The effect of Ojo de Liebre Lagoon on the hydrodynamics of Bahia Vizcaino

I.Ramírez (1), R. Navarro (2), E. Santamaría (3) M. Ortiz (1) R. Ramírez (1) and H. Bustos (3)

1:CICESE, 2:SEMAR, 3: UABC

PICES 2018

Sanctuary of the gray whale and the biggest Salt company of the world

Objectives/Team

- SEMAR-CICESE-UABC
- To characterize, define and describe the hydrodynamic of Vizcaino Bay to define the better sites for discharge residual waters

Measurements and Modeling

- Field campaign, August 2017
- Field campaign March 2018
- Field campaign Abril 2018

- Modeling August 2017

data

Collected in situ

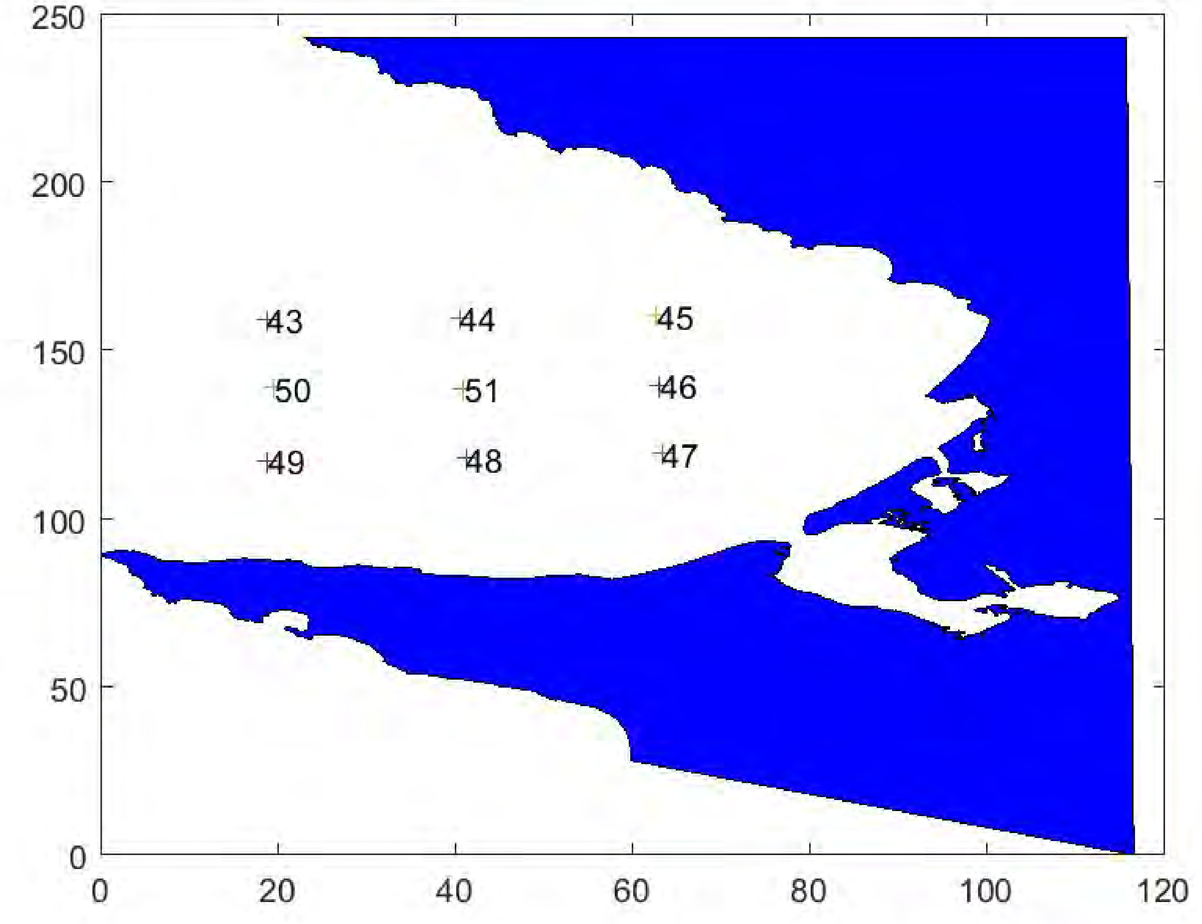
- CTD: Salinity, temperature, turbidity, ph, oxygen.
- 9 sites and a time series
- Drogues trajectories

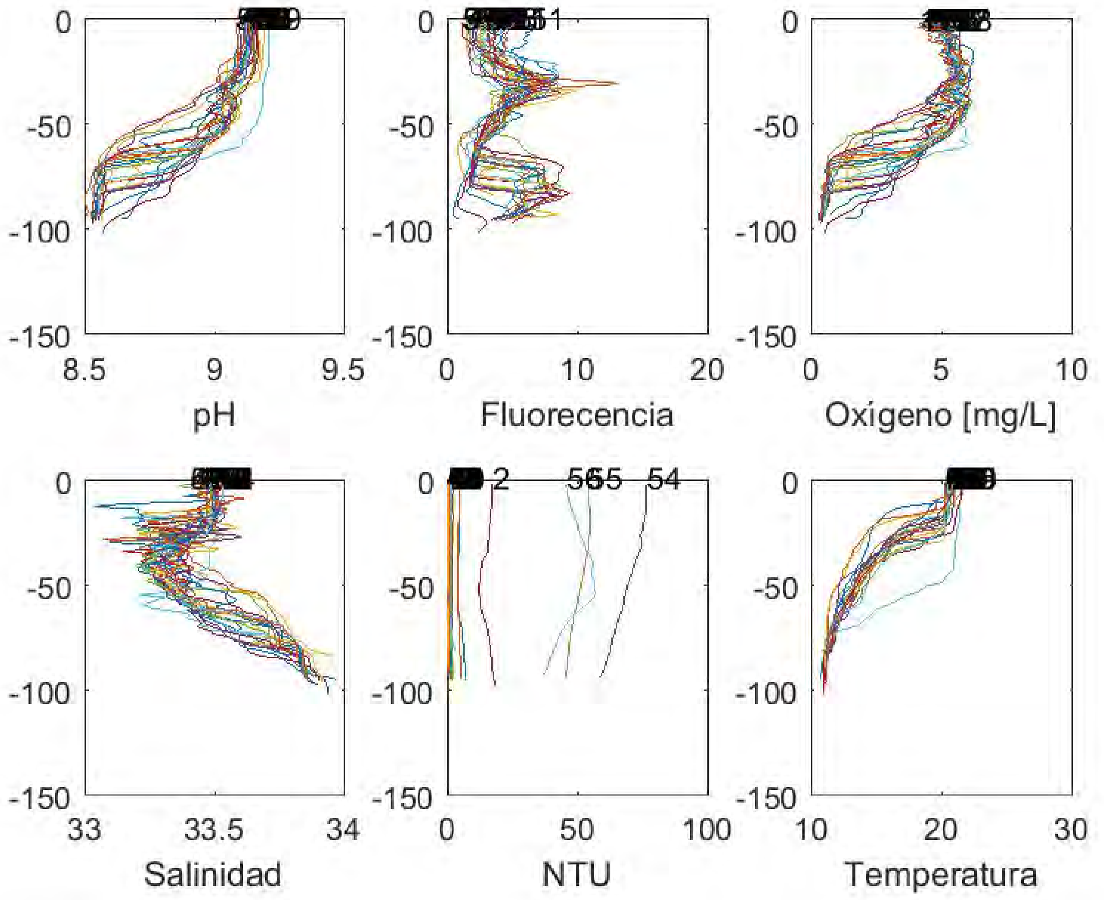
Collected for the model for OB

- Time series of sea level from Cedros Island Station
- Time series of meteorological variables from Cedros Island

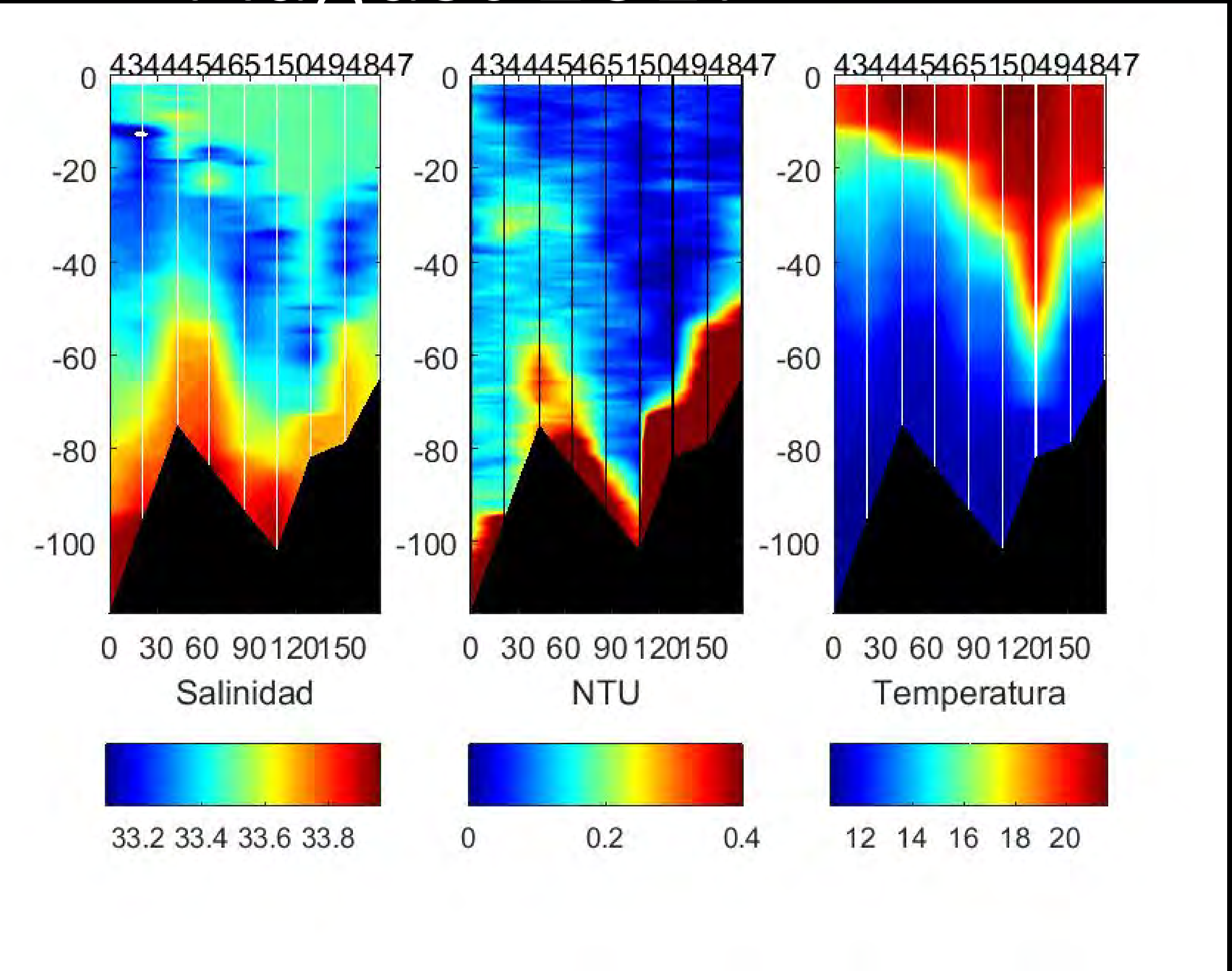
CTD and Rio Tecolutla RV

Field results CTD profiles





August 2017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0
-20
-40
-60
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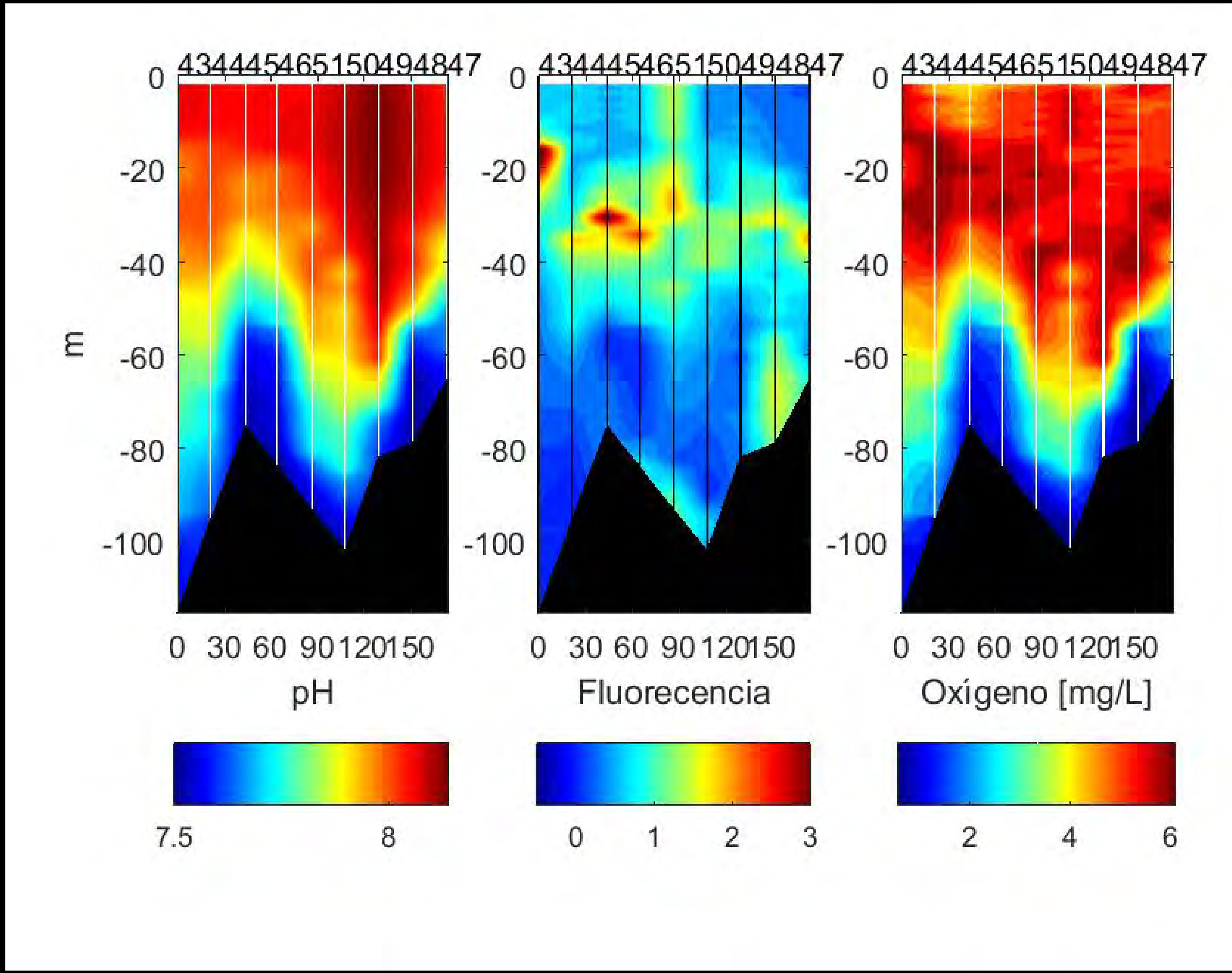
Salinidad
33.2 33.4 33.6 33.8
NTU
0 0.2 0.4
Temperatura
12 14 16 18 20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m
0
-20
-40
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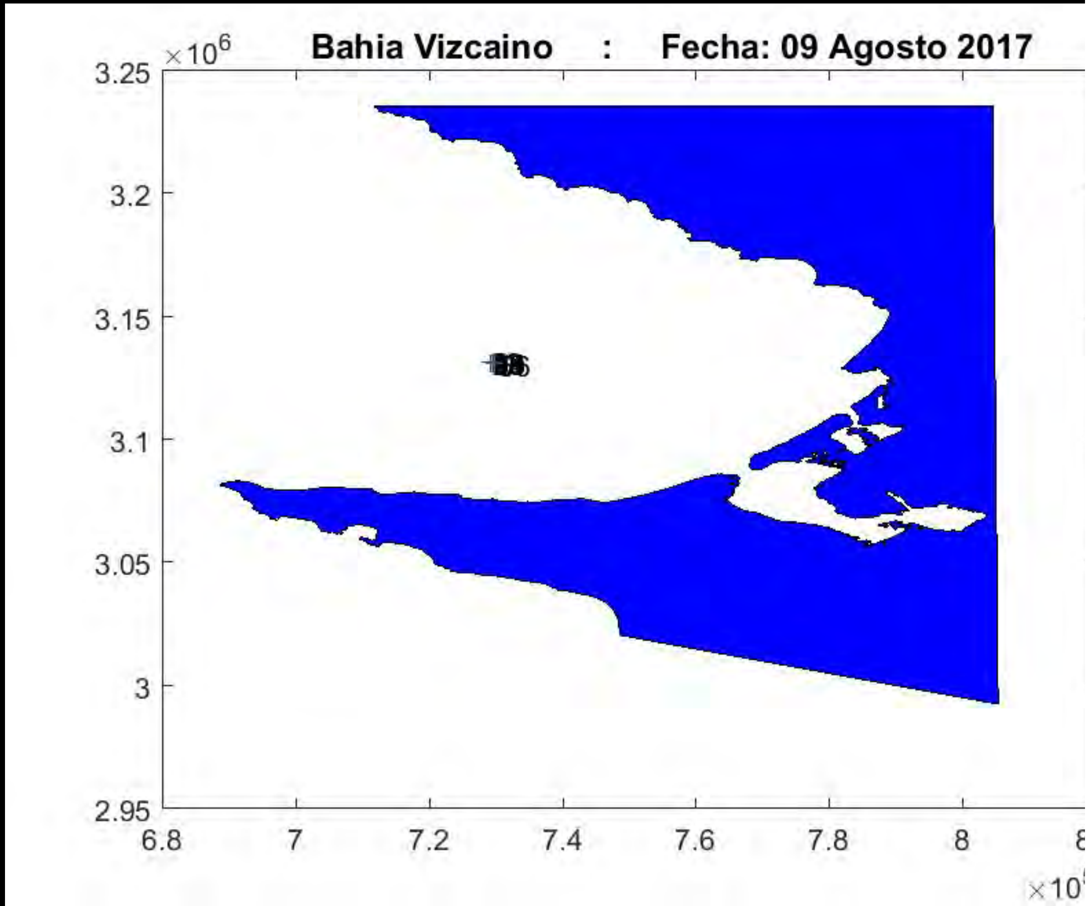
0 30 60 90 120150
pH
7.5 8
Fluorecencia
0 1 2 3
Oxígeno [mg/L]
2 4 6

