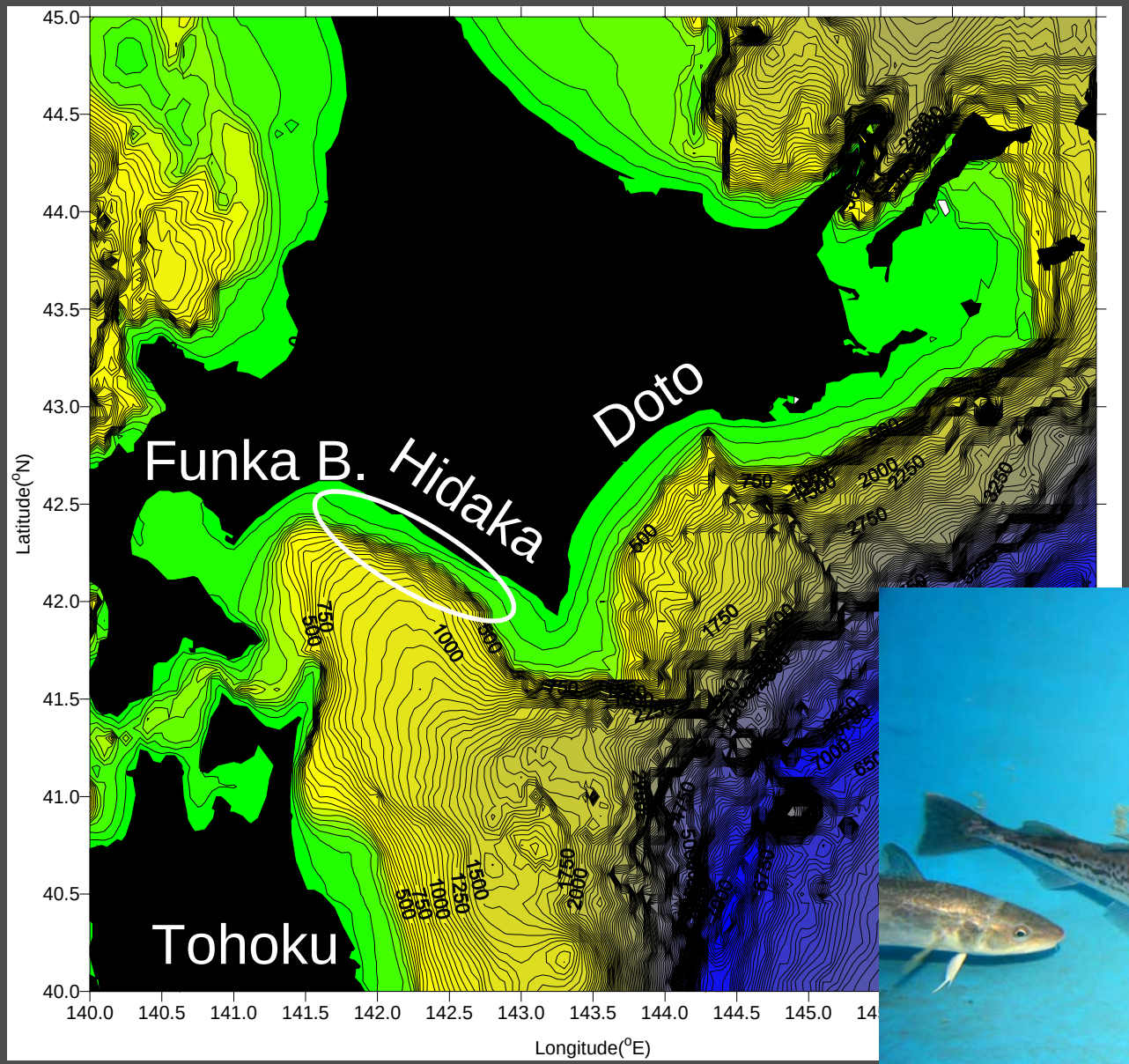
Transport of walleye pollock (*Theragra chalcogramma*) egg between 1989 and 1995 and its causes on the southwest coast of Hokkaido, Japan

Tokihiro Kono, Tomonori Hamatsu, Keizo Yabuki, Kazutoshi Watanabe, and Michael G. Foreman

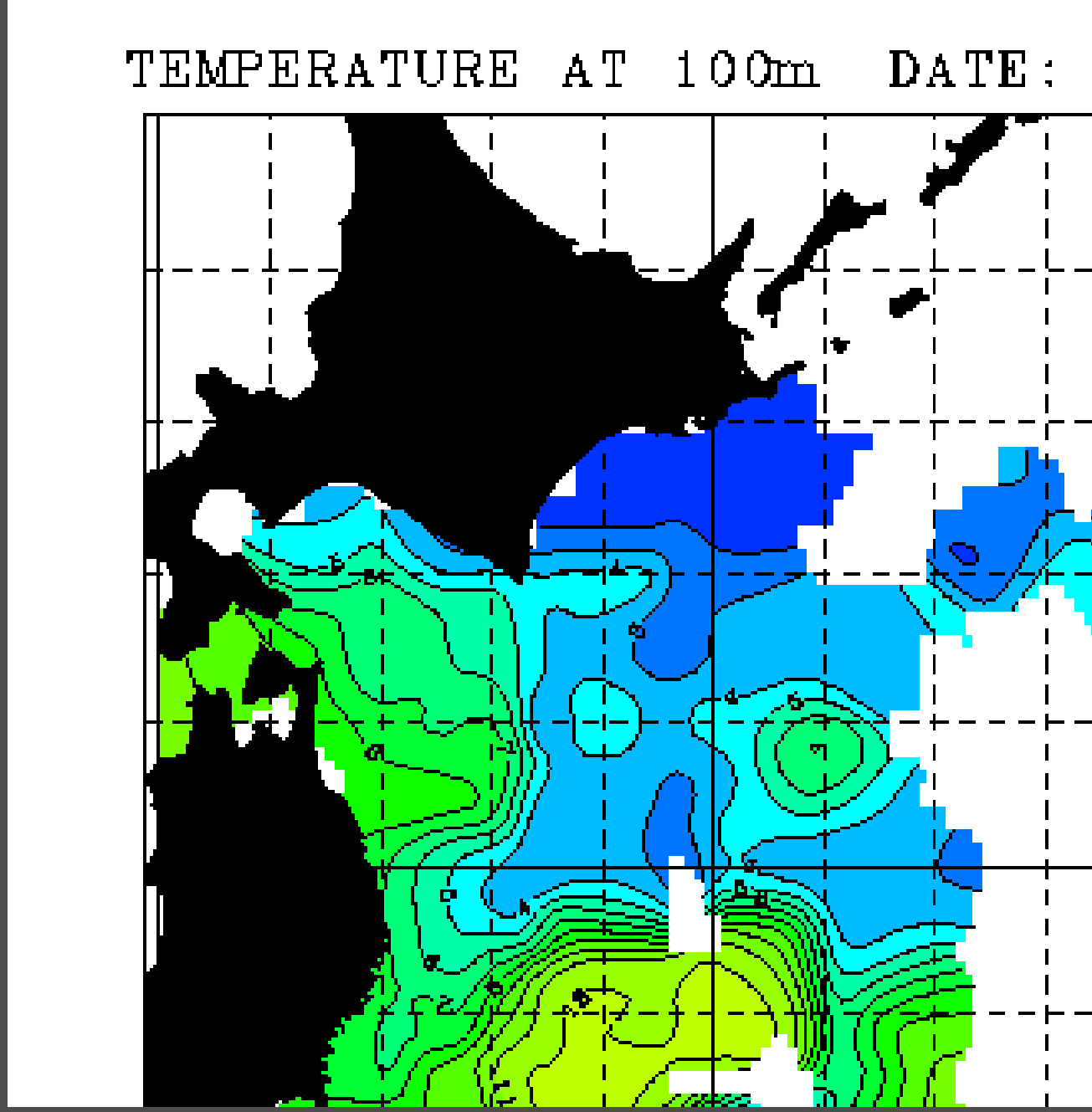


Wall-eye Pollock

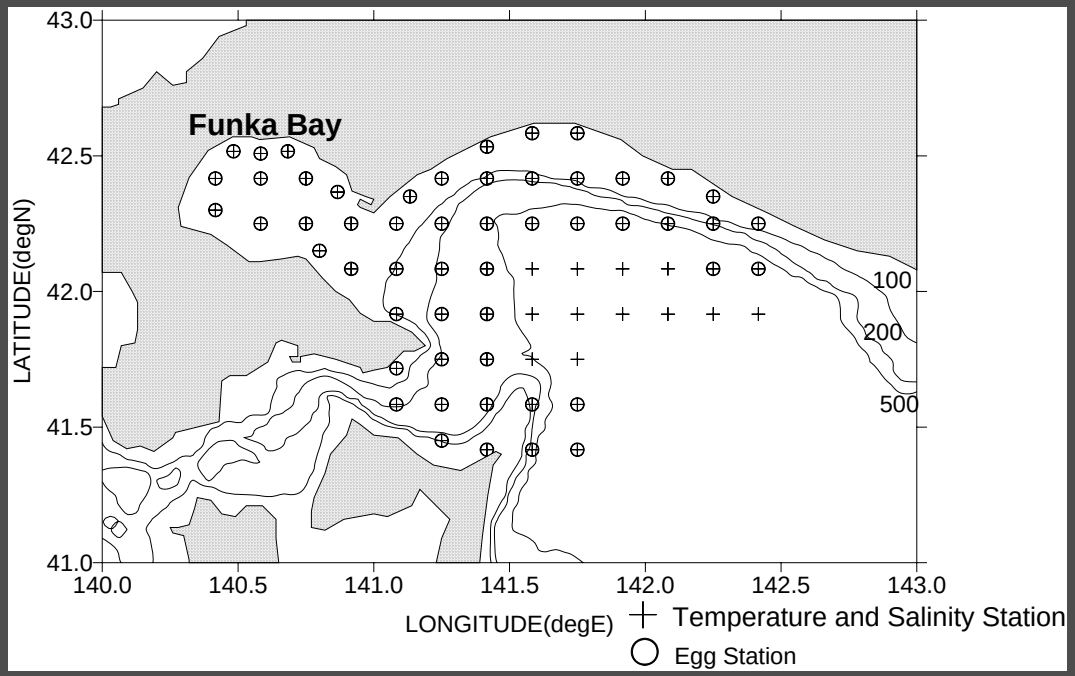
In late winter and spring

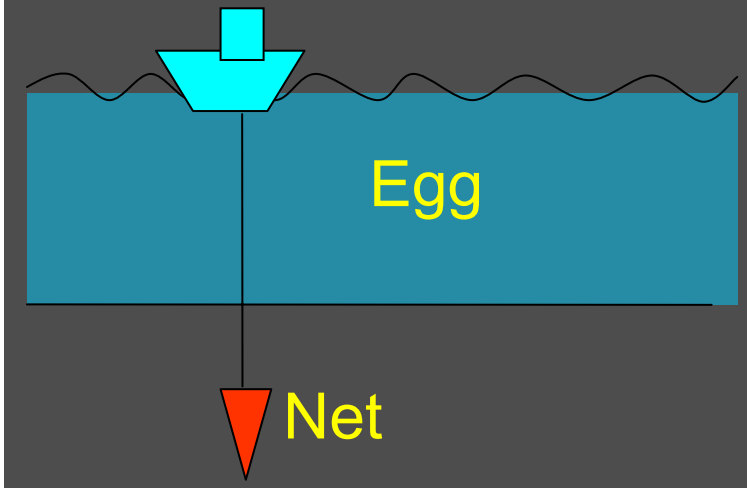
CO locates

on the coast



Repeated Observation





Jan.-Mar.
1989 – 1995

3 - 5 times a year
2 - 4days for each observation

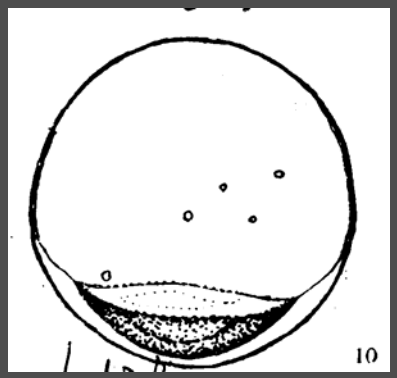
DATA

Temperature and salinity

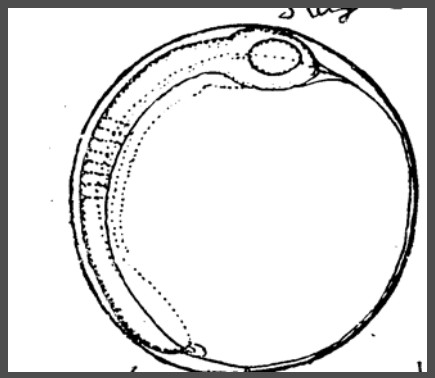
Classified Egg Number into each Development Stage

