

# Distribución de masas de agua: análisis óptimo multiparamétrico extendido (eOMP)

*Marcos Fontela, 2019*

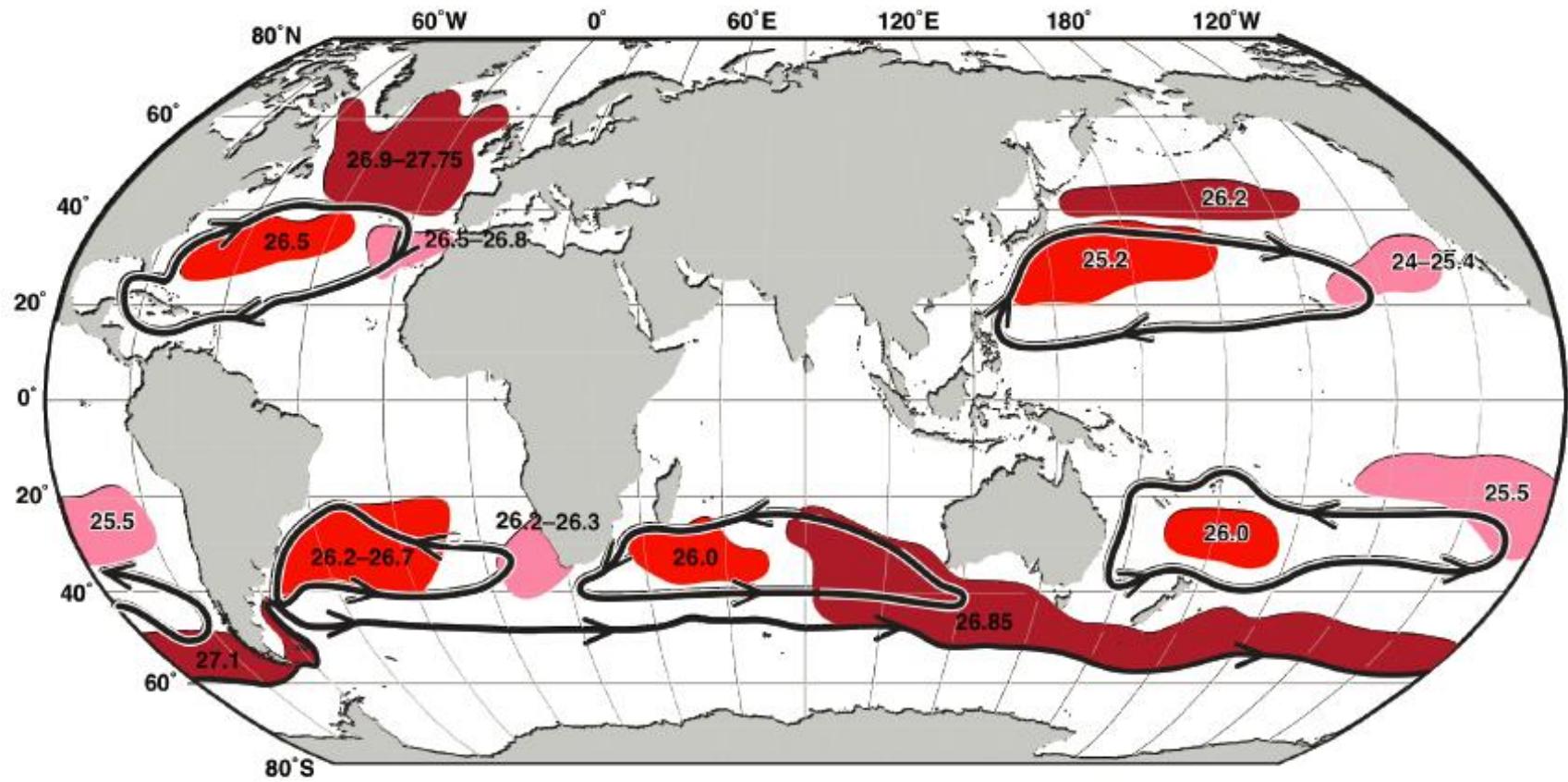
\*Materiales en:  
<https://github.com/mfontela/CO2AO>

- Introducción
- Concepto “masa de agua”
- OMP: definición y referencias
  - SWT: “source water type”
  - Propiedades conservativas & no conservativas
  - Caso práctico

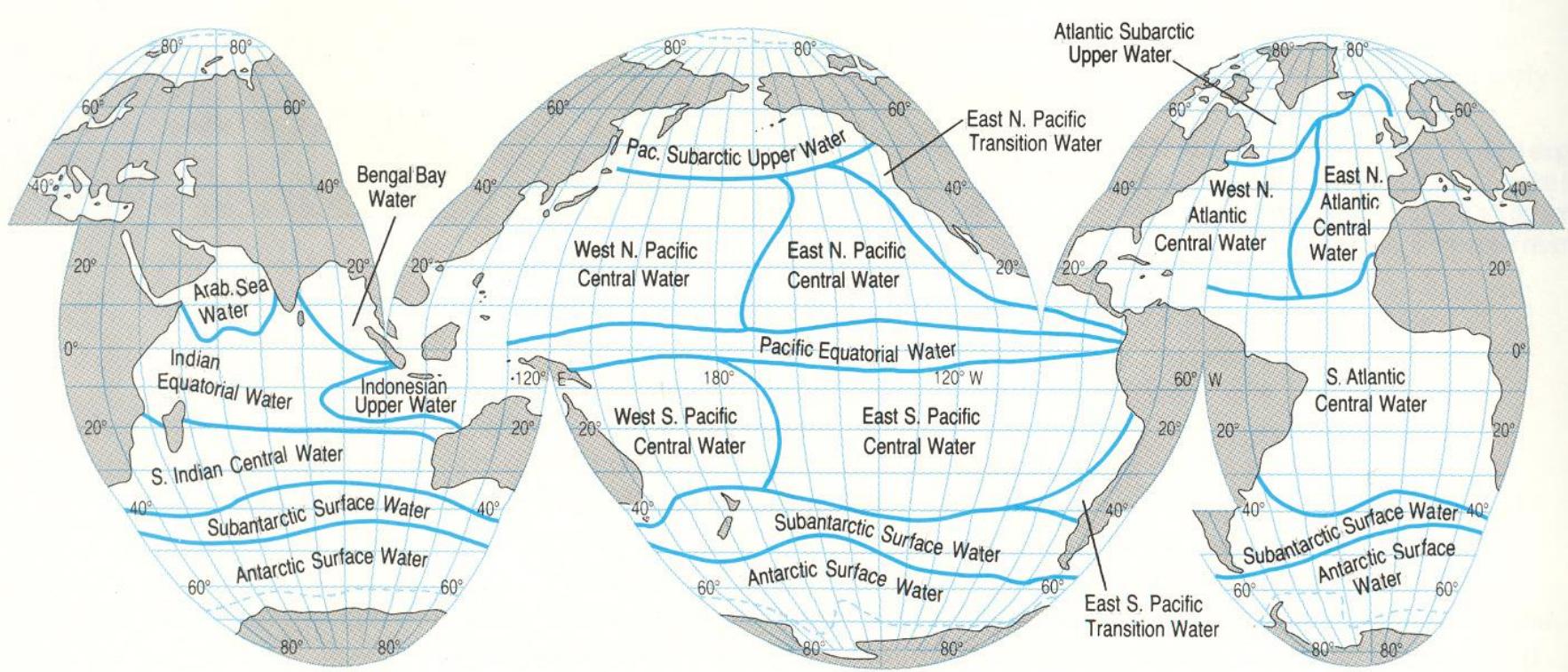
- “*A body of water parcels that originates in a particular area of the ocean with a common formation history.*”  
(Tomczak, 1999)
- Las propiedades de las masas de agua se constituyen en regiones específicas denominadas **regiones de formación**.
- Las masas de agua tienen una extensión medible y por lo tanto un **volumen** cuantificable.

- Formación por procesos físicos:
  - Convección
  - Subducción
  - Importación
  - Mezcla/consolidación

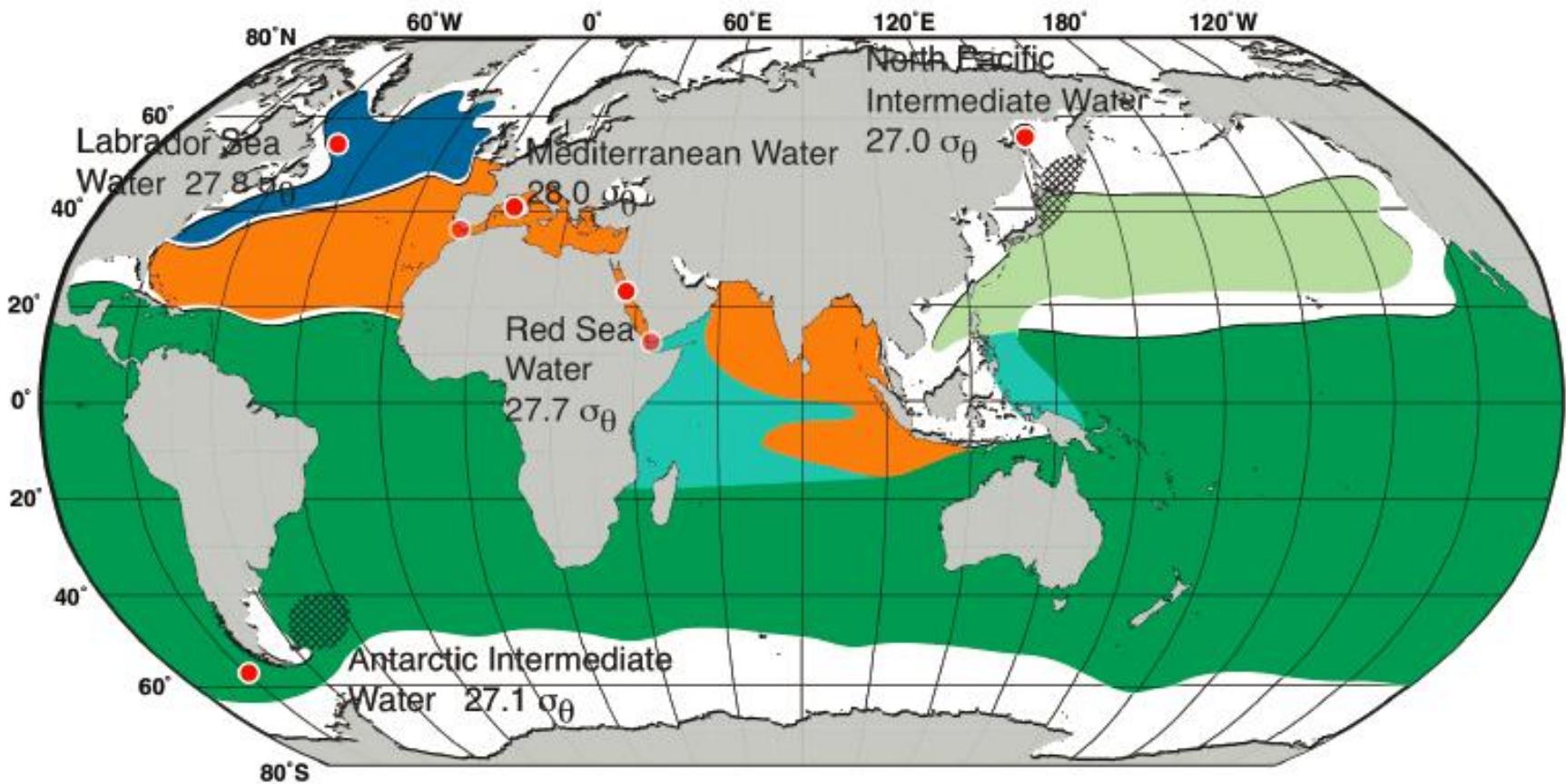
## Global water masses (glimpse) distribution