Time Serie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3.15
3.1
3.05
3
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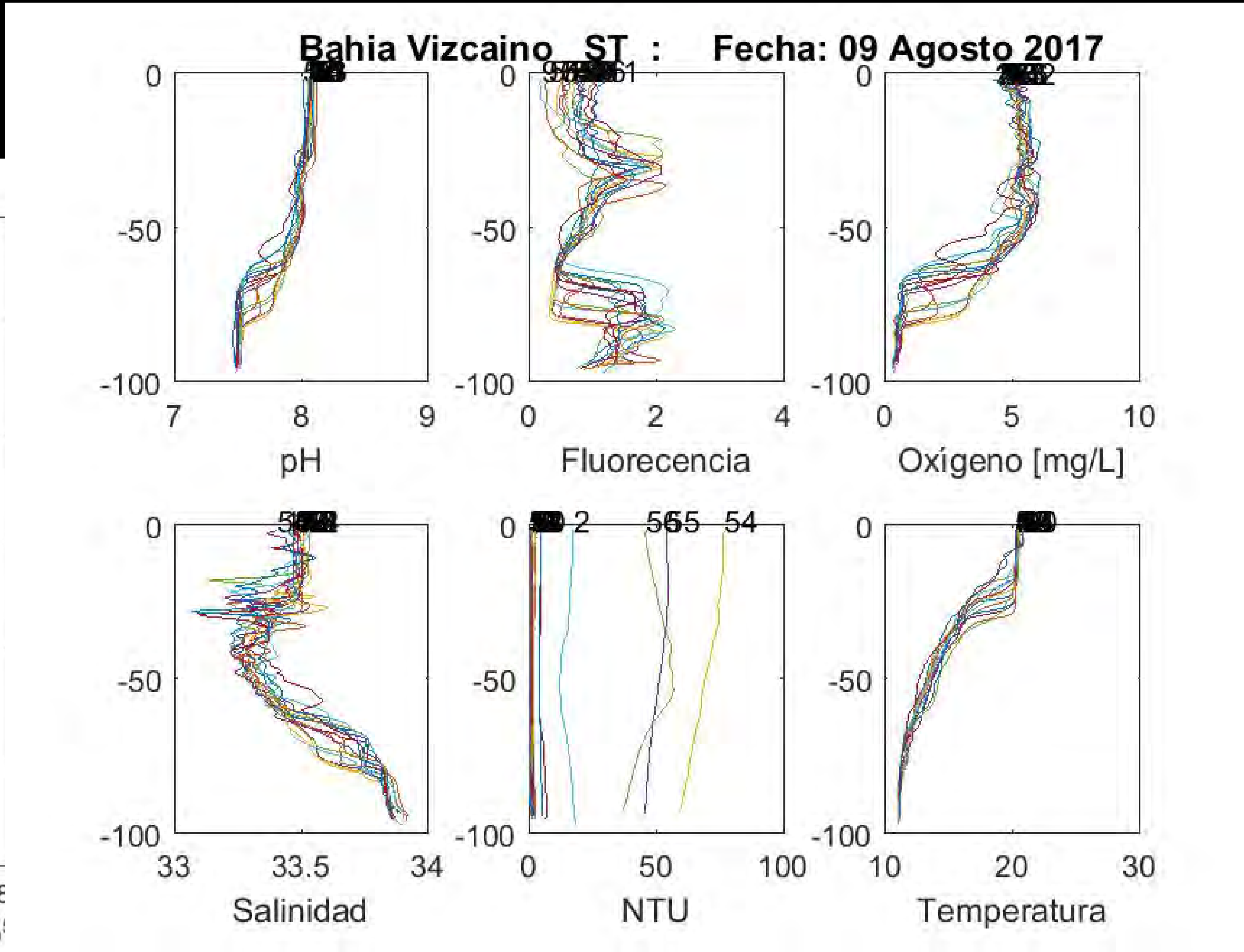
7
7.2
7.4
7.6
7.8
8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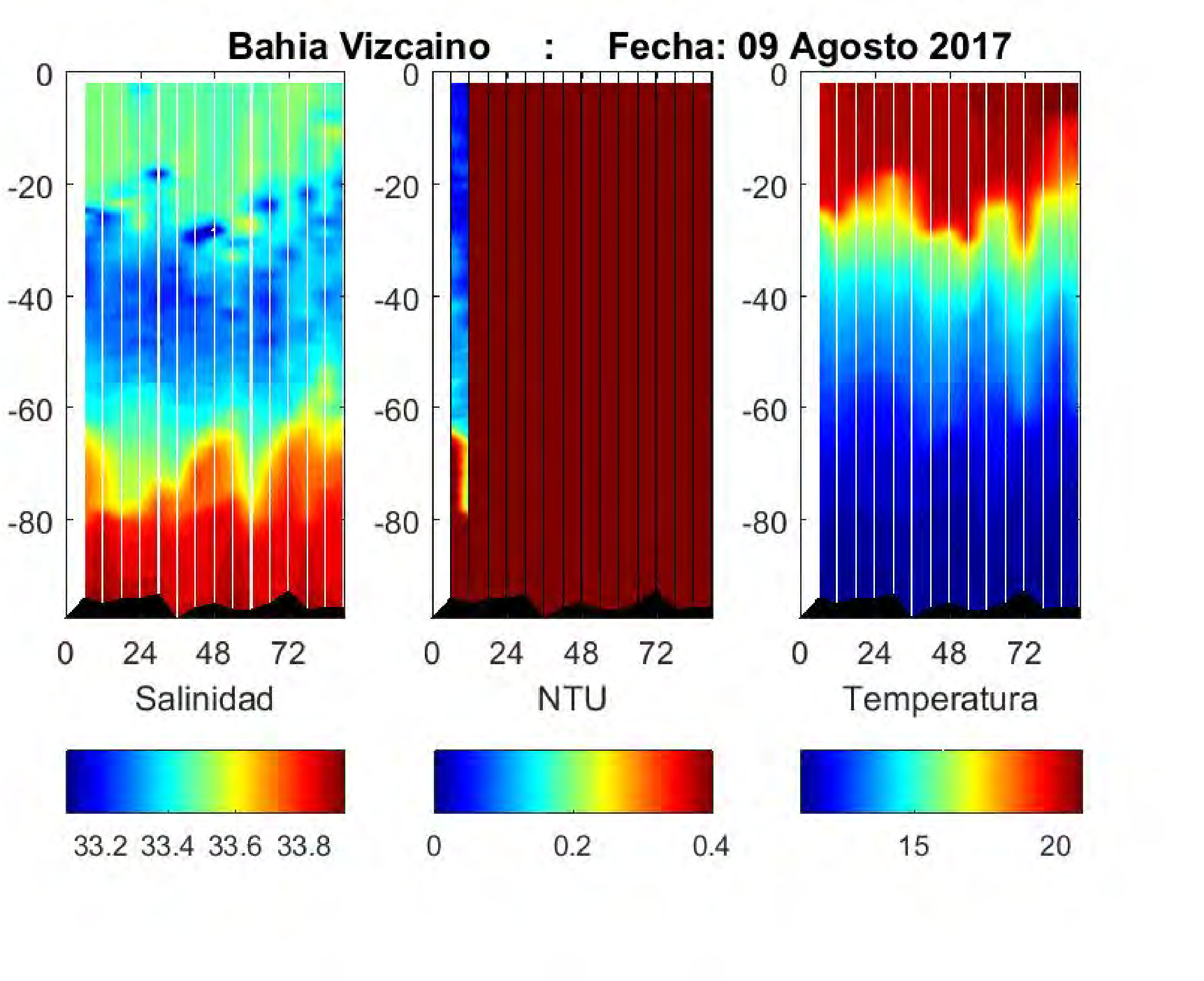
pH
Fluorecencia
Oxígeno [mg/L]
Salinidad
NTU
Temperatura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0
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NTU
Temperatura
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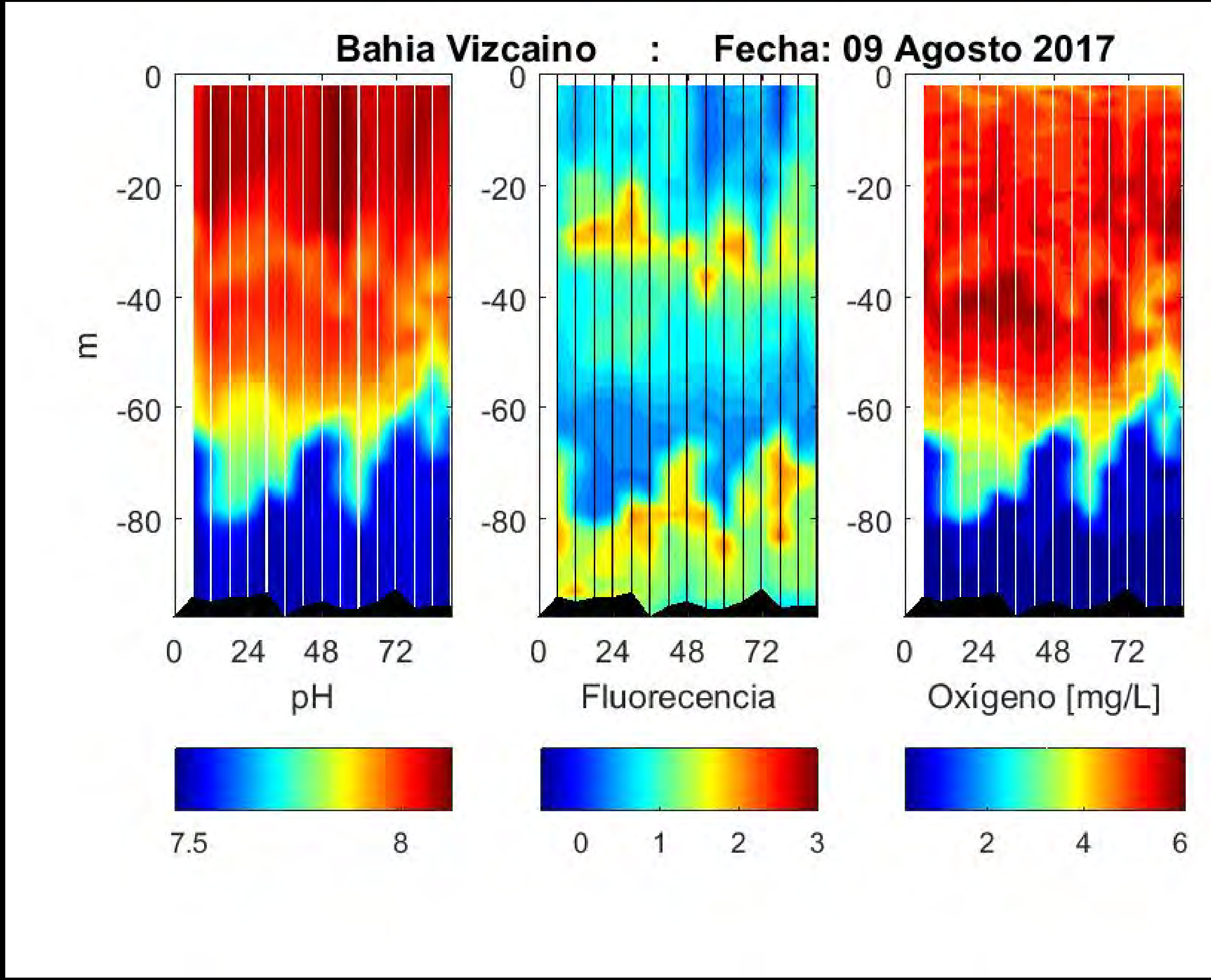
0 0.2 0.4
15 20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m
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-60
-80
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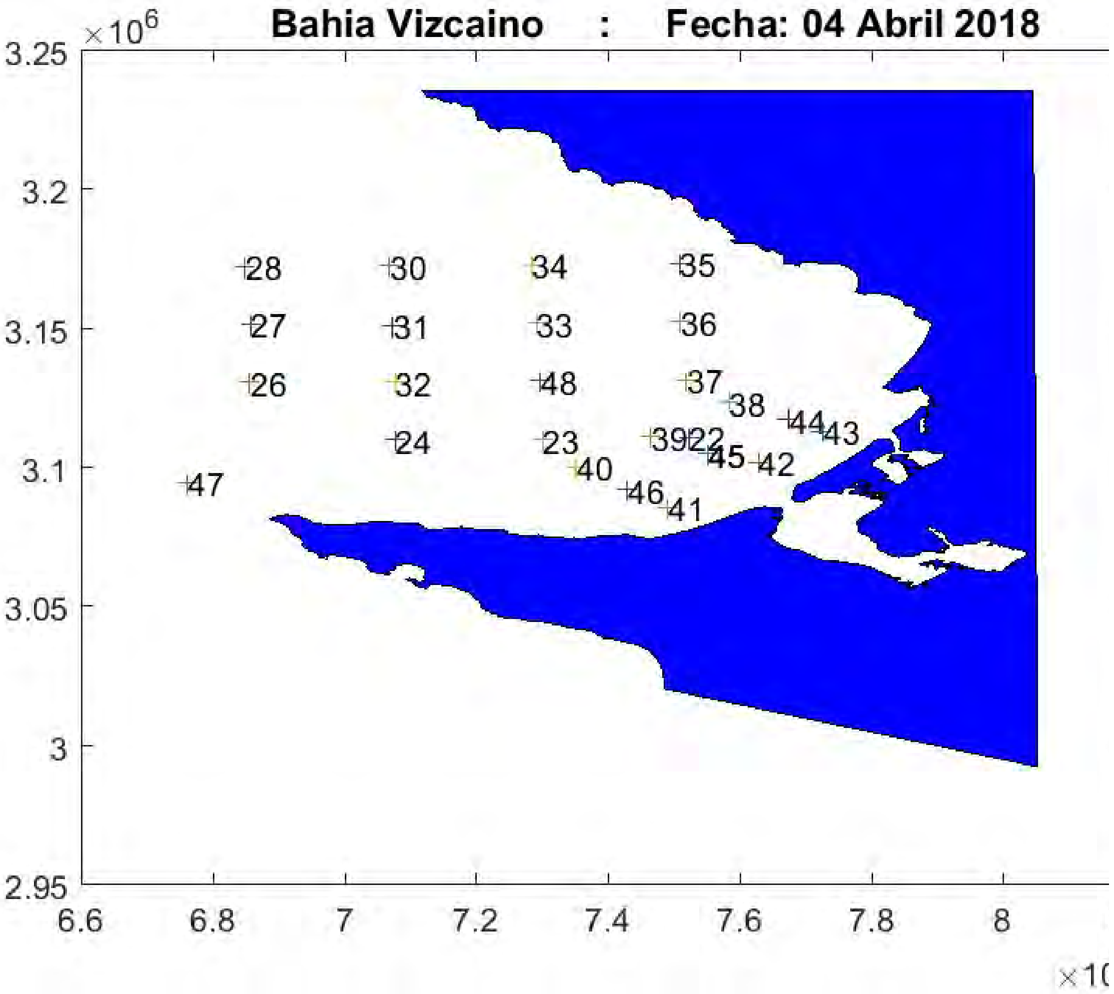
pH
Fluorecencia
Oxígeno [mg/L]
7.5 8
0 1 2 3
2 4 6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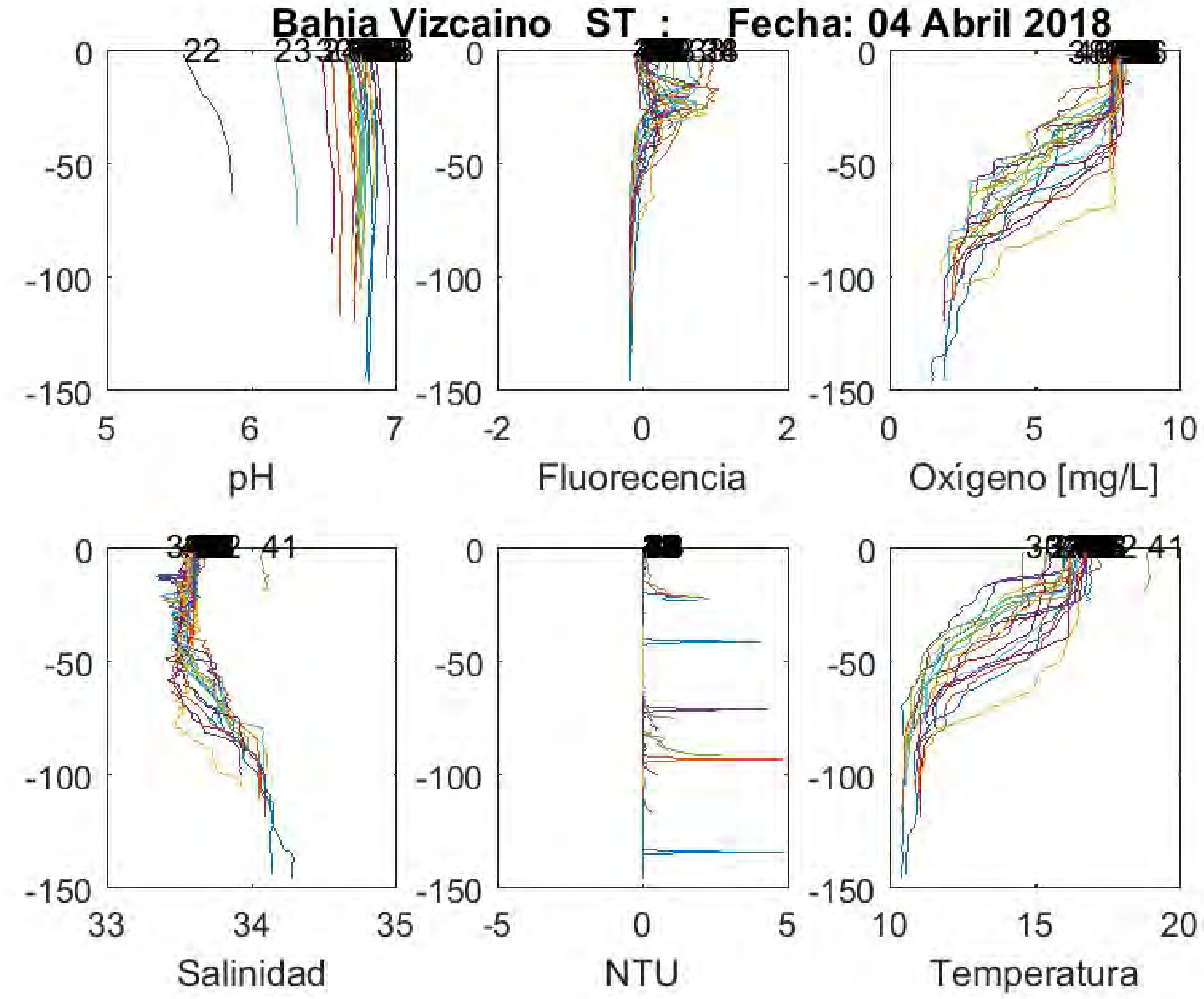
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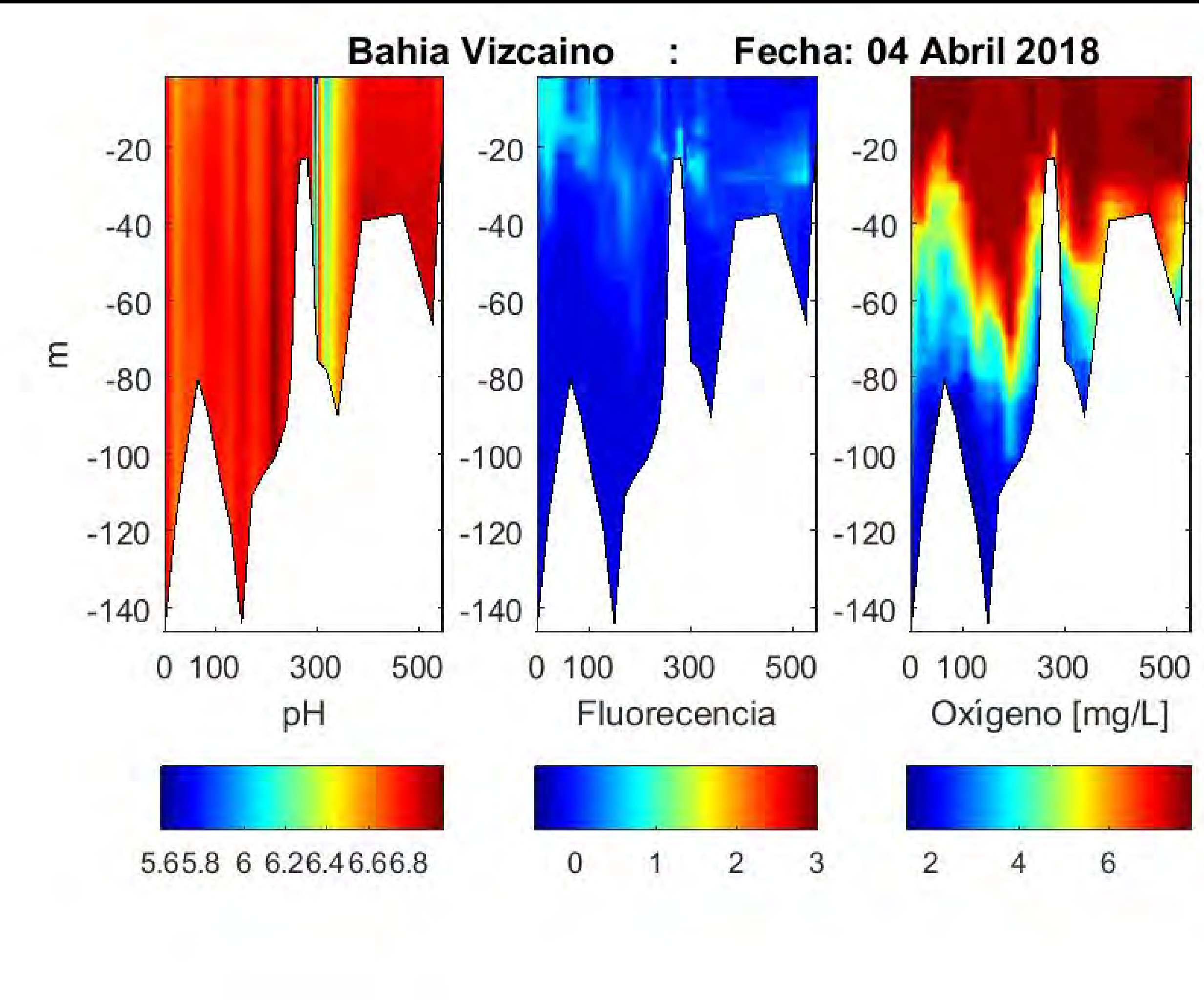