Development Stages

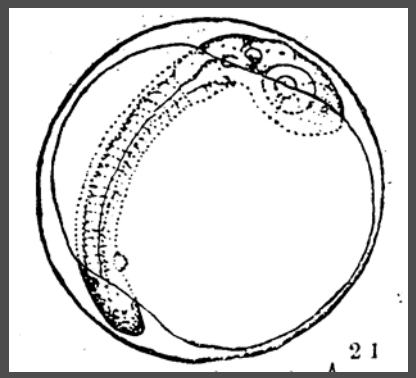
Stage1
1day



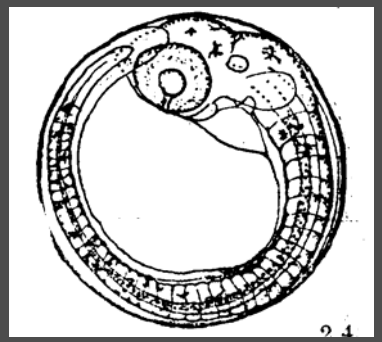
Stage2
3.125day



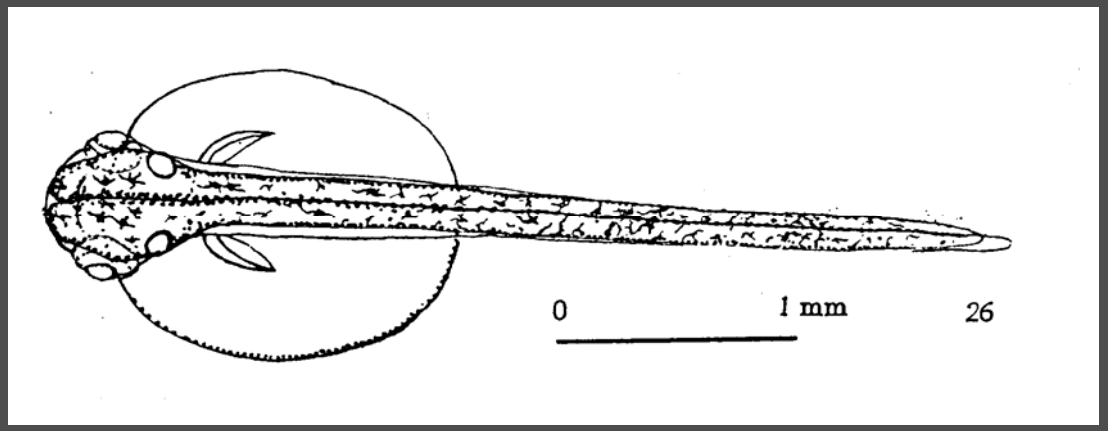
Stage3
3.25day

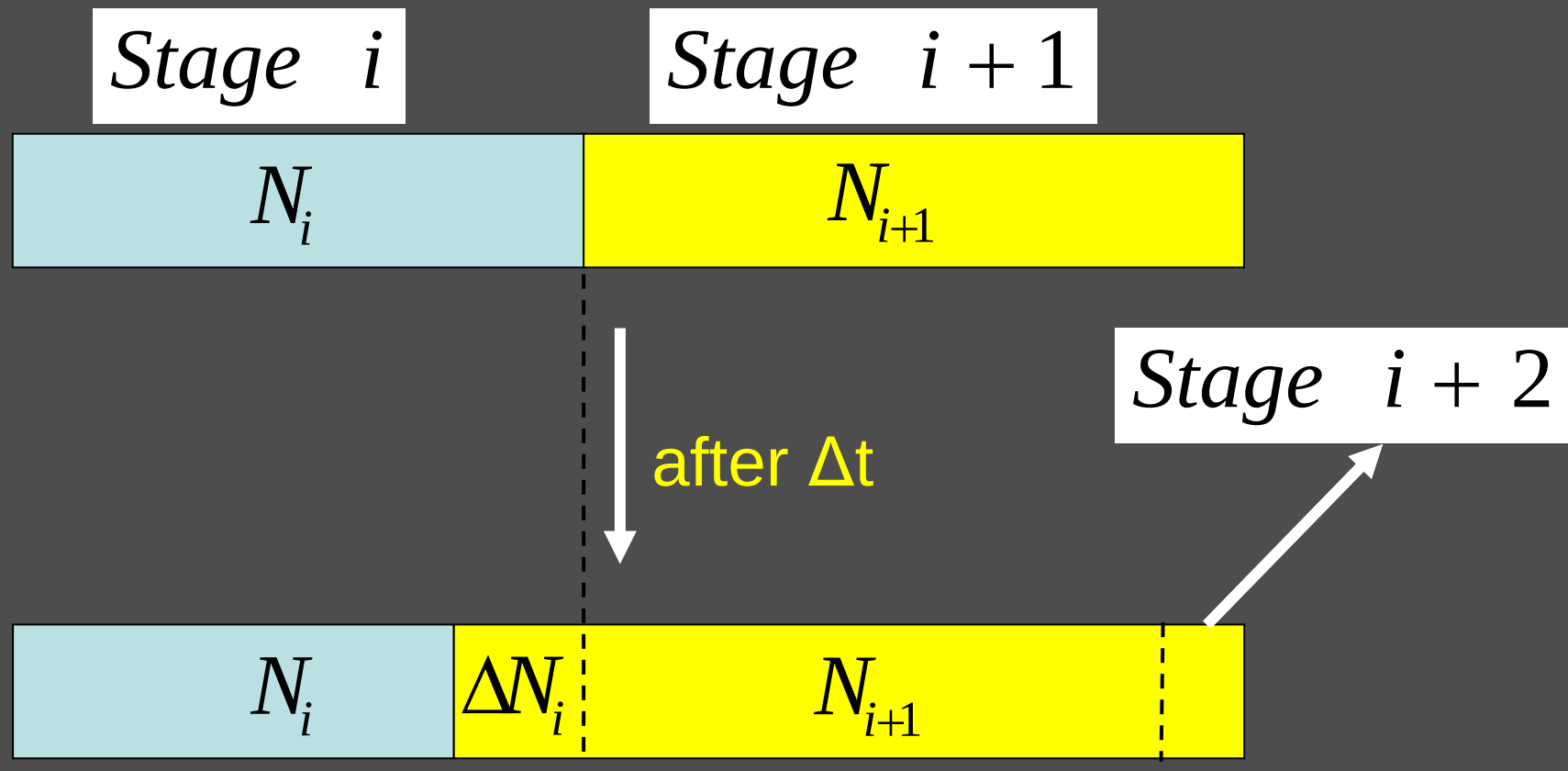


Stage4
3.5day



After
12days



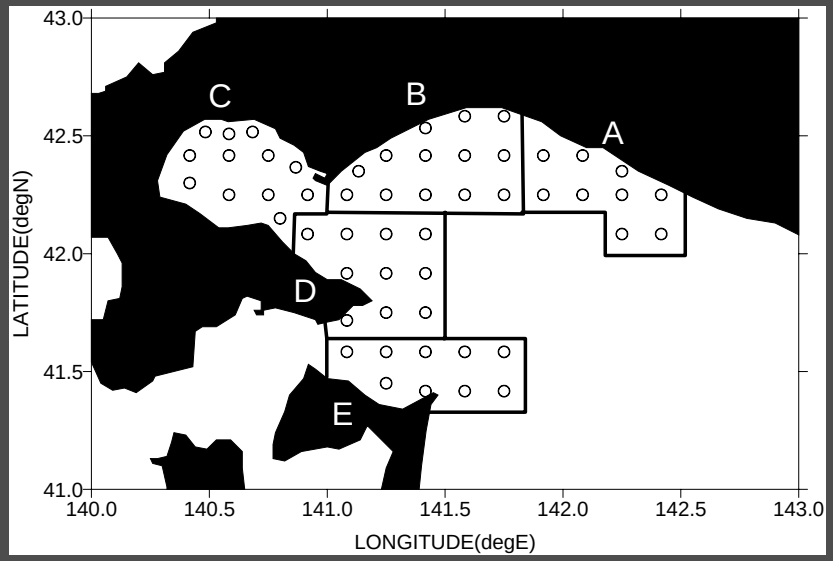


A number of the change is

$$\Delta N_i = \frac{N_i}{\Delta T_i} \Delta t$$

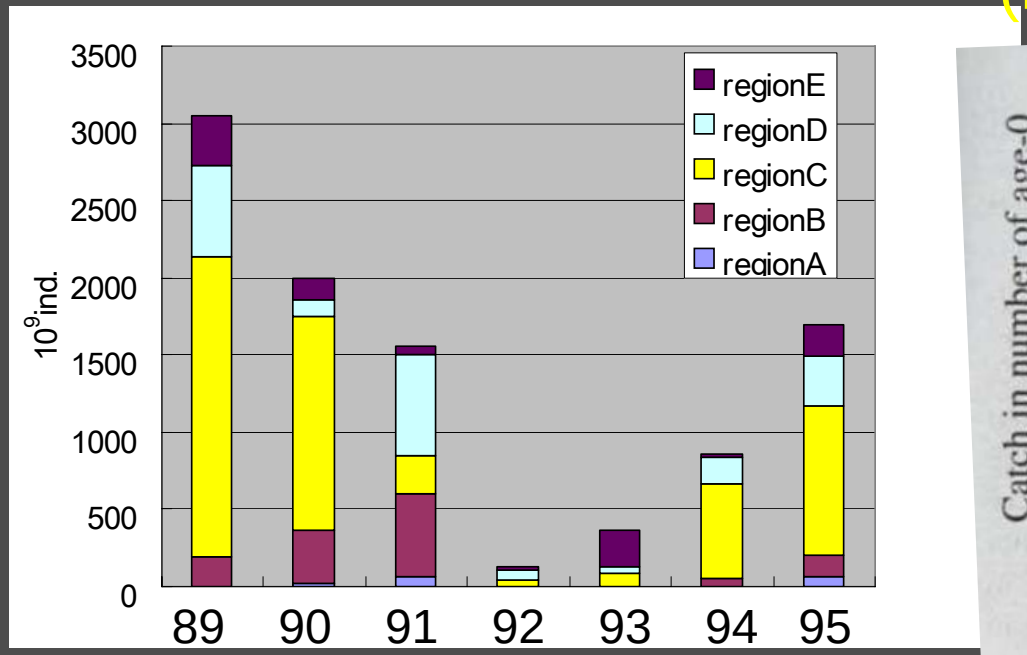
Hatching Rate

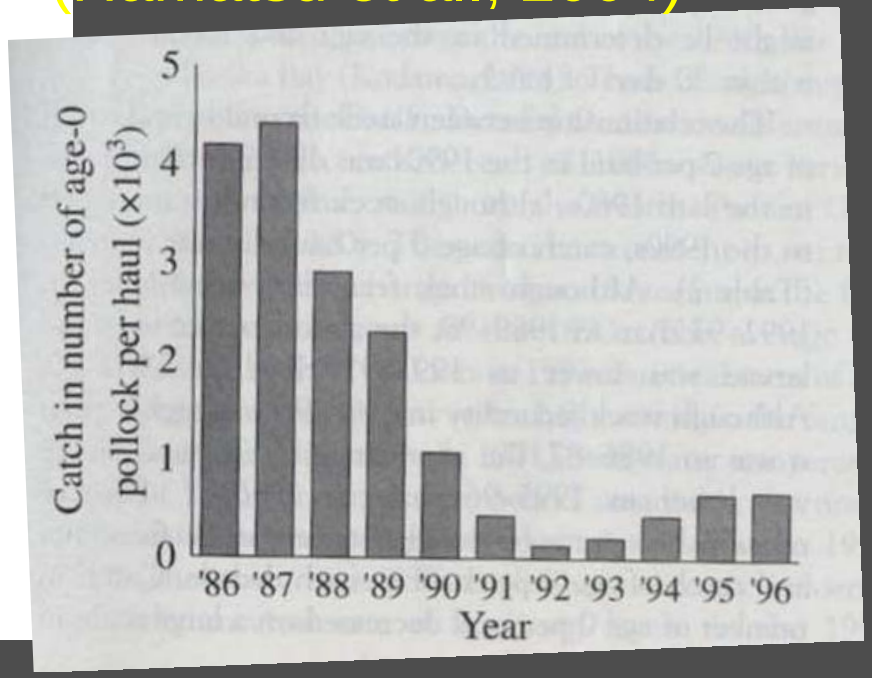
= Stage4 EggNumber / ΔT_4



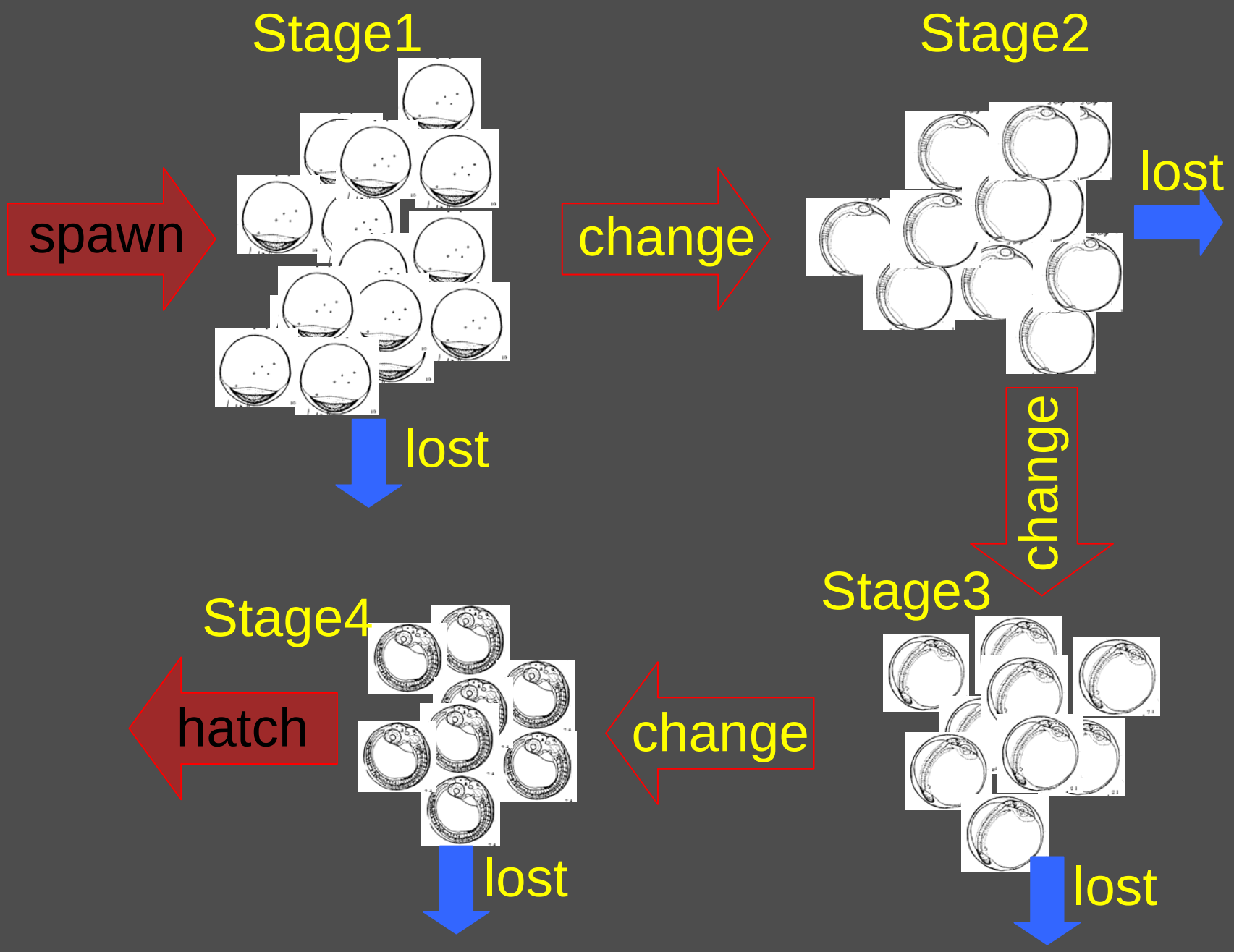
The catch of age0 per haul (Hamatsu et al., 2004)

Total Hatching Eggs (10^9 ind.)





par¥a¥bol¥ic


Stage1
spawn
lost
change
Stage2
lost
change
Stage3
lost
change
Stage4
hatch
lost

Developing and Advection Model (Case0)

Conservation equation was formulized

Summation of

$$When\ i = 1,\ (i\ means\ the\ stage\ number)$$

$$\frac{dN_1}{dt} = \boxed{kN_1} + \boxed{F_{sp}} \boxed{- l_1 N_1}.$$