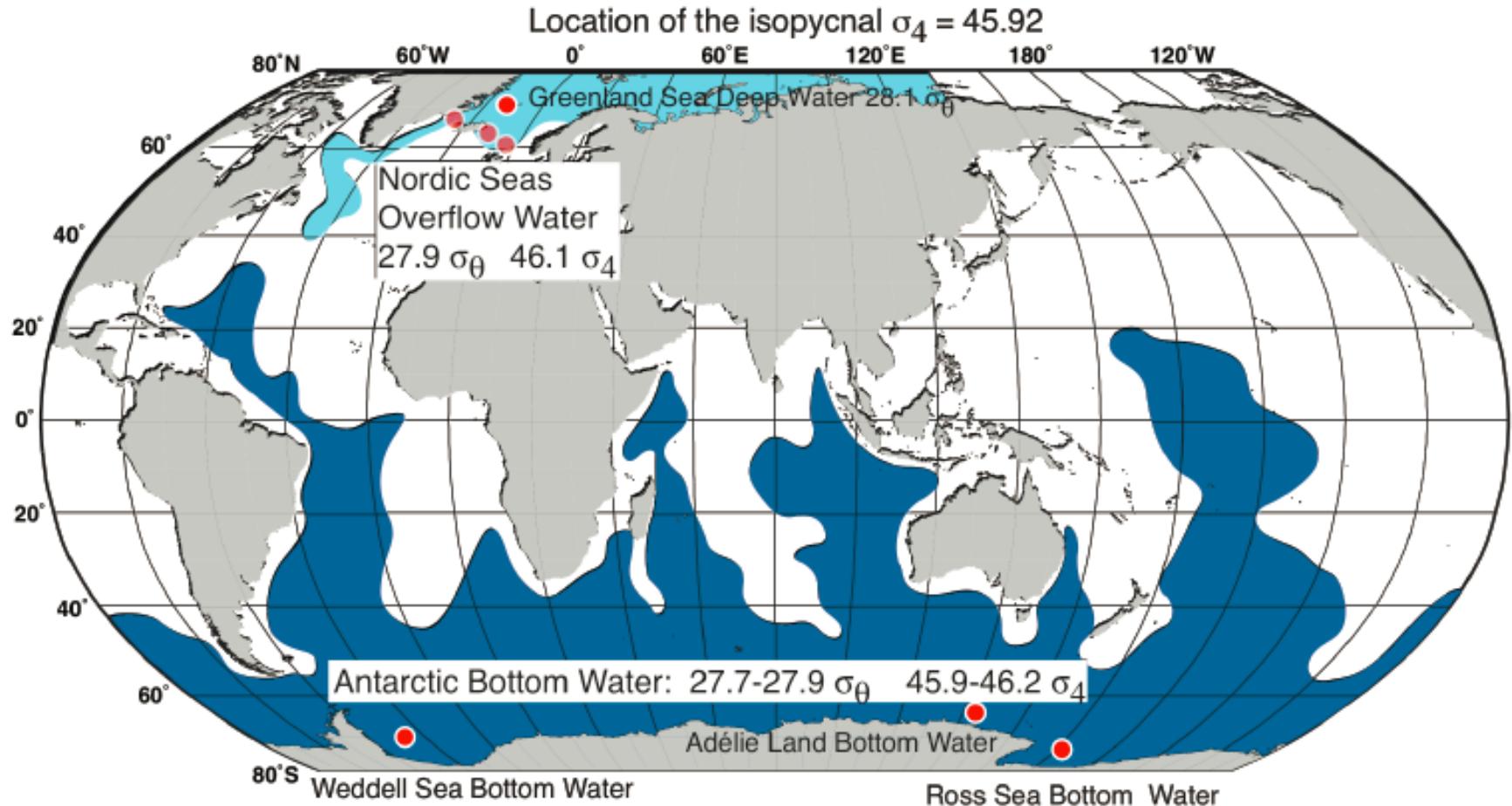
## Global water masses (glimpse) distribution



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# Global water masses (glimpse) distribution



- **El análisis OMP:**

- **¿para qué?**: el objetivo es cuantificar la contribución relativa de un grupo predefinido de masas de agua en una muestra de agua.
- **¿Cómo?** A través de una técnica de modelización inversa, una minimización lineal por mínimos cuadrados no negativos. (lsqnonneg en Matlab/OCTAVE & R [library “pracma”])

- **El análisis OMP:**

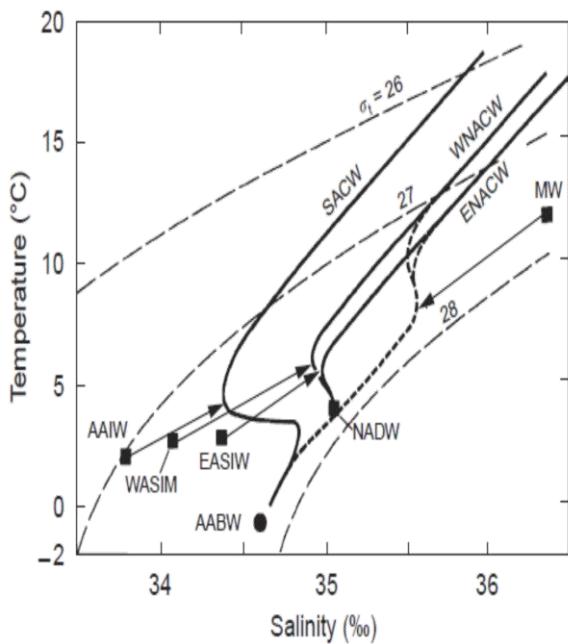
➤ **¿para qué?**: el objetivo es cuantificar la contribución relativa de un **grupo predefinido de masas de agua** en una muestra de agua.

Source water types → SWT

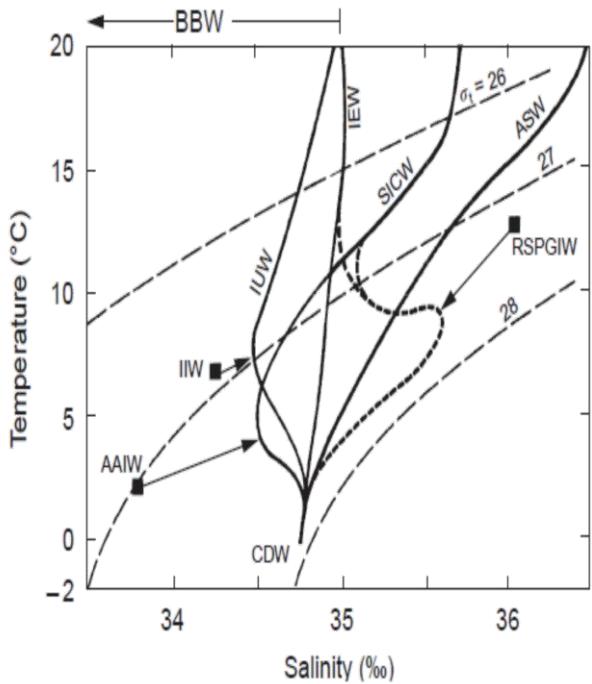
- **Source Water Type (SWT):**

- Características físicas químicas muy bien conocidas.
- Es un concepto ideal, teórico, un punto “matemático” en el espacio de las  $n$ -dimensiones que se consideren.
- Una correcta definición y caracterización previa de las SWT es un paso esencial para el análisis OMP.

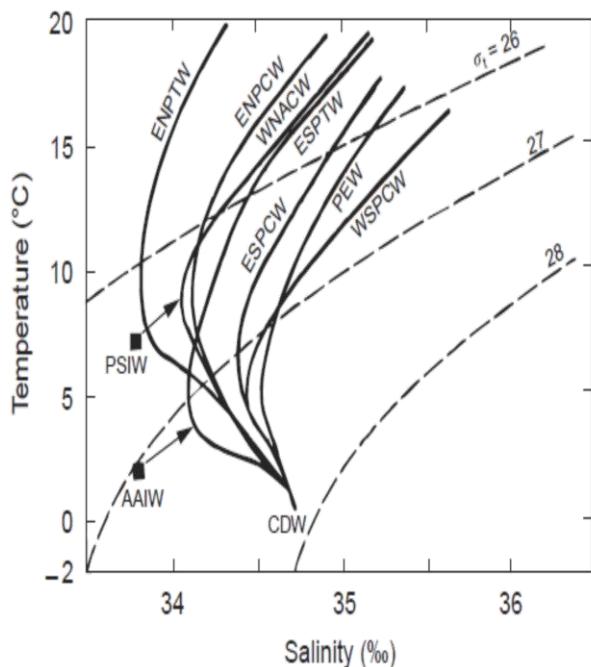
- Source Water Type (SWT):



Atlántico

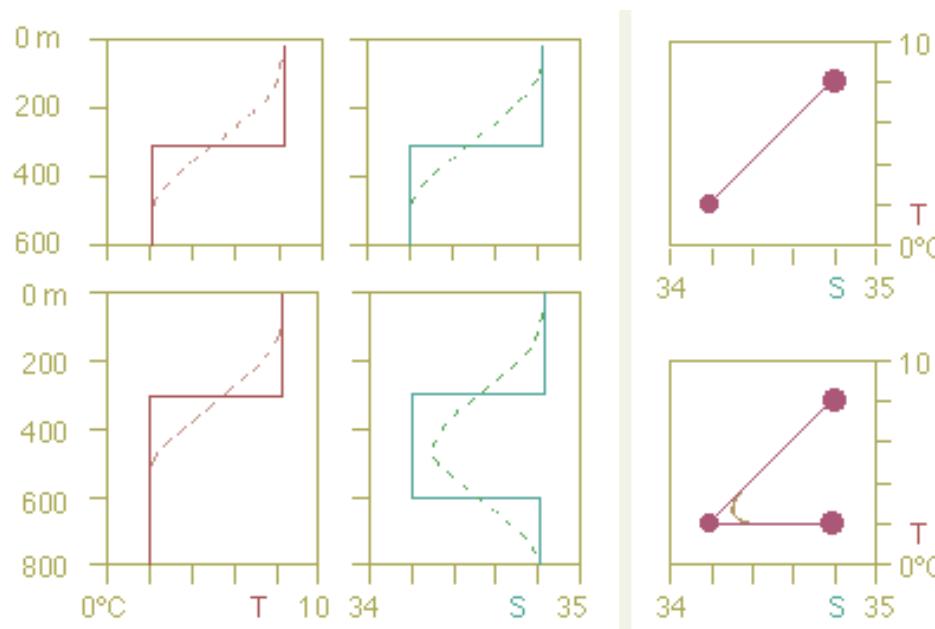


Pacífico



Índico

- Los análisis OMP parten de las siguientes **asunciones**:
  - 1.- Los procesos de mezcla entre las SWT son **lineales**.



Tomczak lessons in:

<https://www.mt-oceanography.info/IntroOc/lecture07.html>

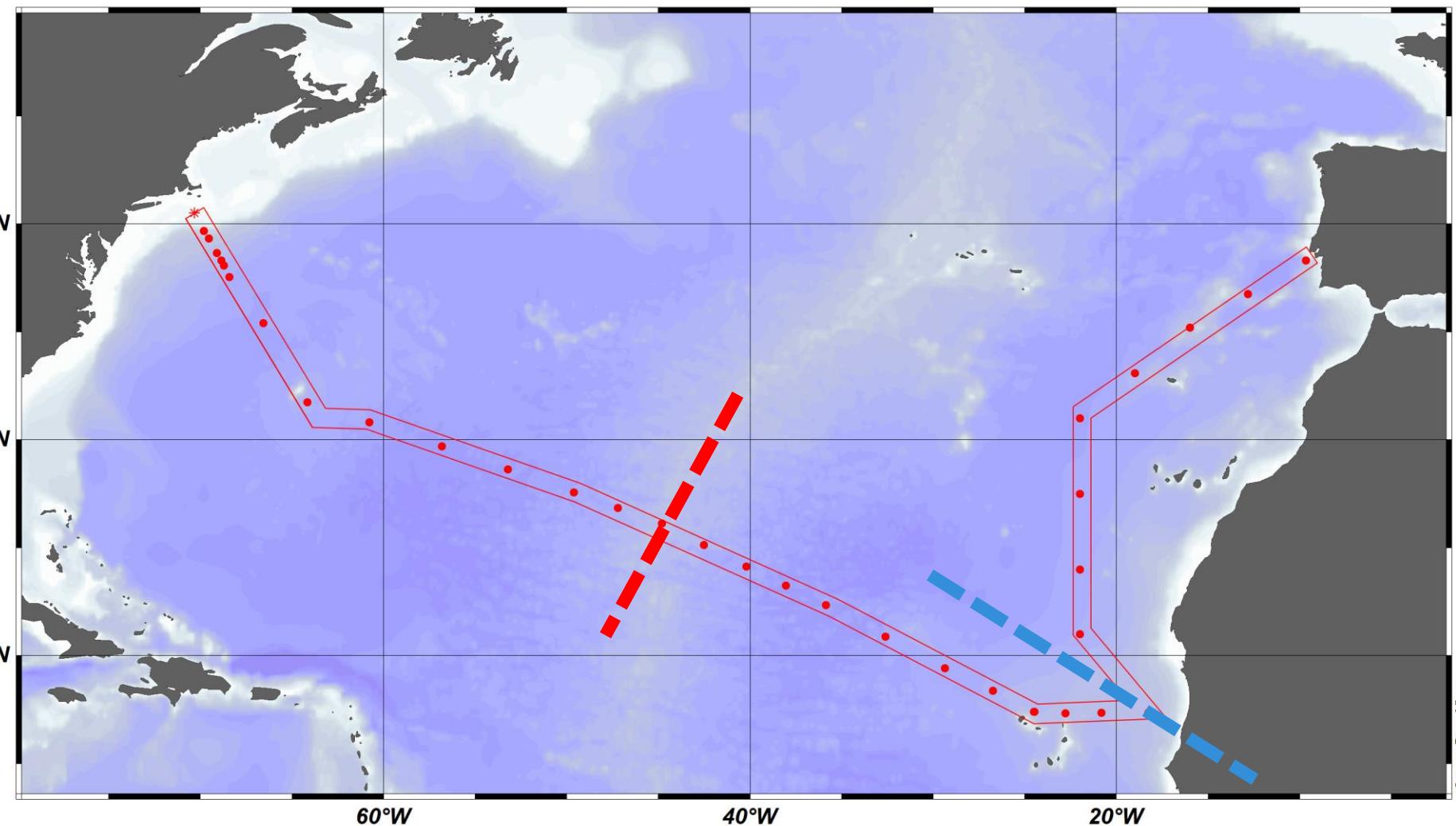
- Los análisis OMP parten de las siguientes **asunciones**:
  - 1.- Los procesos de mezcla entre las SWT son **lineales**.
  - 2.- Las **propiedades de las SWT** se conocen con precisión (y con una desviación estándar conocida).
  - 3.- Las propiedades medidas son **conservativas** y poseen idénticos coeficientes de difusión y/o mezcla.