pH
Fluorecencia
Oxígeno [mg/L]
Salinidad
NTU
Temperatura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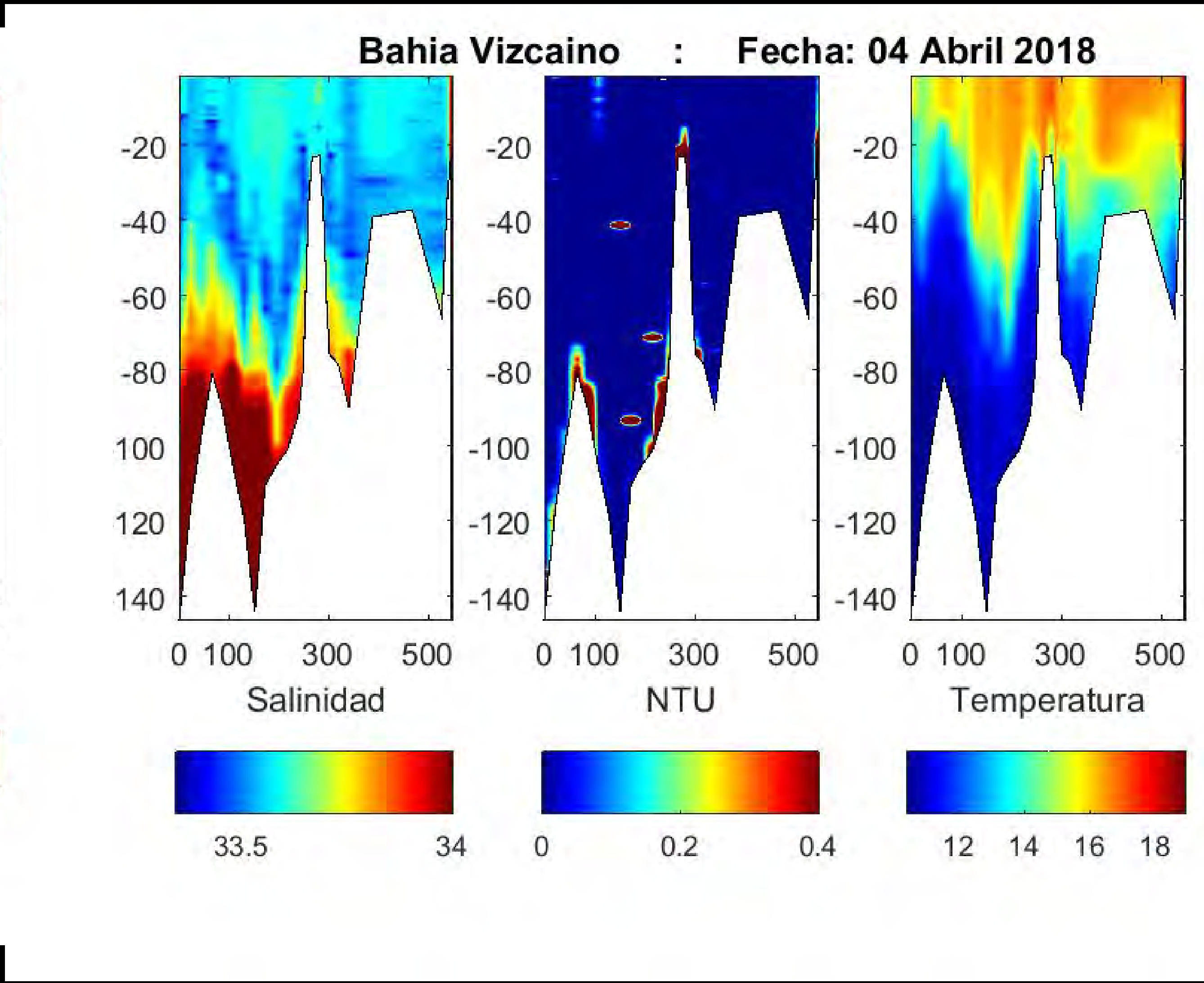
m
-20
-40
-60
-80
-100
-120
-140
0 100 300 500
pH
Fluorecencia
Oxígeno [mg/L]
5.65.8 6 6.26.46.66.8
0 1 2 3
2 4 6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-20
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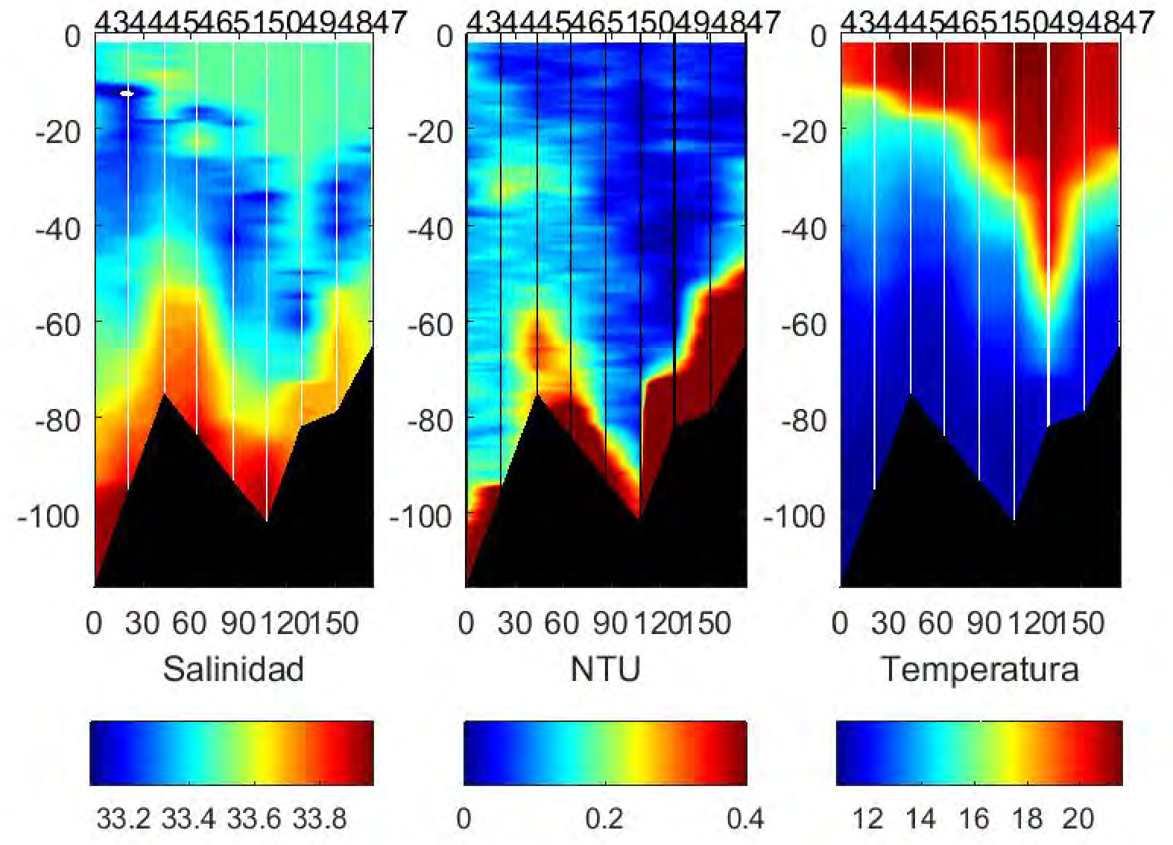
-140
0 100 300 500
Salinidad
NTU
Temperatura
33.5 34
0 0.2 0.4
12 14 16 18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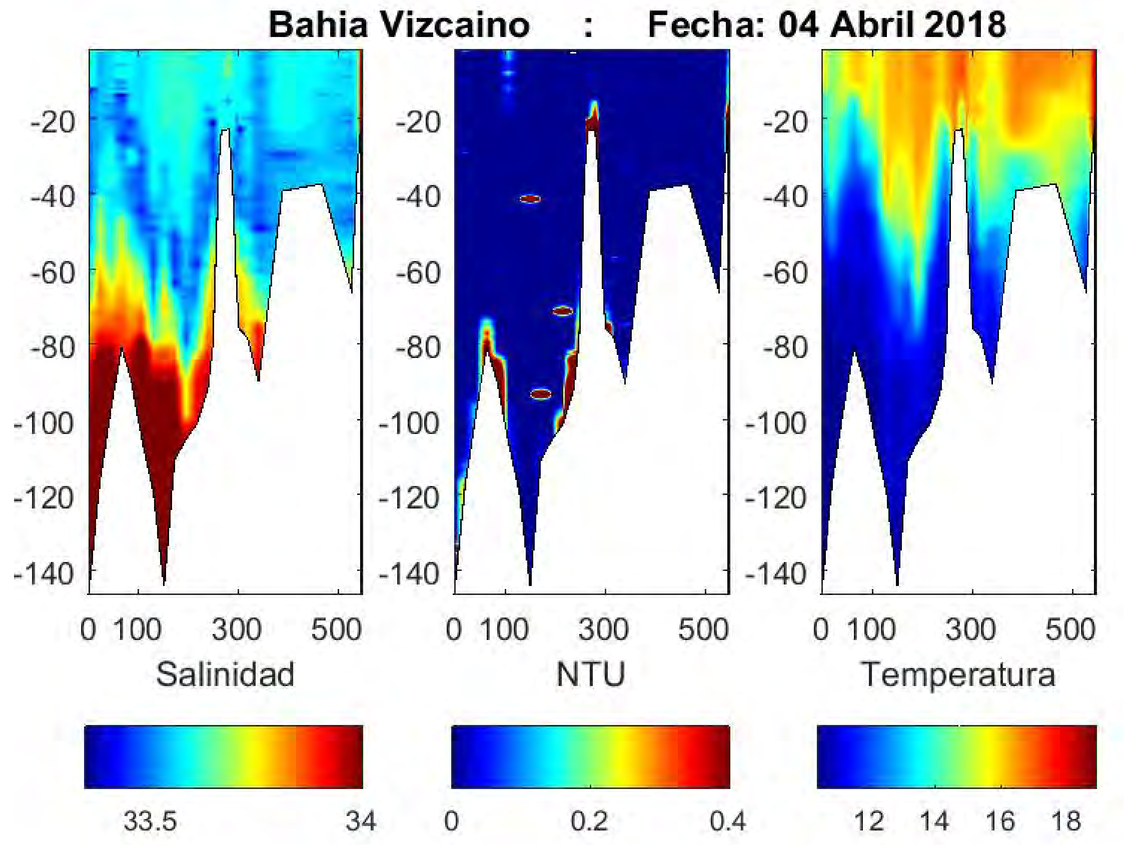
Salinidad
NTU
Temperatura
0 30 60 90 120 150
0 -20 -40 -60 -80 -100
33.2 33.4 33.6 33.8
0 0.2 0.4
12 14 16 18 20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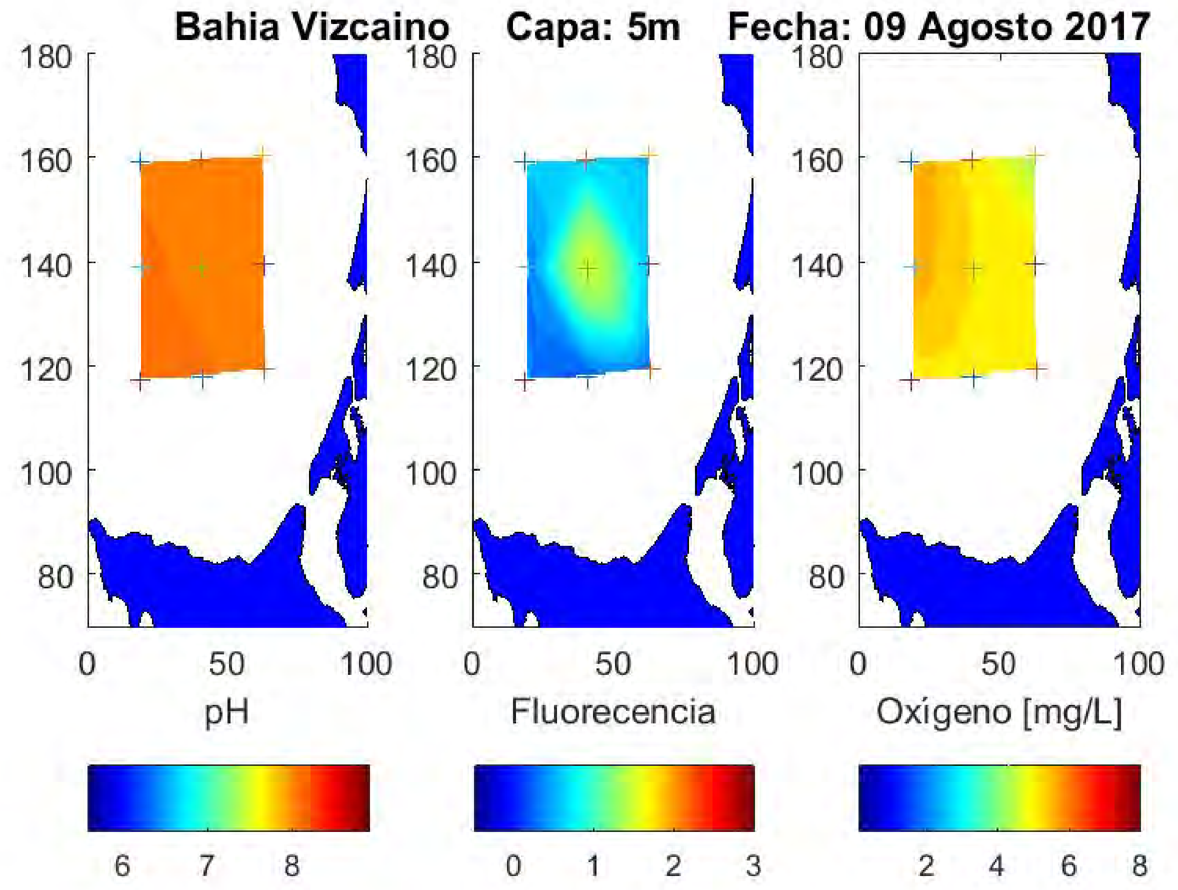
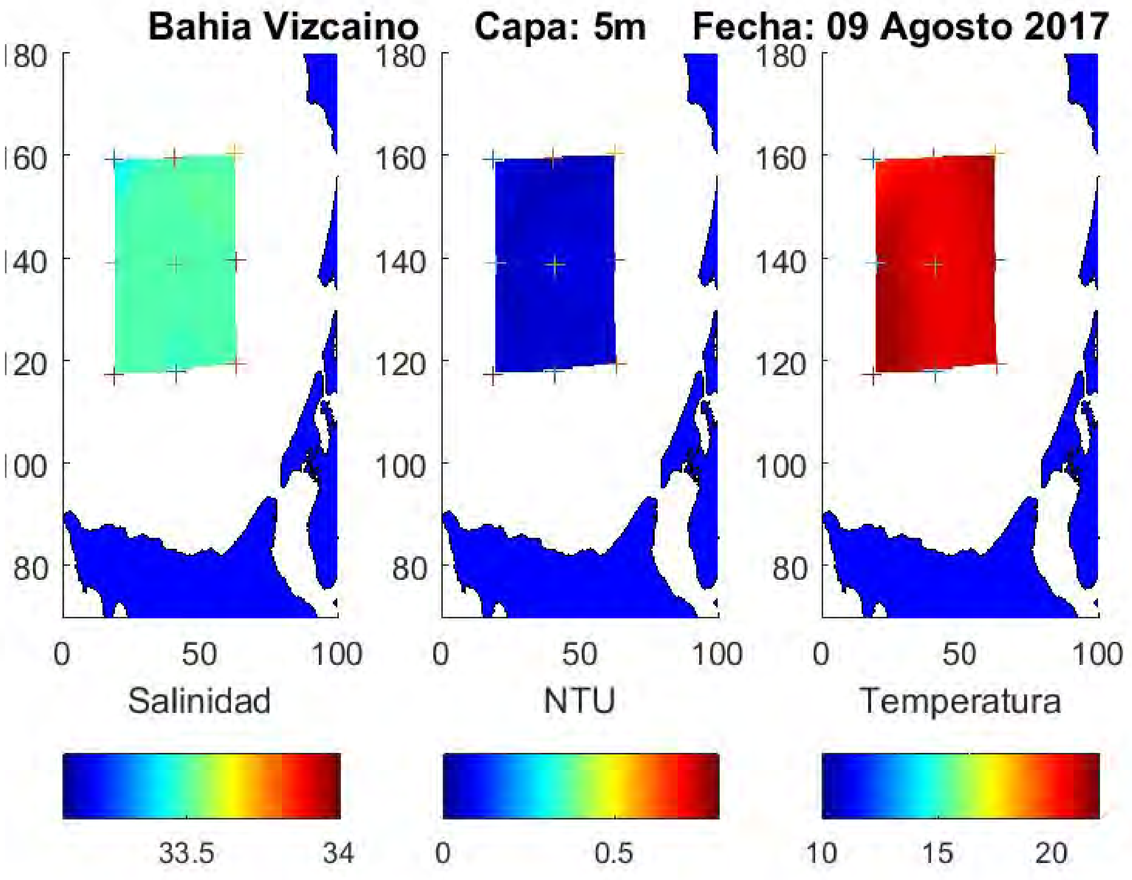
Salinidad
NTU
Temperatura
0 100 300 500
-20 -40 -60 -80 -100 -120 -140
33.5 34
0 0.2 0.4
12 14 16 18