Lost

Spawning

Change Stage

$$When\ i > 1,$$

$$\frac{dN_i}{dt} = kN_i \boxed{+ l_{i-1} N_{i-1} - l_i N_i},$$

$$where$$

$$k : advection\ coeffis.,\ l_i : change\ coeffis.\ to\ higher\ stage,$$

$$and\ S\ an\ increase\ rate\ by\ spawning.$$

$$The\ rate\ l_i\ is\ estimated\ as$$

$$l_i = 1/T_i\ ,$$

$$where\ T_i\ is\ the\ period\ of\ each\ developement\ stage$$

Developing and Advection Model (Case1)

$$\frac{dN_1}{dt} = \boxed{k_1 N_1} + \boxed{F_{sp}} \boxed{- l_1 N_1}$$

$$\frac{dN_2}{dt} = \boxed{k_1 N_2} \boxed{+ l_1 N_1 - l_2 N_2}$$

$$\frac{dN_3}{dt} = k_2 N_3 + l_2 N_2 - l_3 N_3$$

$$\frac{dN_4}{dt} = k_3 N_4 + l_3 N_3 - \boxed{l_4 N_4}$$

Lost

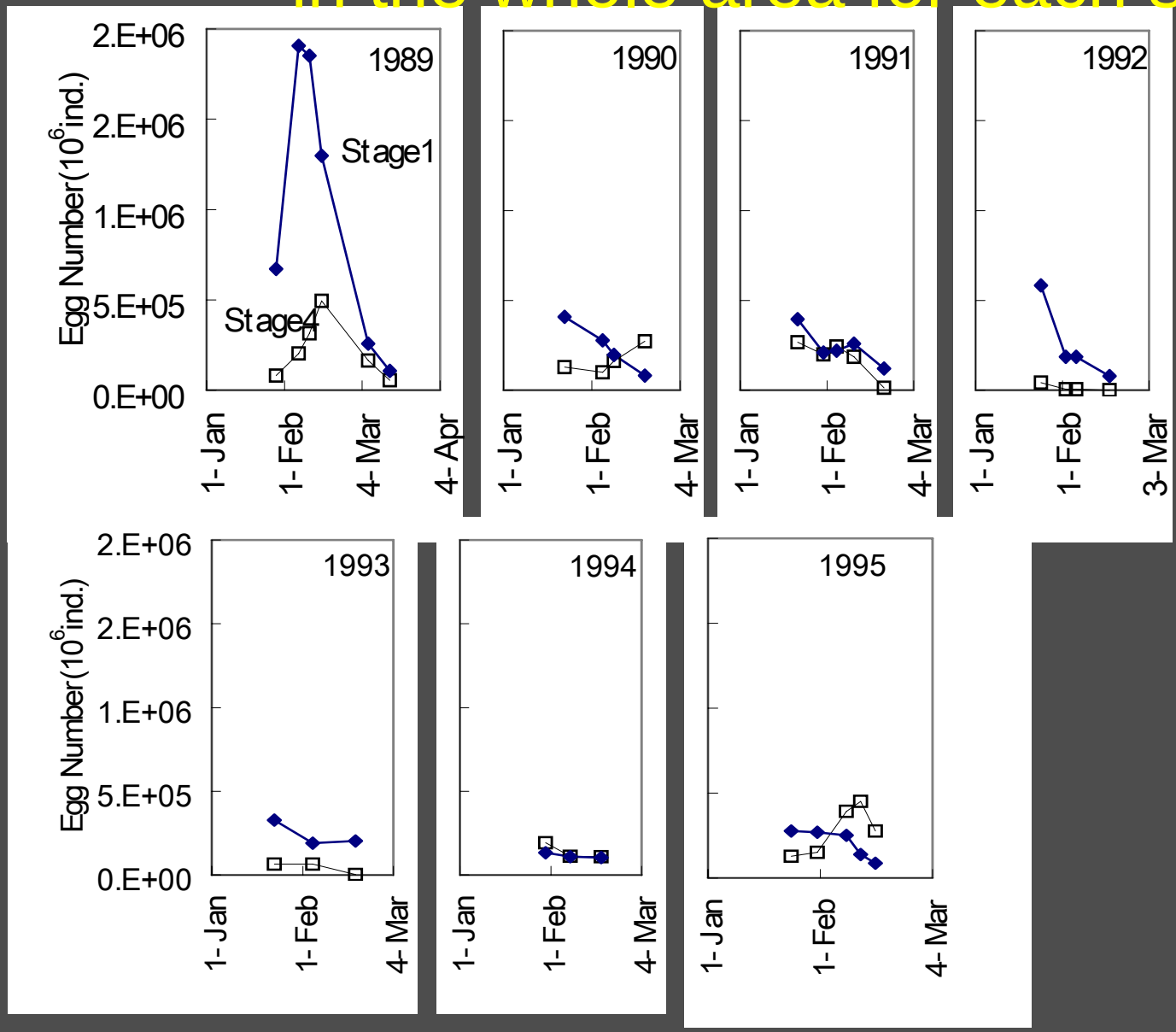
Spawning

Change Stage

Hatched or Died

k and F_{sp} are solved by the linear equation system.

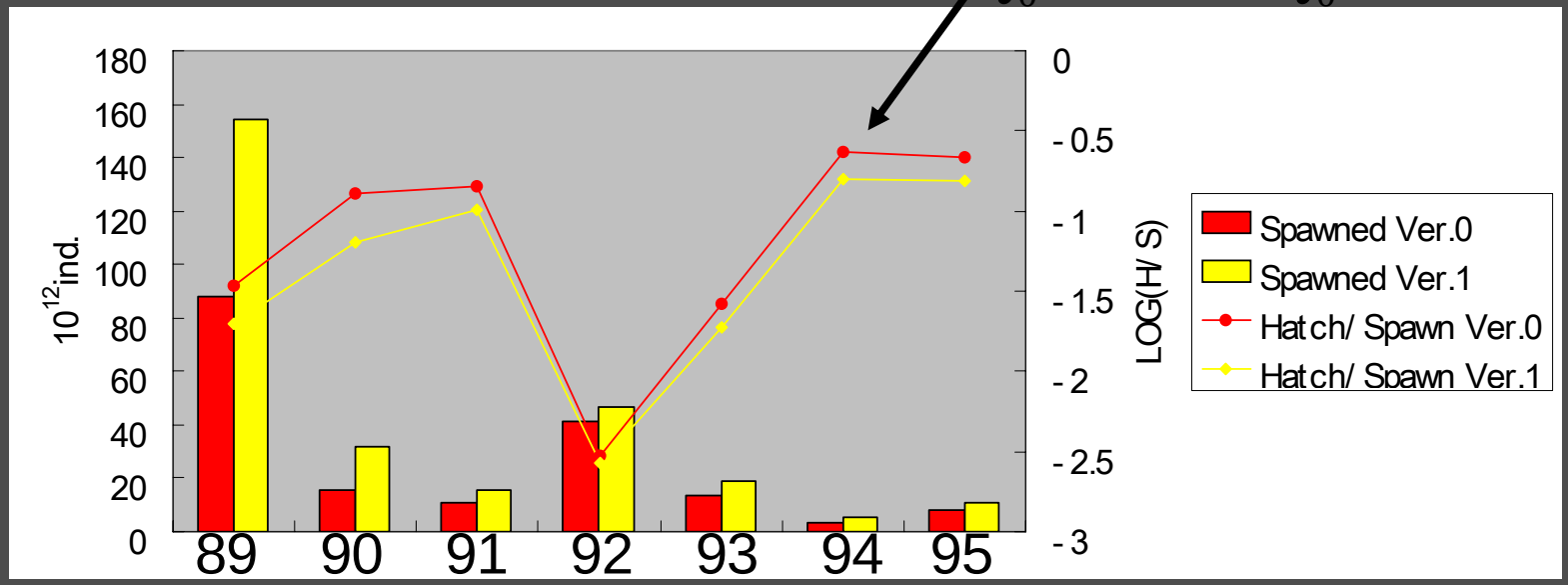
The time series of total egg number in the whole area for each stage.



