A biophysical model for walleye pollock in the Gulf of Alaska to study recruitment variability:

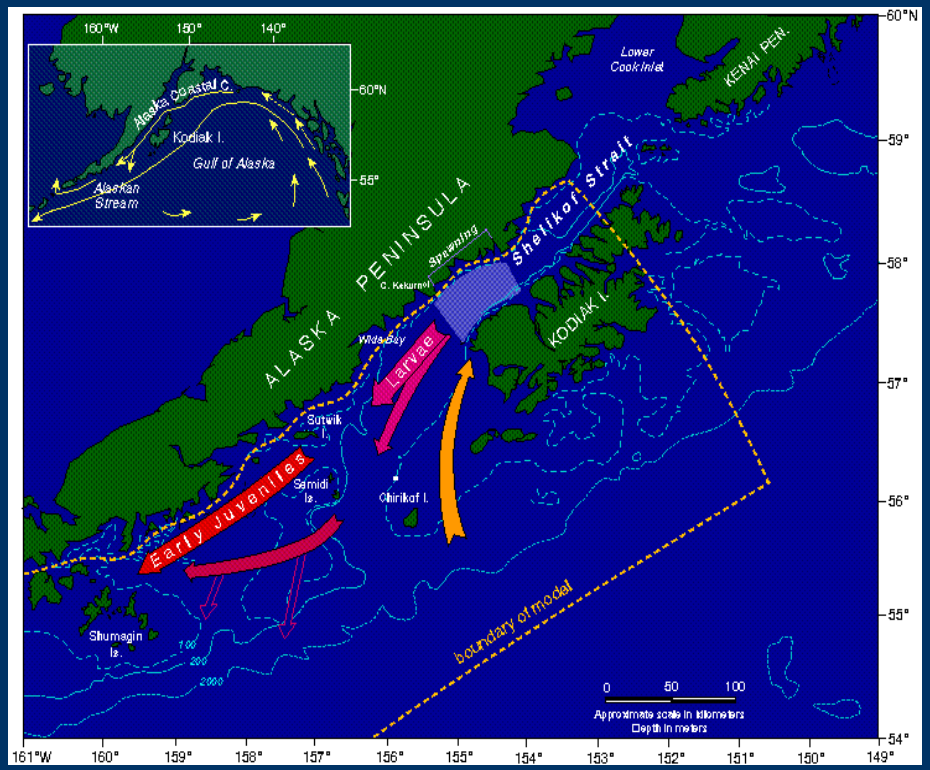
A coupled modeling approach

Carolina Parada , Sarah Hinckley & Albert Hermann

Alaska Fisheries Science Center
Pacific Marine Environmental Laboratory
NOAA, Seattle

Life history of walleye pollock in Gulf of Alaska …

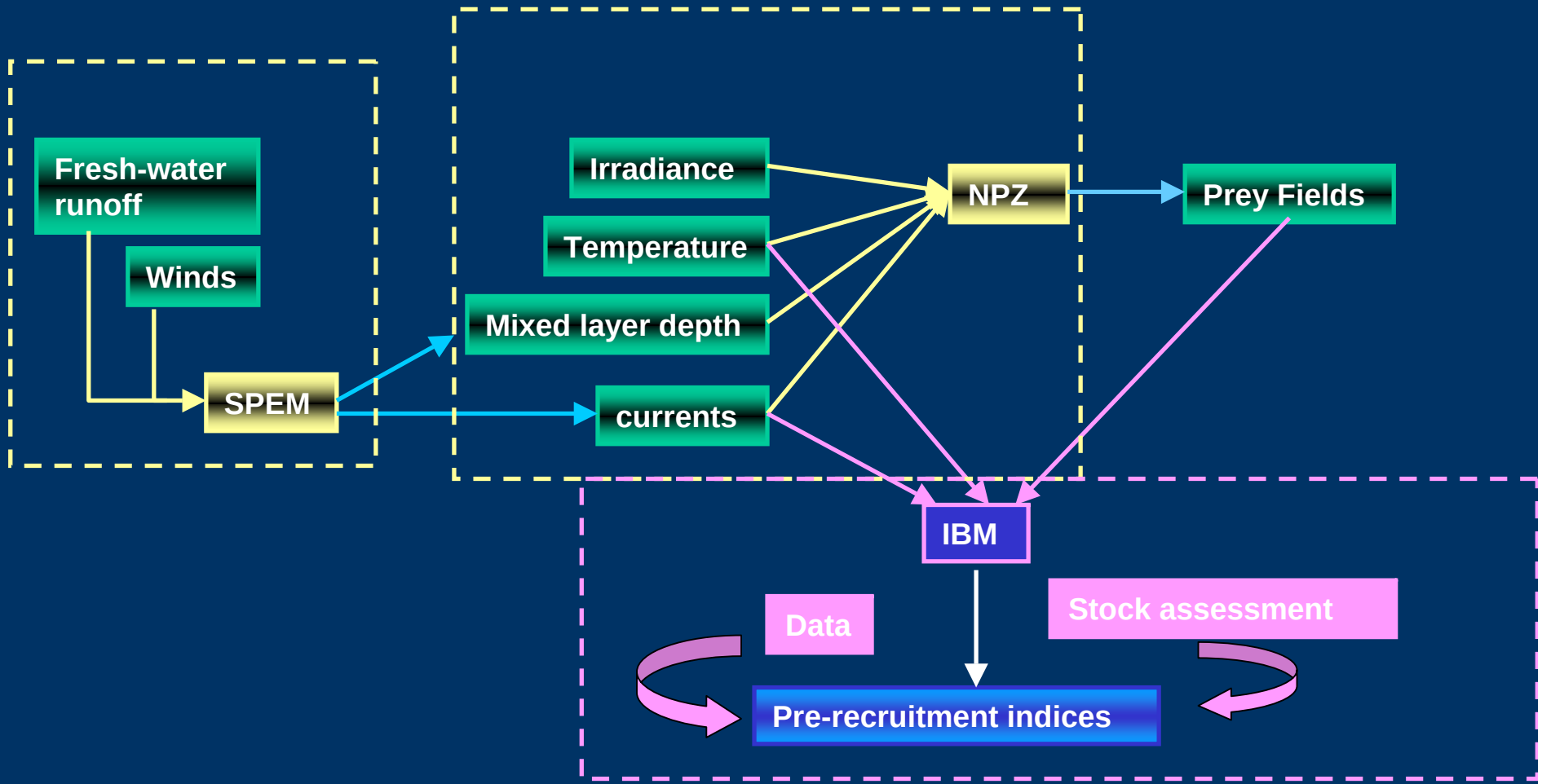
Spawning and Nursery grounds



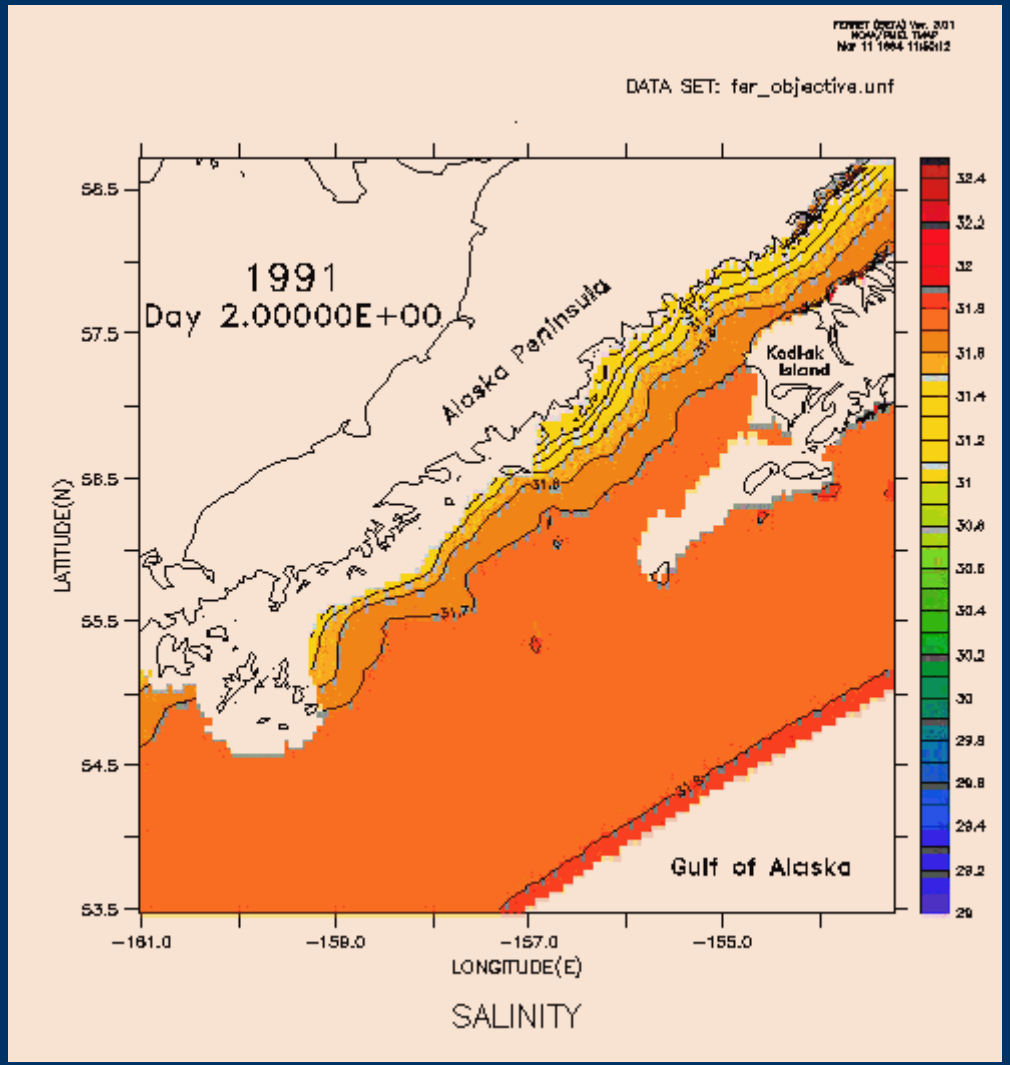
Recruitment variability: Assessment model Age-2

Objective ...