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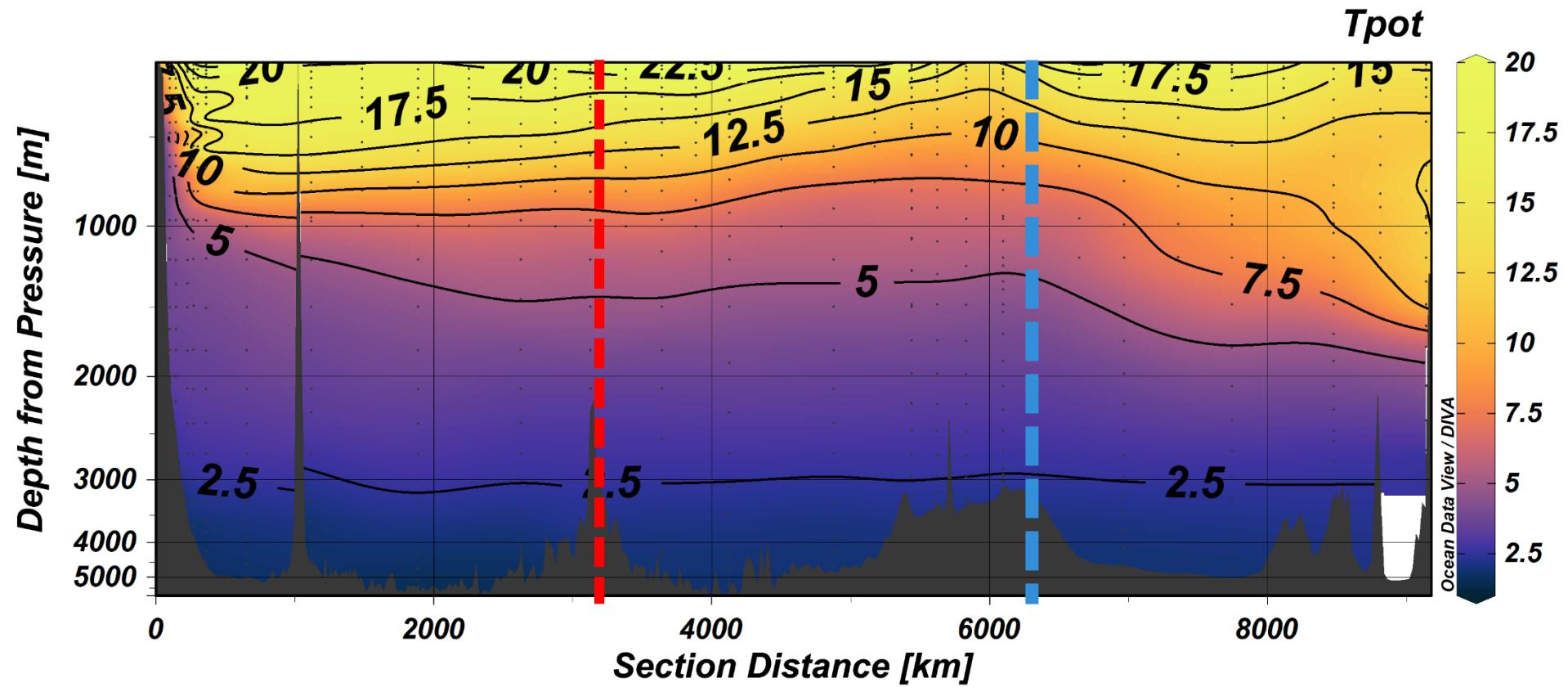
- Propiedades conservativas vs no conservativas:
  - ❖ conservativas: variables cuyos valores solo pueden ser modificados por procesos de mezcla →  $T_{pot}$ , Sal
  - ❖ No conservativas: variables que, además de cambios por procesos de mezcla, están sujetas a cambios biogeoquímicos. →  $O_2$ , nutrientes

- Además, los análisis OMP están constreñidos por tres **reglas**:
  - 1.- La ecuación del balance de masa ha de cumplirse en cualquier punto
  - 2.- Las contribuciones a la mezcla ( $X_i$ ) son siempre positivas
  - 3.- El número de SWT ha de ser siempre inferior o igual al número de propiedades medidas, para tener, al menos, un grado de libertad en el análisis.

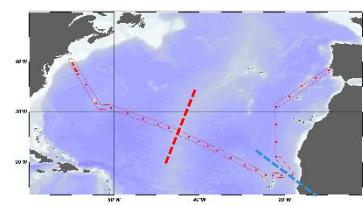
# Caso práctico



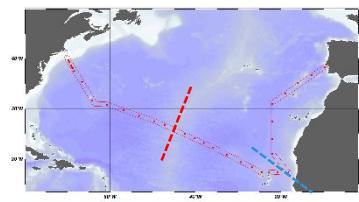
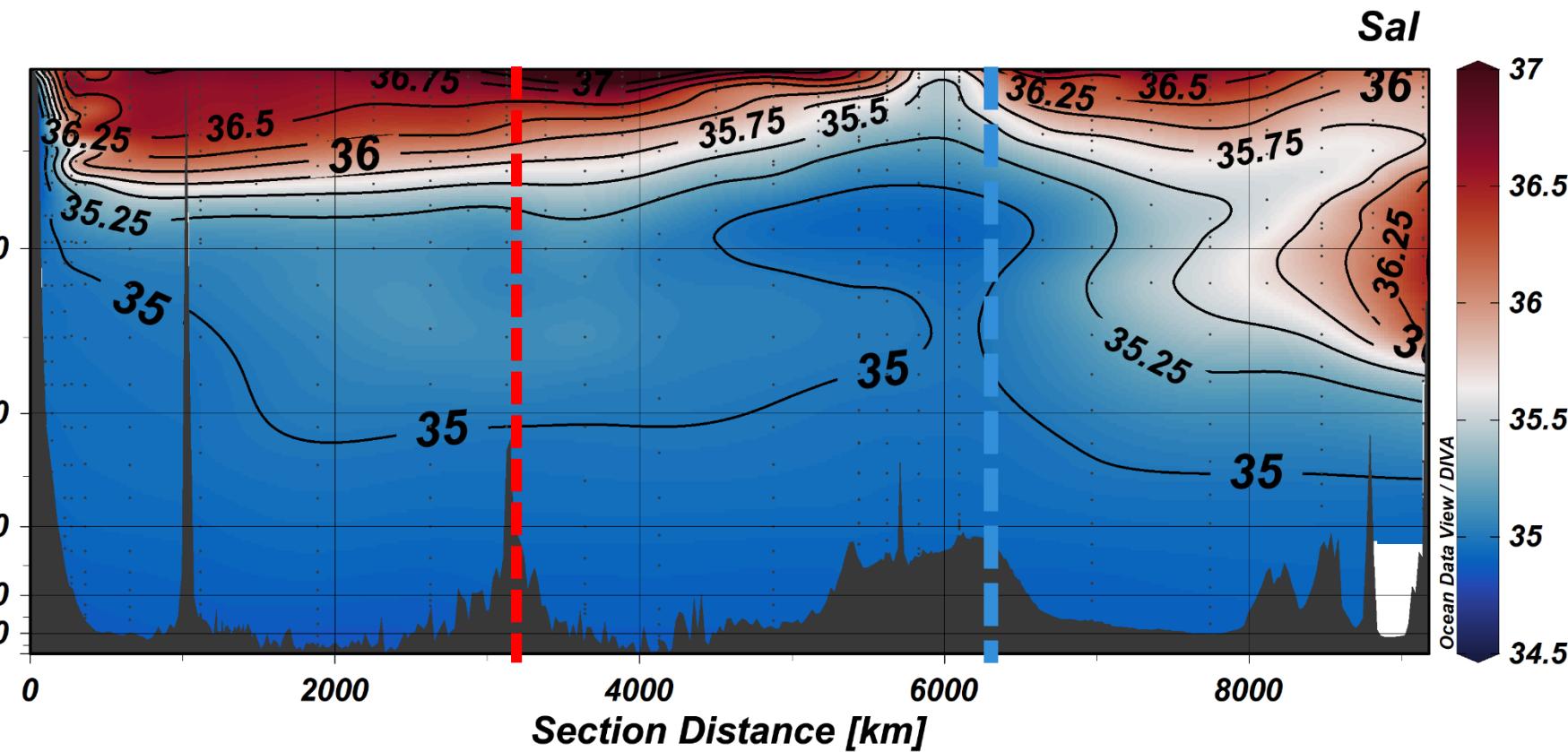
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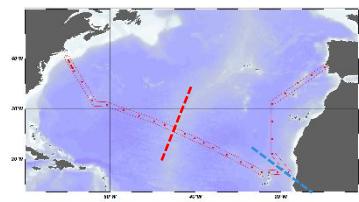
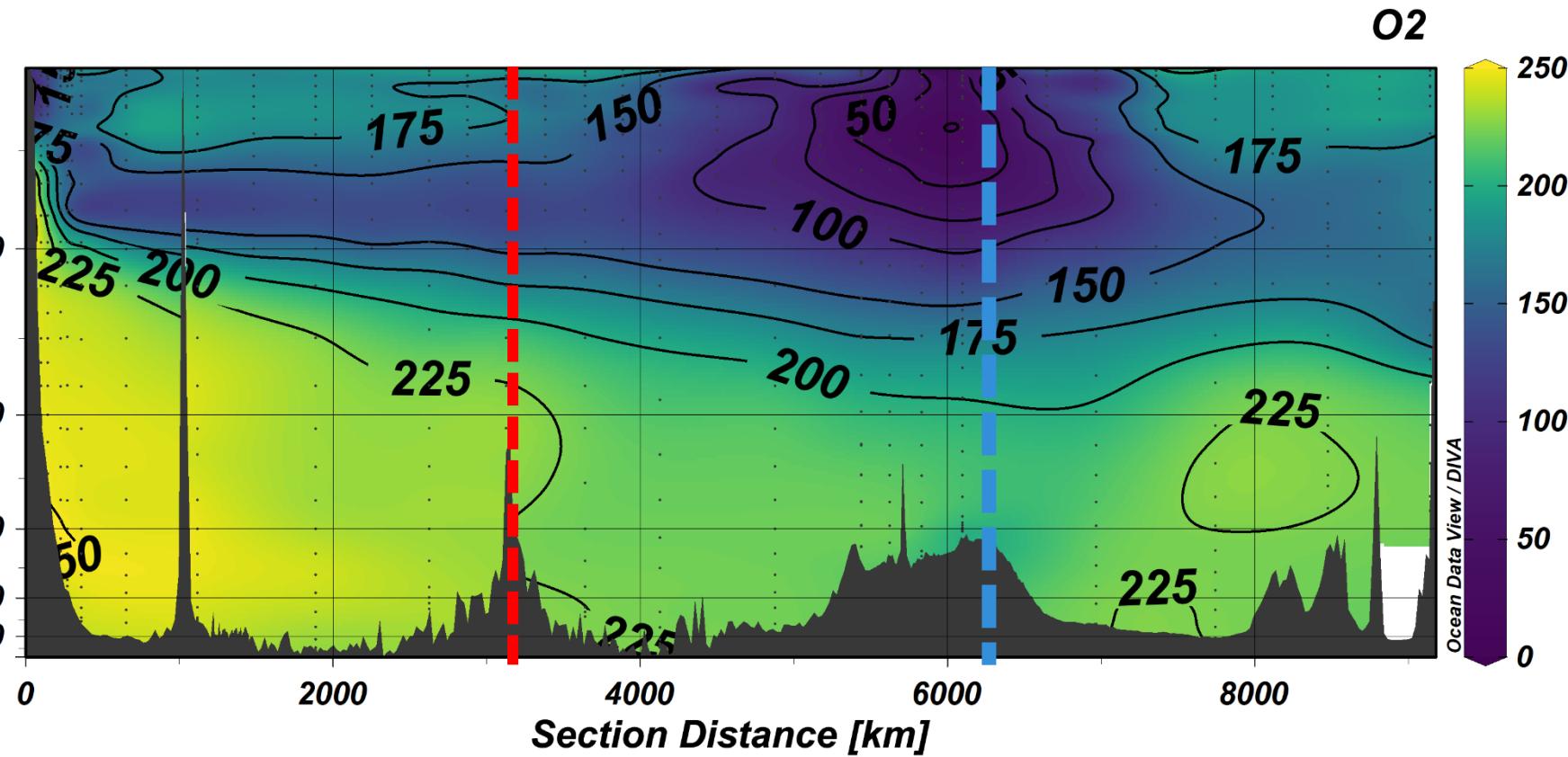
*Marcos Fontela, 2019*