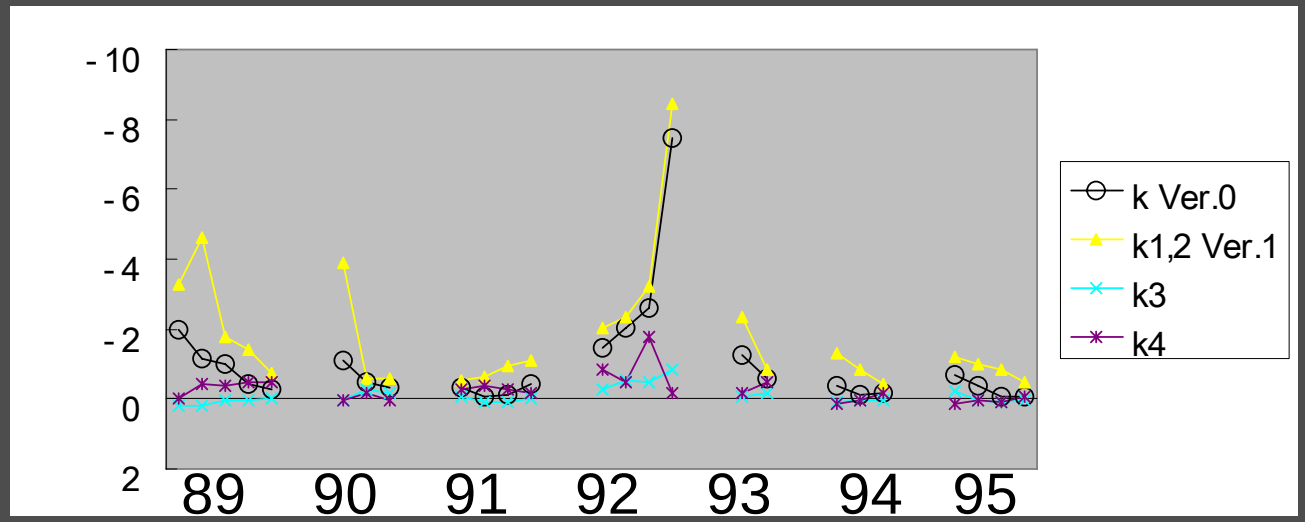
Model Results

$$\int_0^T l_4 N_4 \, dt \Big/ \int_0^T F_{sp} \, dt$$

Total Spawned Eggs



Lost Coeffis.

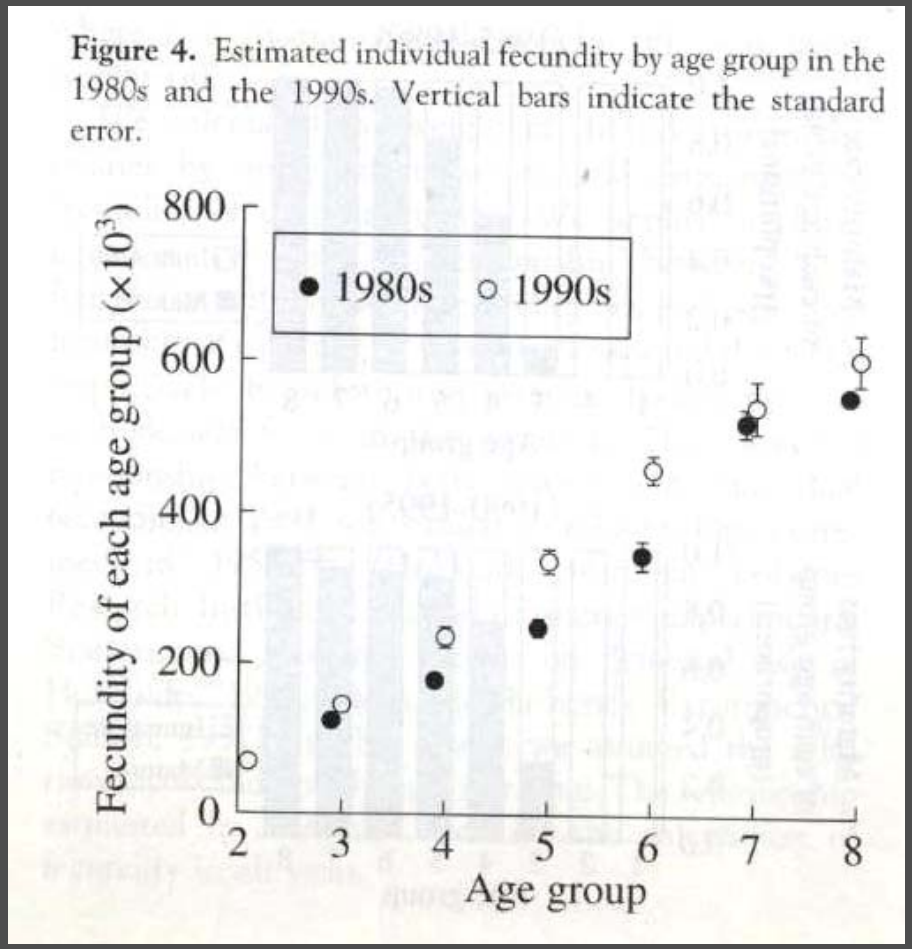


Model Results Validation

Total Spawned Eggs
estimated in this study
~ 10^{13}-10^{14}ind.

Total fish abundance
older than 2 year
~ 10^{9} ind.

Fecundity (egg/ind.)
~ 10^{5}

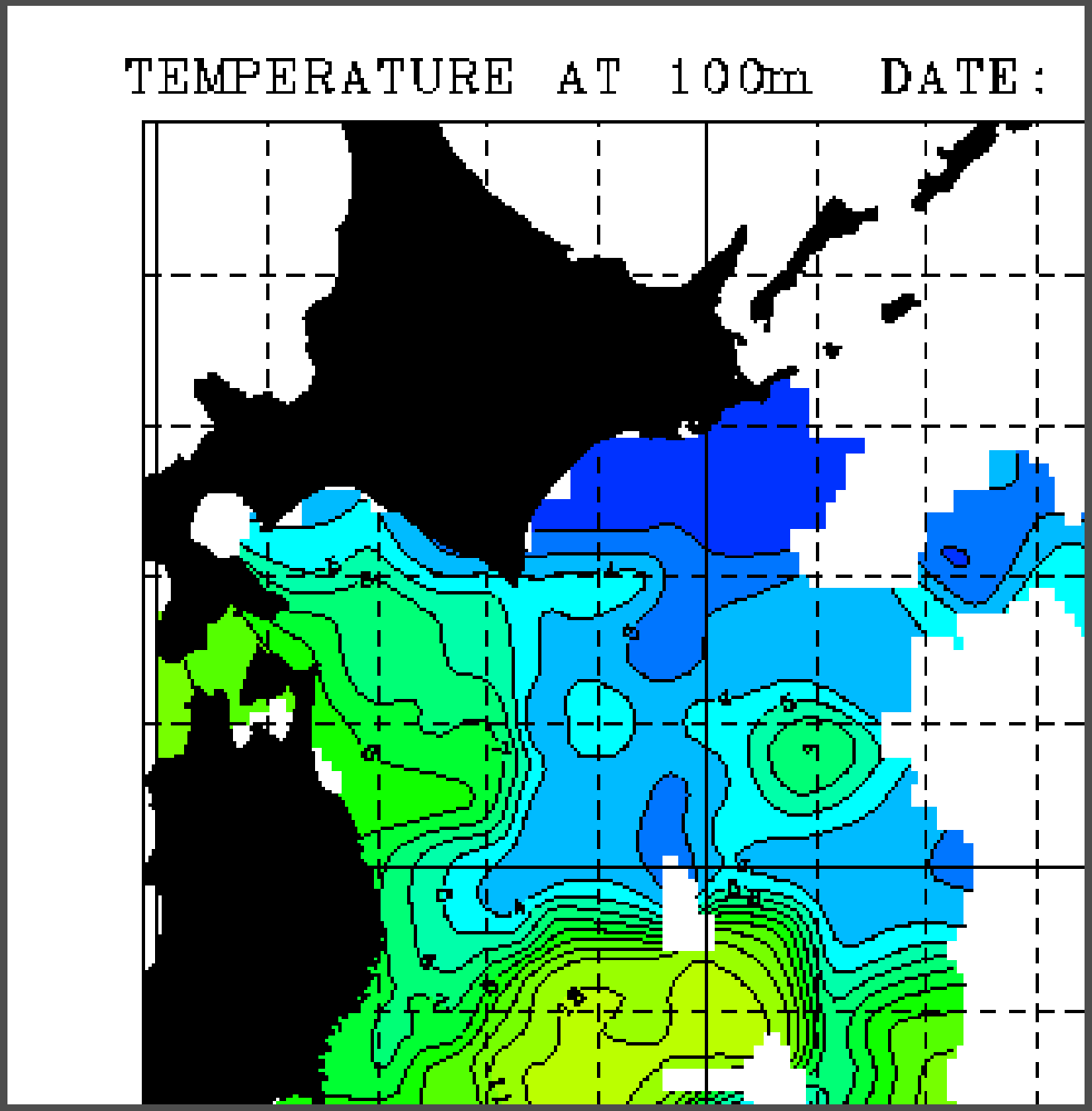


From Hamatsu et al.(2004)