Implement an Individual-based model for walleye pollock coupled to hydrodynamic and NPZ models to estimate pre-recruitment indices



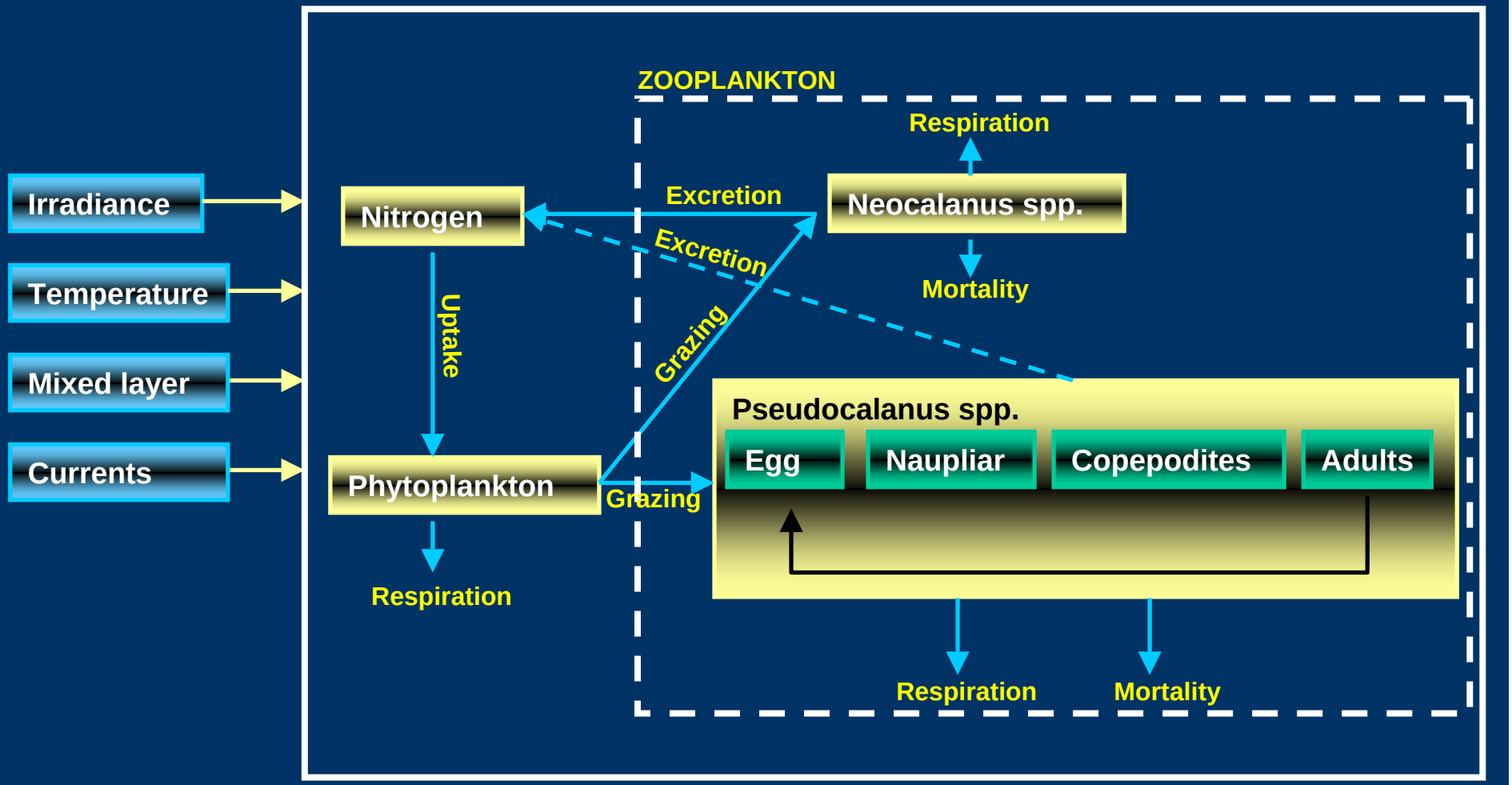
Experiments : Hydrodynamic model



The *hydrodynamic model* (SPEM, Haidvogel *et al.*, 1991) is a

- 3-D prognostic,
- rigid lid,
- Eddy resolving model of velocity and salinity fields
- Topography-following: sigma-coordinates
- Horizontal orthogonal curvilinear coordinate grid
- Horizontal model grid (258x98) has a coastal resolution of 4 km
- 9 vertical layers
- The model was forced by winds and fresh-water runoff from 1978-2002.

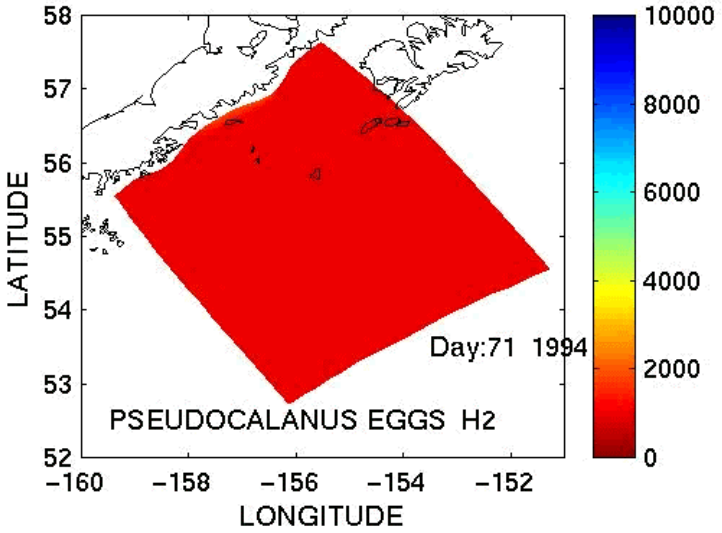
Experiments : NPZ Model

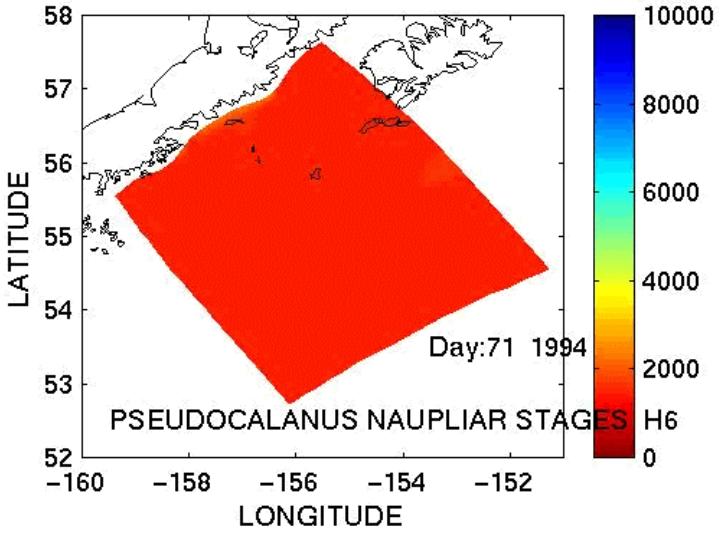


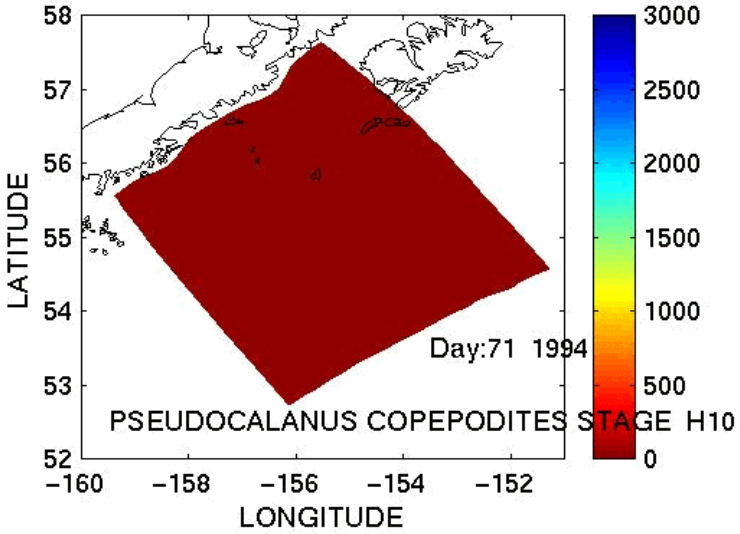
The *NPZ model* has a 3-layered structure similar to that described in Frost (1993).

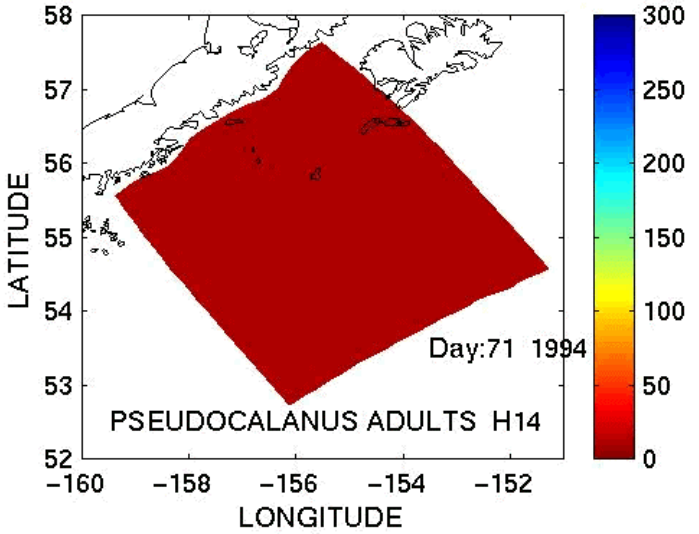
- The model runs through the spring transition period from the middle of March to the middle of June.
- NPZ provides a temporally and spatially varying food source for young pollock