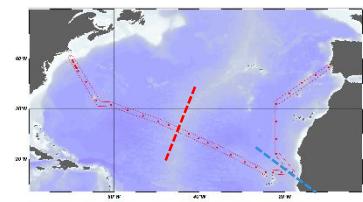
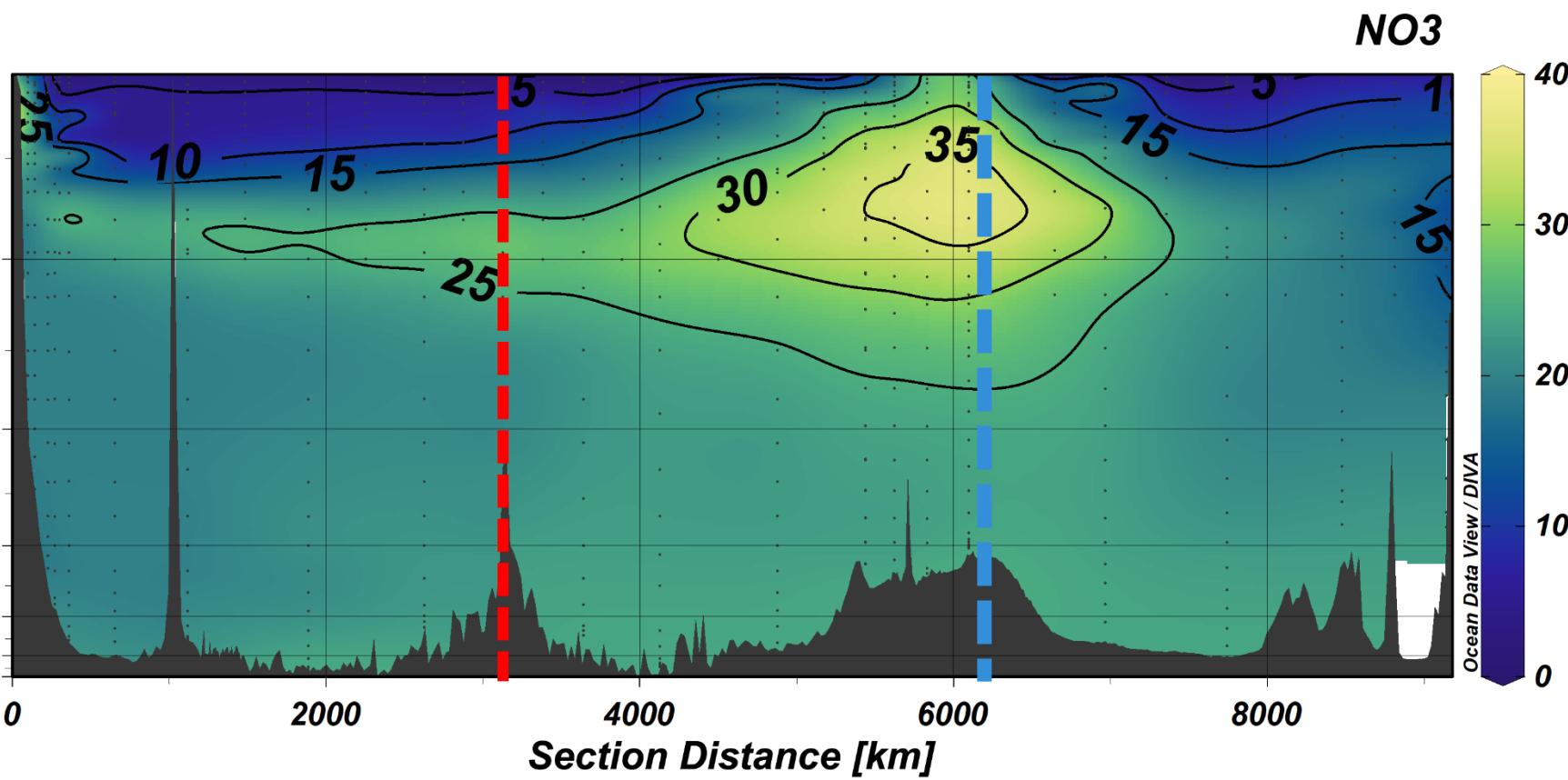
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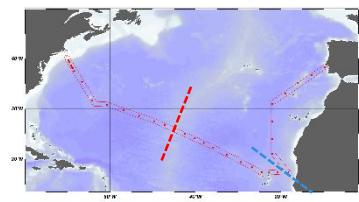
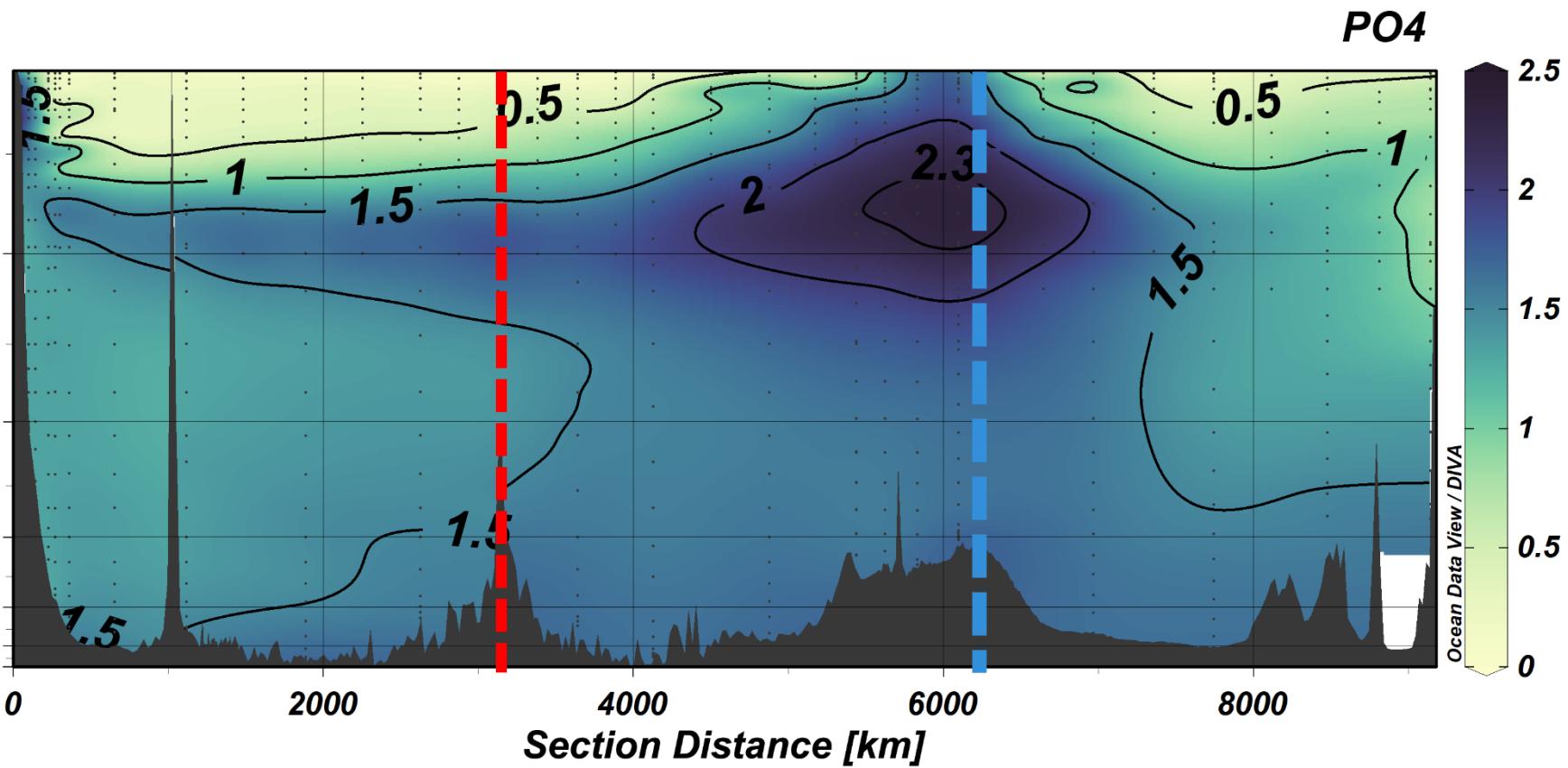
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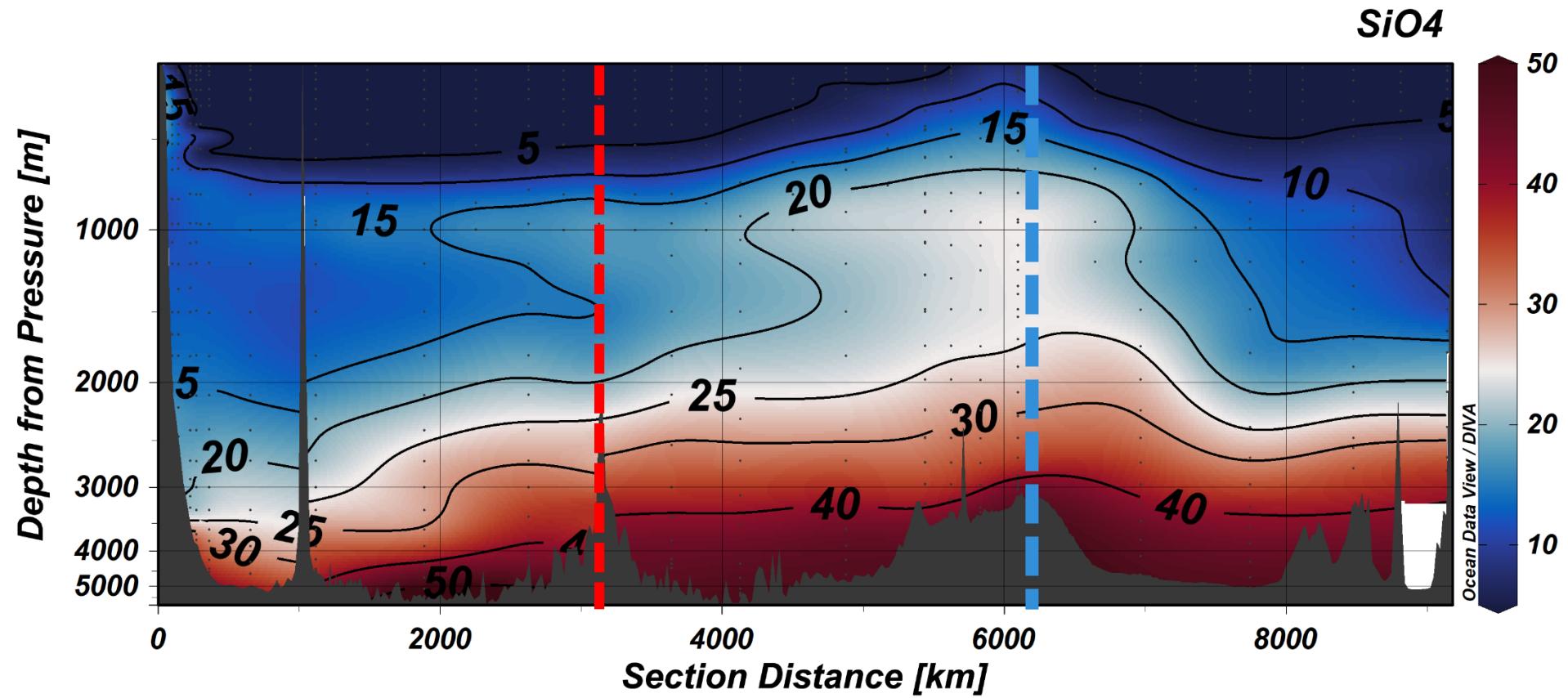
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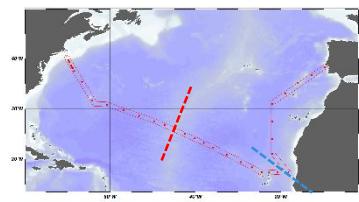
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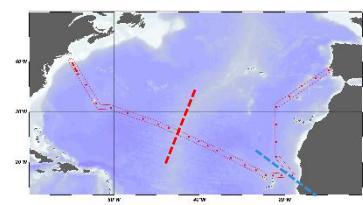
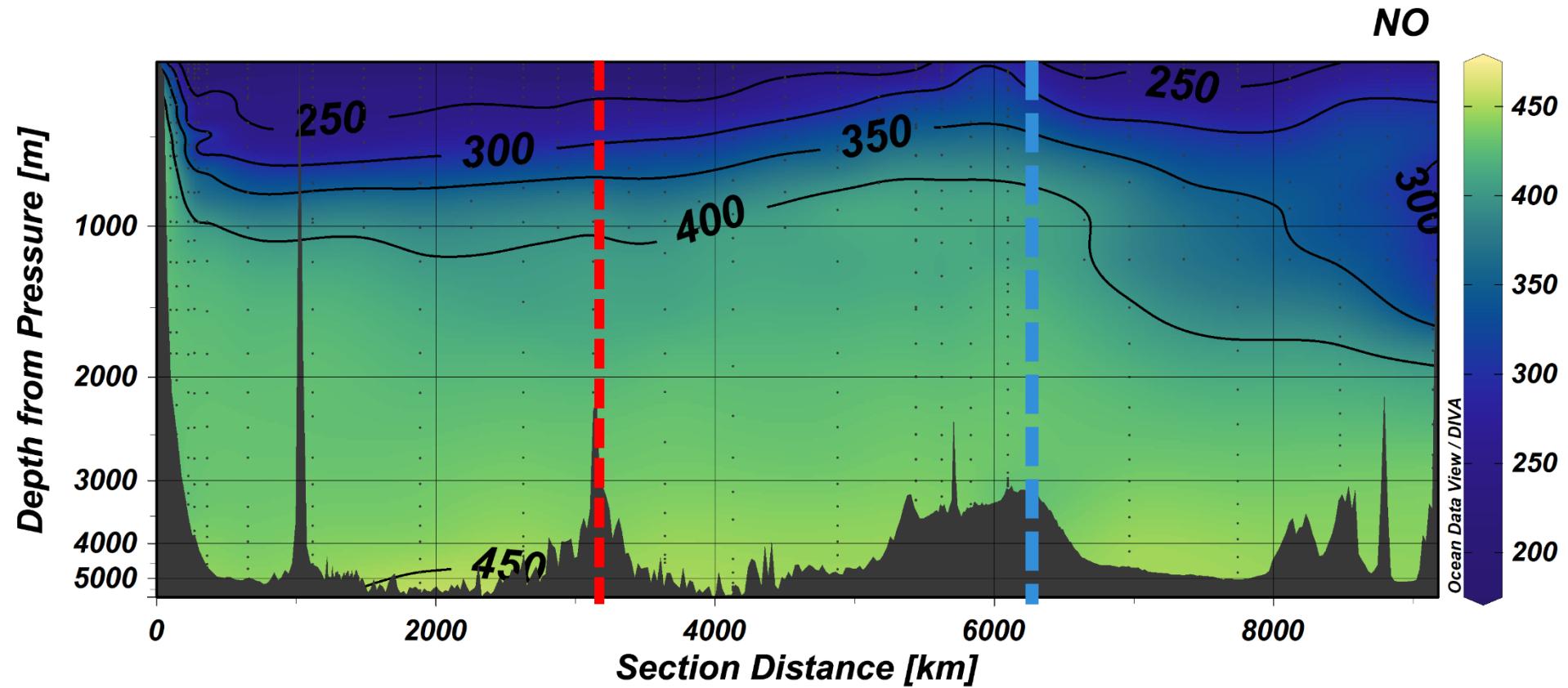
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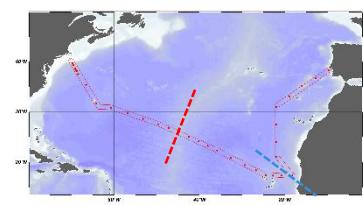
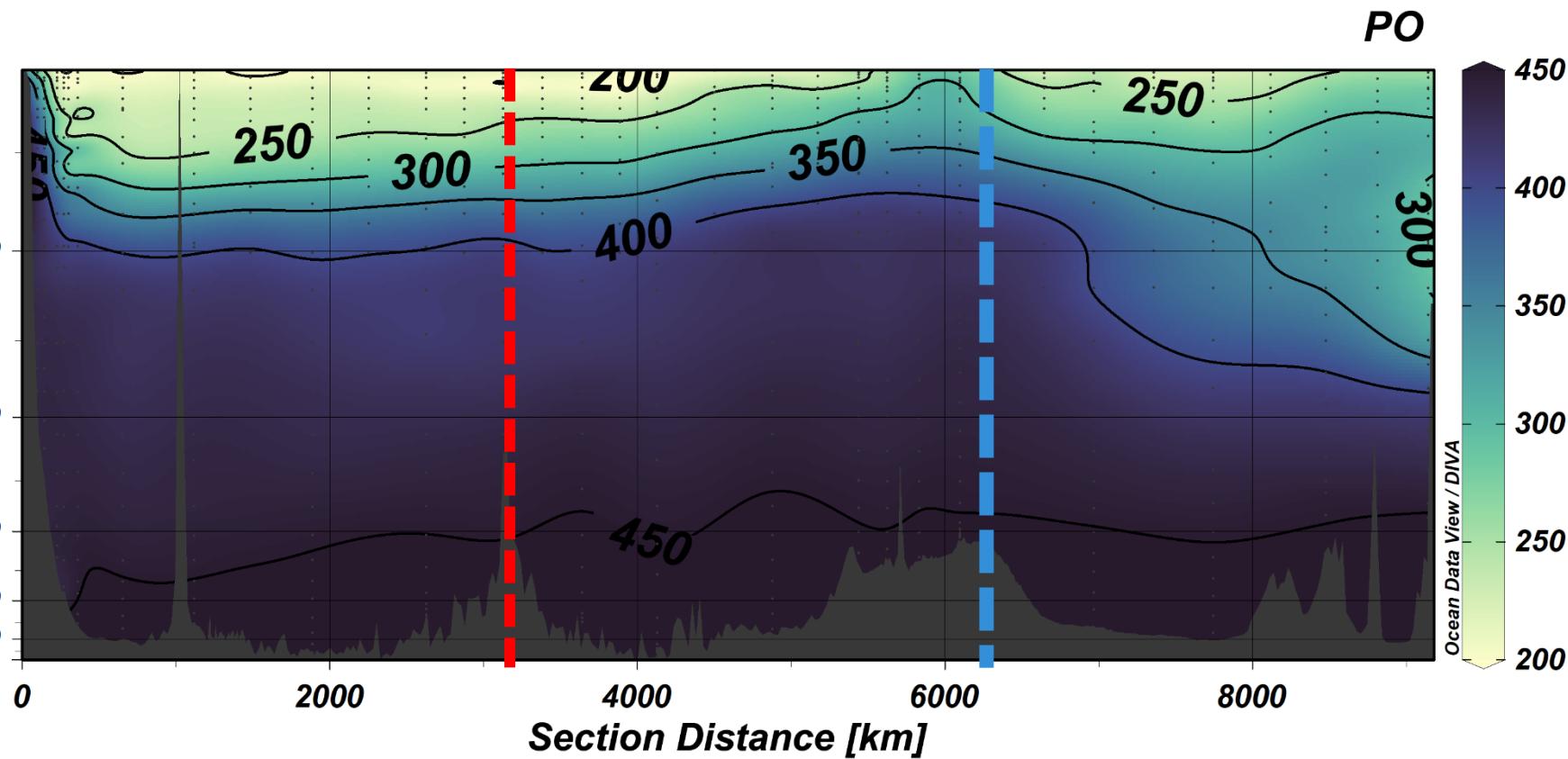
Marcos Fontela, 2019