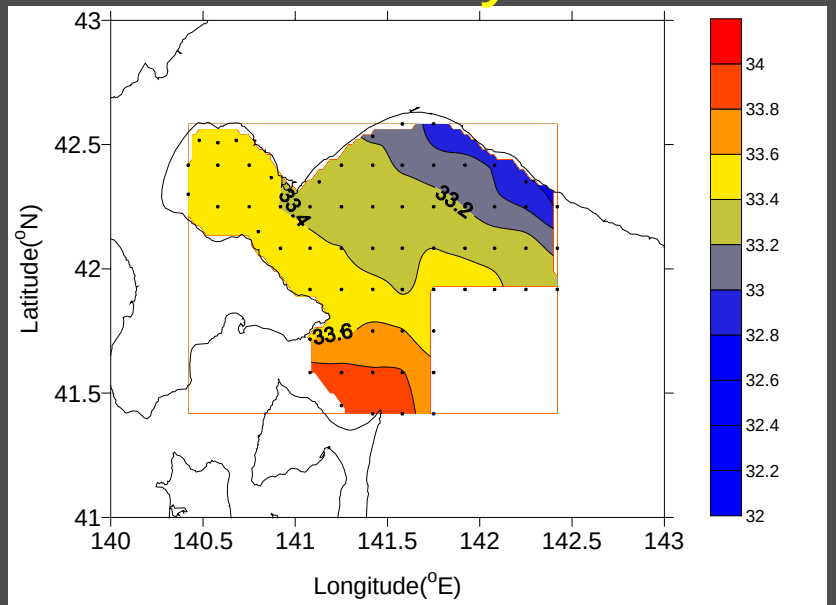
In Spring

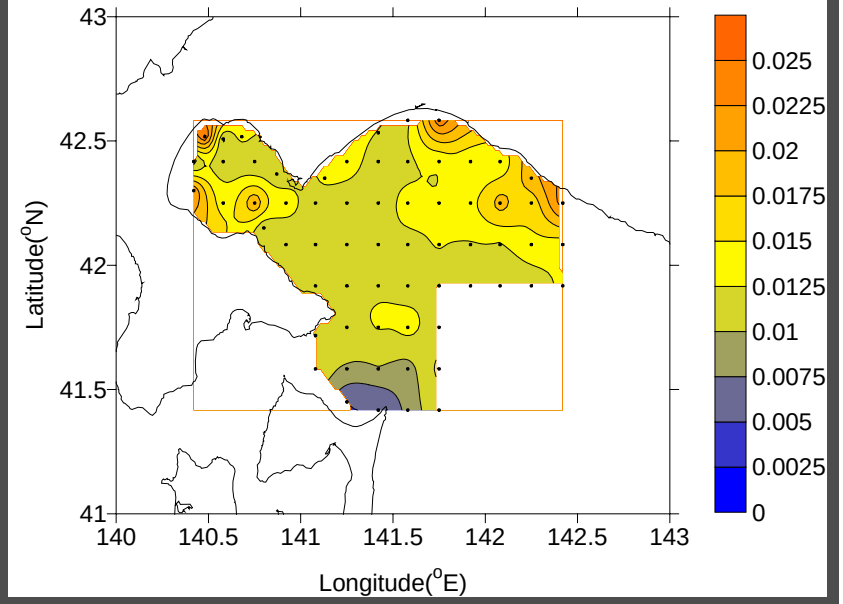
CO intrudes

into the bay

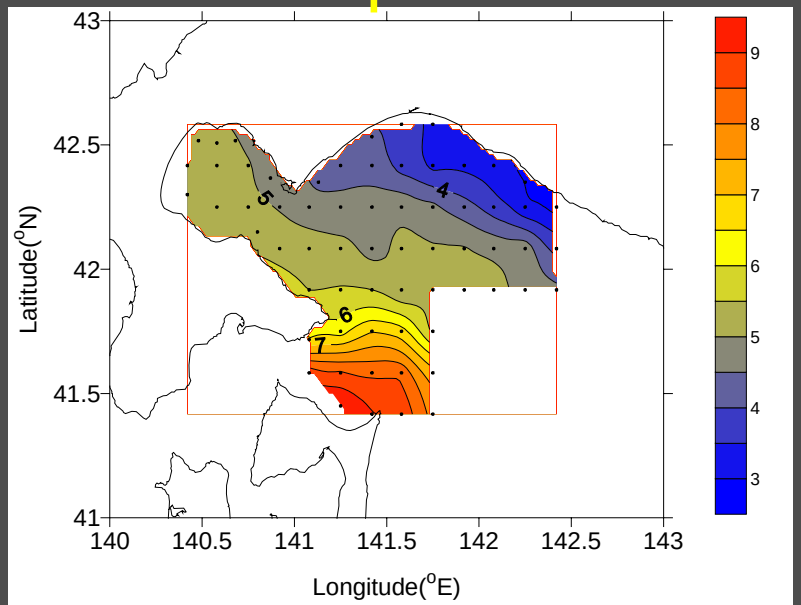


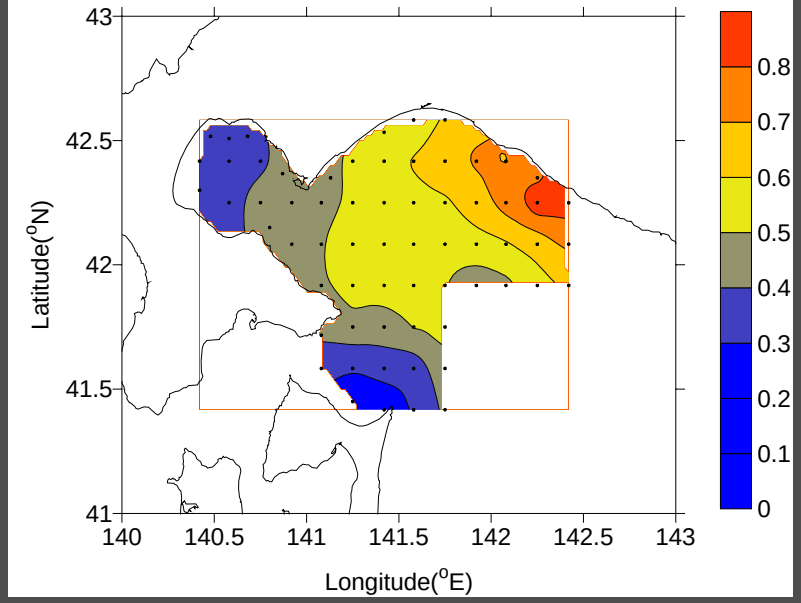
Salinity

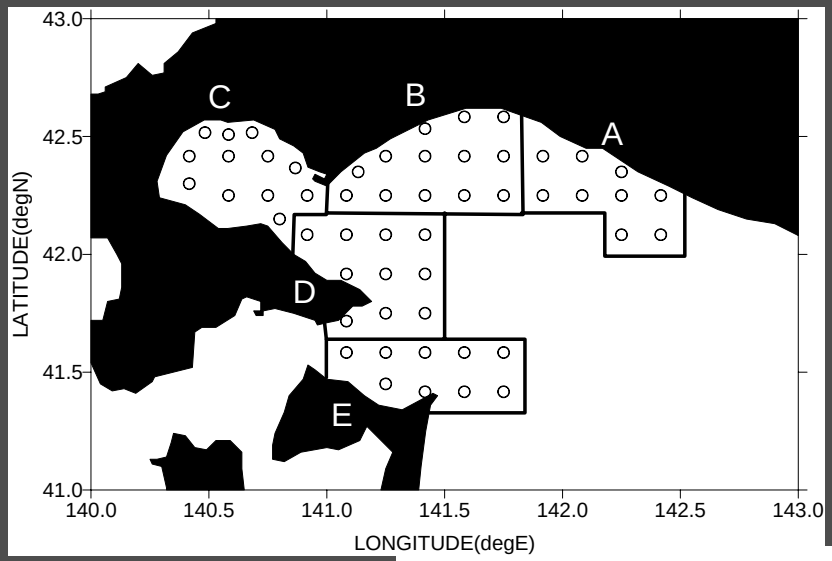




Temperature

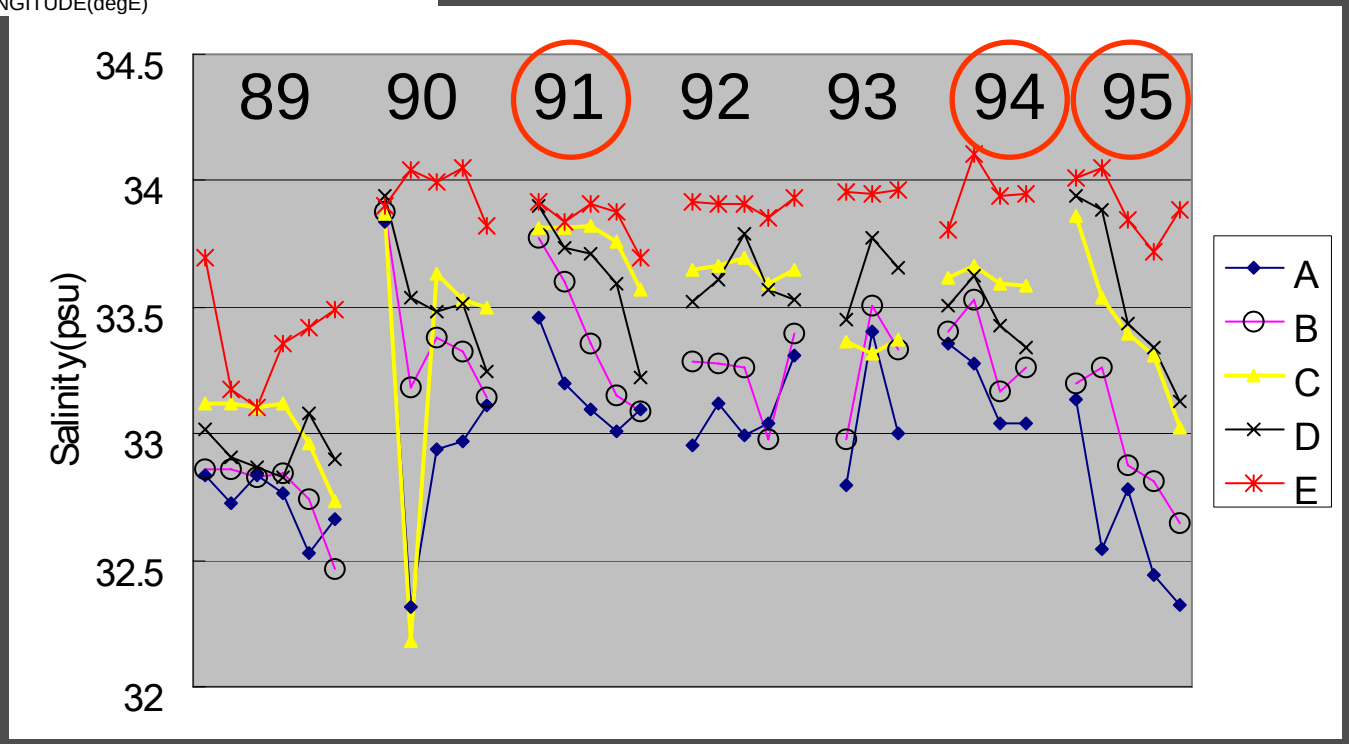






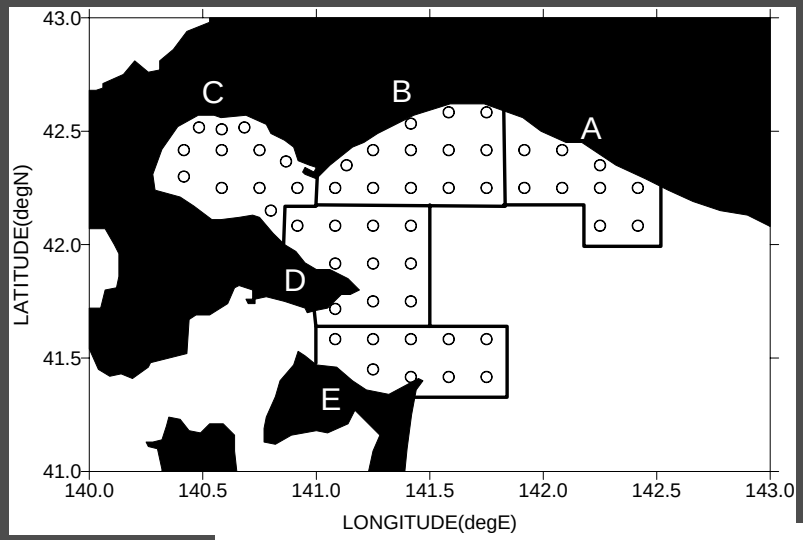
Salinity temporal change for each year

good survival year

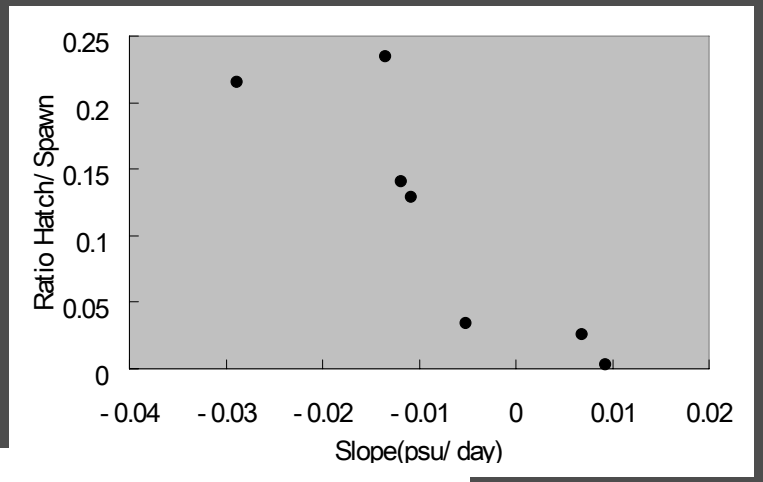


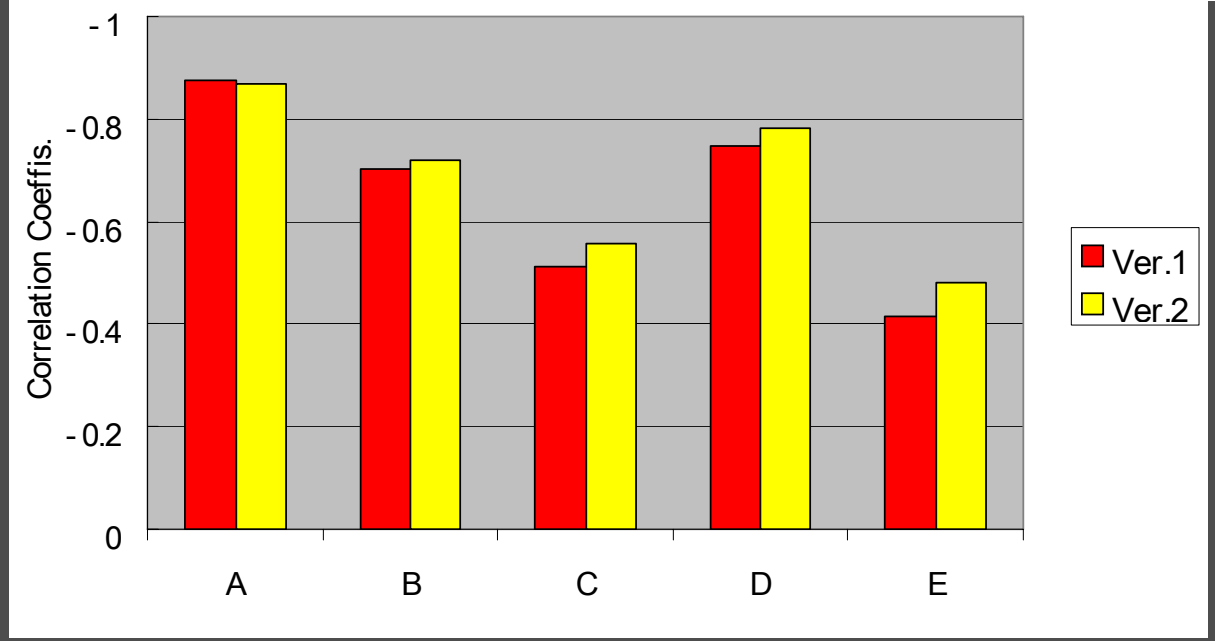
sep¥a¥rate