Experiments : NPZ 1978-2002

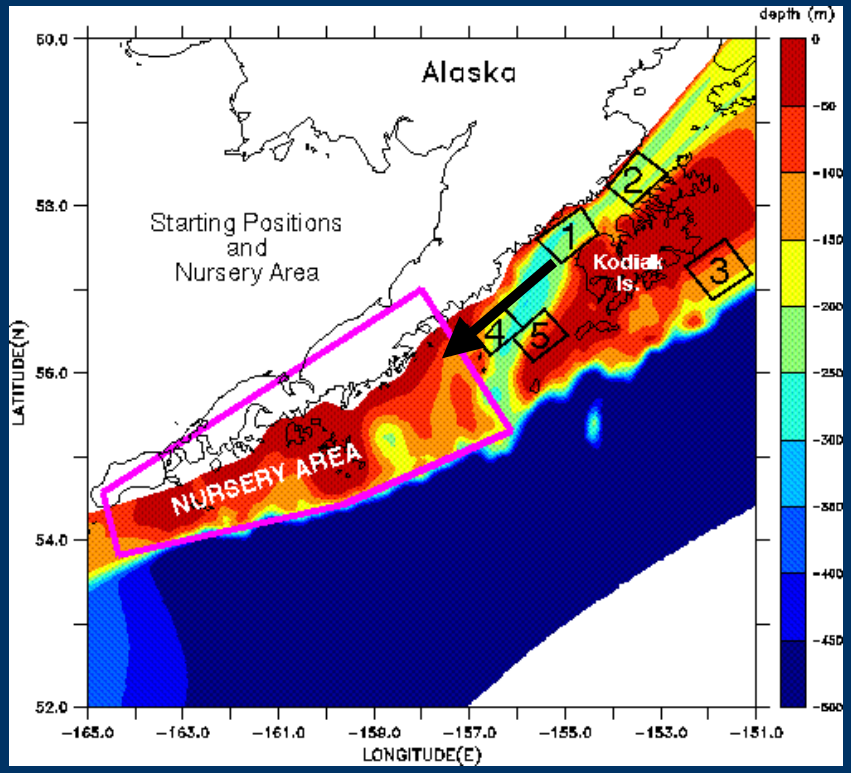








Experiments : IBM 1978-2002



The *IBM* for eggs to juveniles of pollock age-0 was run from 1978-2002 coupled to SPEM and NPZ

The initial conditions independent of the spawner biomass (same every year)

Setting the spawning parameters:

Area : Shelikof Strait

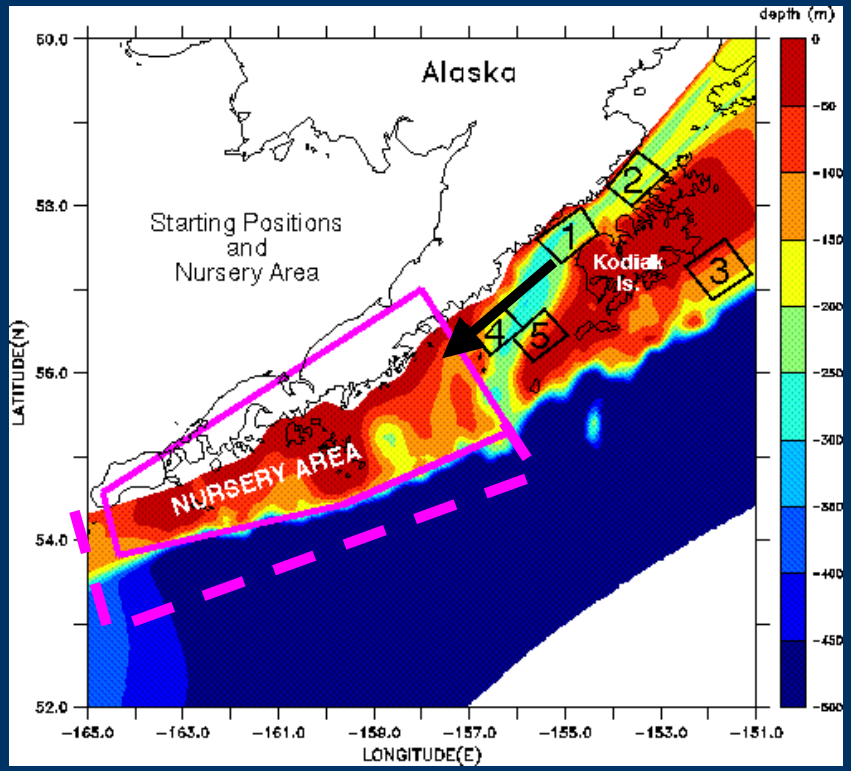
Date : Middle March to Middle April

Depth: 100-200 m

Pre-recruitment indices from IBM:

Proportion of individuals in a determined stage that arrive at nursery area weighed by the residence time.

Experiments 1: Transport to nursery Area



Indices extracted from the IBM :

Larval index (Feeding larvae) at Nursery area: Proportion of individuals in the larval stage that arrive at the nursery area weighed by the residence time.

Juvenile index at Nursery area: Proportion of individuals in juvenile stage that arrive at the nursery area weighed by the residence time.

Transport...