Bahia Vizcaino
Capa: 5m
Fecha: 09 Agosto 2017
180
160
140
120
100
80
0
50
100
pH
Fluorecencia
Oxígeno [mg/L]
6
7
8
0
1
2
3
2
4
6
8


Bahia Vizcaino
Capa: 5m
Fecha: 09 Agosto 2017
180
160
140
120
100
80
0
50
100
Salinidad
NTU
Temperatura
33.5
34
0
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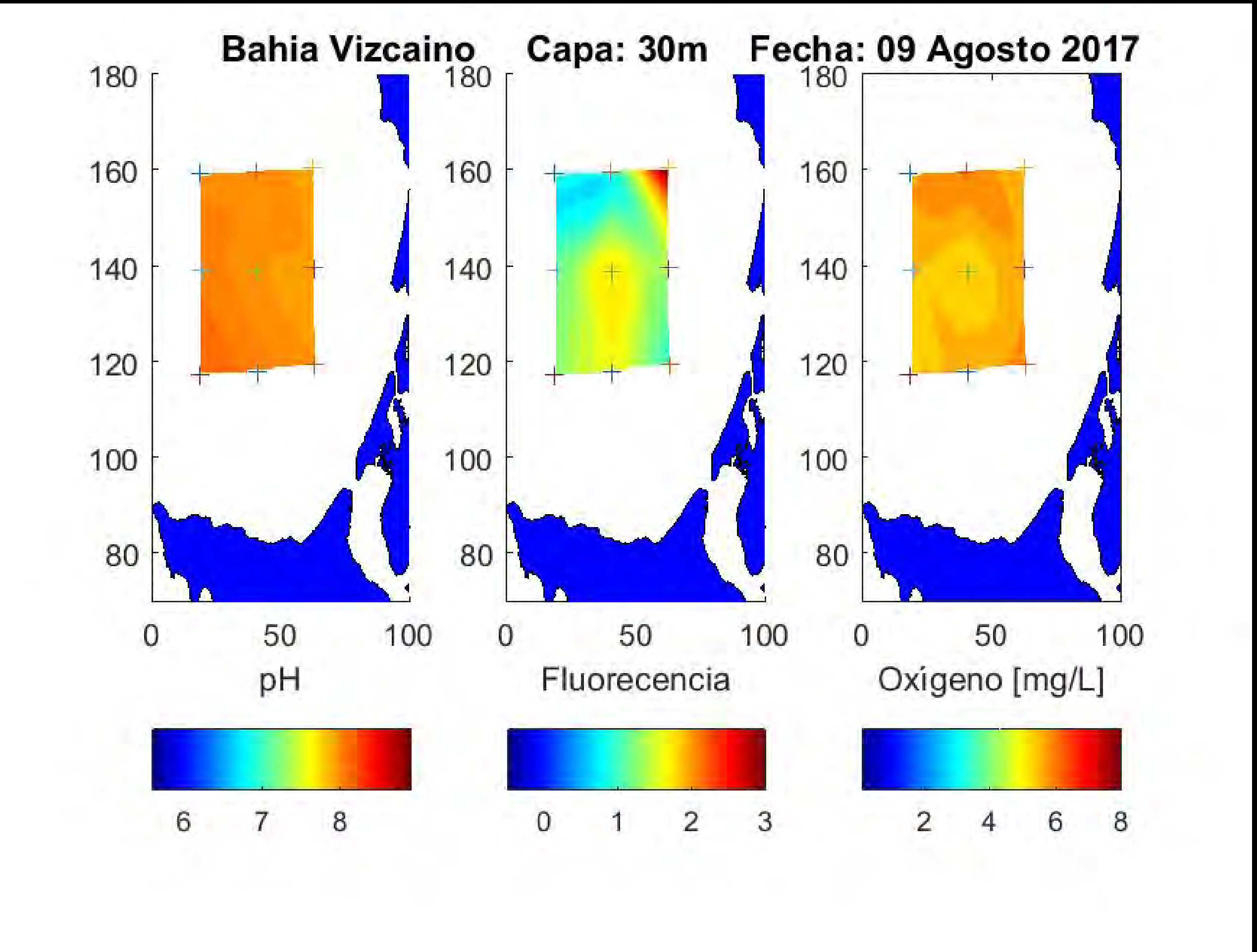
20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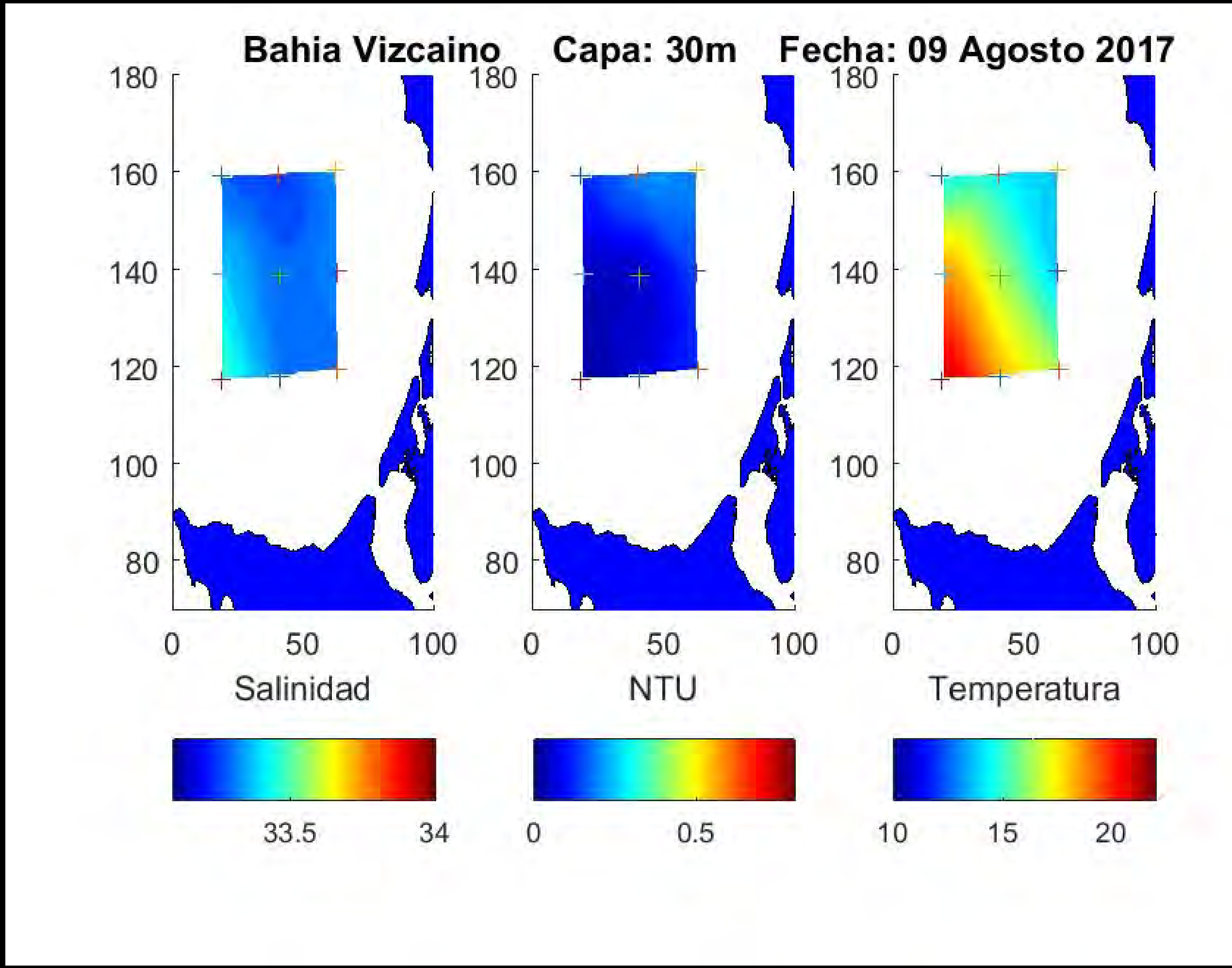
Capa: 30m
Fecha: 09 Agosto 2017
pH
Fluorecencia
Oxígeno [mg/L]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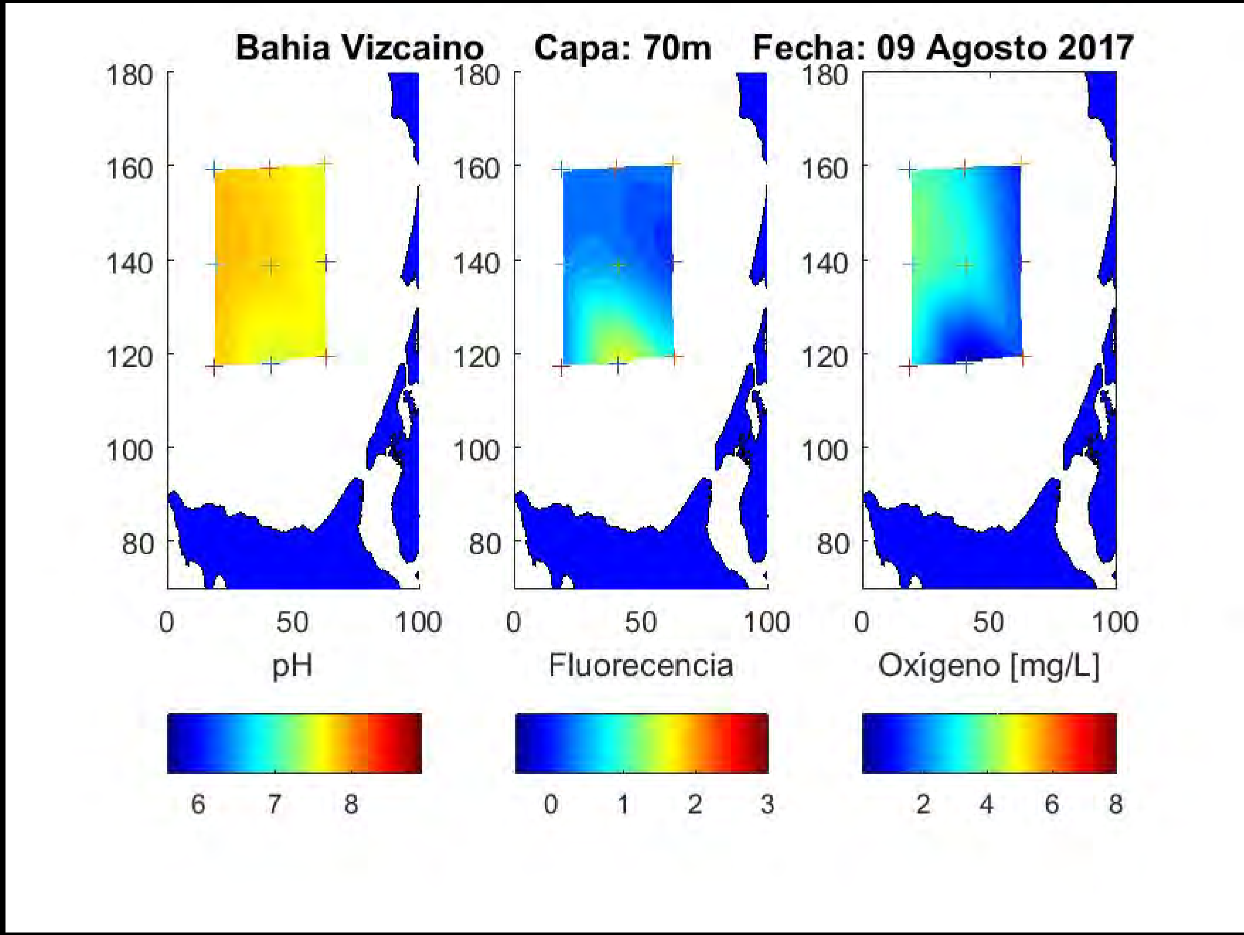
Capa: 30m
Fecha: 09 Agosto 2017
Salinidad
NTU
Temperatura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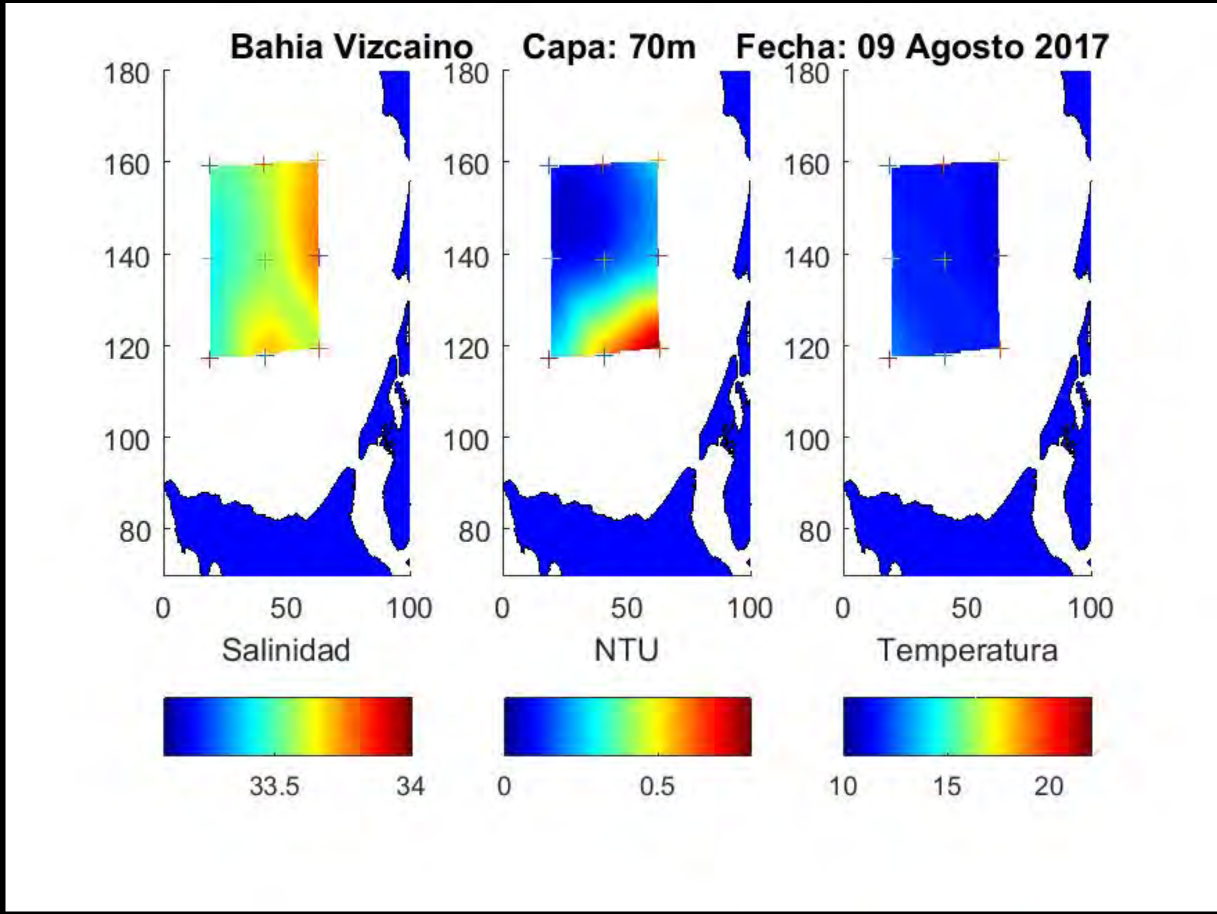
160
140
120
100
80
0 50 100
pH
Fluorecencia
Oxígeno [mg/L]
6 7 8
0 1 2 3
2 4 6 8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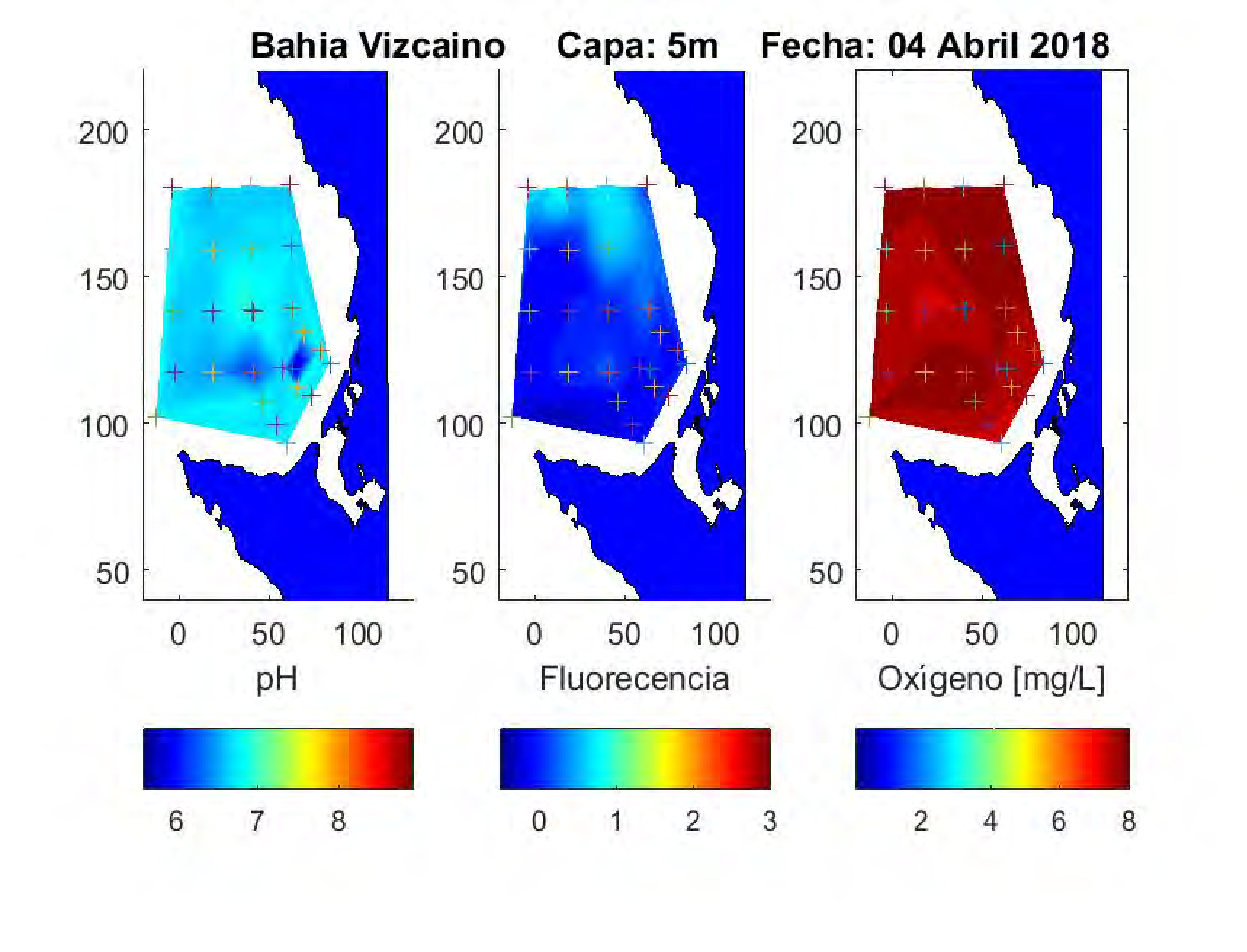
0 50 100
Salinidad
NTU
Temperatura
33.5 34
0 0.5
10 15 20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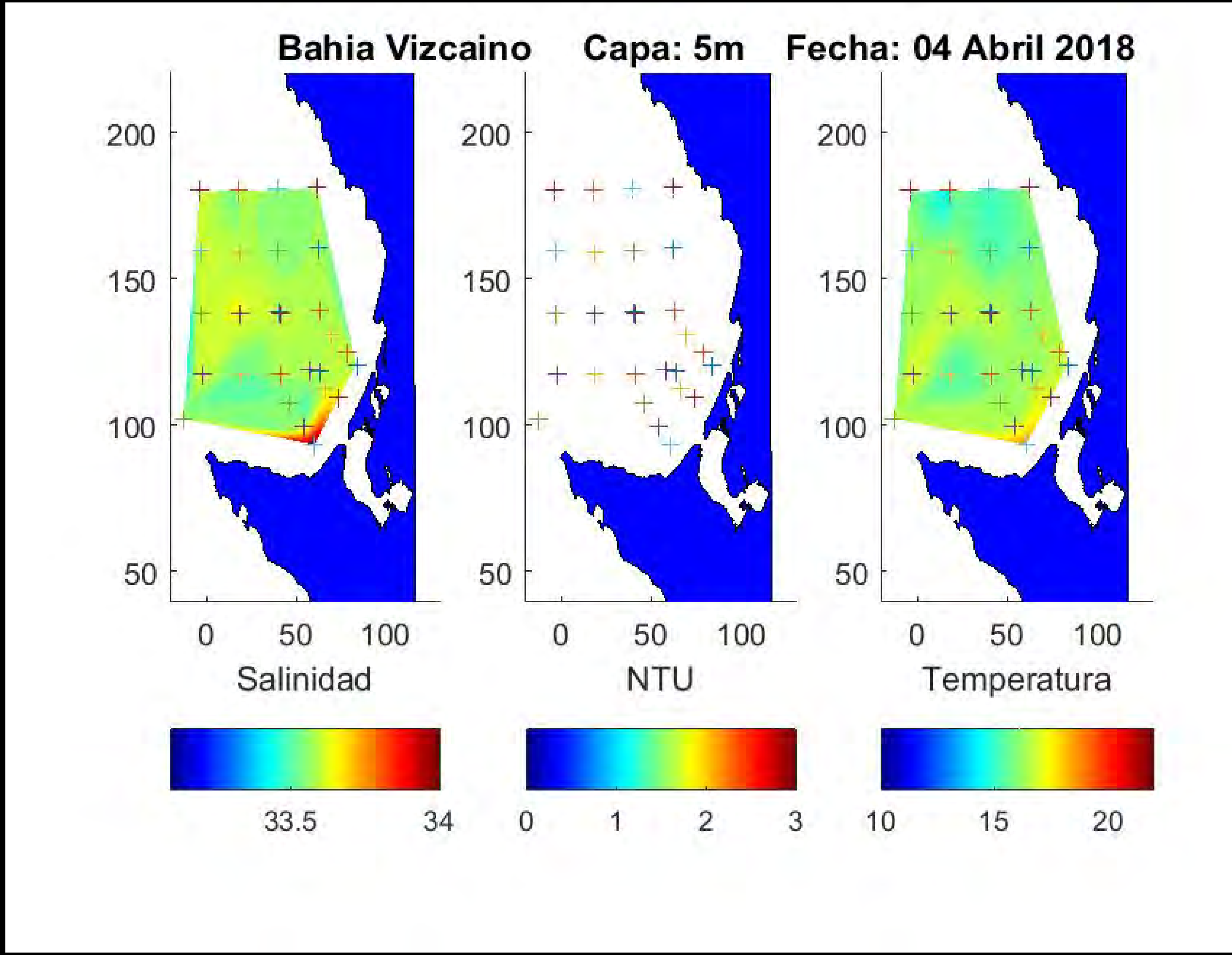
pH
Fluorecencia
Oxígeno [mg/L]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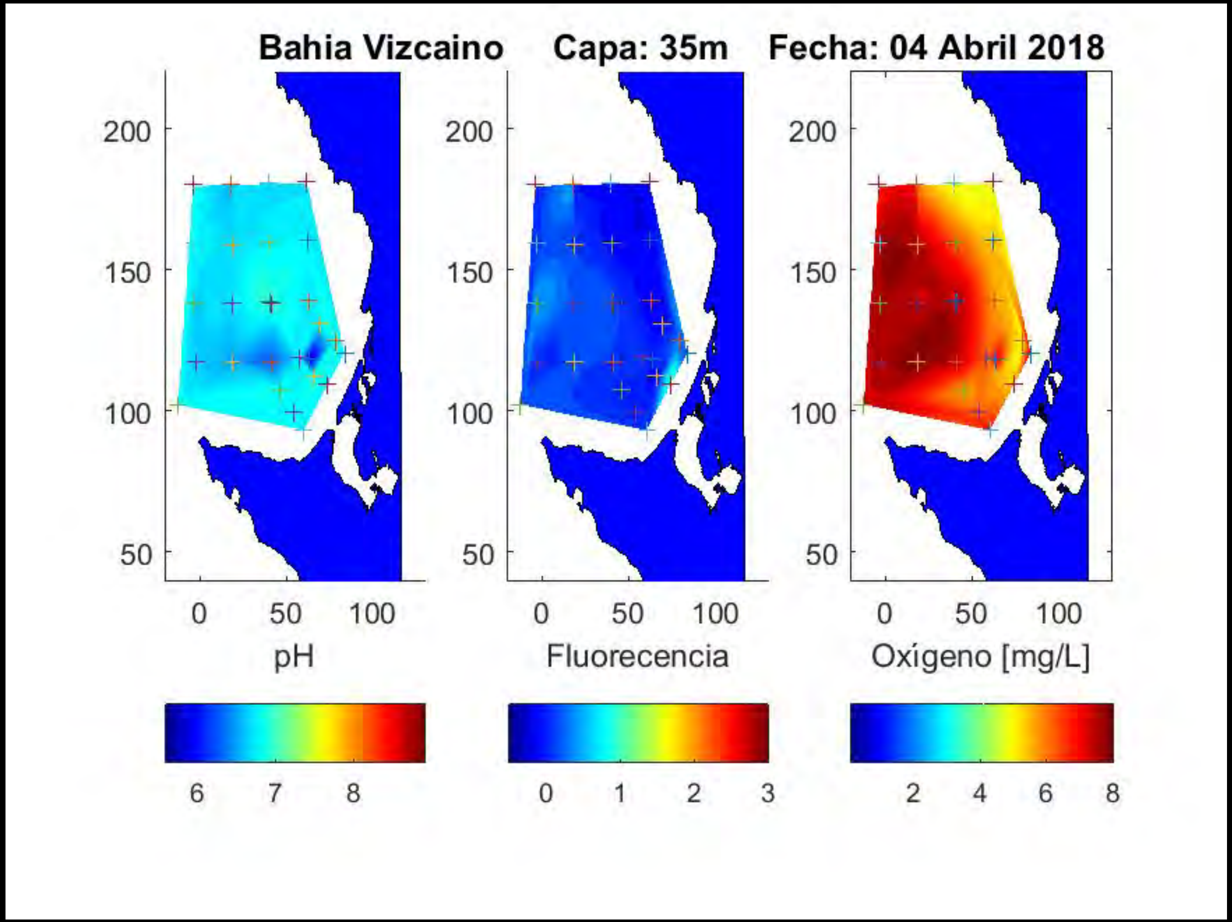
Salinidad
NTU
Temperatura