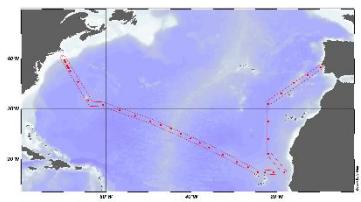
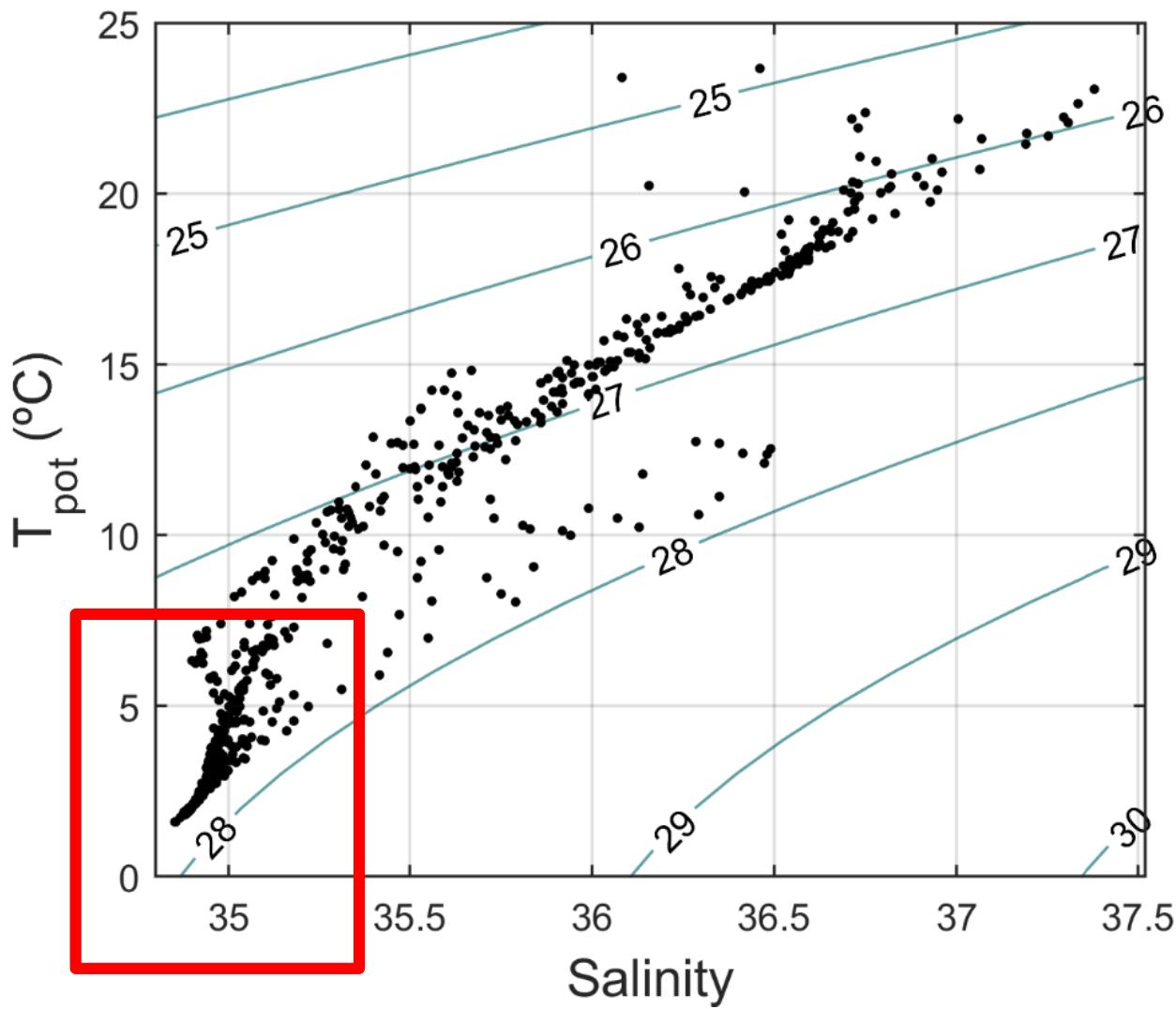
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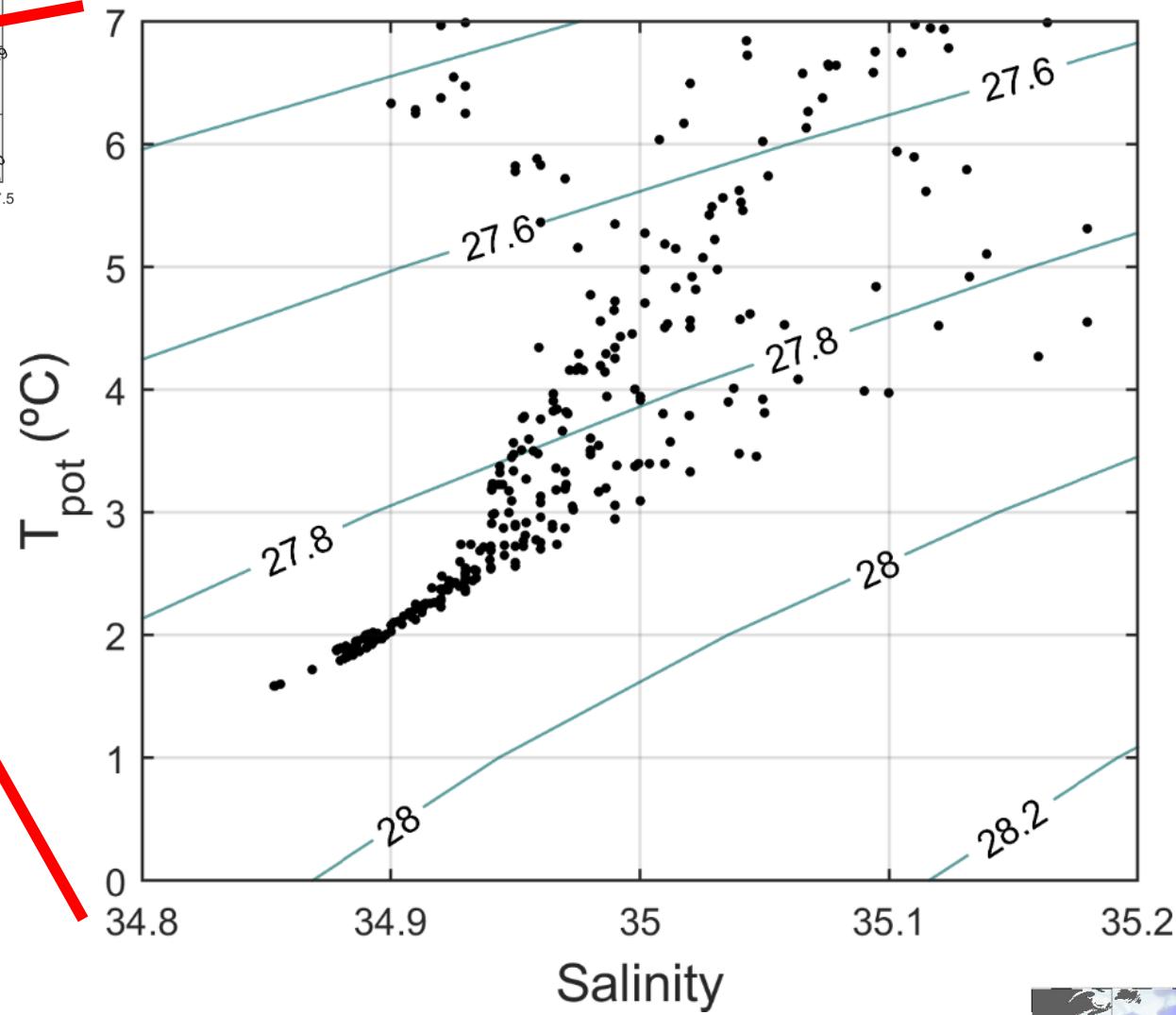
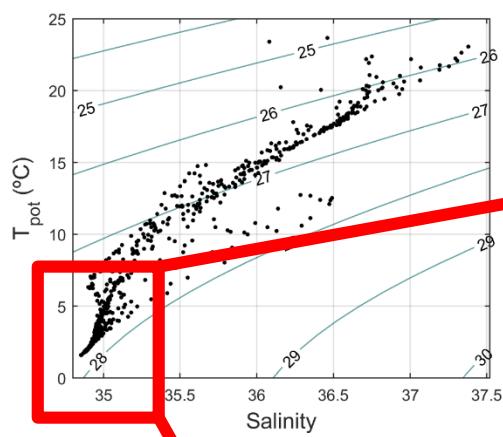
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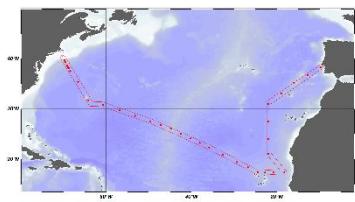
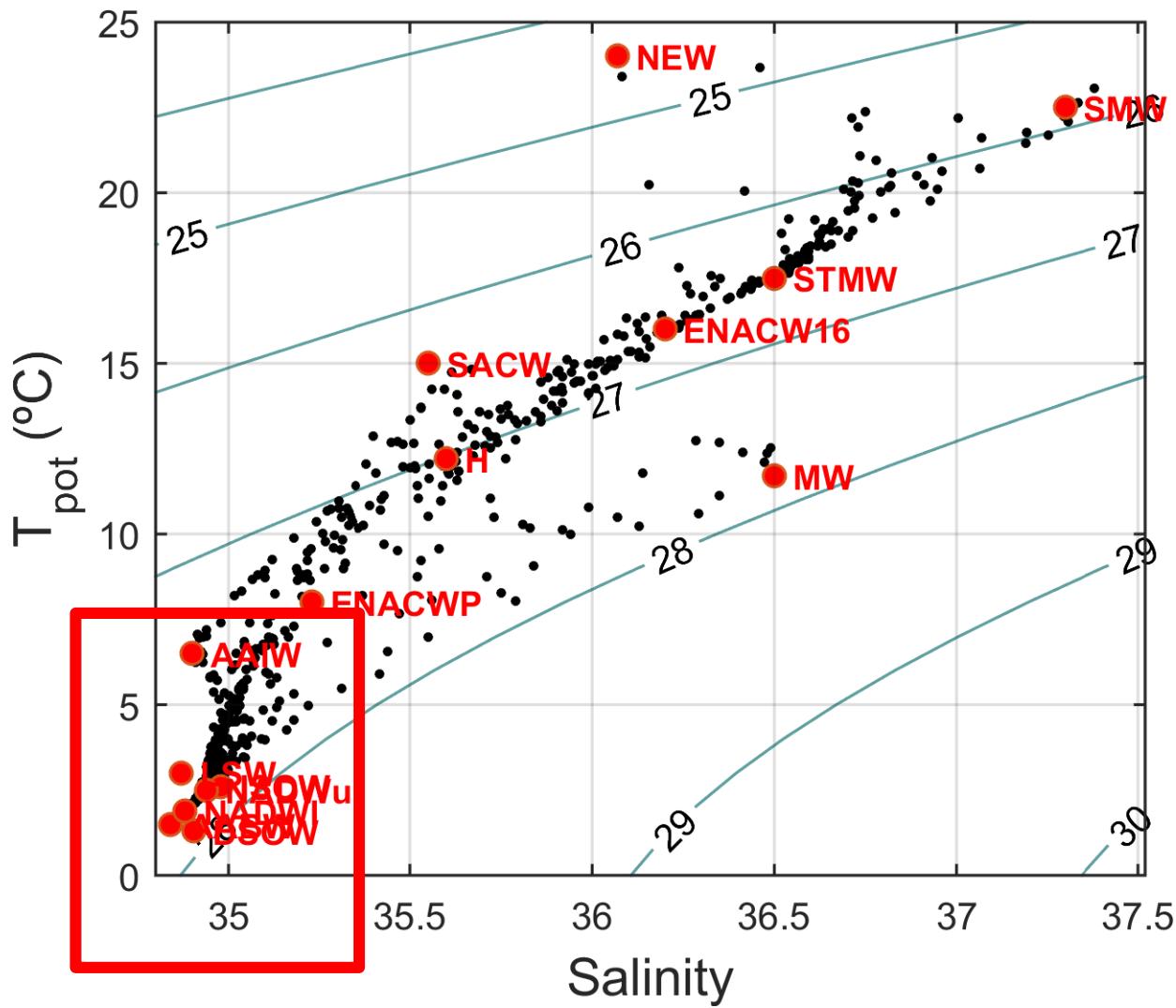