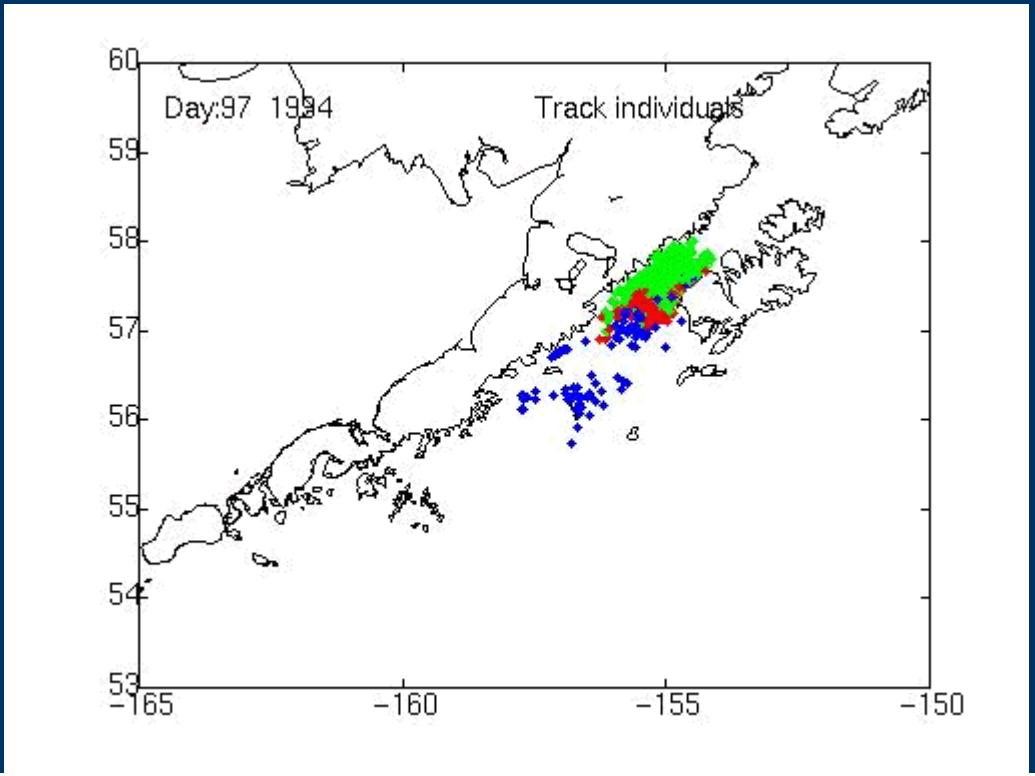
Eggs

Yolk sac larvae

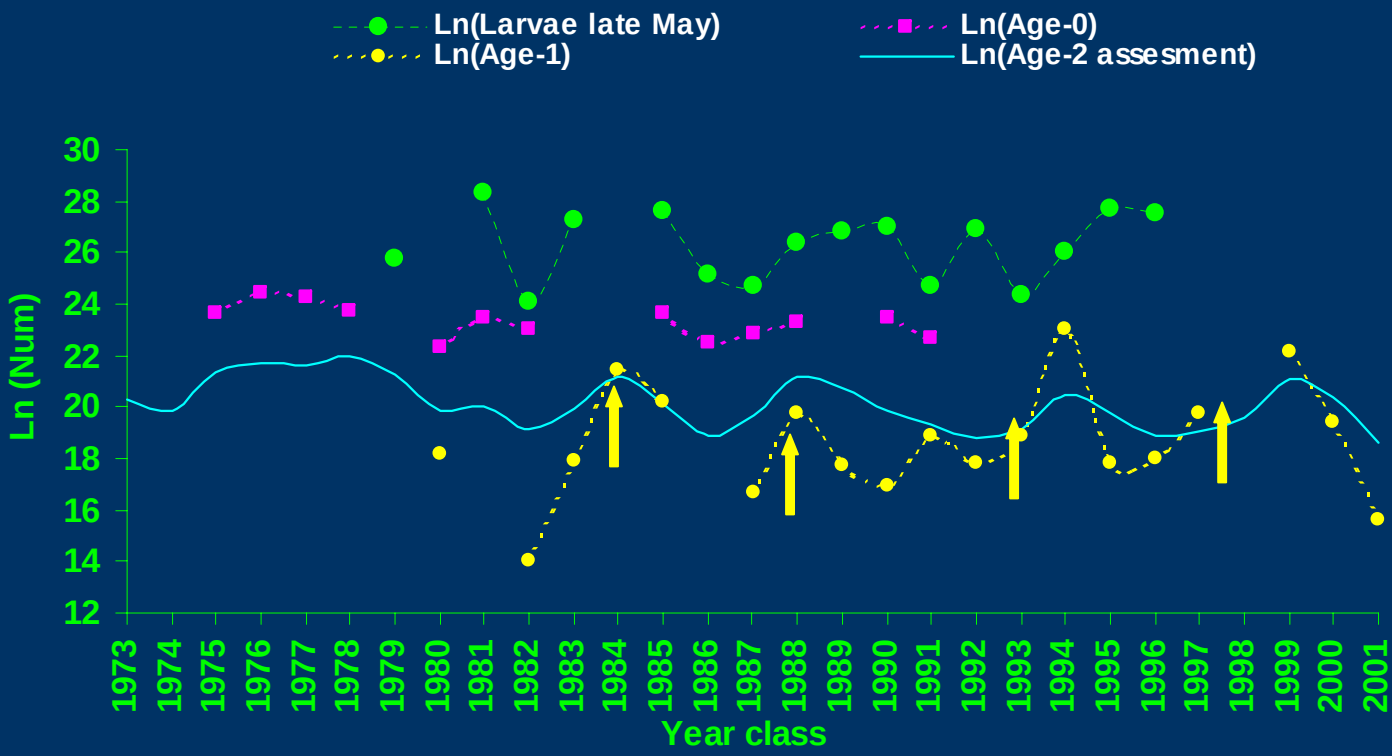
Feeding larvae

Juvenile Age-0

1994

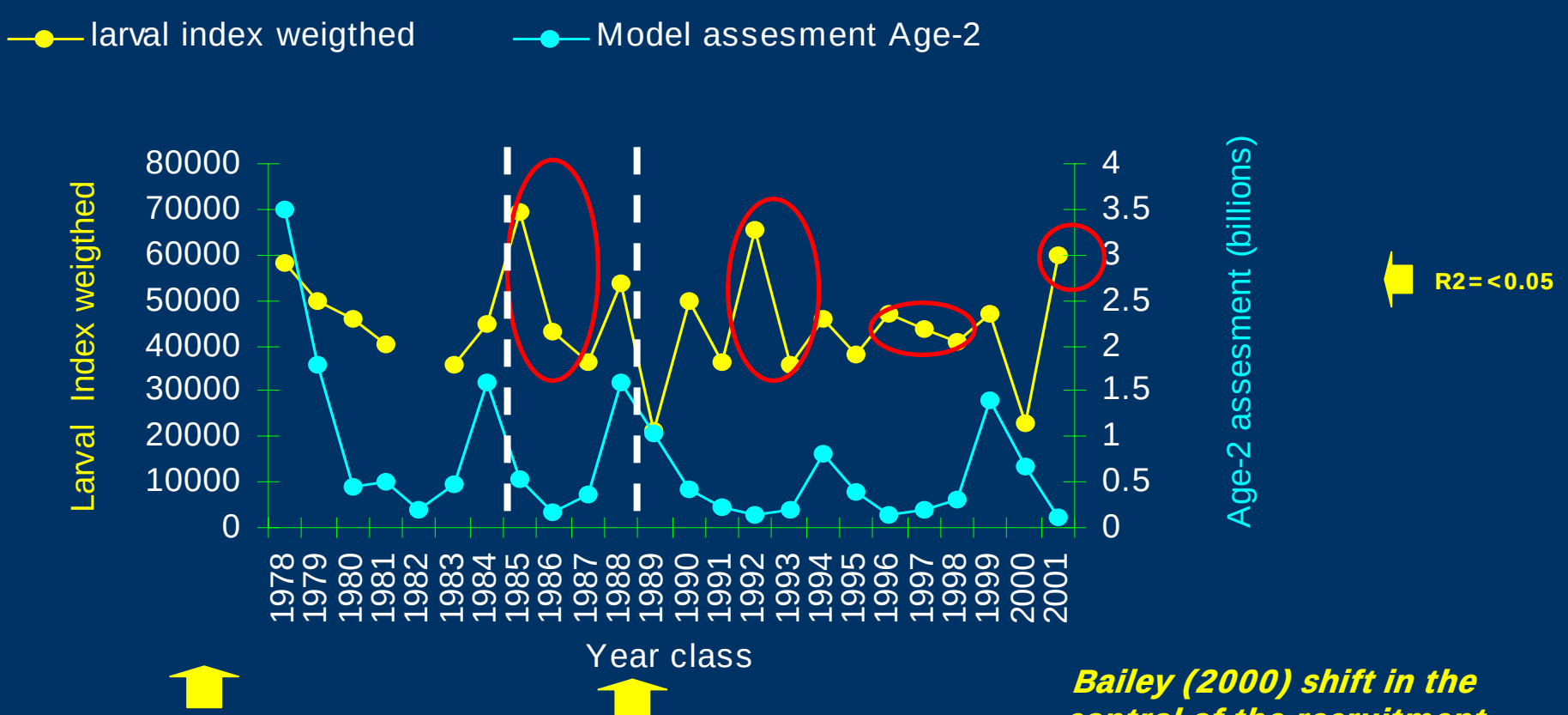


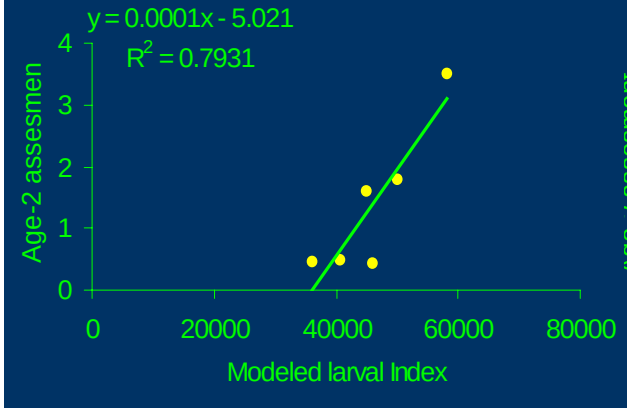
Data and assessment Age-2...

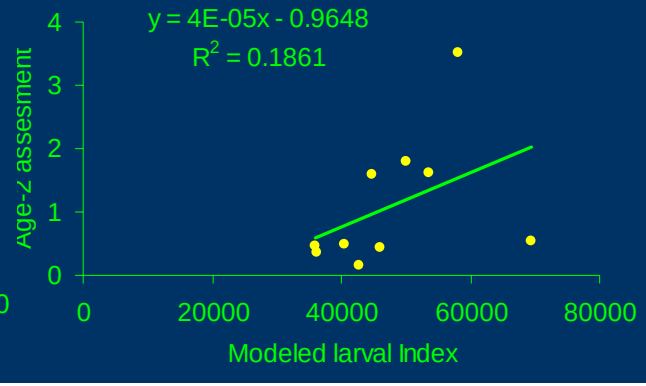


	Ln(Larvae)		
Ln(Age-0)	0.690	Ln(Age-0)	
Ln(Age-1)	0.064	0.062	Ln(Age-1)
Ln(Age-2 model)	0.045	0.641	0.374