Bahia Vizcaino
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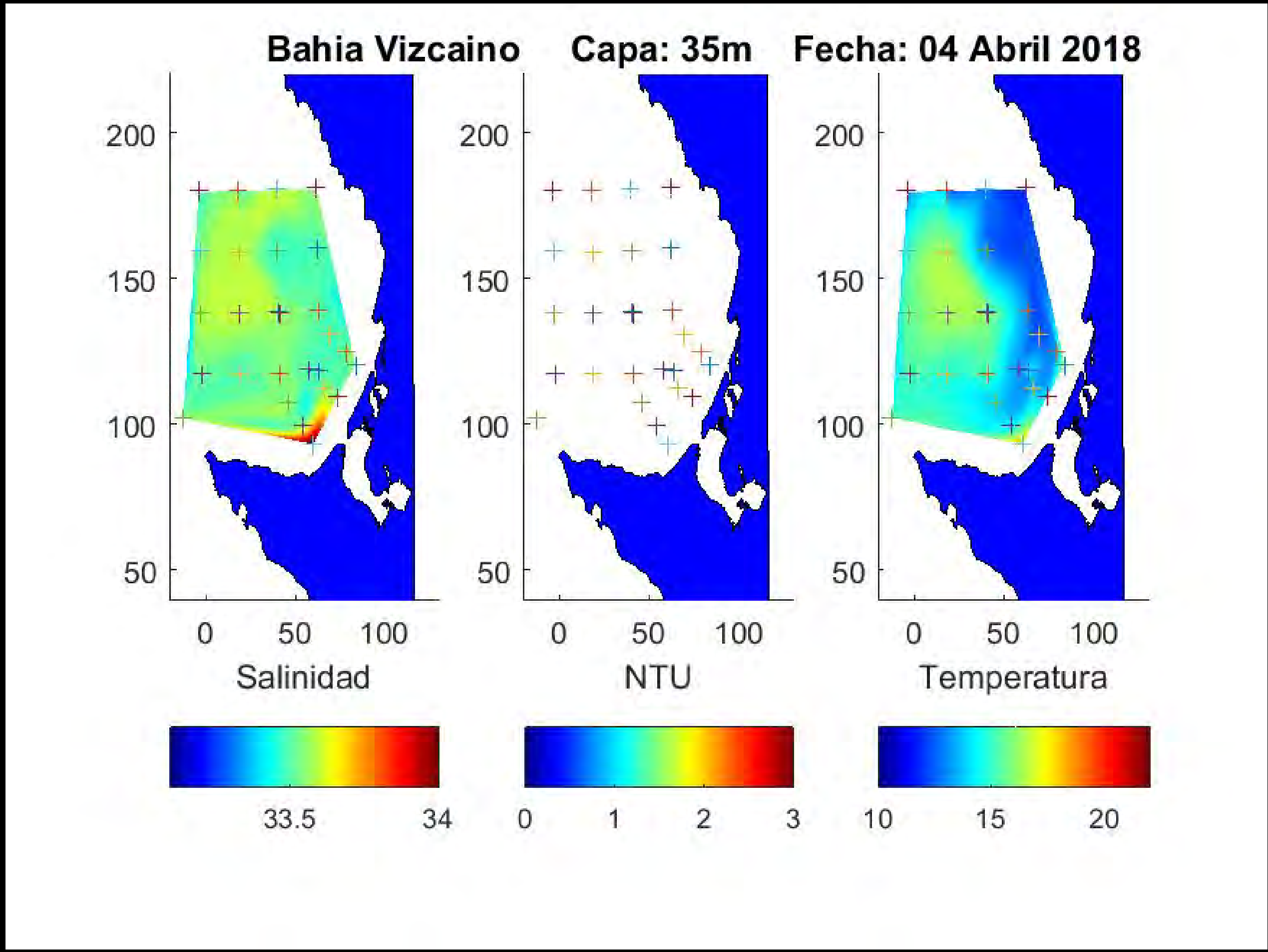
Fecha: 04 Abril 2018
pH
Fluorecencia
Oxígeno [mg/L]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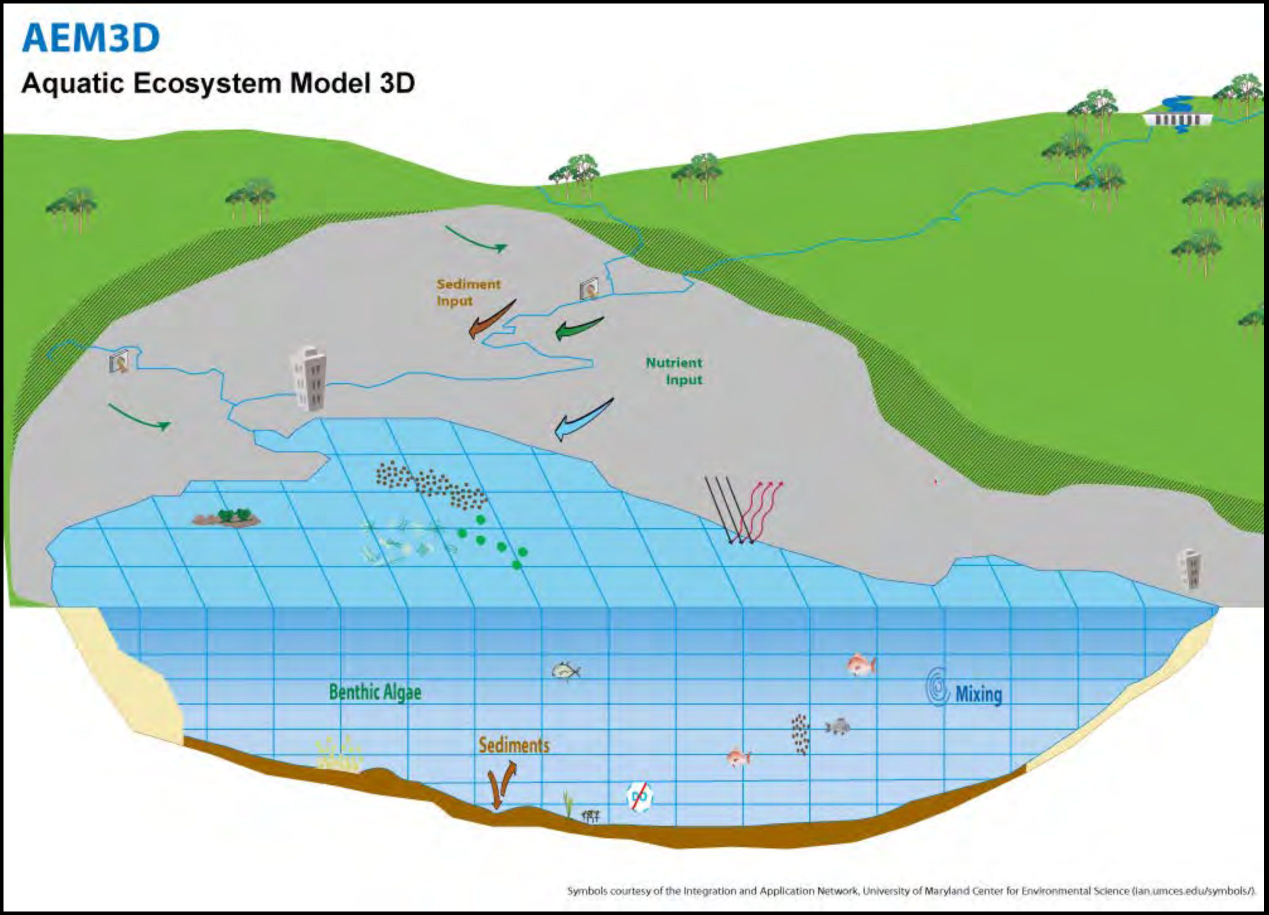
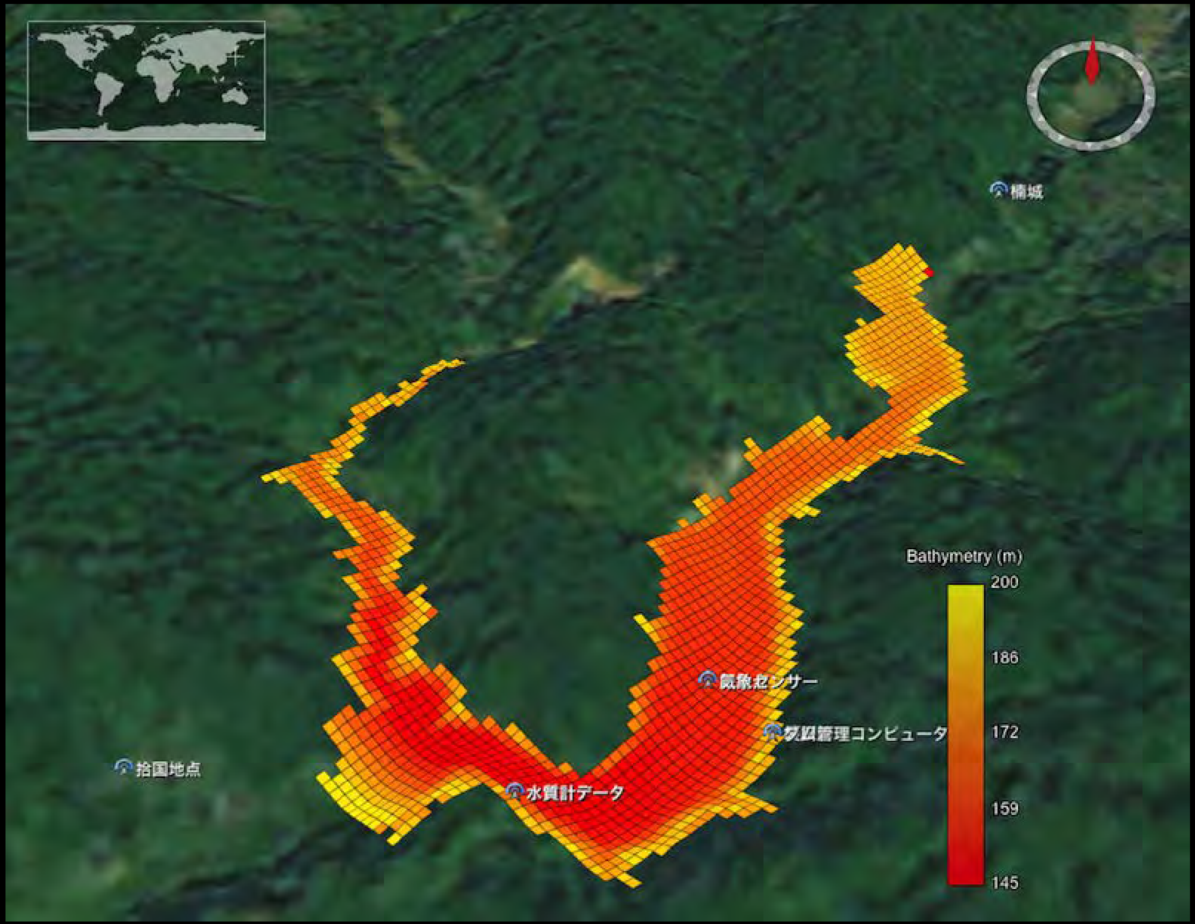
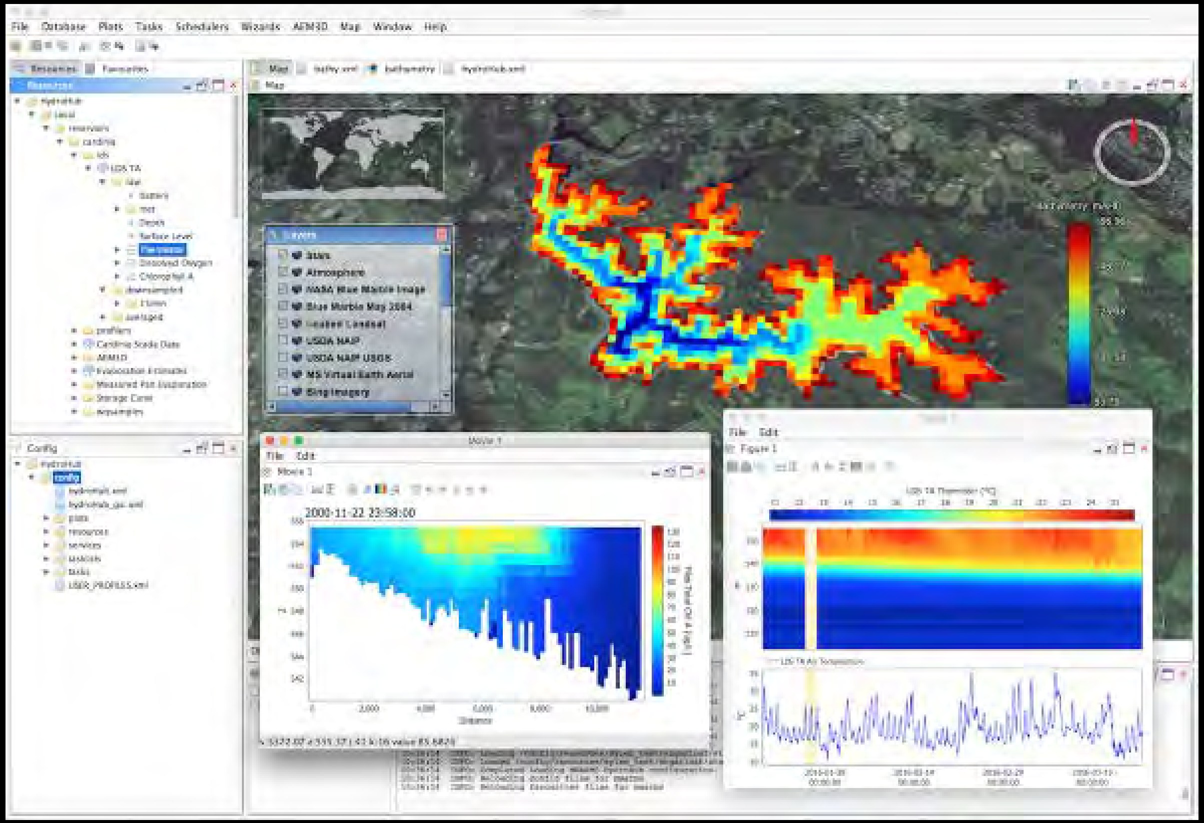
Salinidad
NTU
Temperatura