Correlation between Salinity Slope and Hatch/Spawn



Region A vs. Ver.0



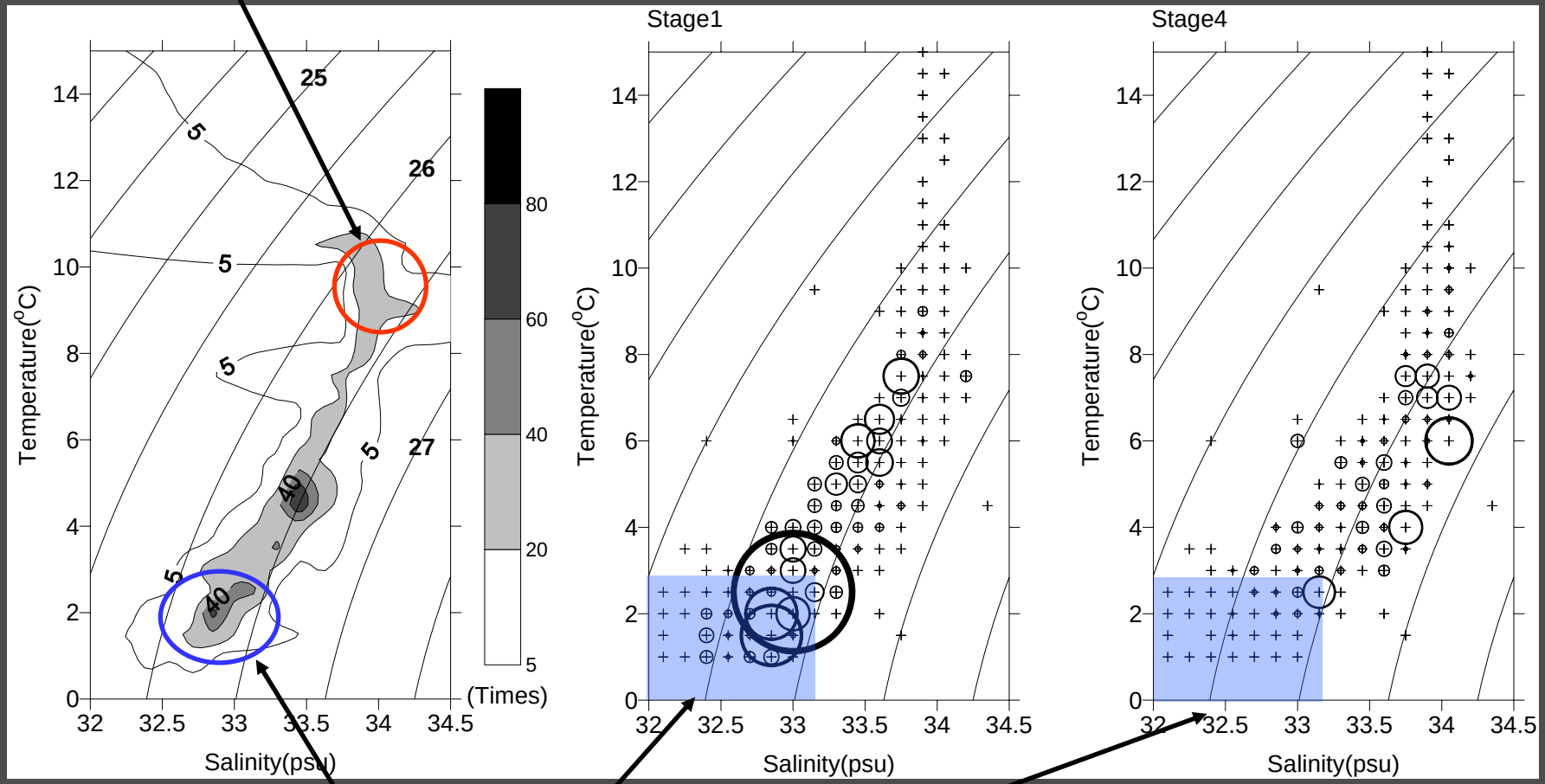


What water having many eggs?

Tsugaru Warm

Stage1

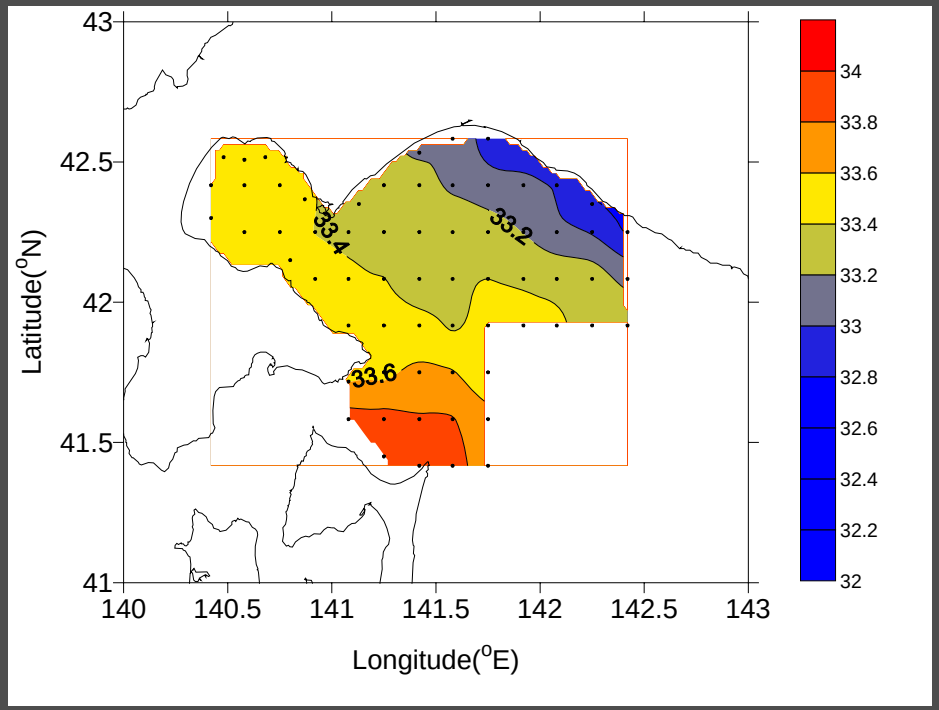
Stage4



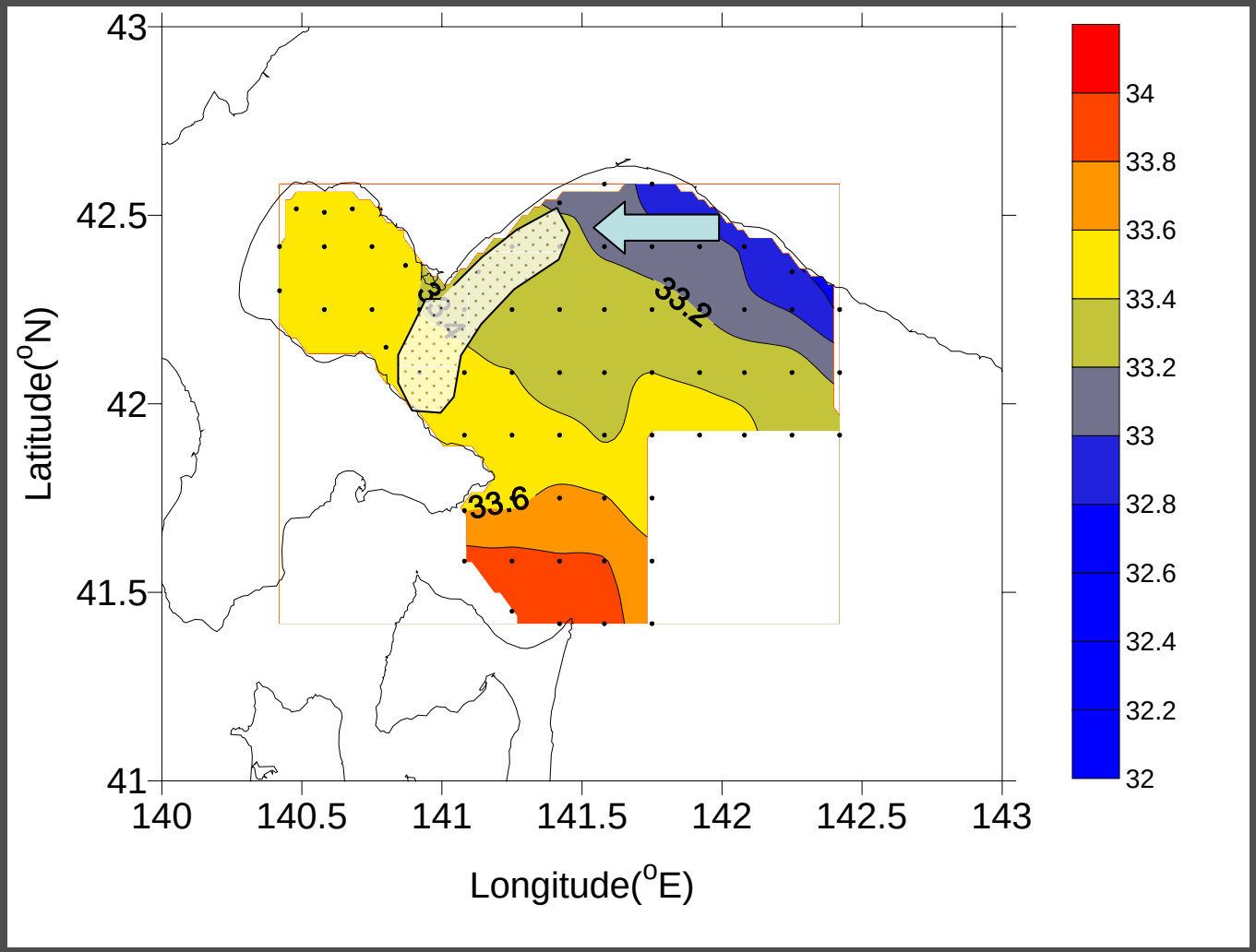
Coastal Oyashio

Results of Observation

1. Many eggs were spawned on the Hidaka Coast.
2. Many eggs hatched in Funka Bay
3. When salinity decreased, eggs were survived well.



Since the CO pushes eggs into the bay, they can be hatched more???



