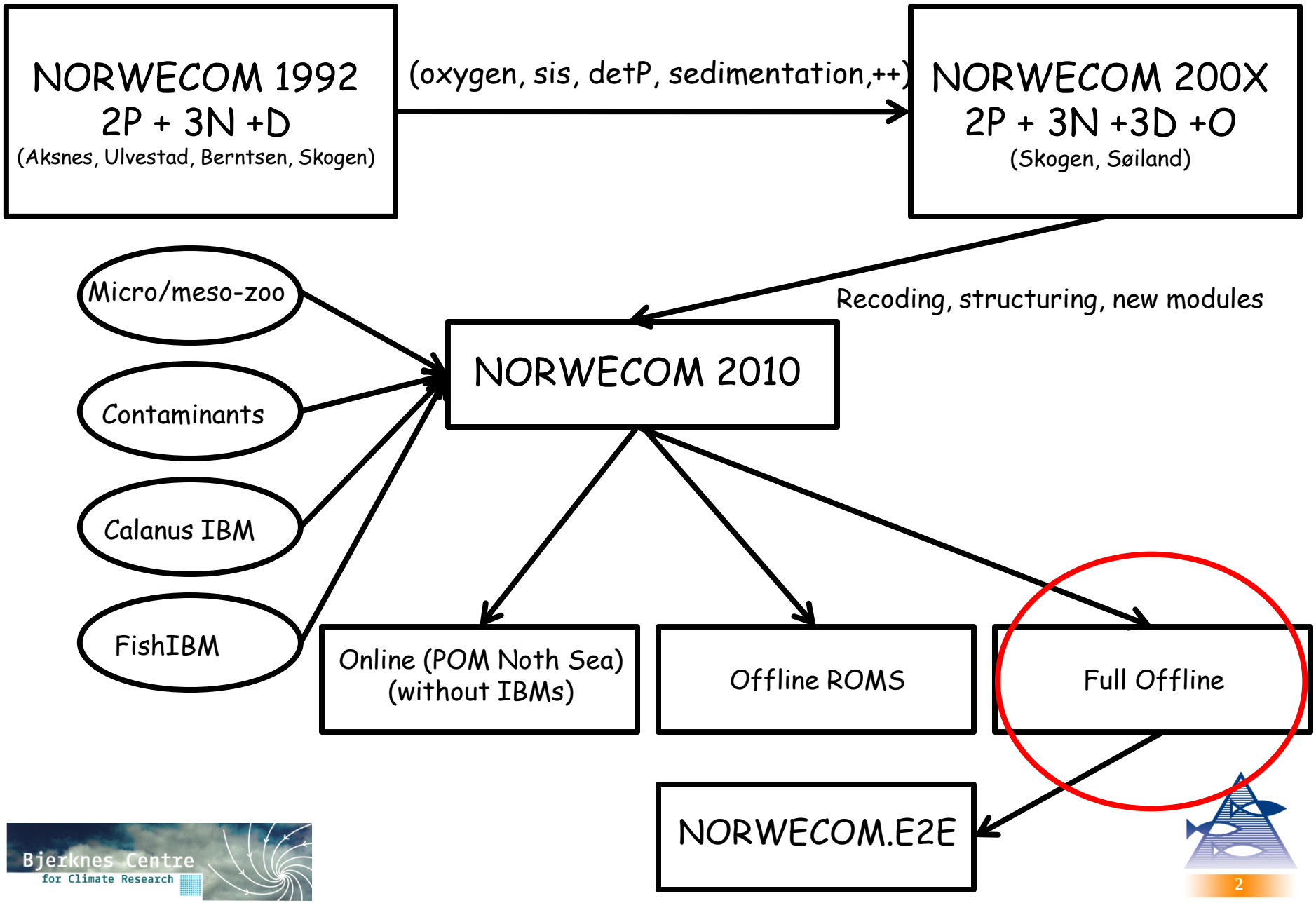
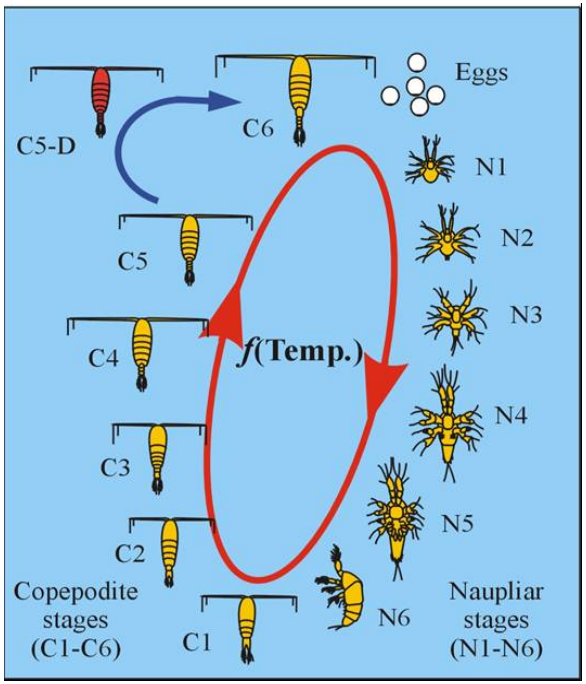