Modeled Larval Index & Age-2 from assessment

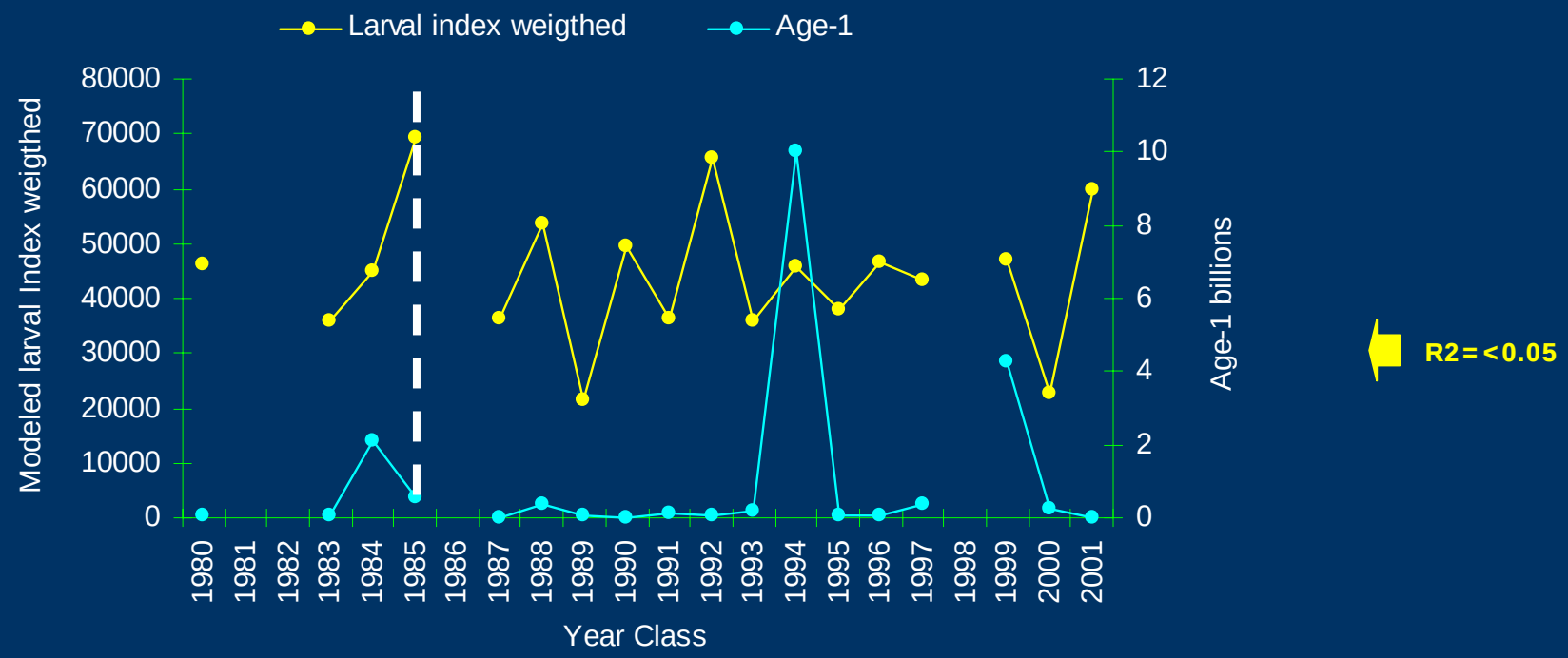




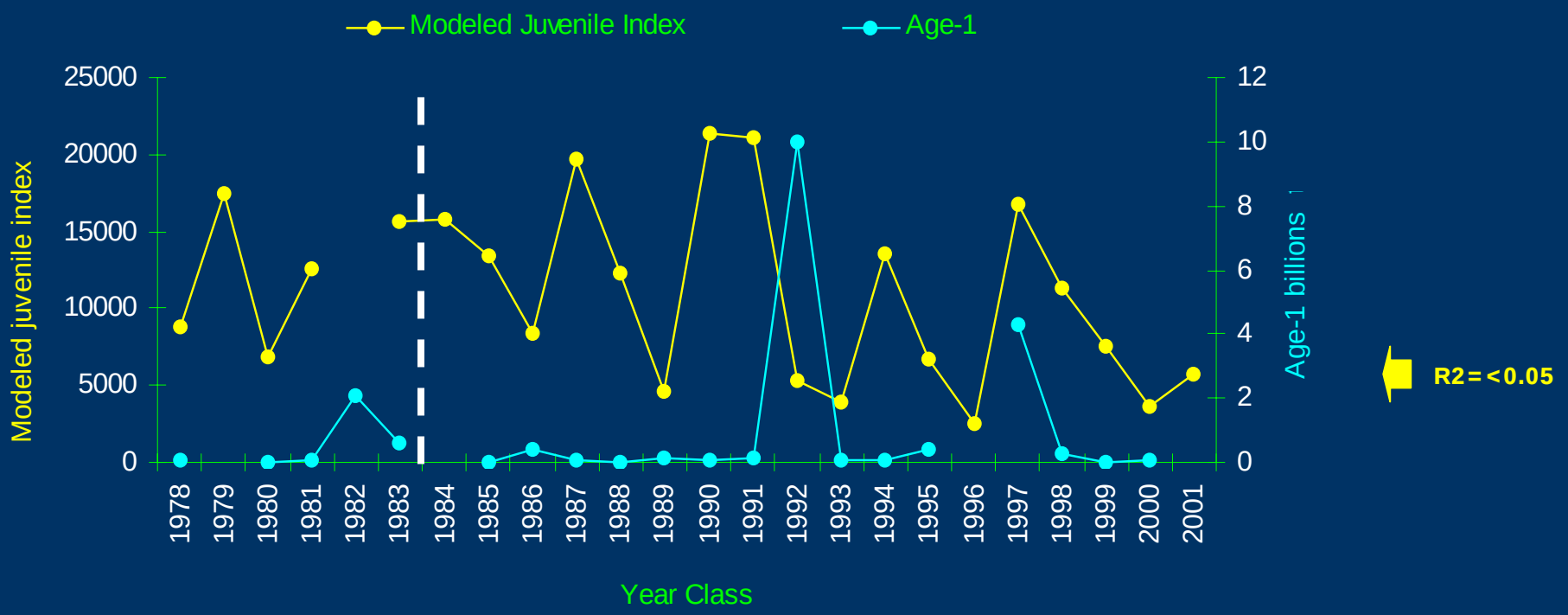


Bailey (2000) shift in the control of the recruitment from larval stage before mid 80´s to juvenile stage after

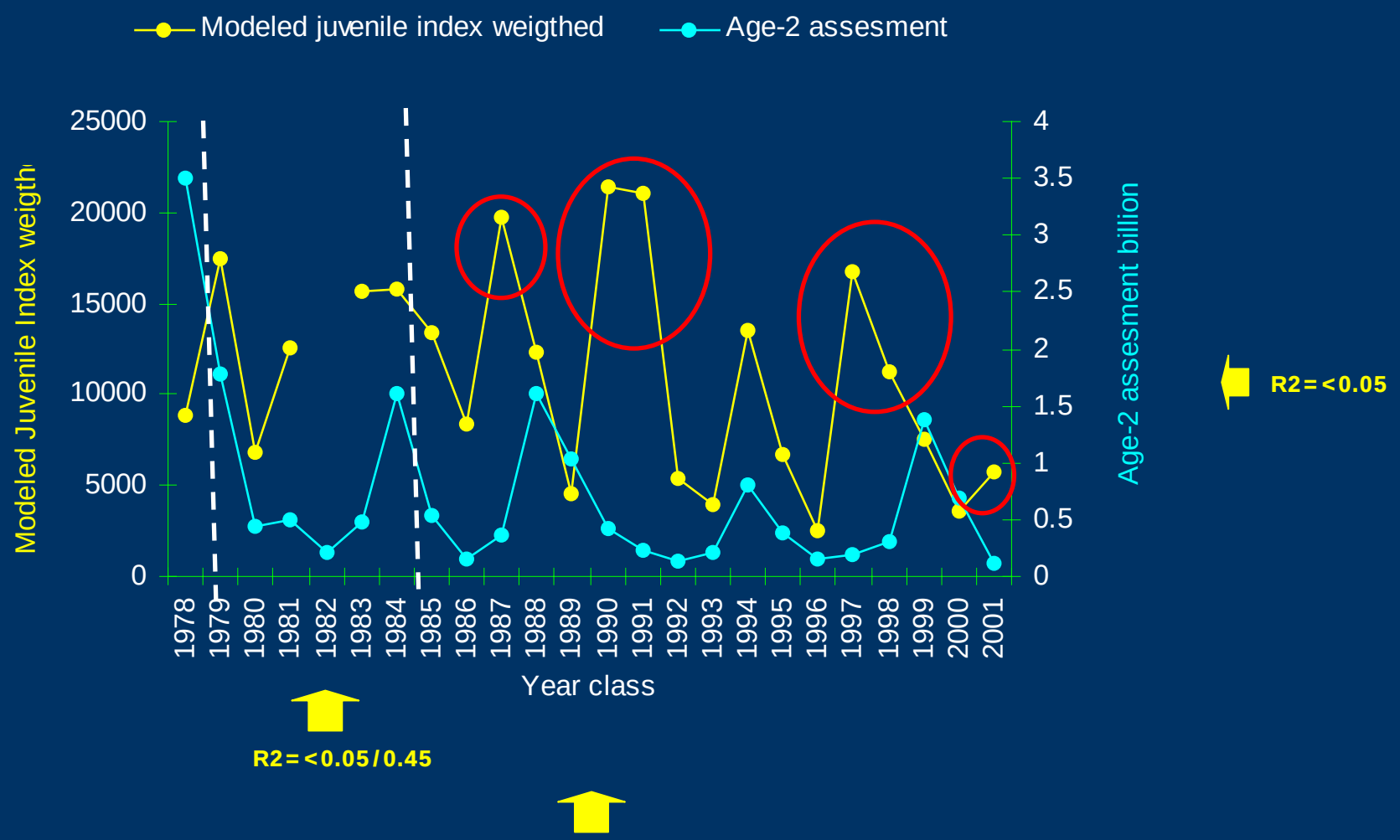
Modeled Larval Index & Juvenile Age-1 data



Modeled Juvenile Index & Age-1 data



Modeled Juvenile Index & Age-2 from assesment



Include mortality sources
-predation given by Cod and Flatfishes

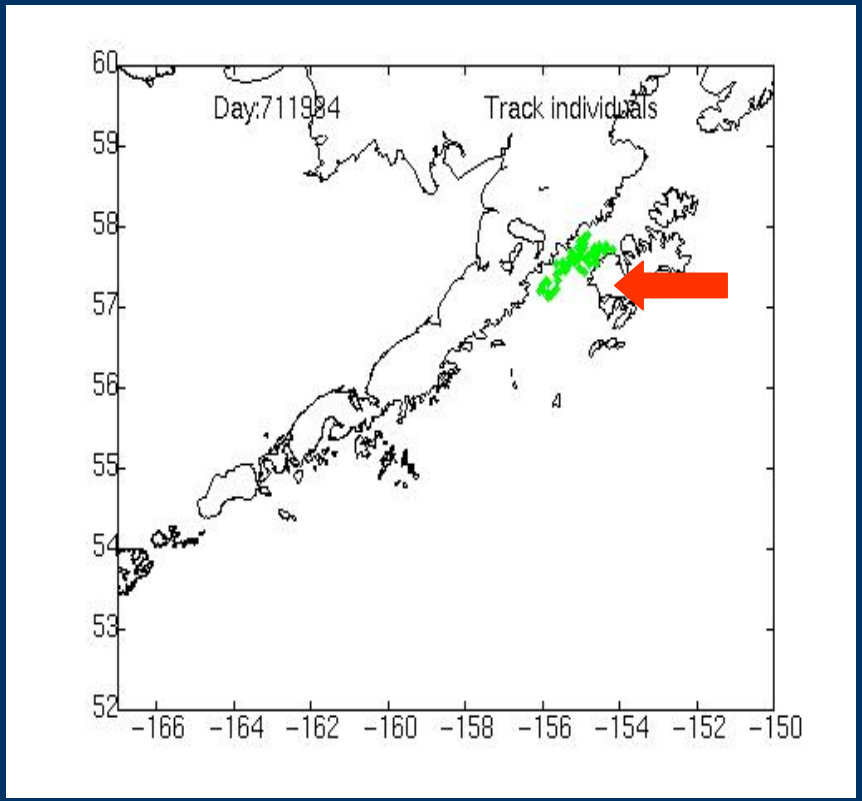
Conclusion

- A poor correlation was found between modeled larval Index and juvenile Age-2 assesment for 1978 to 2002.
- However, a better correlation was observed between Larval index and Age-2 during late 70´s to late 80's (R2=0.18) and up to the middle of the 80's (R2=0.79).
- A poor correlation was found between modeled juvenile Index and the Age-2 assessment for the whole time series 1978 to 2002, improving between late 70´s to middle 80´s.
- These preliminar results seems to be consistent with the ideas from Bailey (2000) where he proposed a shift in the recruitment control
- The poor correlation between modeled juvenile index from IBM and age-2 assessment might be related to the lack of mortality sources in the model.
- A following step would be to incorporate in the IBM a source of mortality associated to the level of predators such as Cod and flatfishes considering interannual and spatial variability.

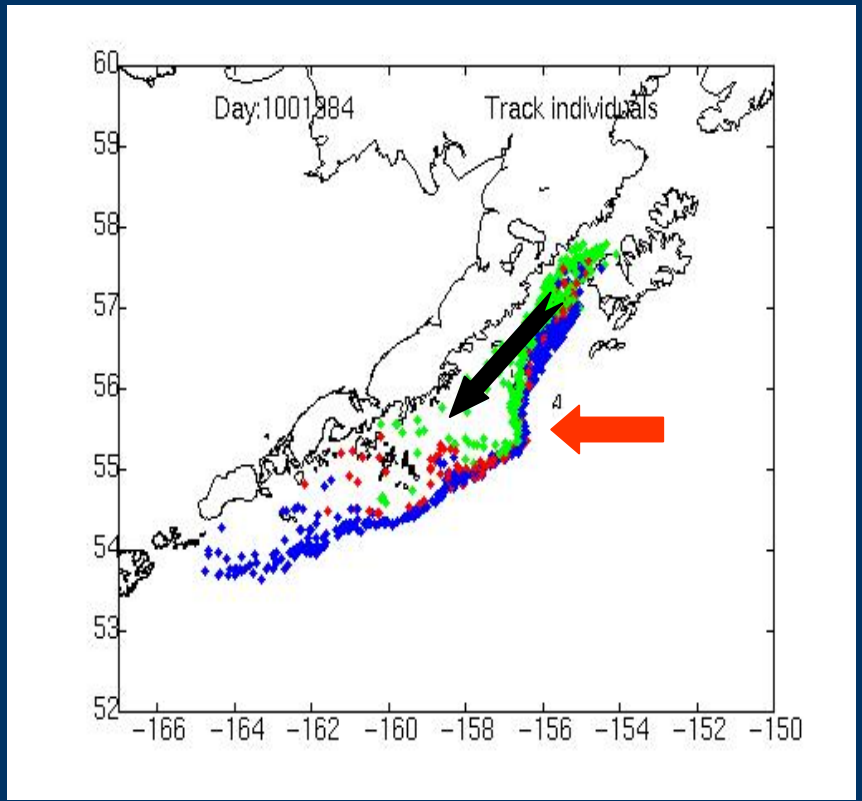
Discussion: SPEM model

- Over-estimation speed of modelled currents
- Domain boundaries (limitation of experiment designs)
- Temperature fields

11 March



12 April



Discussion: NPZ model

- Need to perform a sensitivity analisis to the:
  - initial conditions
  - Model parameters

- Gather data to fit model (i.e. Line 8)

Discussion: IBM

- Sensititvity to the:
  - Initial conditions of spawning (Shelikof Strait)
  - Nursery area definition
- Need to incorporate important processes:
  - Juvenile movements (i.e. Swimming toward “food concentration”)
  - Predation
- Technical problem (Number of particles released)

Acknowledegments . . .