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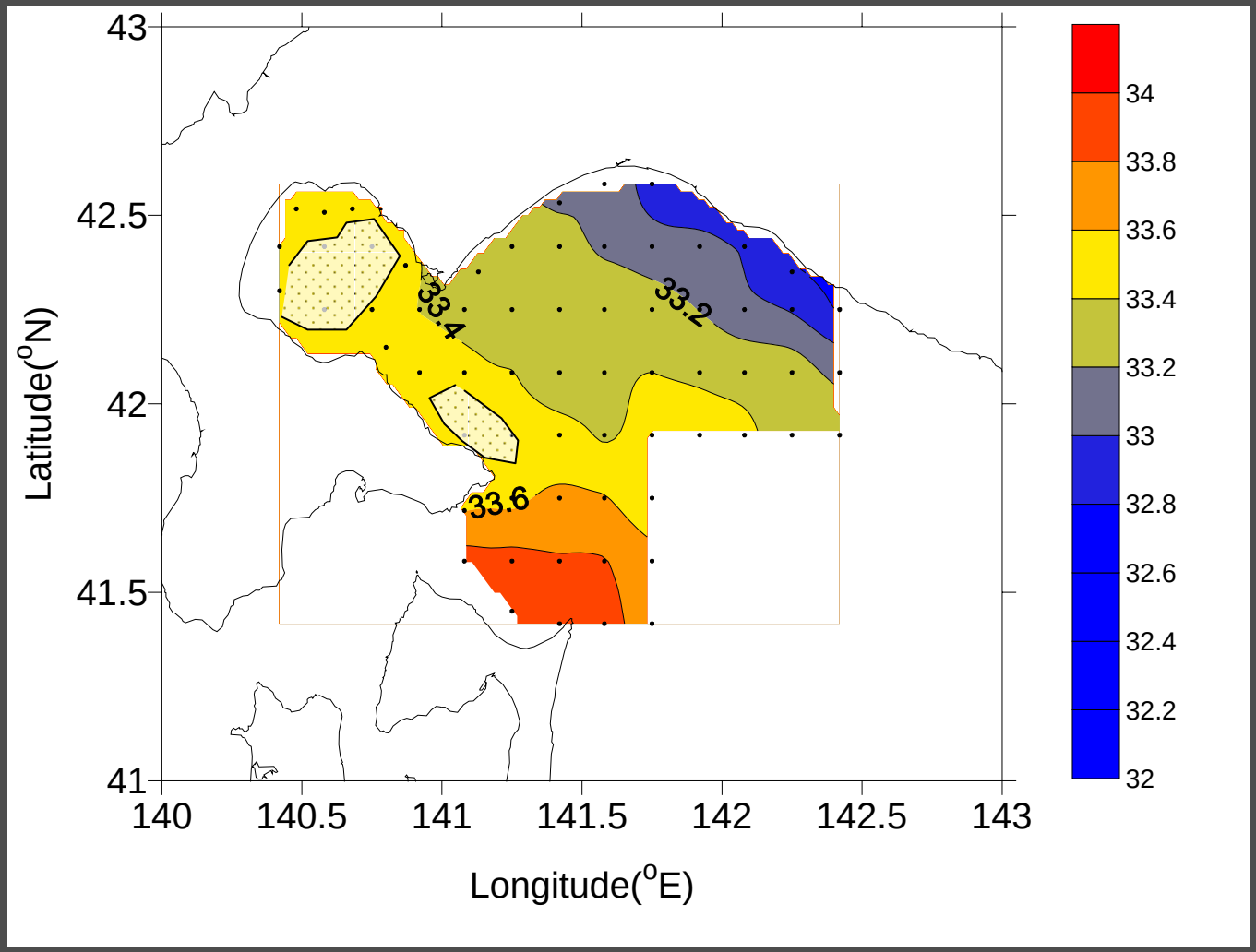
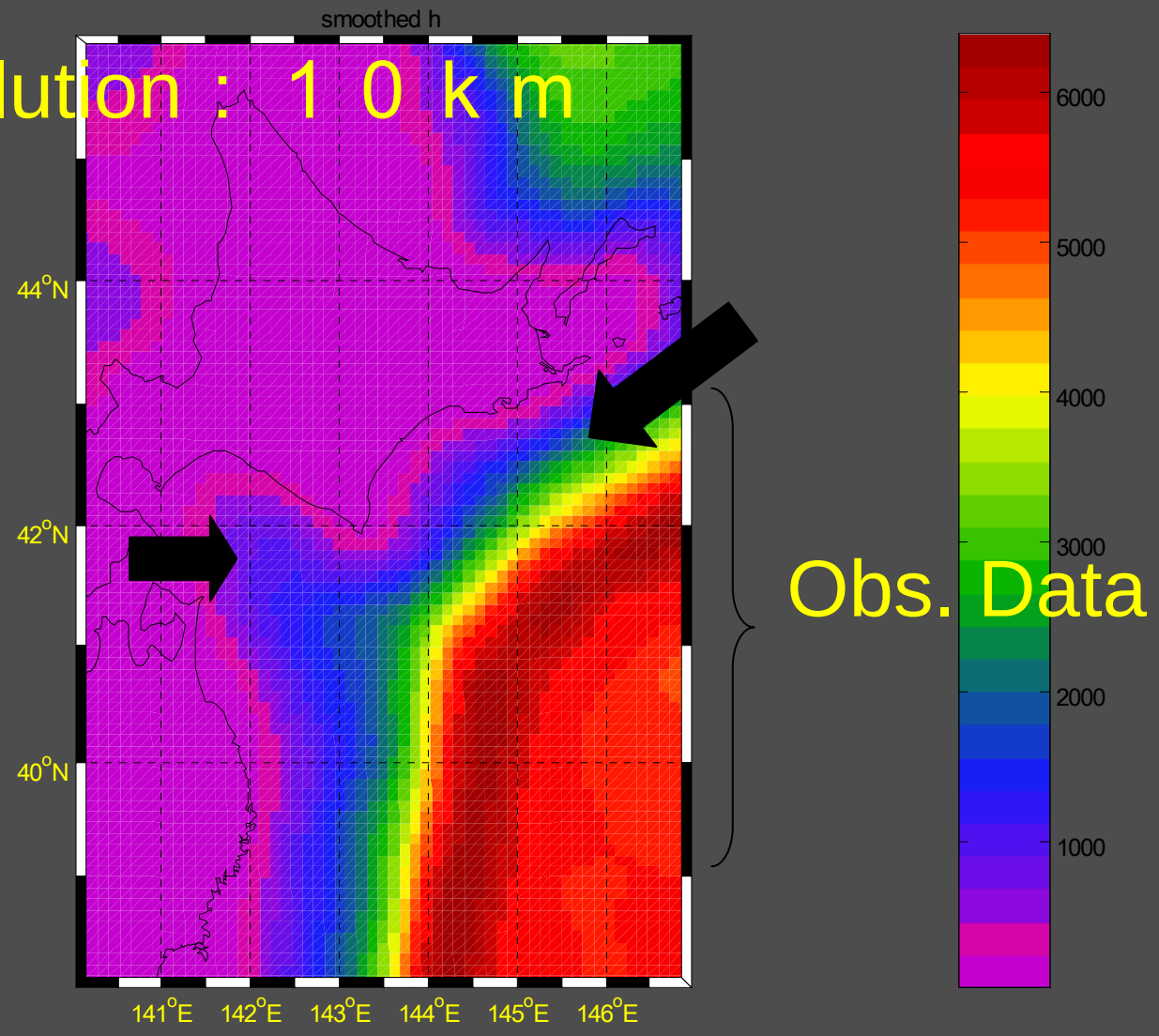
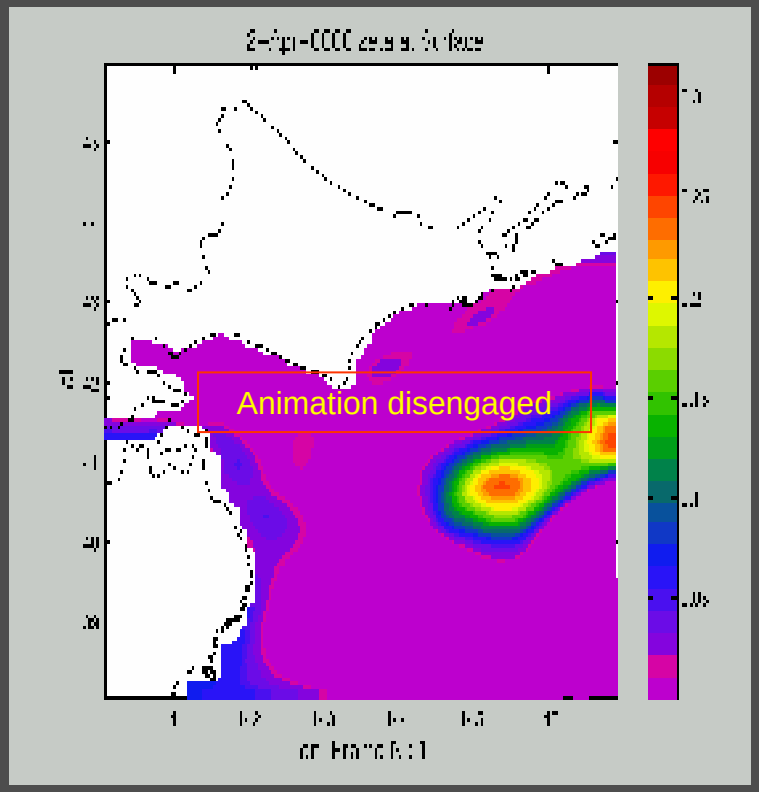
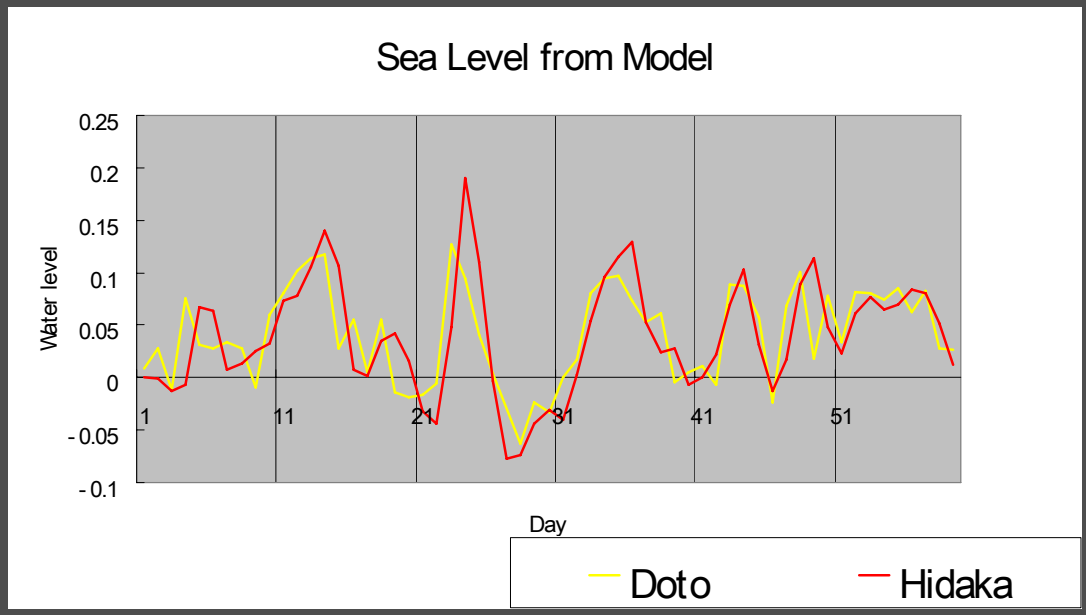


Model Area (88× 5 8 × 2 0)