NORWECOM 1992
2P + 3N +D
(Aksnes, Ulvestad, Berntsen, Skogen)
(oxygen, sis, detP, sedimentation,++)
NORWECOM 200X
2P + 3N +3D +O
(Skogen, Søiland)
Recoding, structuring, new modules
Micro/meso-zoo
Contaminants
Calanus IBM
FishIBM
NORWECOM 2010
Online (POM Noth Sea)
(without IBMs)
Offline ROMS
Full Offline
NORWECOM.E2E

IBM Calanus module



From http://pulse.unh.edu/

Stage

Structural weight

Individual number

Fat content

Position

Depth

Feeding: functional response, type 2 (Campbell 2001)

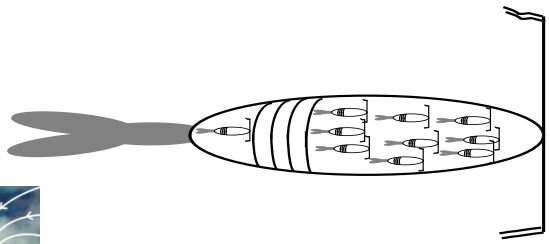
Growth: bioenergetics (Carlotti & Wolf 1998)

Mortality: predation, starvation, spawning

Reproduction: mature adults above weight and fat thres.

Vertical movement: ontogeny, dvm

Horizontal movement: by currents



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Object oriented approach

Object oriented programming - is a programming paradigm that uses "objects"- data structures consisting of data fields and methods together with their interactions – to design applications and computer programs

1) define a datatype with all necessary information about a calanus (or fish or krill) superindividual and use it inside a data type that contains all information about a stock/species…..

and

2) define routines that operates on these data types

```
module zoo_generic

! Type with attributes and strategy vector ++
type superind
        logical   :: alive      ! True if alive, false if dead
        integer :: stage        ! 0 egg, 1-6 naupli, 7-13 copepod
        integer :: inumb        ! Number of individuals in superind.
        real      :: x,y,z      ! Position (x,y,z)
        ……
end type superind

! Type for a whole population. Superind+ population specific parameters
type zoopop
        character(len=6) :: species   ! Name of species
        integer                :: pop       ! Pointer to last super ind.

        …….population specific parameters…….

        type(superind), dimension(:), allocatable :: zoopl
end type zoopop
```