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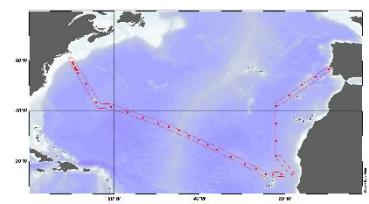
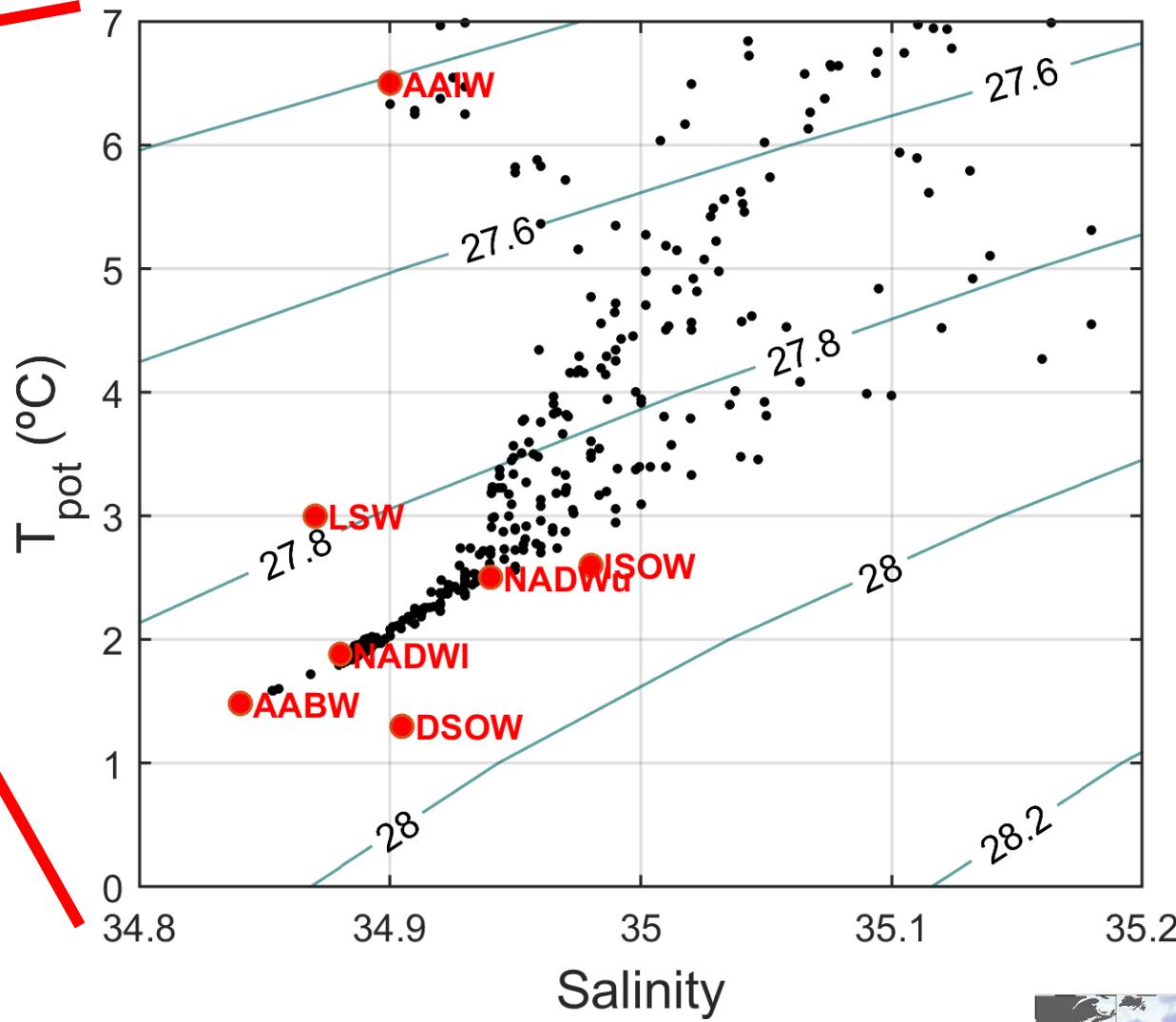
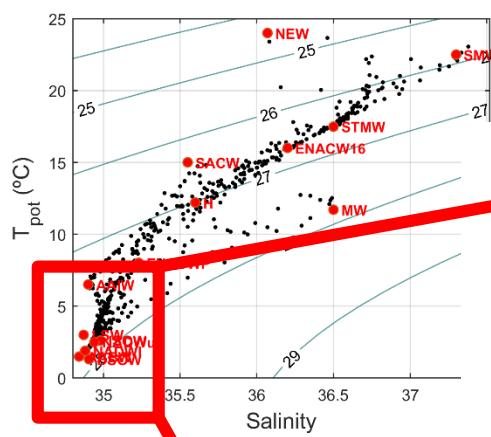
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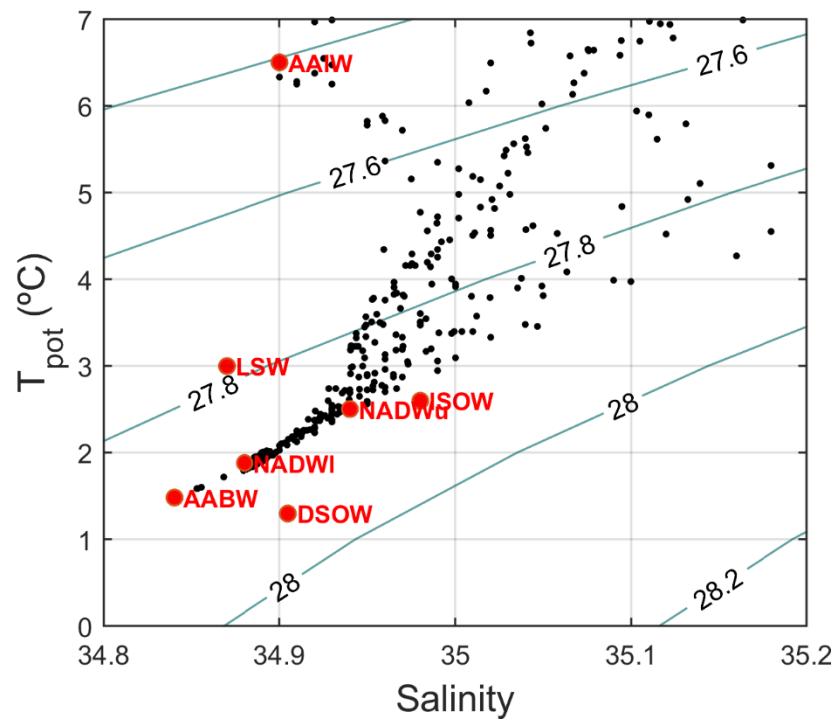
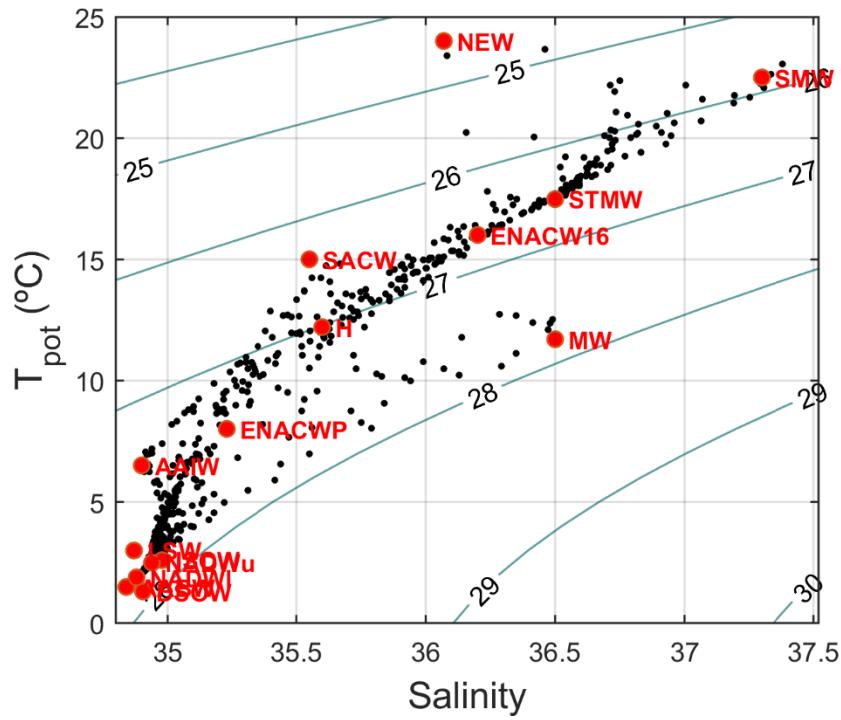
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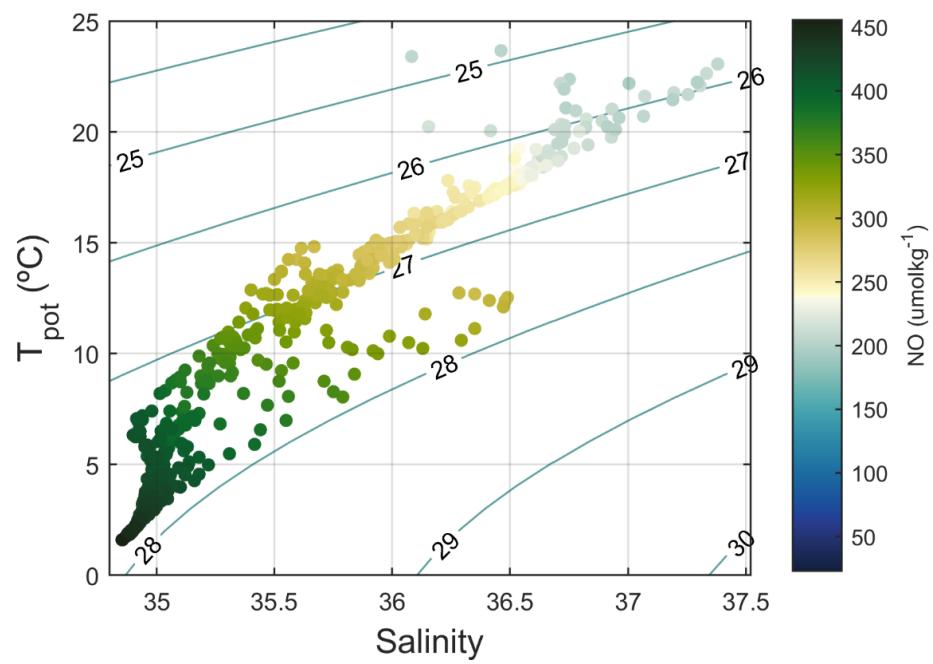