- *Liz Dobbins*
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- *Matt Wilson*
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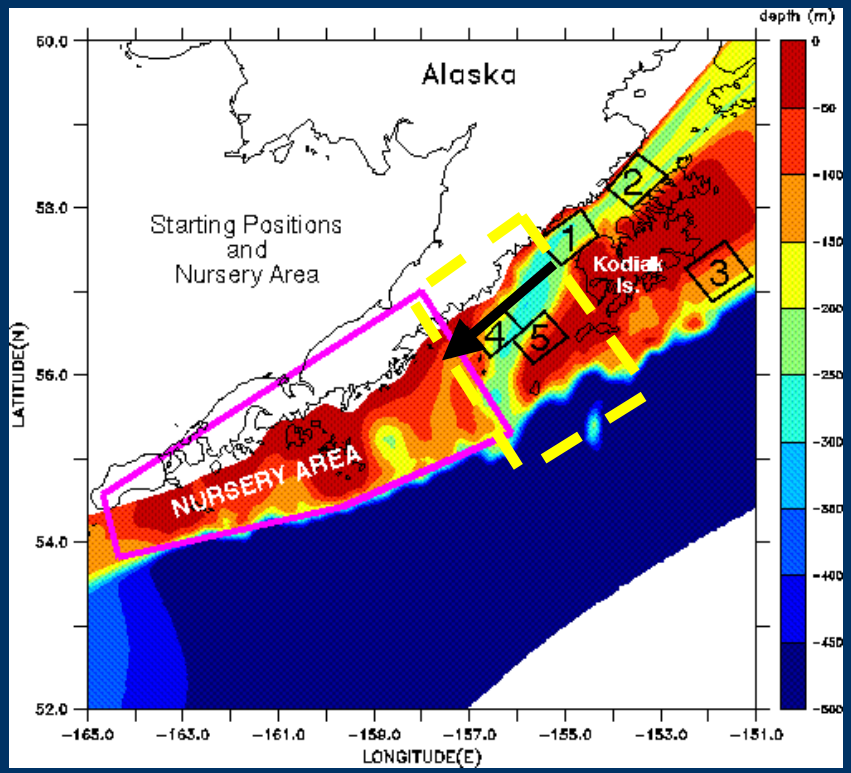
- *Kevin Bailey*
- *Martin Dorn*
- *Billy Ernst*
- *Carlos Alvarez*

Experiments 1: Intermediate Area



Larval index (yolk sac) at Intermediate area: Proportion of individuals in the yolk sac larval stage that arrive at the intermediate area weighed by the residence time.

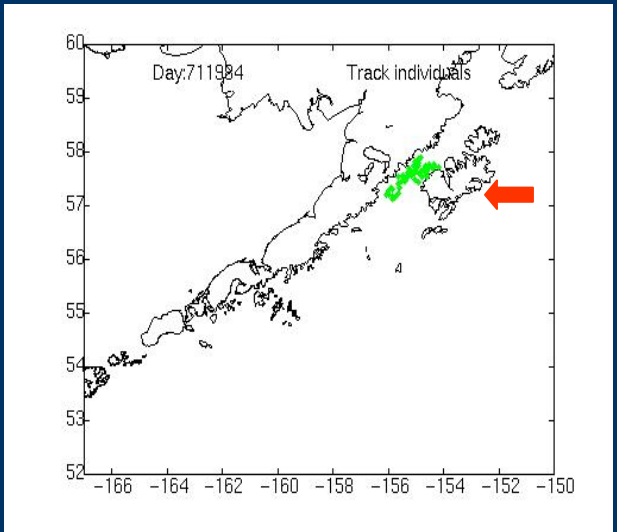
Larval index (Feeding larvae) at Intermediate area: Proportion of individuals in the feeding larval stage that arrive at the intermediate area weighed by the residence time.

Juvenile index at Intermediate area: Proportion of individuals in juvenile stage that arrive at the intermediate area weighed by the residence time.

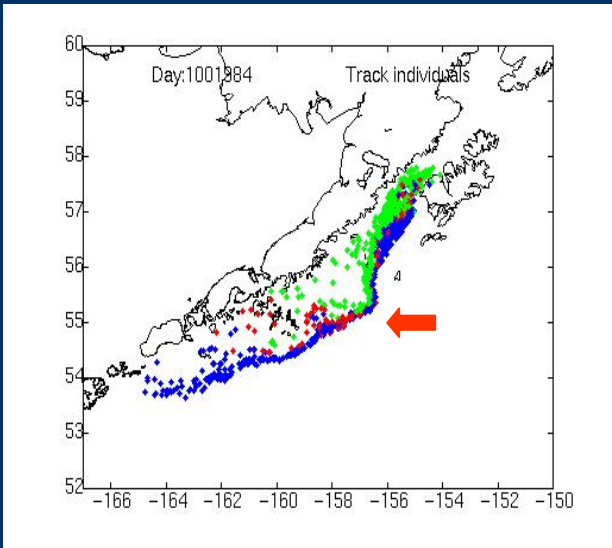
Experiments 2: Spawning Area

Shelikof Strait

11 March

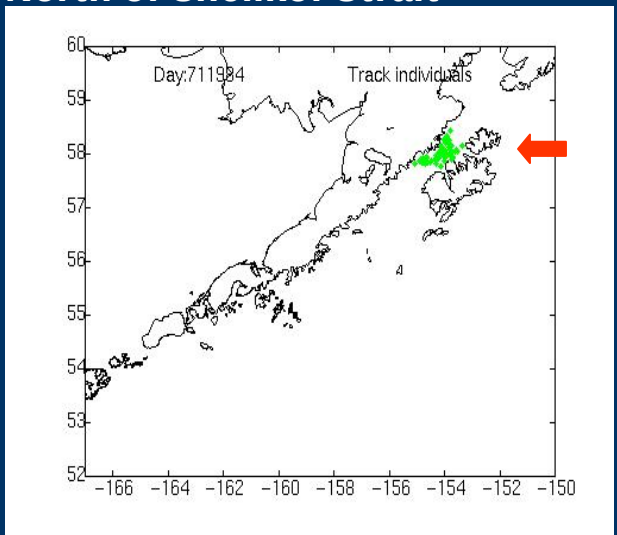


12 April



North of Shelikof Strait

11 March



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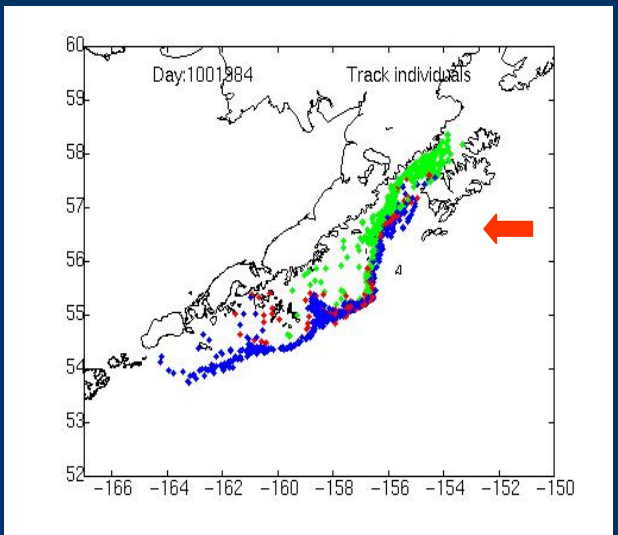
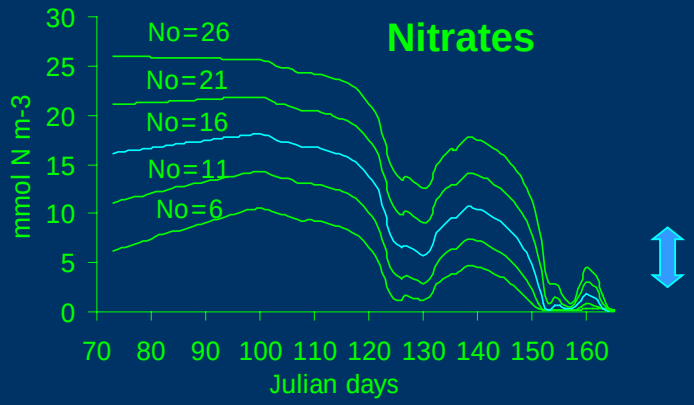
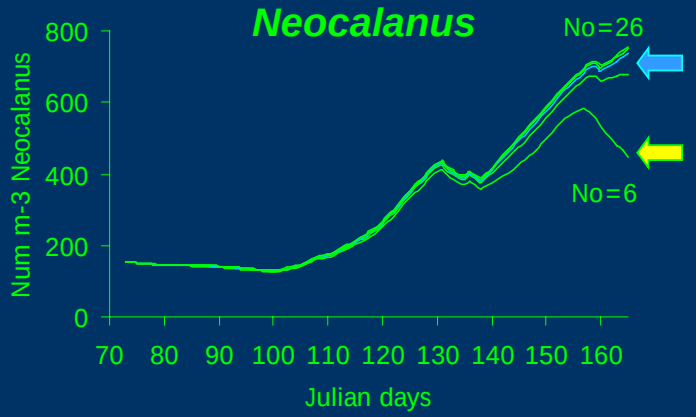
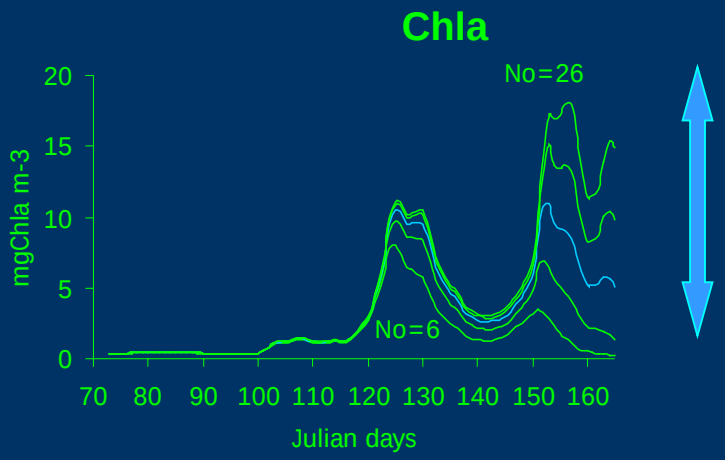
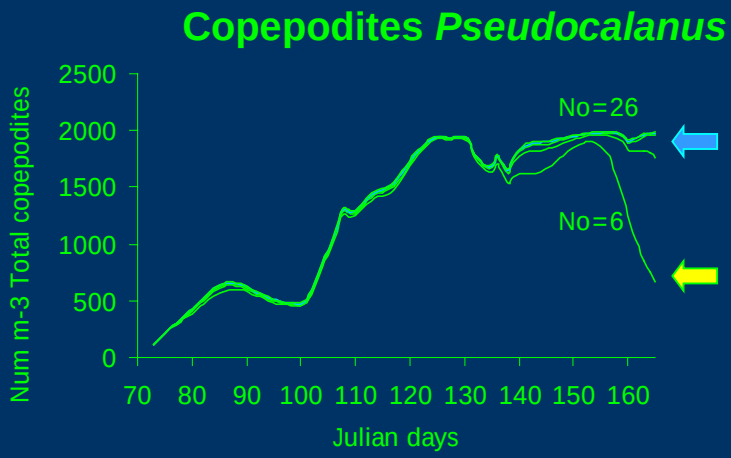