The Model AEM3d from Hydronumerics





Hydrohub



File Database Plots Tasks Schedulers Wizards AEM3D Map Window Help
Layers
Stars
Atmosphere
NASA Blue Marble Image
Blue Marble May 2004
i-cubed Landsat
USDA NAIP
USDA NAIP USGS
MS Virtual Earth Aerial
Bing Imagery
2000-11-22 23:58:00

Hydrodynamic

Navier-Stoke (Momentum) equations:

$$\frac{\partial \overline{u}}{\partial t} + \overline{u}\frac{\partial \overline{u}}{\partial x} + \overline{v}\frac{\partial \overline{u}}{\partial y} + \overline{w}\frac{\partial \overline{u}}{\partial z} = -g\left\{\frac{\partial \eta}{\partial x} + \frac{1}{\rho_o}\frac{\partial}{\partial x}\int_z^{\eta} \rho' dz\right\} + \frac{\partial}{\partial x}\left\{V_1 \frac{\partial \overline{u}}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{V_2 \frac{\partial \overline{u}}{\partial y}\right\} + \frac{\partial}{\partial z}\left\{V_3 \frac{\partial \overline{u}}{\partial z}\right\} + f\overline{v}$$

$$\frac{\partial \overline{v}}{\partial t} + \overline{u}\frac{\partial \overline{v}}{\partial x} + \overline{v}\frac{\partial \overline{v}}{\partial y} + \overline{w}\frac{\partial \overline{v}}{\partial z} = -g\left\{\frac{\partial \eta}{\partial y} + \frac{1}{\rho_o}\frac{\partial}{\partial y}\int_z^{\eta} \rho' dz\right\} + \frac{\partial}{\partial x}\left\{V_1 \frac{\partial \overline{v}}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{V_2 \frac{\partial \overline{v}}{\partial y}\right\} + \frac{\partial}{\partial z}\left\{V_3 \frac{\partial \overline{v}}{\partial z}\right\} - f\overline{u}$$

$$\frac{\partial \overline{w}}{\partial t} + \overline{u}\frac{\partial \overline{w}}{\partial x} + \overline{v}\frac{\partial \overline{w}}{\partial y} + \overline{w}\frac{\partial \overline{w}}{\partial z} = -g\left\{\frac{\partial \eta}{\partial z} + \frac{1}{\rho_o}\frac{\partial}{\partial z}\int_z^{\eta} \rho' dz\right\} + \frac{\partial}{\partial x}\left\{V_1 \frac{\partial \overline{w}}{\partial x}\right\} + \frac{\partial}{\partial y}\left\{V_2 \frac{\partial \overline{w}}{\partial y}\right\} + \frac{\partial}{\partial z}\left\{V_3 \frac{\partial w}{\partial z}\right\}$$

Hydrodynamic

Free surface elevation:

$$\frac{\partial \eta}{\partial t} = -\frac{\partial}{\partial x}\int_{-h}^{\eta} \overline{u}dz - \frac{\partial}{\partial y}\int_{-h}^{\eta} \overline{v}dz$$

Wind at the surface:

$$(u_o)^2 = C_{10m}\frac{\rho_{aire}}{\rho_{agua}}(W_yW_y)^{\frac{1}{2}}W_x;\ (v_o)^2 = C_{10m}\frac{\rho_{aire}}{\rho_{agua}}(W_xW_x)^{\frac{1}{2}}W_y$$

Momentum due to the wind:

$$\frac{\partial \overline{u}}{\partial t} = \frac{(u_*)^2}{h};\ \frac{\partial \overline{v}}{\partial t} = \frac{(v_*)^2}{h}$$

Thermodynamic

Radiación de onda corta y ecuación de Beer-Lambert:

$$Q_{sw} = Q_{sw(total)}\left(1 - r_a^{(sw)}\right);\ Q(z) = Q_{sw}e^{-\eta_o z}$$

Ecuación de radiación de onda larga:

$$Q_{lw} = \left(1 - r_a^{(lw)}\right)(1 + 0.17C^2)e_a(T_a)\sigma T_a^4 - e_w\sigma T_w^4$$

Calor sensible Fischer et al. 1979 ec. 6.19:

$$Q_{sh} = C_s\rho_a C_p U_a(T_a - T_s)\Delta t$$

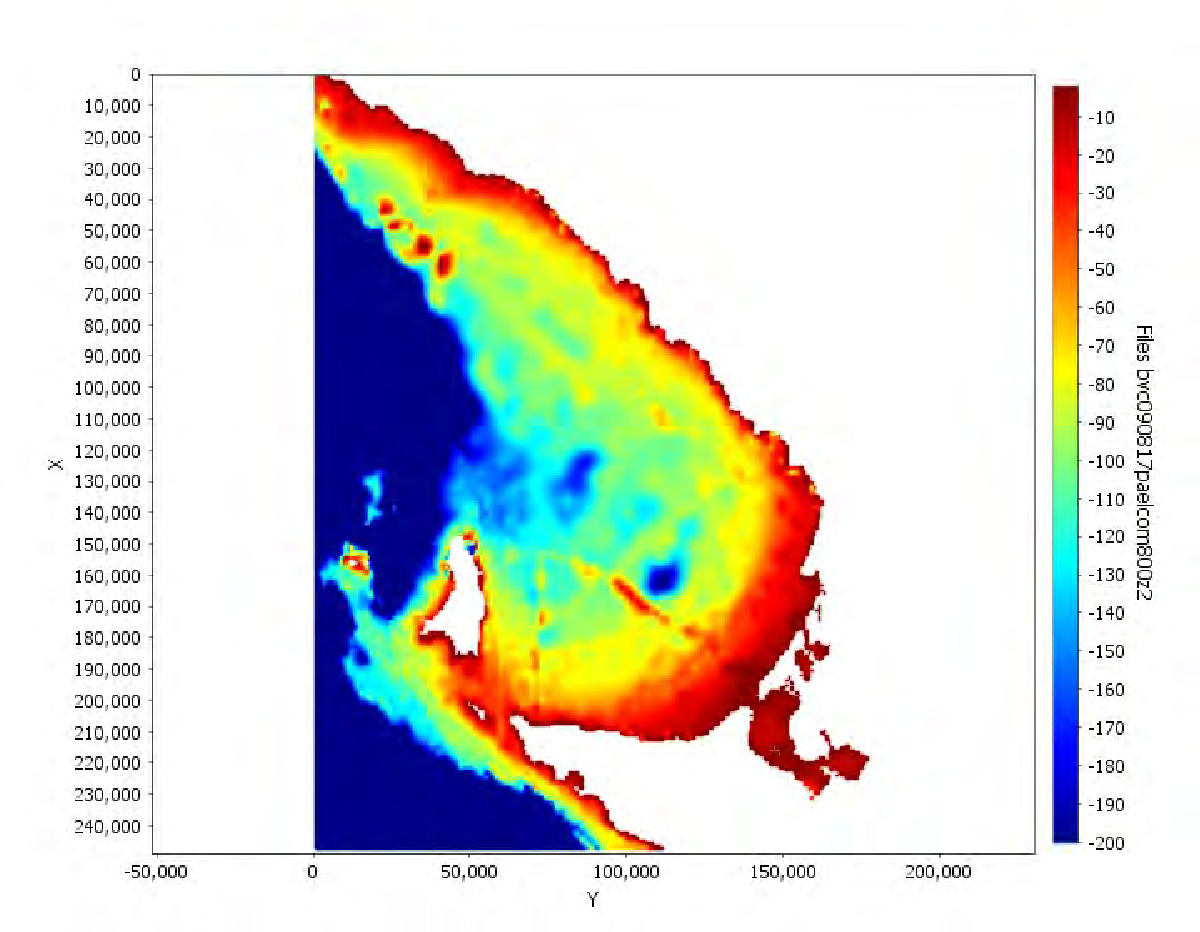
Calor latente Fischer et al. 1979 ec. 6.20:

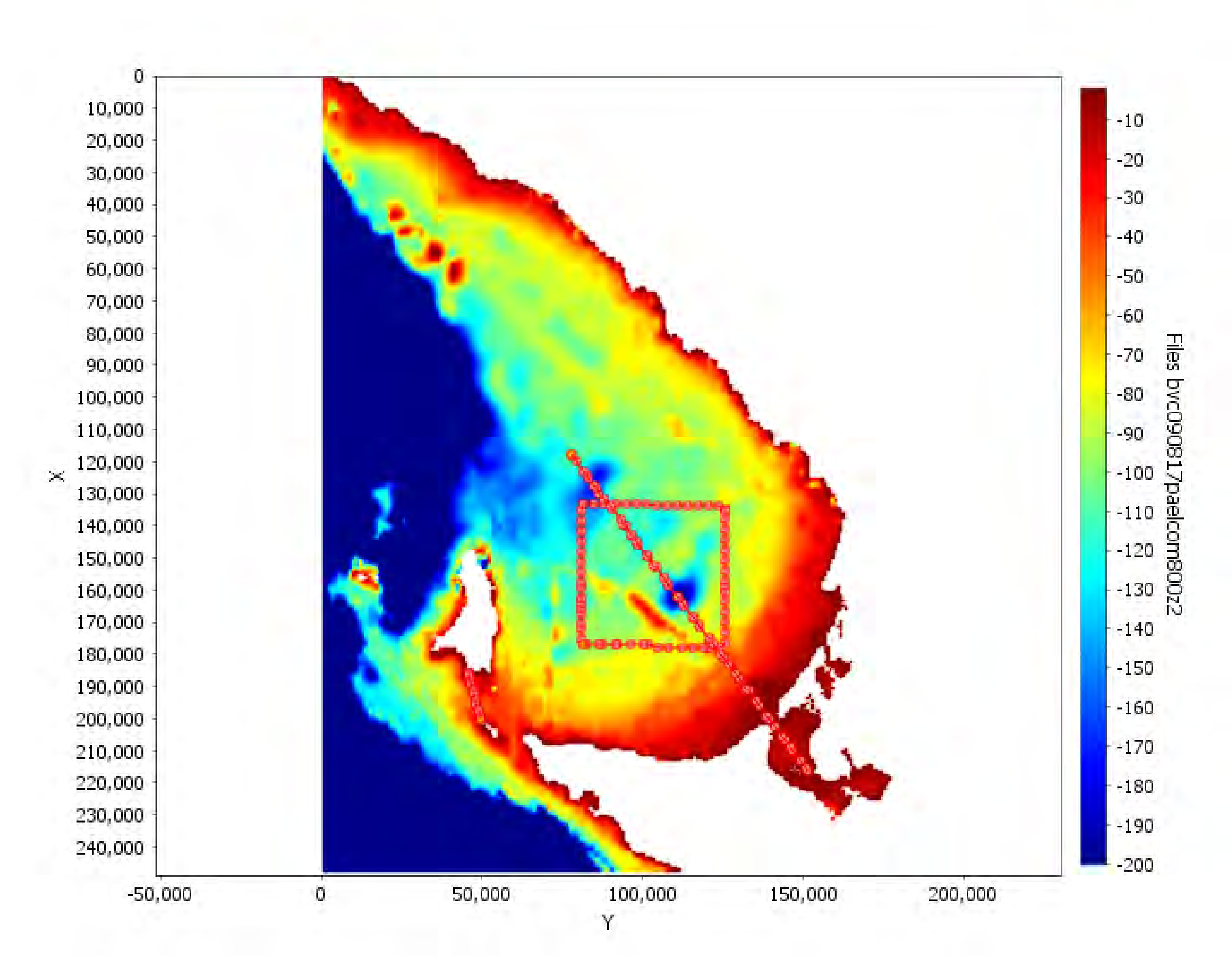
$$Q_{lh} = min\left(0, \frac{0.622}{P}C_L\rho_a L_E U_a(e_a - e_s(T_s))\Delta t\right)$$

Balance de calor en la superficie:

$$Q_{non-pen} = Q_{lw} + Q_{sh} + Q_{lh}$$

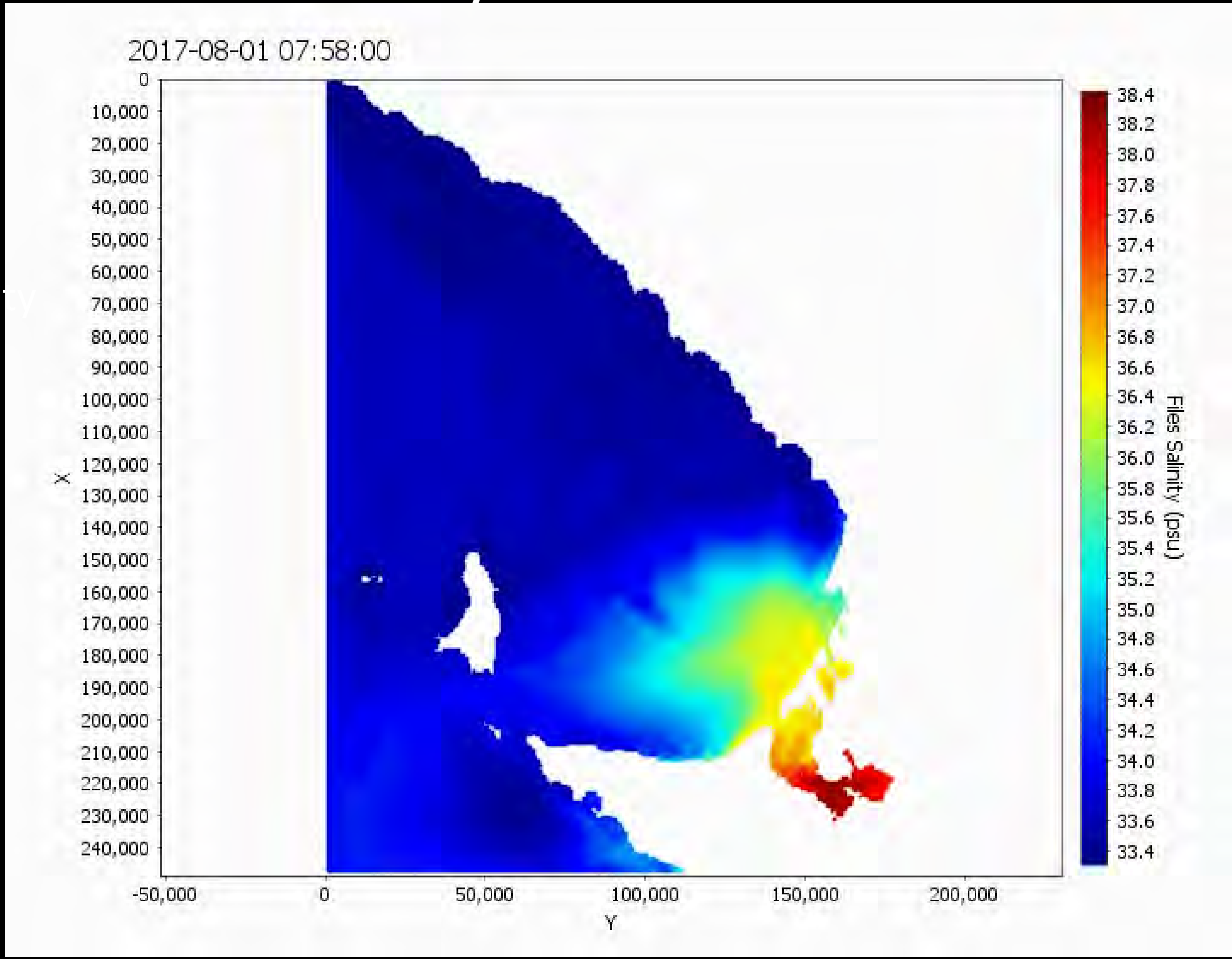
The Bathymetry: dx=dy=800mts dz=5mts, dt=60segs