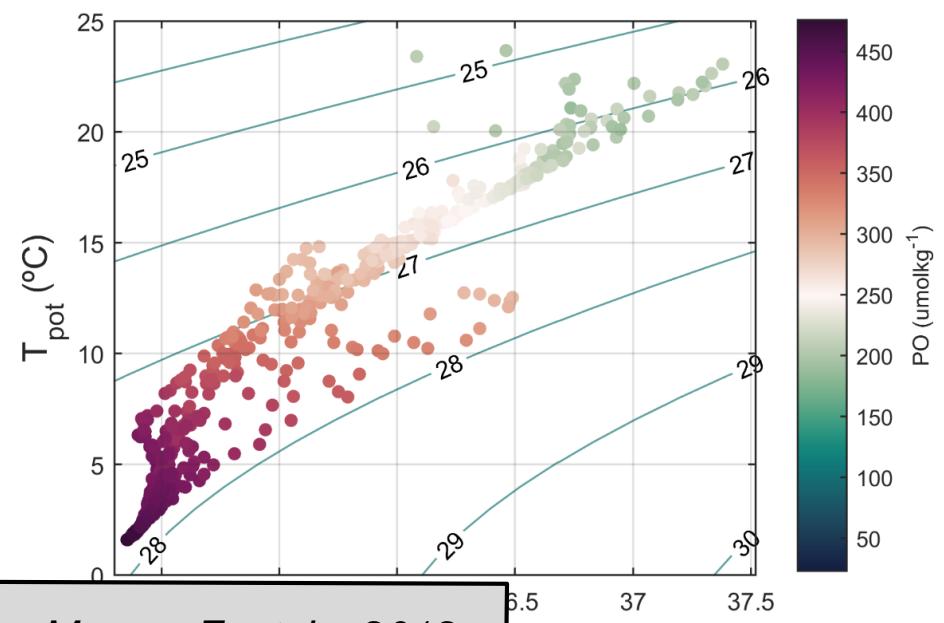
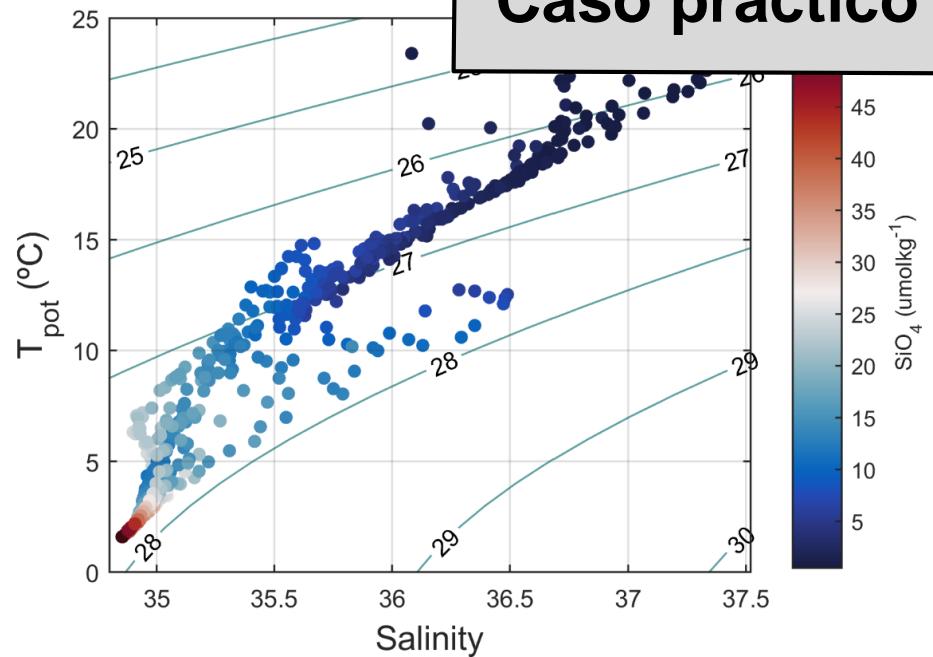
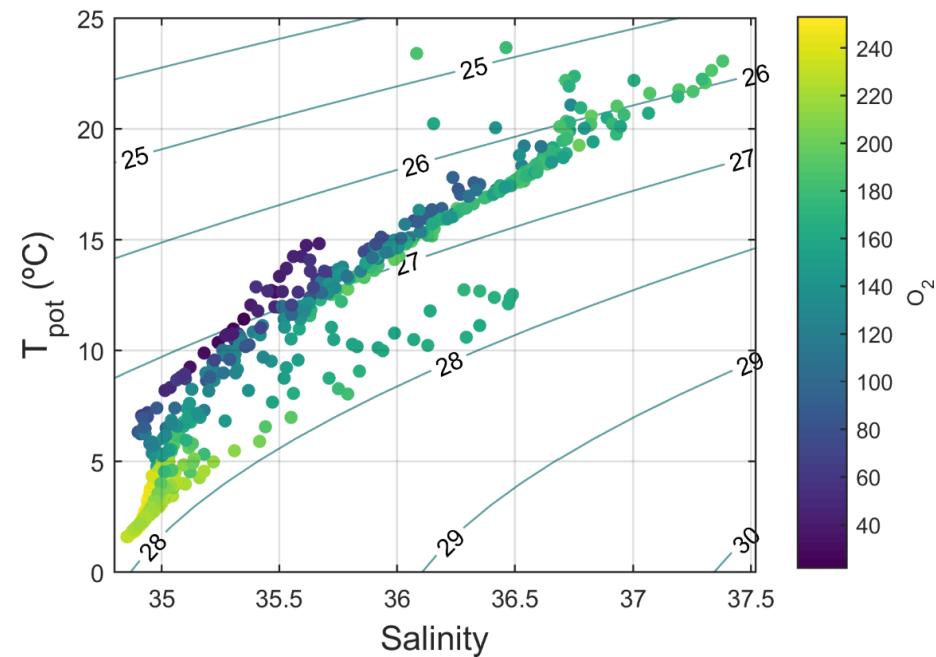
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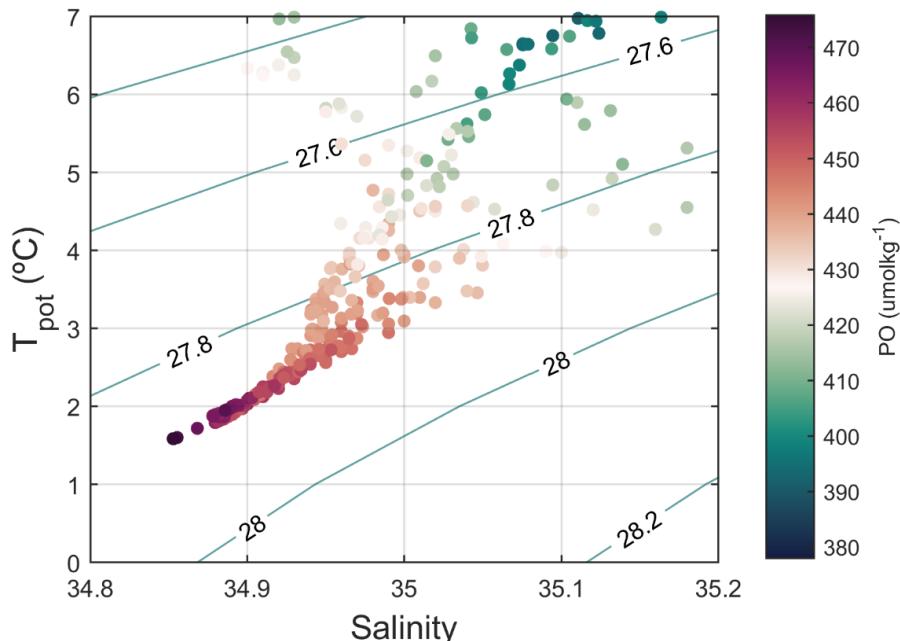
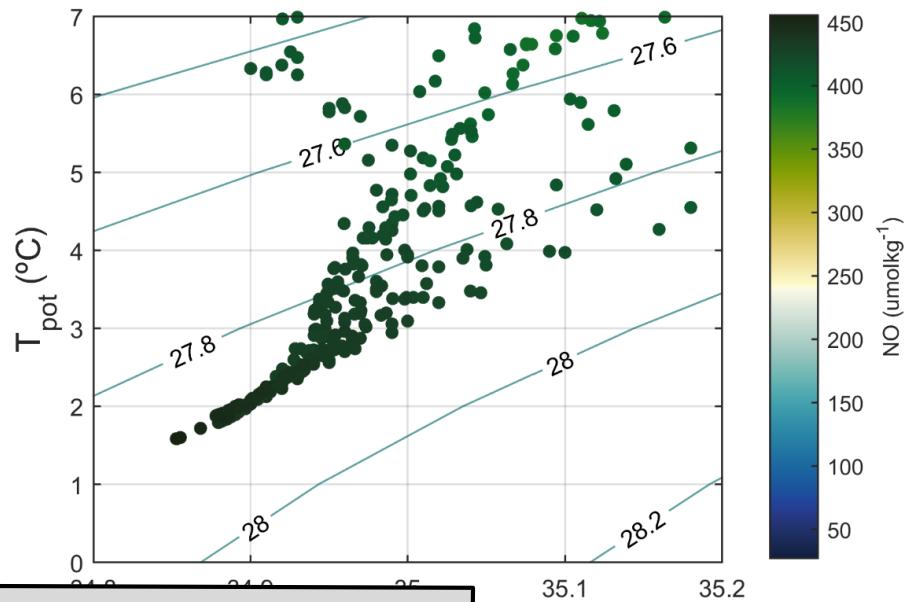
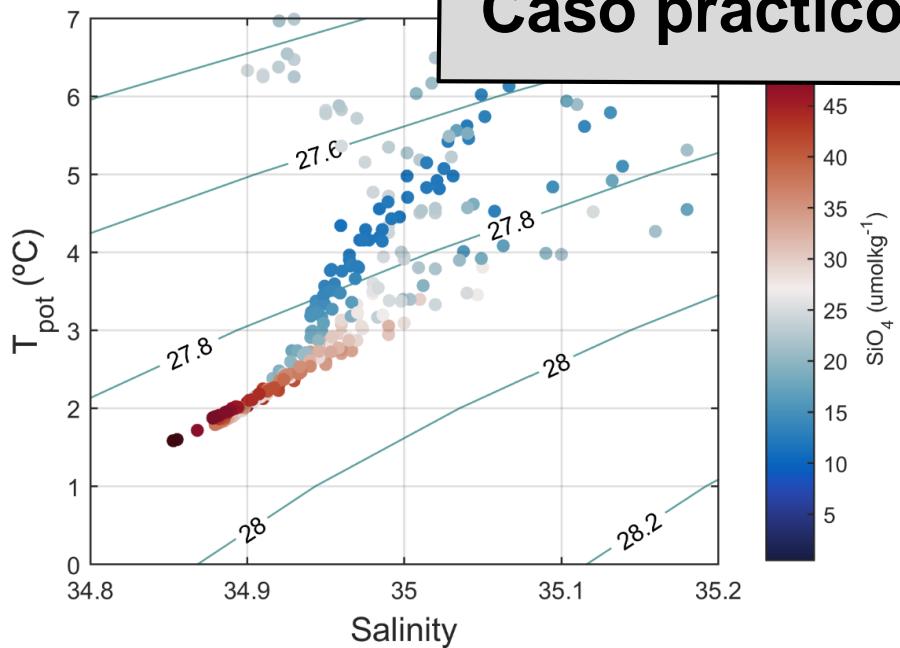
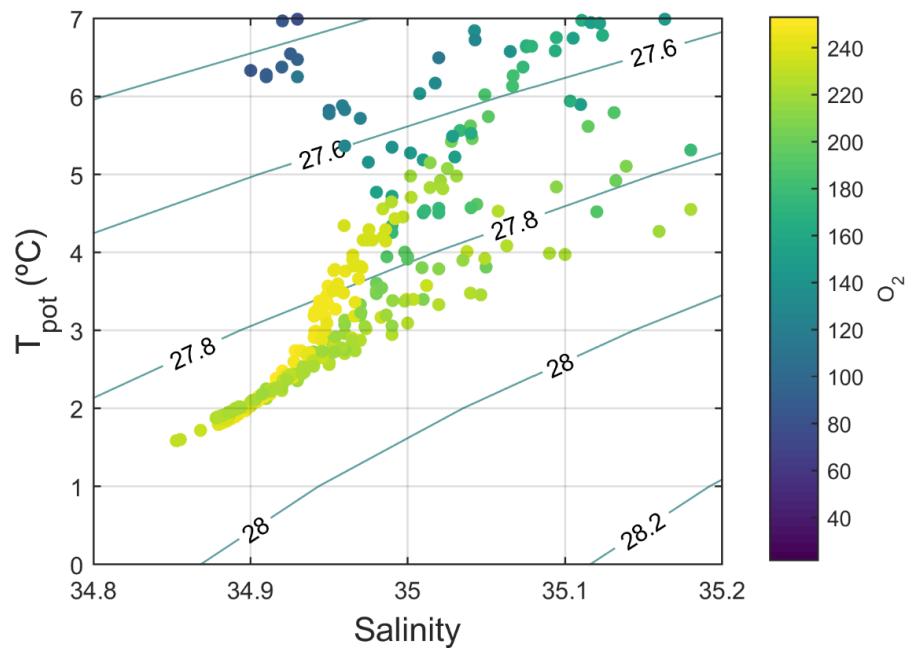
# Caso práctico