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…….

```
 type zooplankton
! Attribute vector

      logical :: alive          ! true if alive, false if dead
      integer :: stage          ! 0 is egg, 1-6 nauplia, 7-11 copepodits, 12 adult
      real    :: inumb          ! Internal number in individuals
      real    :: sweight        ! Structural weight  in micrograms
      real    :: lstage         ! Stage longevity
      real    :: fat            ! Fat energy level in KJ
      real    :: moult          ! Moult cycle fraction (Egg,N2,N3) | cum. egg number (adult)
      real    :: maxegg         ! Total number of eggs in a super individual
      real    :: xpos,ypos,zpos ! Position (x,y,z)
      integer :: diapause       ! 0 diapause,1 active,2 move down,3 move up
      real    :: growth         ! Summing of daily growth
      real    :: egestion       ! Summing of hourly egestion
      integer :: mynumb         ! Unique identifier
      real    :: ingestion      ! Ingestion rate
      real    :: grate          ! growth rate
      integer :: numegg         ! number of spawned eggs
      real    :: inumb_int      ! Internal number in individuals at birth
! Strategy vector
      integer :: wud            ! Wake_Up_Day
      real    :: fsr            ! FSR
      integer :: afd            ! Allocation_to_Fat_Day
      integer :: owd            ! Over_Wintering_Depth
      integer :: vm1
      real    :: vm2
! Predation risk
      real    :: prisk(4)       ! Predation risk. Species dependent. Level set in CALCPRISK
    end type zooplankton
```

Population specific parameters *C.finmarchicus*:

```
real, dimension(0:13) :: st_wgt     ! Stage weight
real, dimension(0:13) :: mort       ! Mortality rates
real, dimension(0:13) :: a          ! Stage longevity parameter
real          :: stloli       ! Lower limit stage weight factor before starvation
real          :: strate       ! Starvation rate
integer       :: maxmoult     ! Maximum number of eggs to be spawned
integer       :: maxlstage    ! Maximum number of days in each stage
integer       :: mthresh      ! Mortality threshold, predation or MonteCarlo
real          :: cmat         ! Structural weight for spawning
real          :: eggw         ! Egg weight
real          :: cs           ! Fat/eggw ratio for spawning
real          :: initw        ! Initial weight at spawning
real          :: starvation   ! Rate of starvation at low stage_weight
real          :: meffect      ! Mutation effect
real          :: mprob        ! Mutation probability
…….           :: ……..
```

Fortran 90 modules:

- zoo_generic: typedefinitions and subroutines that operates on these (and are assumed general)
  - kill_zoopl, init_zoopl, copy_zoopl, spawn_zoopl, count_zoopl, popzip, phytomort, calmort, calrep, vertmov, combind
- tools (bad name..): useful routines that does not operate on the zooplankton types
  - val3d, getr, easyr, deriv, surlig
- ladim: Lagrangian Advecition DIffusion Model (Ådlandsvik)

- calanus_mod (one module for each species): uses the other modules and (until now) the remaining species specific routines
  - calanus (*mainprogram* should be *identical* for all zooplankton) calsta, initialise, calcprisk

First test – implementing a Krill module (Strand + Huse, IMR)……

- swimming behaviour (to be implemented in ladim)
- new/additional strategies:
    - night-depth
    - meters above bottom
    - first and last day for spawning
- additional parameters:
    - maxmig = max daily vertical migration
    - first copepod stage (krill=5, calfin=7)
    - stage for spawning (krill=12, calfin=13)
    - a few other minor details…

- **conclusion**: can easily adapt the generic module, perhaps with a few less elegant: **if(zoopl%species.eq.'krill')then**

Plan to extend model with:

- calanus helgolandicus, glacialis, hyperboreus
- generic fish-module

Remaining issues:

- general coupling between different IBMs (today only two-way hardcoded coupling between phyto and calfin IBM, and coupling between IBM fish model and IBM calfin implemented)
- order of predation – who to eat first – both between superindividuals and between stocks/species
- …….

Thank you for your attention

Bergen seen from Mt. Ulriken