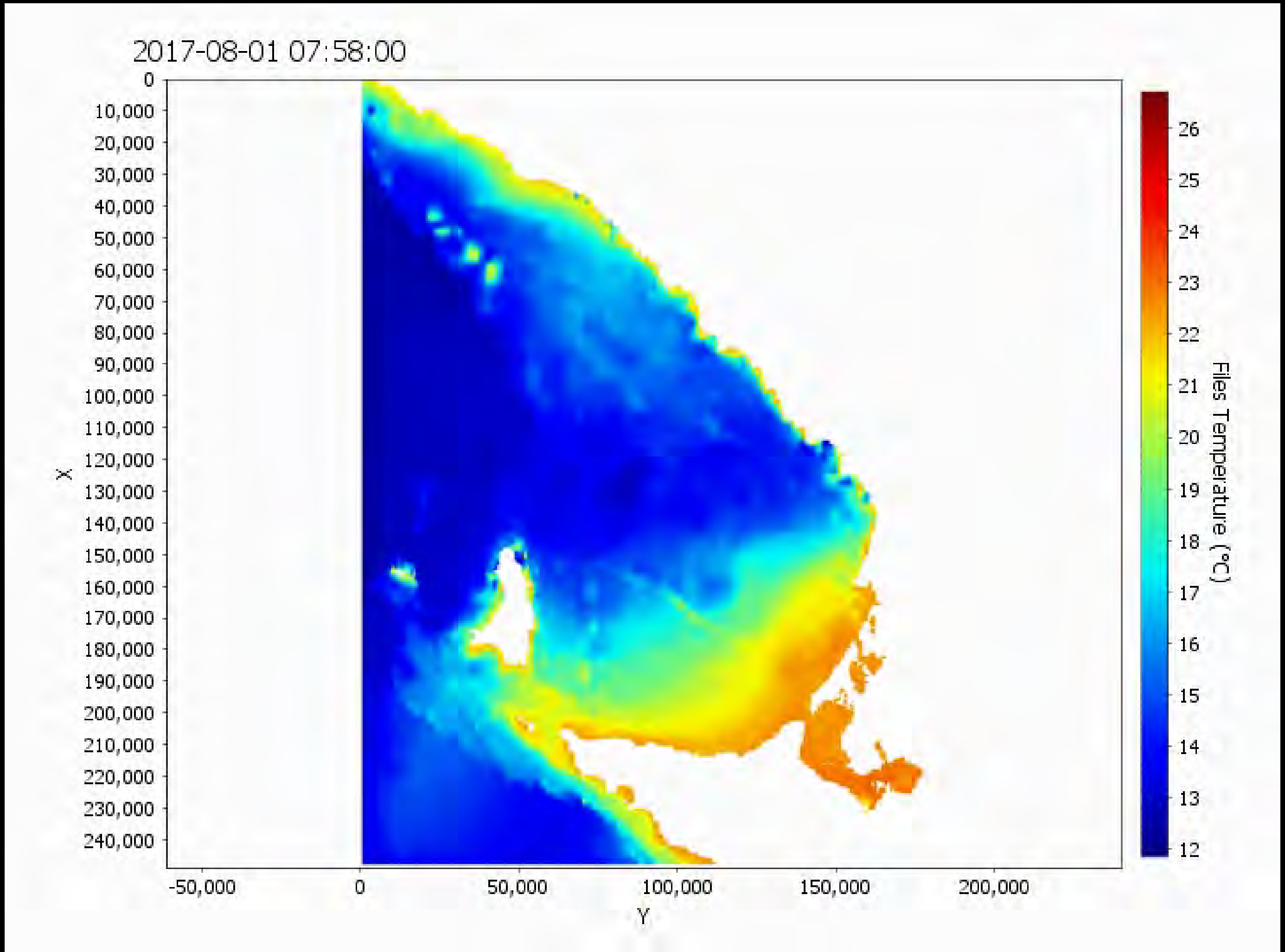


The model results/ do not blink

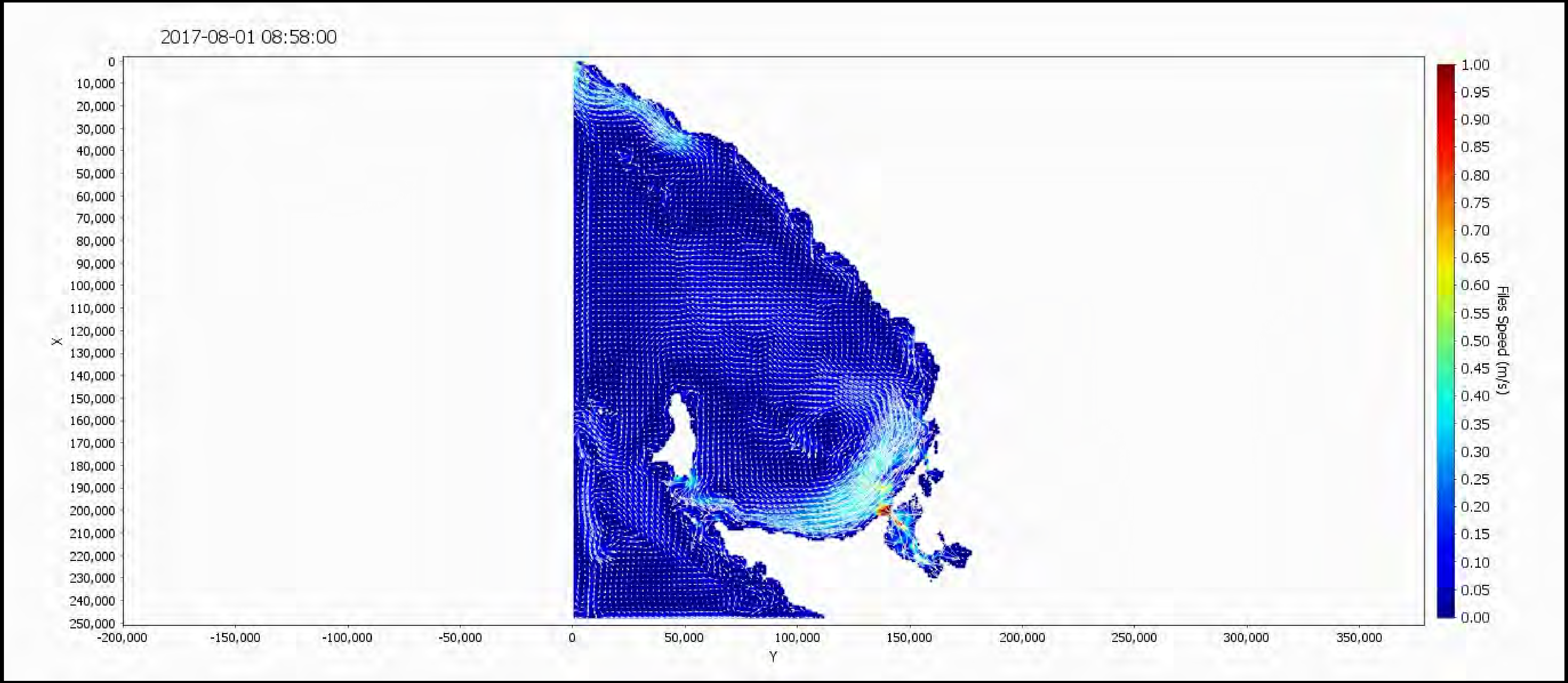
Average salinity



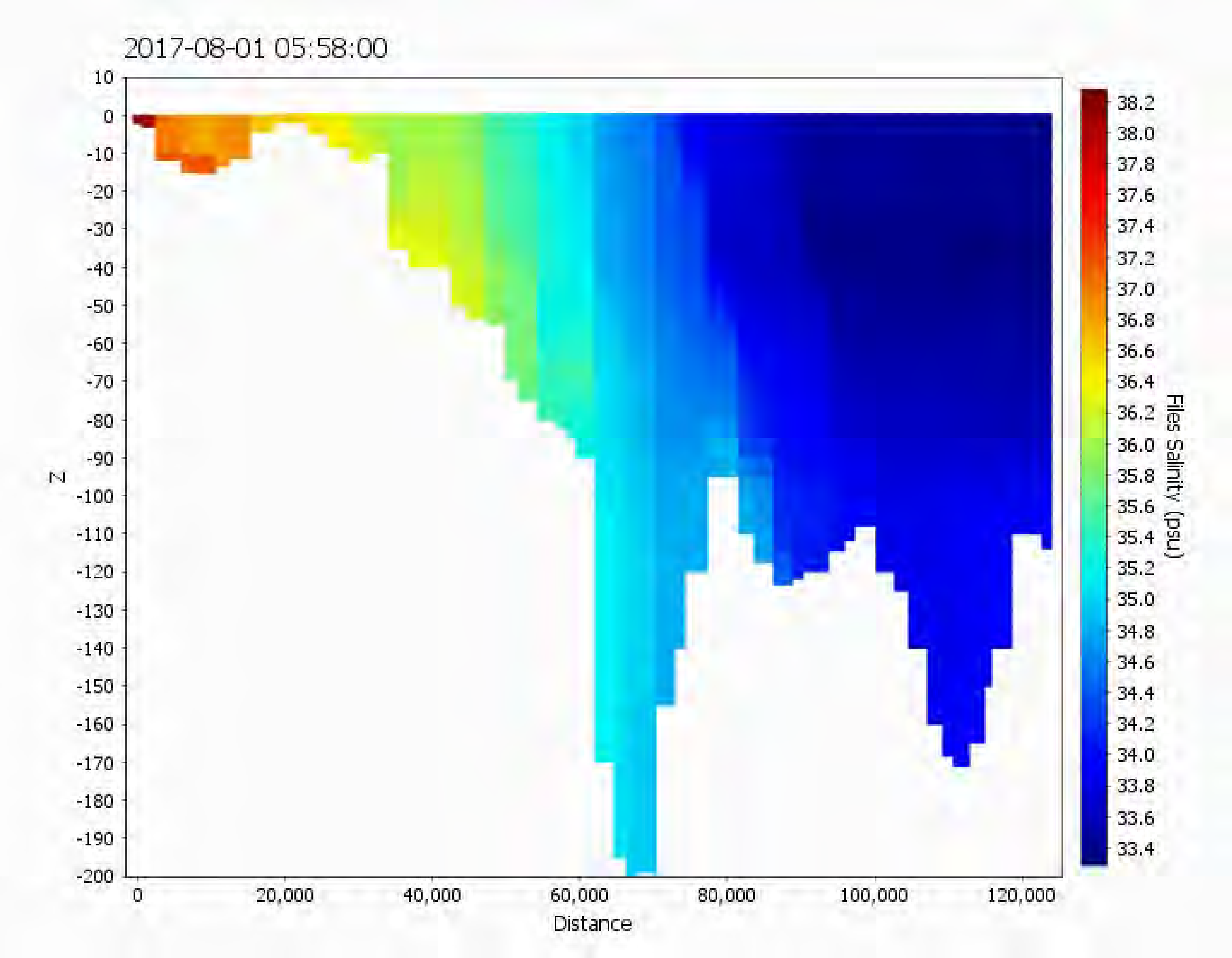
Average temperature



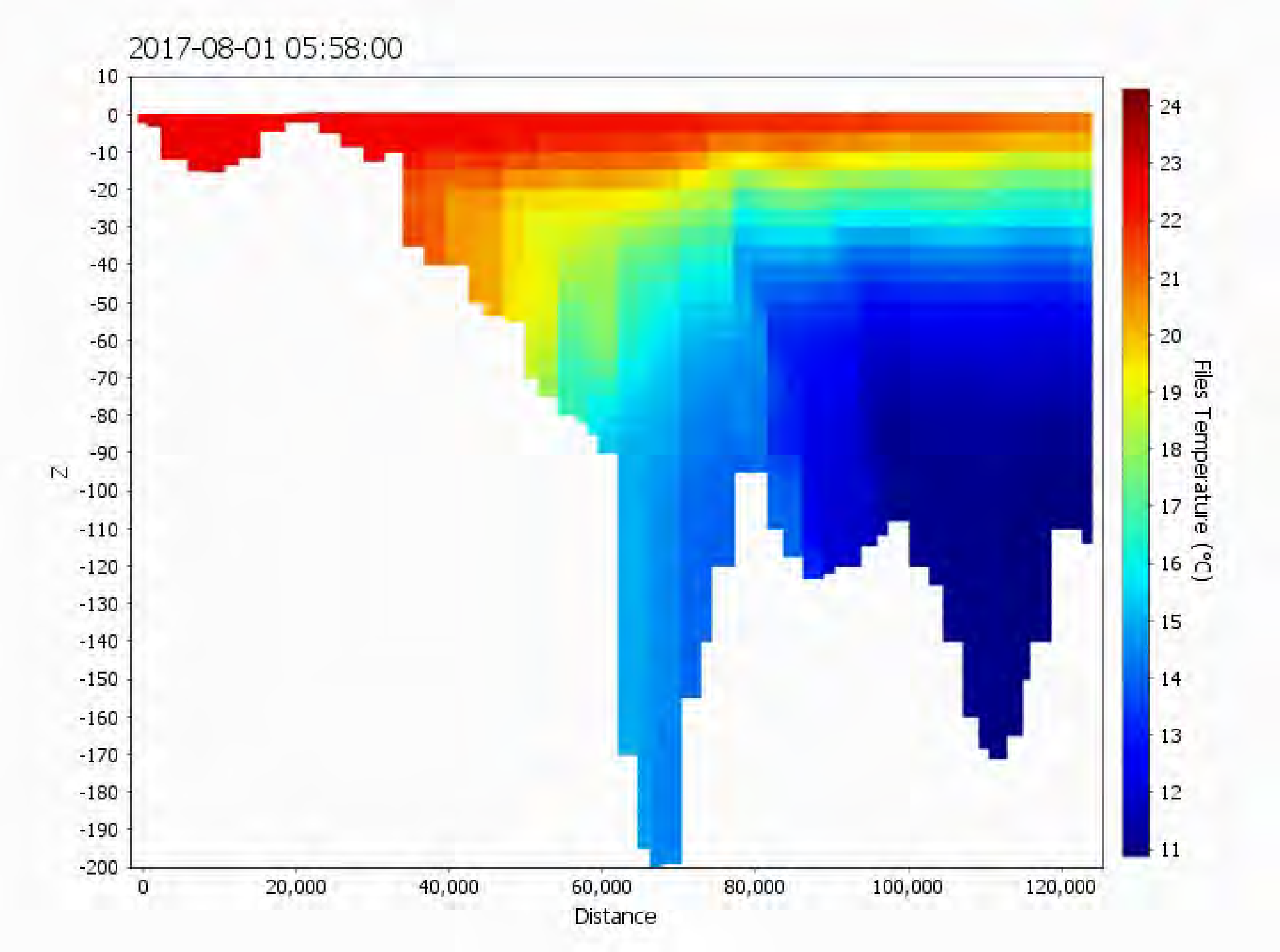
Average velocity



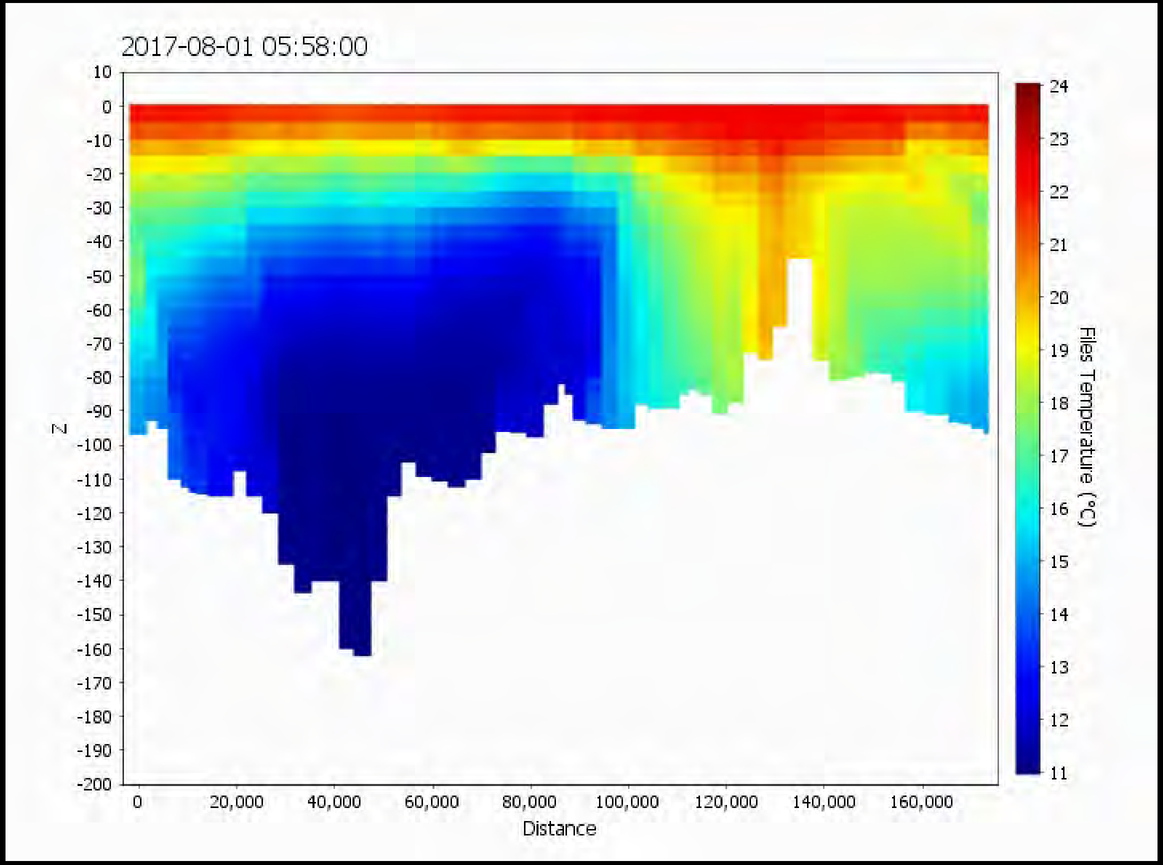
Salinity, vertical resolution from the lagoon to the ocean

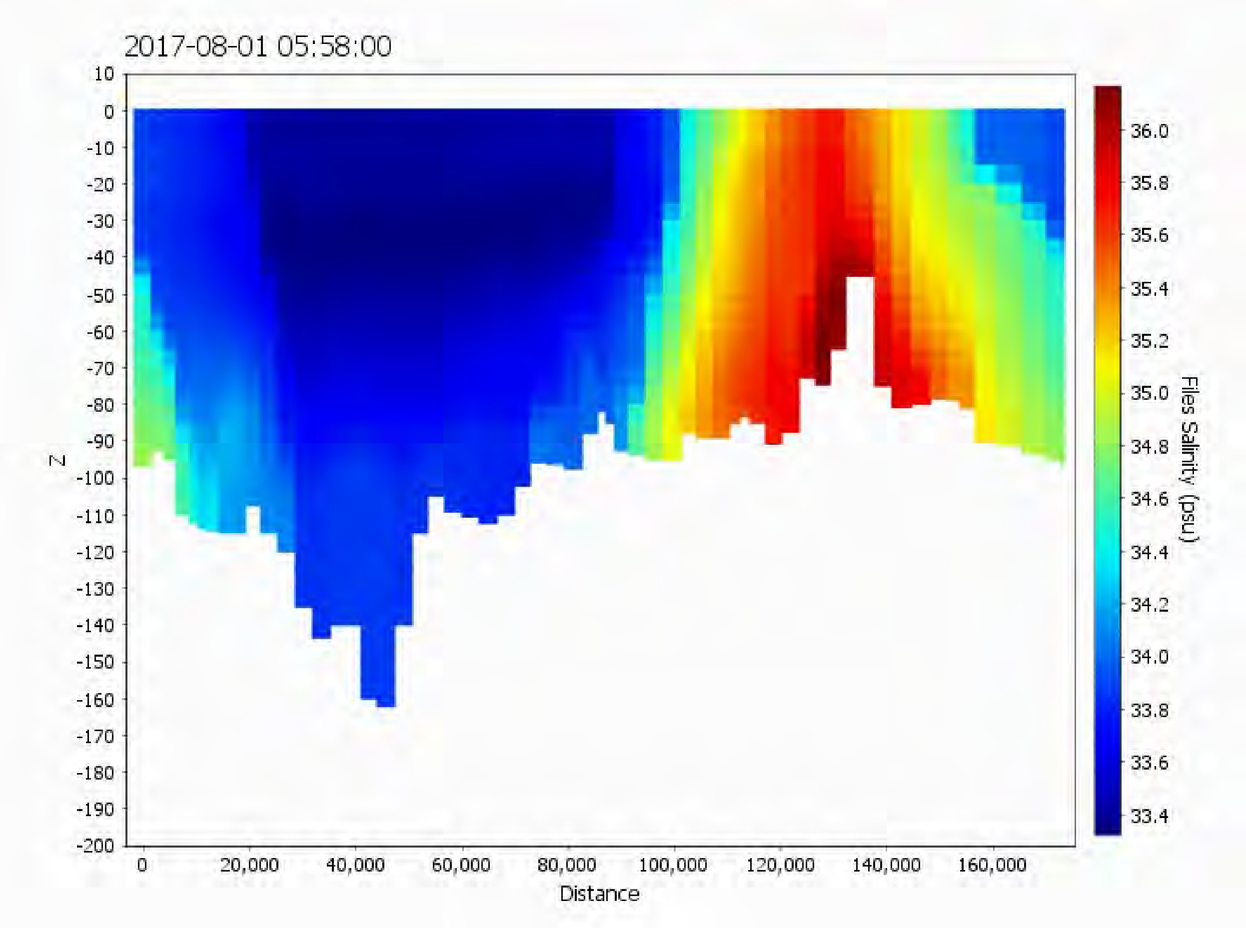


Temperature, vertical resolution



Panel along the sites, temperature

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Z
Distance
Files Salinity (psu)
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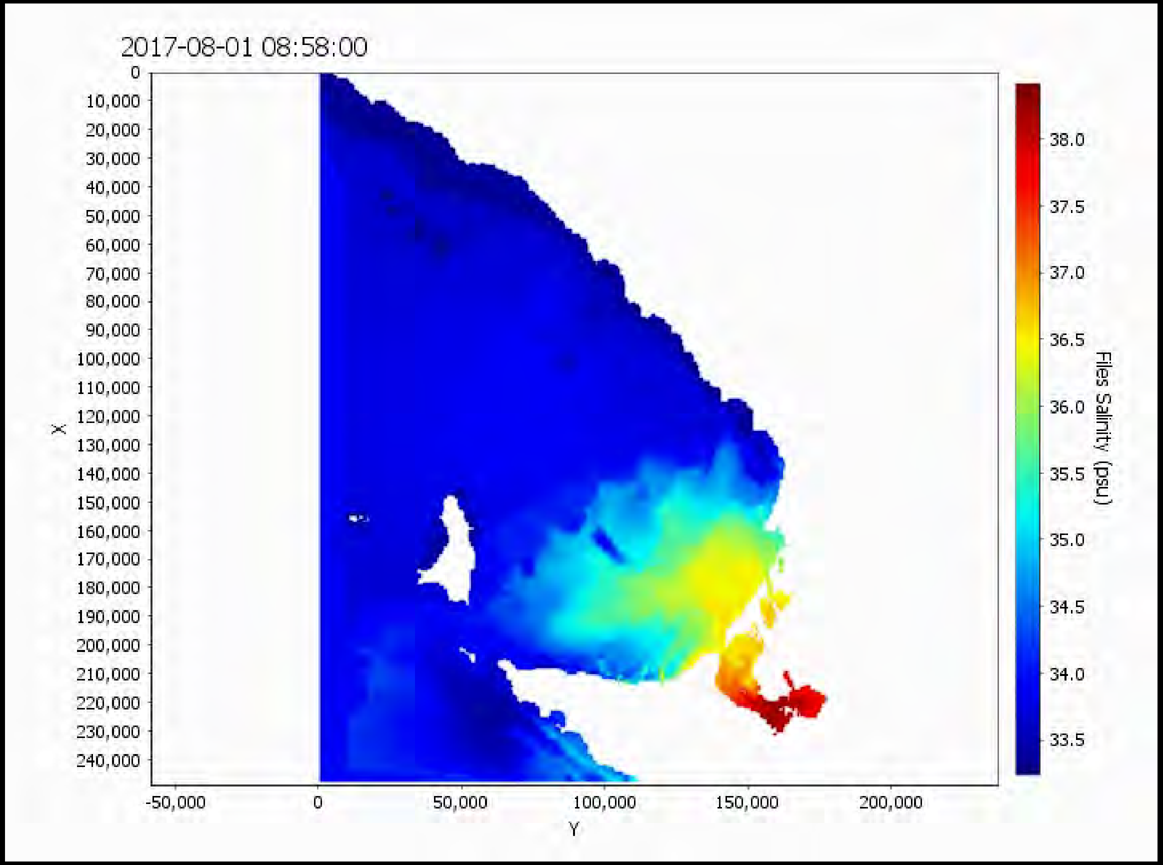
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
36.0
35.8
35.6
35.4
35.2
35.0
34.8
34.6
34.4
34.2
34.0
33.8
33.6
33.4

Bottom distribution of salinity



Conclusions/lots of things to do

- Findings:
- Seasonally variation of variables
- Strong stratification on temperature
- Two peaks of maximum fluorescence
- The influence of the lagoon on the bottom of the bay

needs:

Time series to validate numerically the model, more quality data

Water quality data to model

dreams:

Run the model on real time