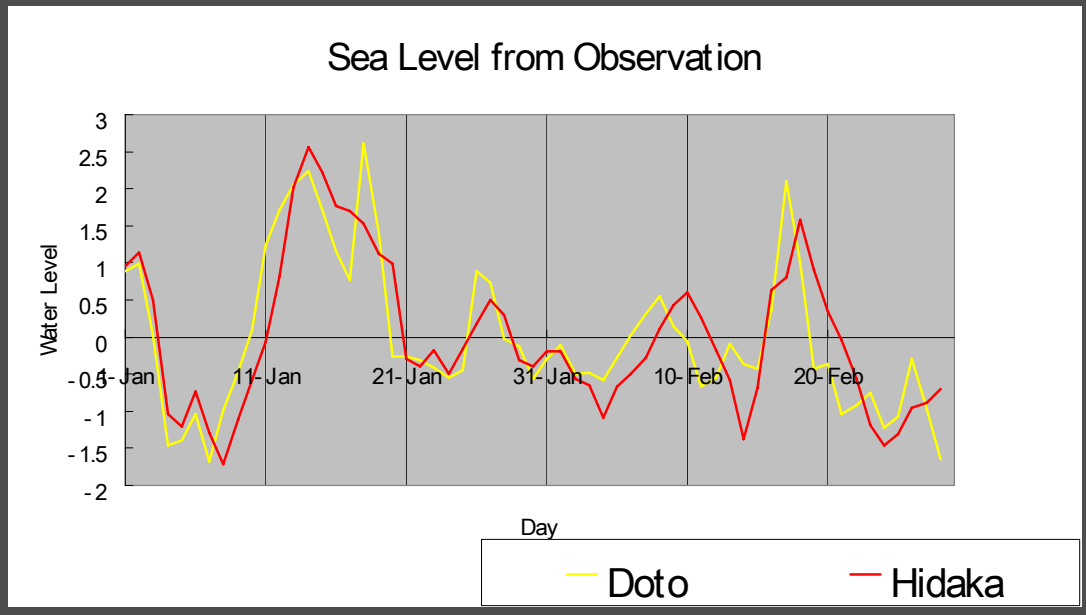
resolution : 1 0 k m

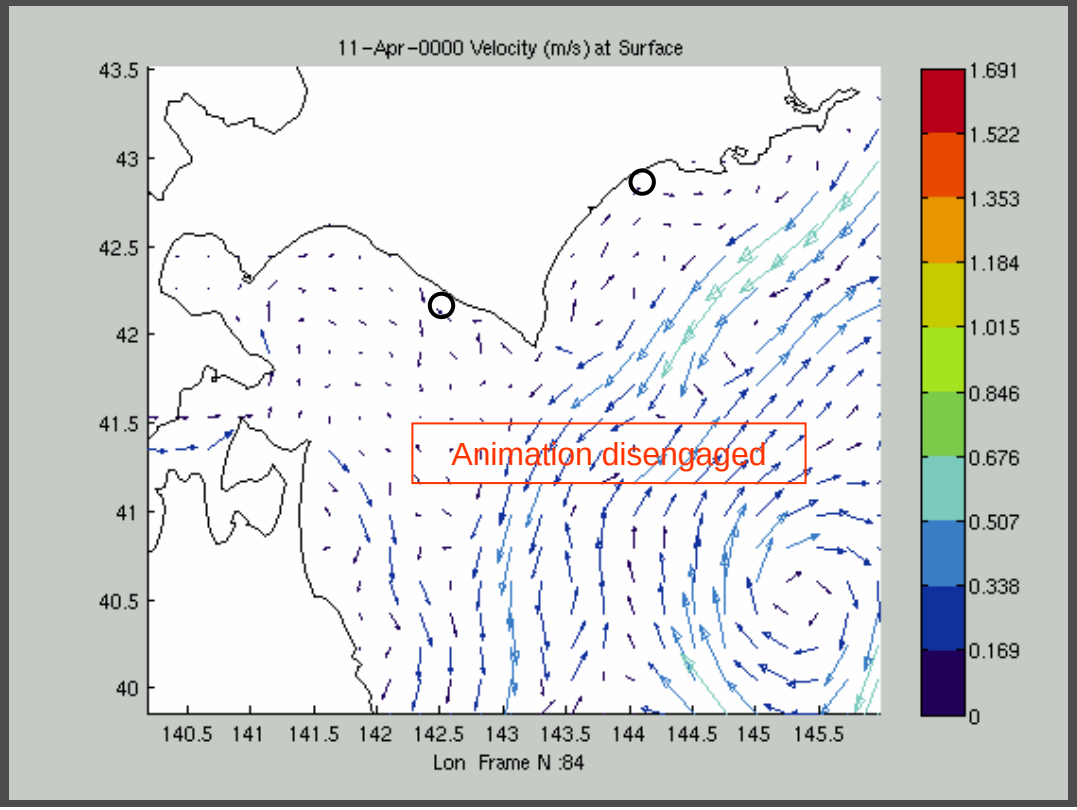


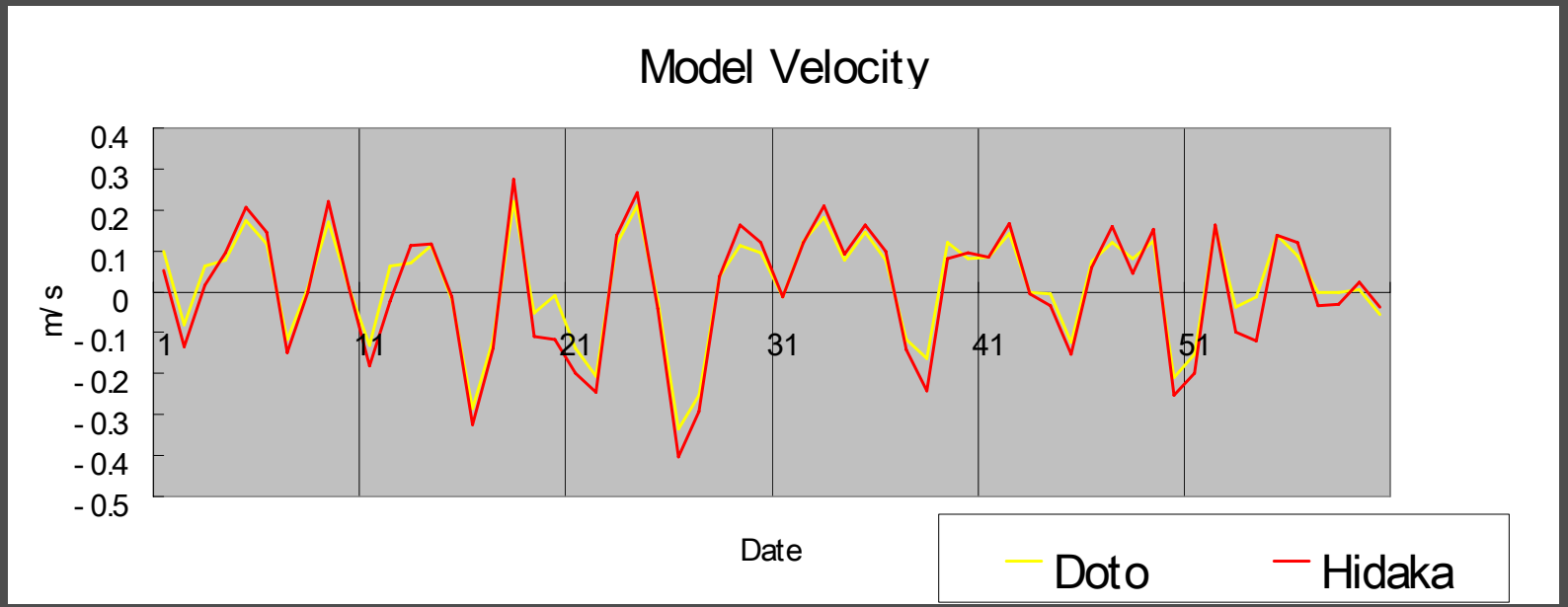




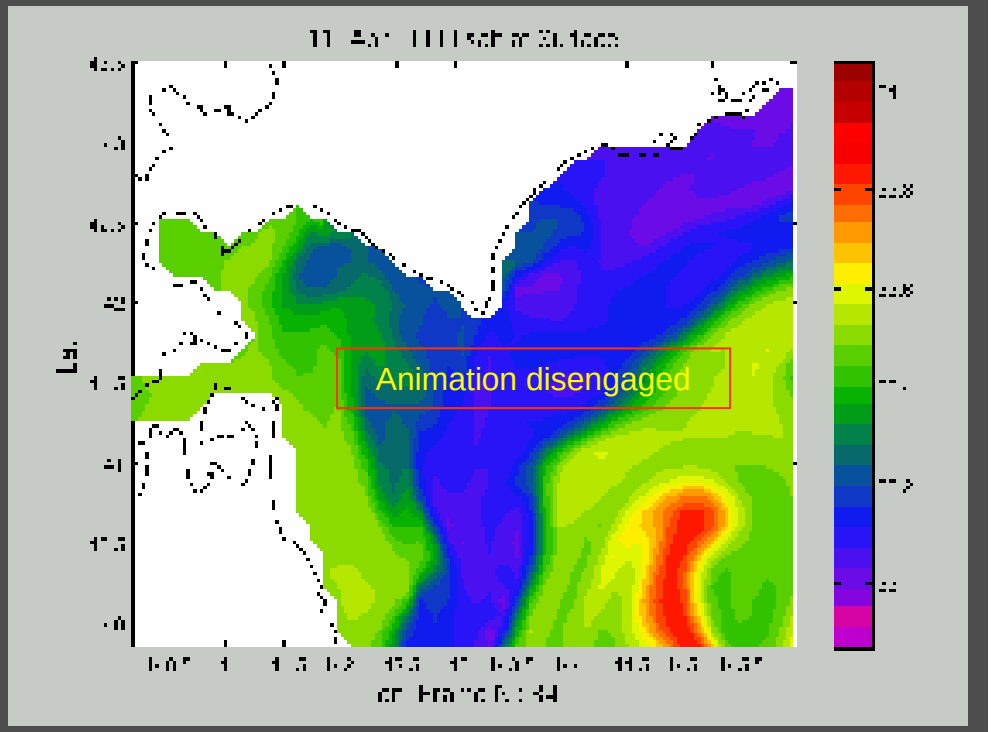
Std.Dev.	Doto	Hidaka	Tohoku
Obs.	0.040	0.047	0.038
Model	0.045	0.055	0.051

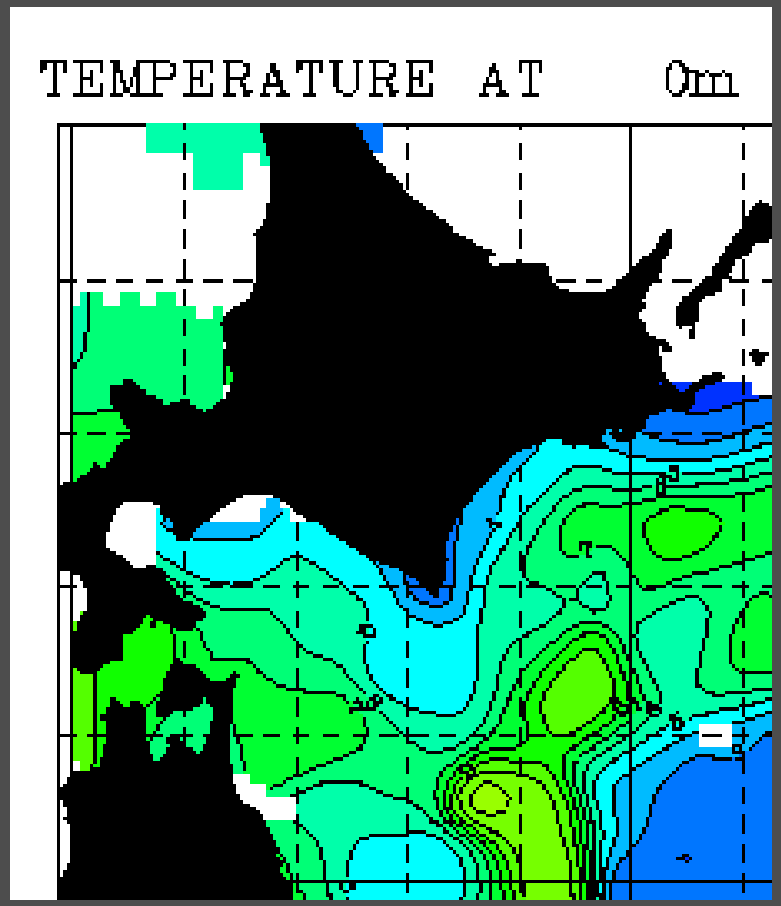



11-Apr-0000 Velocity (m/s) at Surface
43.5
43
42.5
42
41.5
41
40.5
40
140.5 141 141.5 142 142.5 143 143.5 144 144.5 145 145.5
Lon Frame N :84
1.691
1.522
1.353
1.184
1.015
0.846
0.676
0.507
0.338
0.169
0
Animation disengaged


Model Velocity
0.4
0.3
0.2
0.1
0
- 0.1
- 0.2
- 0.3
- 0.4
- 0.5
m/s
1
11
21
31
41
51
Date
Doto
Hidaka

Model Result: Sea Surface Salinity change





Conclusion

1. The eggs survived well in 1991, 1994, 1995, when salinity tended to decrease on the coast.
2. The eggs may carry away when they exist in Coastal Oyashio water.
3. Transportation processes should be examined on this coast near the bay with a wind forcing.