Sensitivity analysis... Varying *initial conditions* for N03





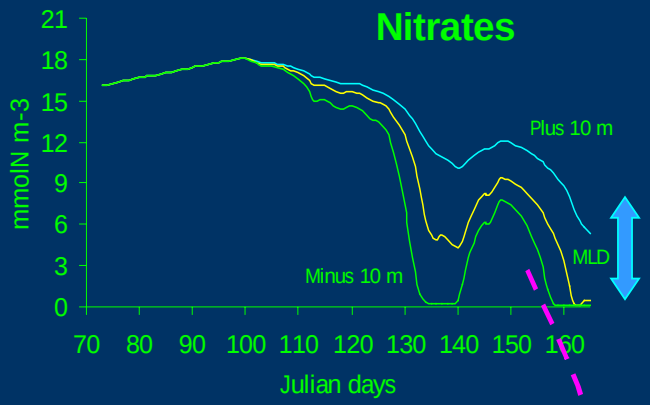


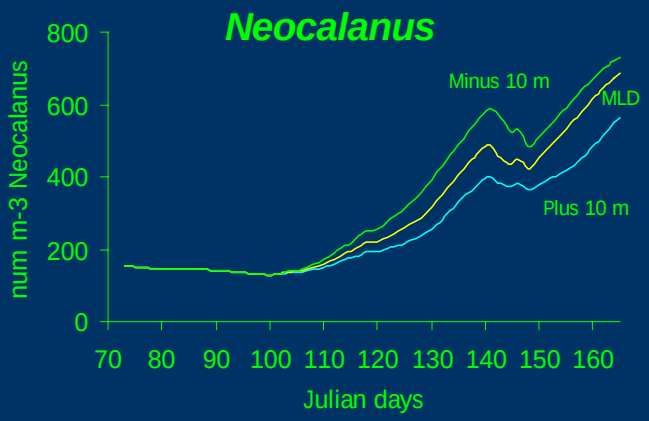


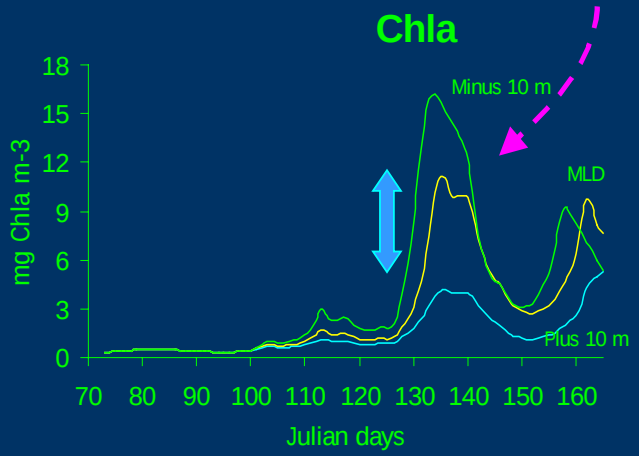
Initial Conditions: influence intensity of the response of Phytoplankton. Low initial [N03] conditions trigger a low second peak of Phytoplankton that will induce a early growth decay of zooplankton

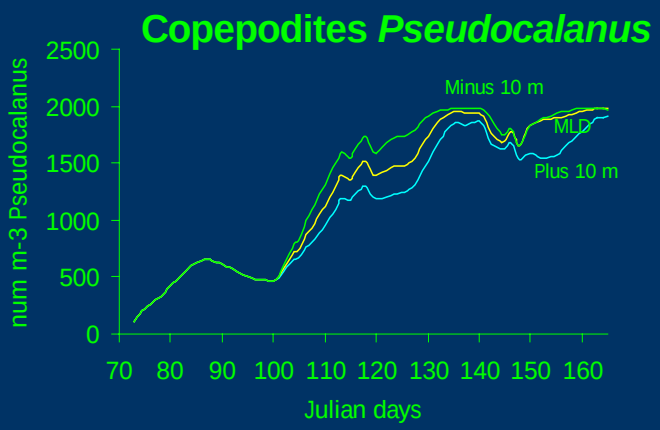
≥

Sensitivity analysis... Varying *magnitude* of Mixed layer depth









Magnitude of the mixed layer depth: influence inversely the response of Phytoplankton and zooplankton

Sensitivity analysis... Varying *value* of parameters ng and qp

$$\frac{dN_m}{dt} = -\frac{\xi}{z_m}\left[\sum_{z=0}^{z_m} P_m \; PMAX \tanh\left(\frac{\alpha PAR_z}{PMAX}\right)\left(\frac{N_m}{d+N_m}\right)\right] + 0.4\sum_i \left(\frac{e_i P_m H_{i,m}}{f_i + P_m}\right) + \frac{k_v}{z_m}\left(N_{z_{m+1}} - N_m\right)$$

$$\frac{dP_m}{dt} = -\frac{1}{z_m}\left[\sum_{z=0}^{z_m} P_m \; PMAX \tanh\left(\frac{\alpha PAR_z}{PMAX}\right)\left(\frac{N_m}{d+N_m}\right)\right] - \sum_i \left(\frac{e_i P_m H_{i,m}}{f_i + P_m}\right) + \frac{k_v}{z_m}\left(P_{z_{m+1}} - P_m\right)$$

Grazing term

Predation term

$$\frac{dH_{1,m}}{dt} = \left(\frac{Y_1 e_1 P_m^{ng}}{f_1^{ng} + P_m^{ng}} H_{1,m} - m_1 H_{1,m}^{qp}\right) + \frac{k_v}{z_m}\left(H_{1,z_{m+1}} - H_{1,m}\right)$$

$$\frac{dH_{i,m}}{dt} = (\tau_{i-1} H_{i-1,m}) + \left(\frac{Y_i e_i P_m^{ng}}{f_i^{ng} + P_m^{ng}} H_{i,m} - m_i H_{i,m}^{qp} - \tau H_{i,m}\right) + \frac{k_v}{z_m}\left(Hi,_{z_{m+1}} - H_{i,m}\right)$$

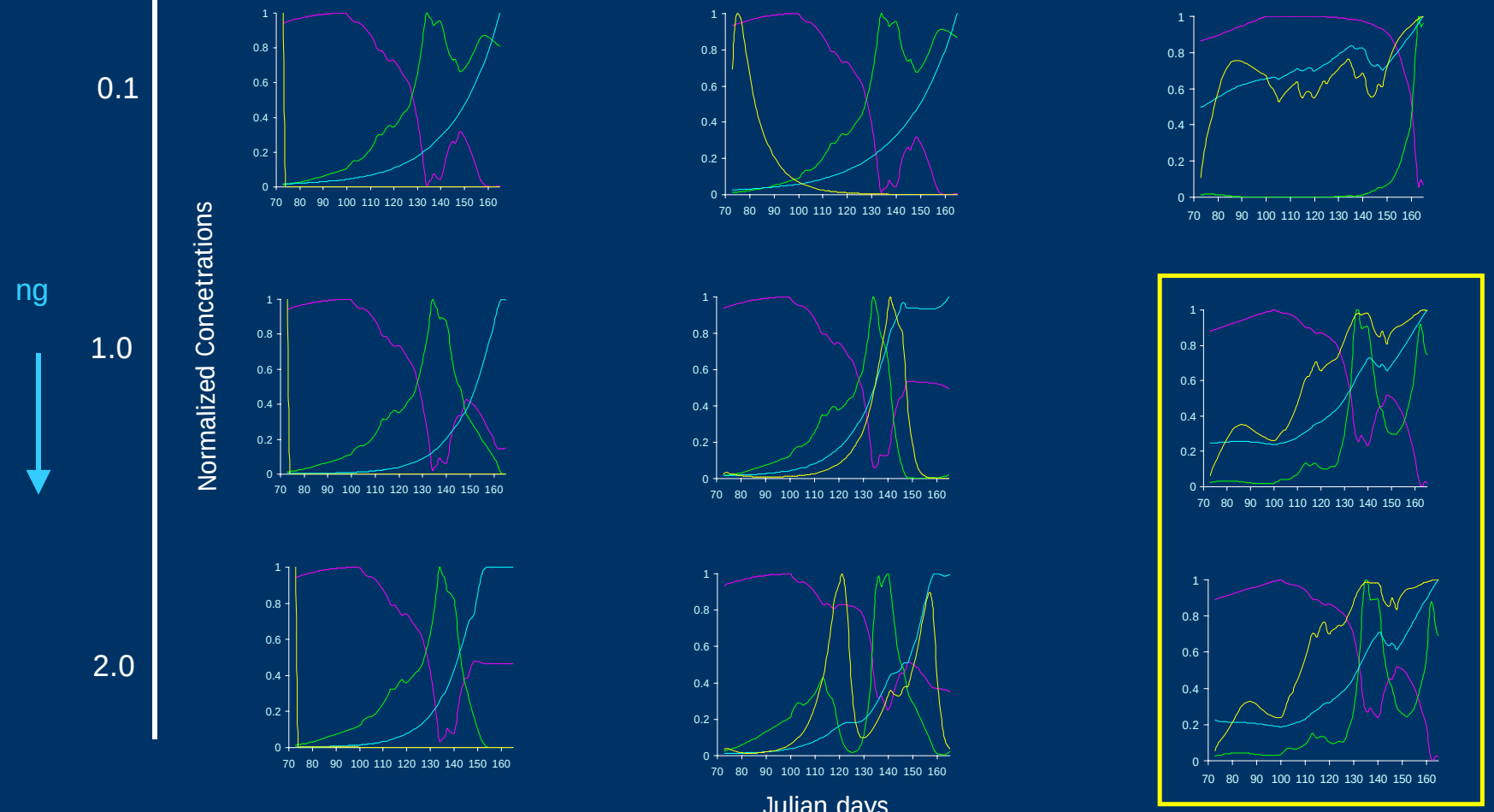
The idea of using these parameters comes from the study of Georgeana Blamey and David Musgrave in Alaska.

Sensitivity analysis... Varying *value* of parameters ng and qp

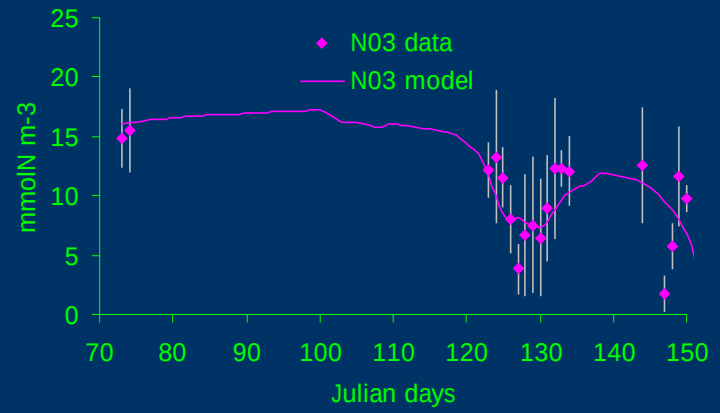
- N03
- Chla
- Pseudocalanus
- Neocalanus

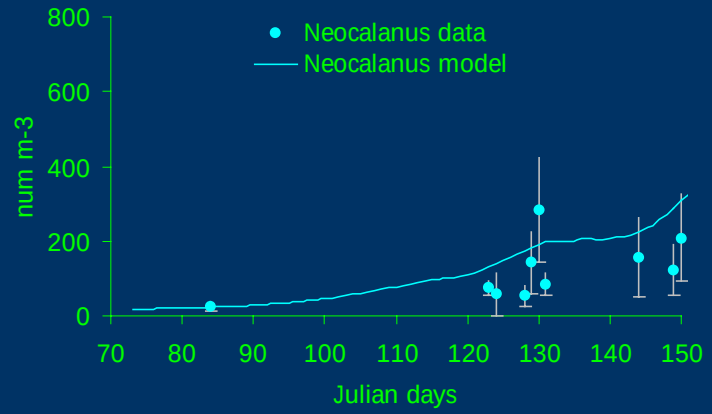
qp → 0.1, 1.0, 2.0

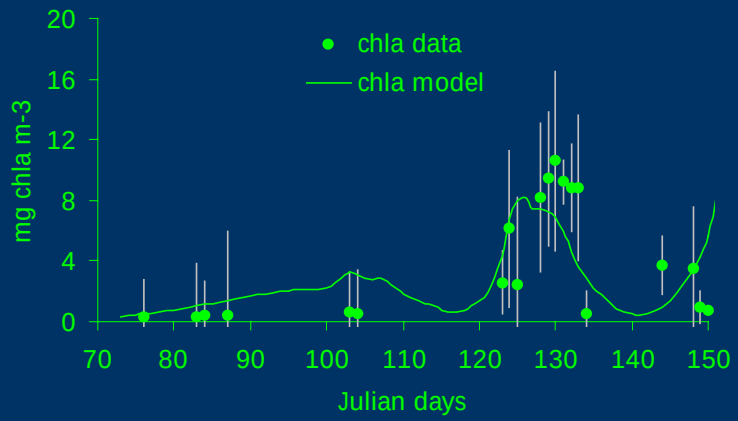
ng ↓ 0.1, 1.0, 2.0

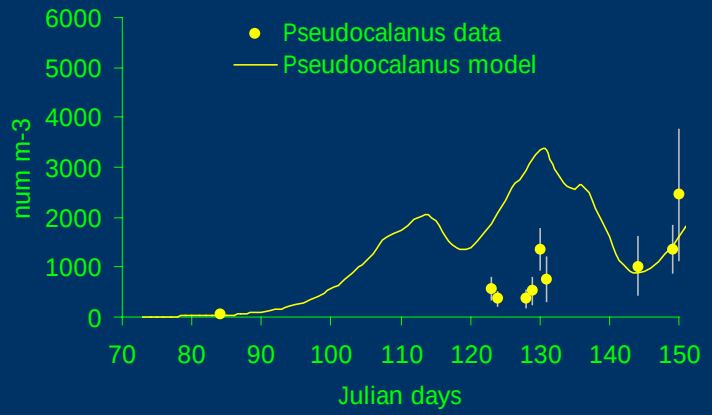


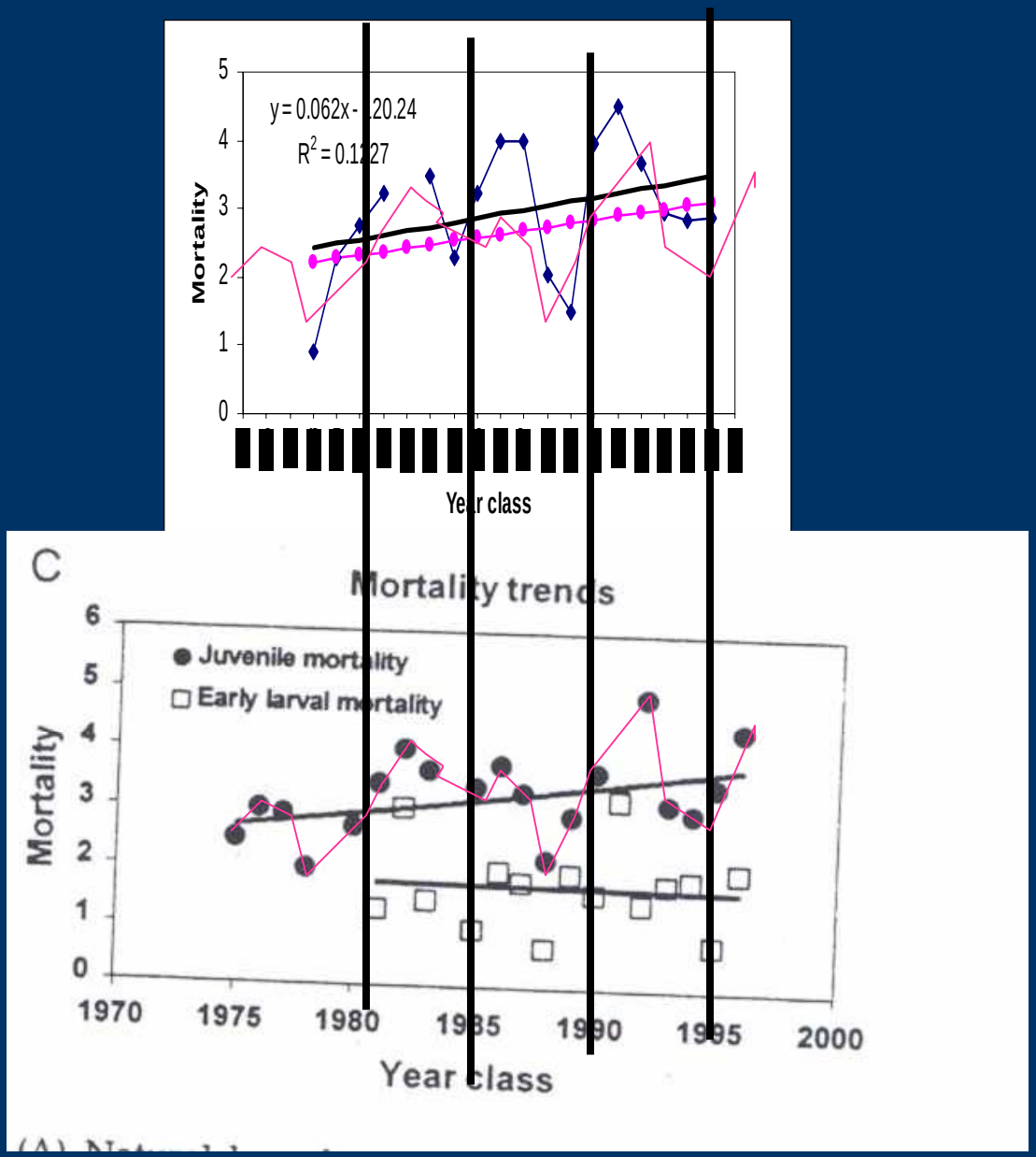
Parameter estimate... Data v/s model










y = 0.062x - 120.24
R2 = 0.1227
Mortality
Year class
C
Mortality trends
Juvenile mortality
Early larval mortality
Mortality
Year class
1970
1975
1980
1985
1990
1995
2000