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# Caso práctico



## Sistema de ecuaciones general (simplificado)

*Medida de la muestra =  $\sum^{\text{numero de masas de agua}} X (\% \text{ SWT}) * \text{Propiedad tipo SWT} + \text{error}$*

## Sistema de ecuaciones

### OMP clásico

$$\theta_{obs} = \sum_{i=1}^{nSWM} X_i * \theta_i^0 + \varepsilon_{\theta_{obs}}$$

$$S_{obs} = \sum_{i=1}^{nSWM} X_i * S_i^0 + \varepsilon_{S_{obs}}$$

$$SiO_2\_{obs} = \sum_{i=1}^{nSWM} X_i * SiO_2\_{i} + \varepsilon_{SiO_2\_{obs}}$$

$$NO_{obs} = \sum_{i=1}^{nSWM} X_i * NO_i^0 + \varepsilon_{NO_{obs}}$$

$$PO_{obs} = \sum_{i=1}^{nSWM} X_i * PO_i^0 + \varepsilon_{PO_{obs}}$$

$$1 = \sum_{i=1}^{nSWM} X_i + \varepsilon_{mass}$$

$$r_{O/N} = 9.3$$
  

$$r_{O/P} = 135$$

### OMP extendido

$$\theta_{obs} = \sum_{i=1}^{nSWM} X_i * \theta_i^0 + \varepsilon_{\theta_{obs}}$$

$$S_{obs} = \sum_{i=1}^{nSWM} X_i * S_i^0 + \varepsilon_{S_{obs}}$$

$$SiO_2\_{obs} = \sum_{i=1}^{nSWM} X_i * SiO_2\_{i} + \varepsilon_{SiO_2\_{obs}}$$

$$NO_3\_{obs} = \sum_{i=1}^{nSWM} X_i * NO_3^0\_{i} + r_{O/N} \Delta O + \varepsilon_{NO_3\_{obs}}$$

$$PO_4\_{obs} = \sum_{i=1}^{nSWM} X_i * PO_4^0\_{i} + r_{O/P} \Delta O + \varepsilon_{PO_4\_{obs}}$$

$$O_2\_{obs} = \sum_{i=1}^{nSWM} X_i * O_2^0\_{i} - \Delta O + \varepsilon_{O_2\_{obs}}$$

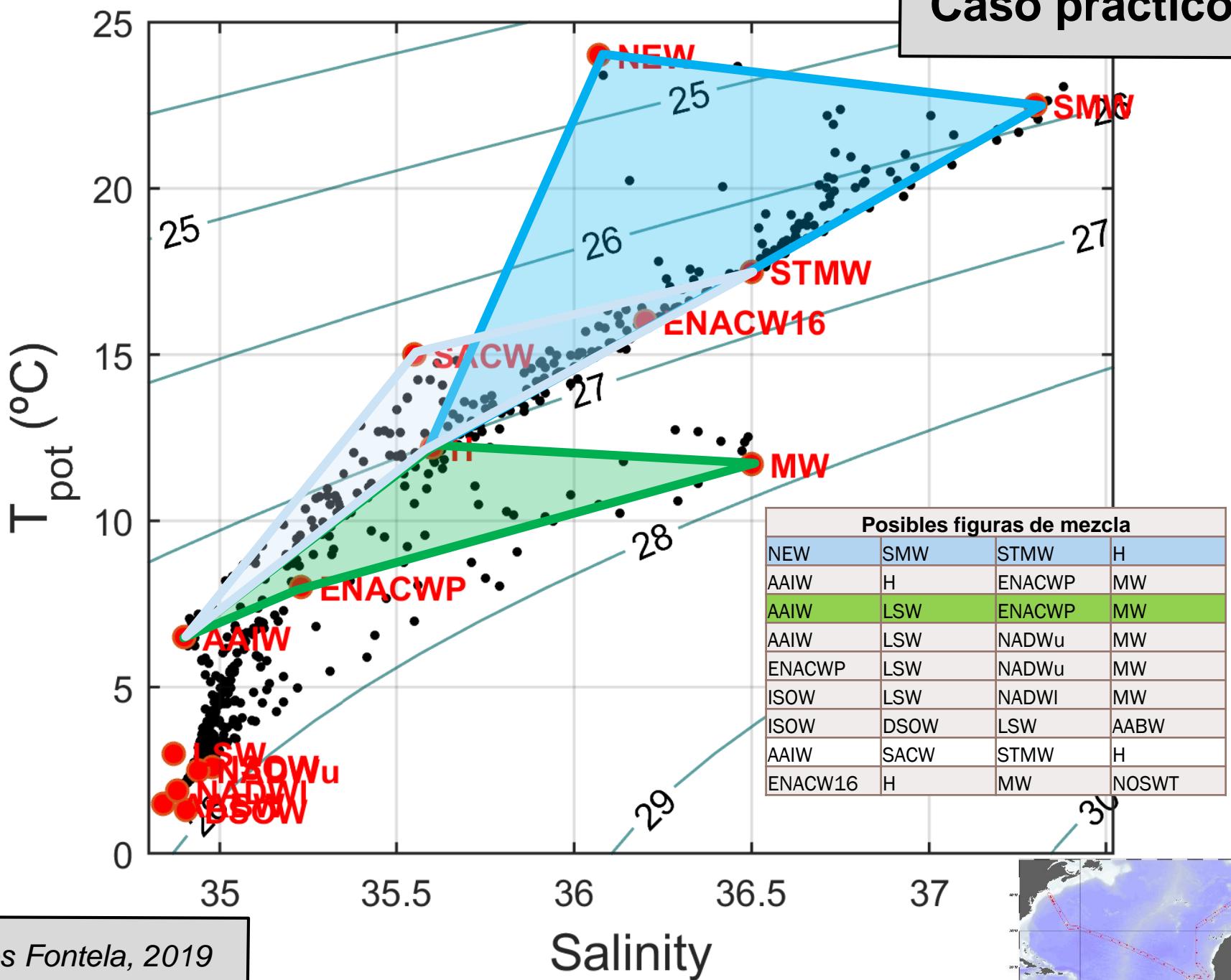
$$1 = \sum_{i=1}^{nSWM} X_i + \varepsilon_{mass}$$

$$NO = r_{O/N} * NO_3 + O_2$$
  

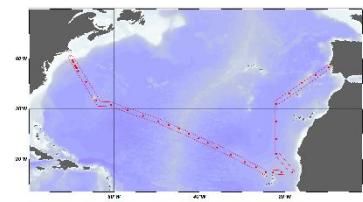
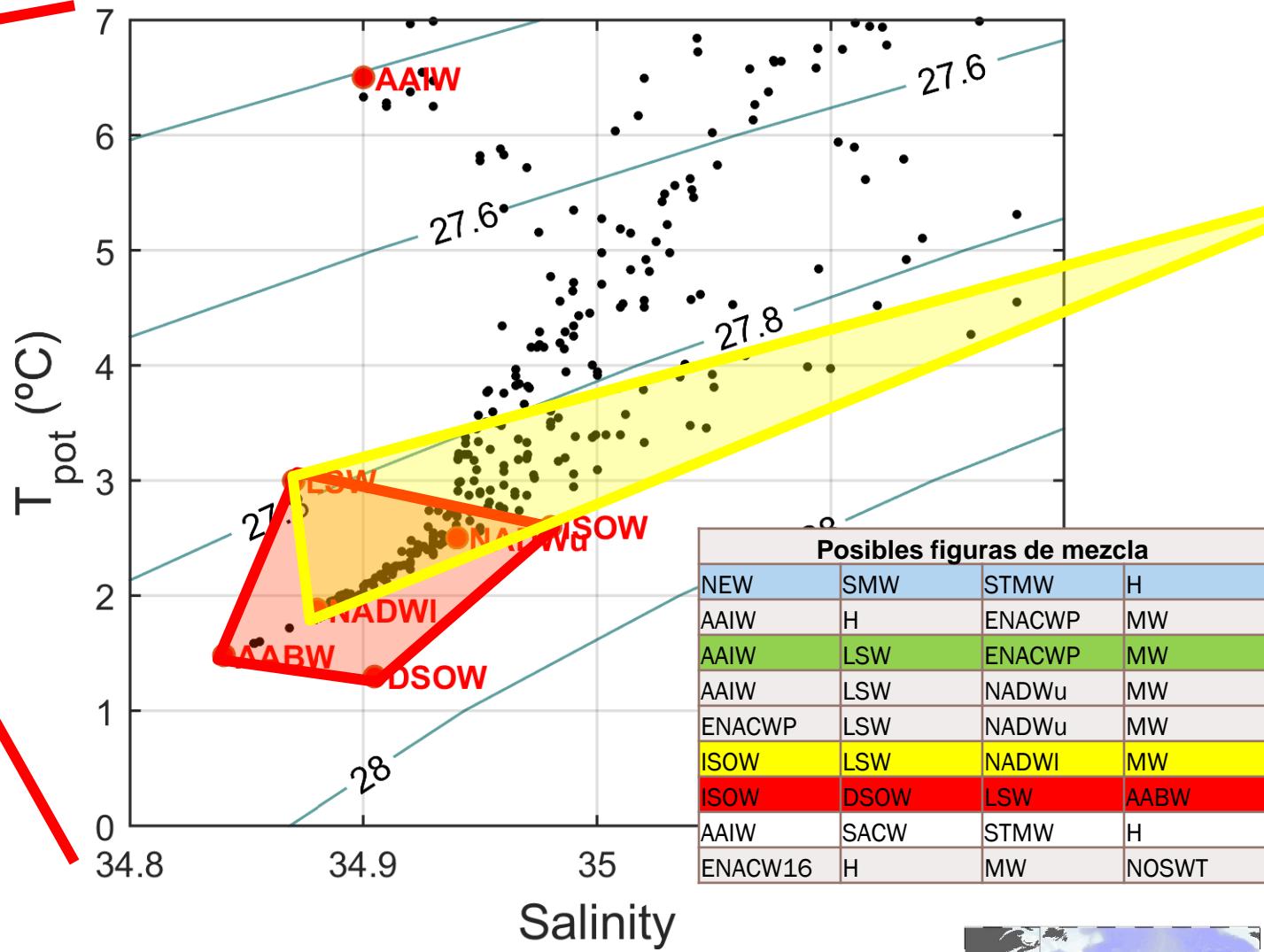
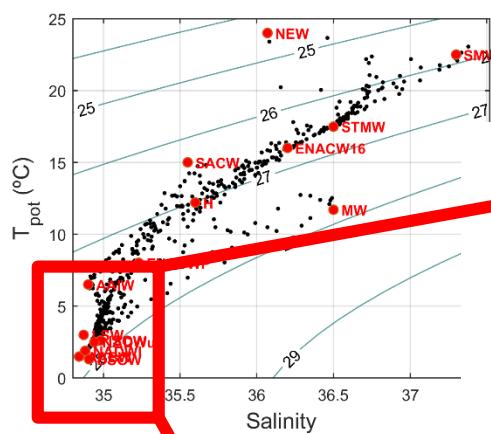
$$PO = r_{O/P} * PO_4 + O_2$$

**Término biológico**

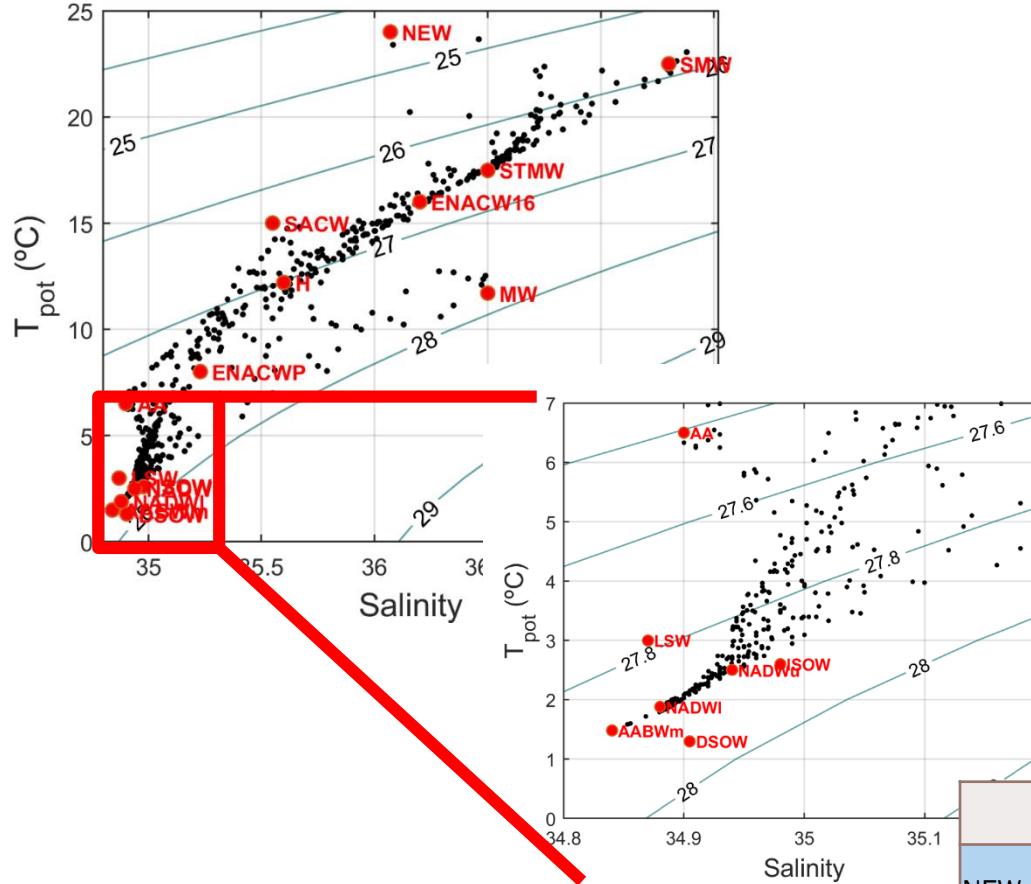
# Caso práctico



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## Criterios oceanográficos



solapadas

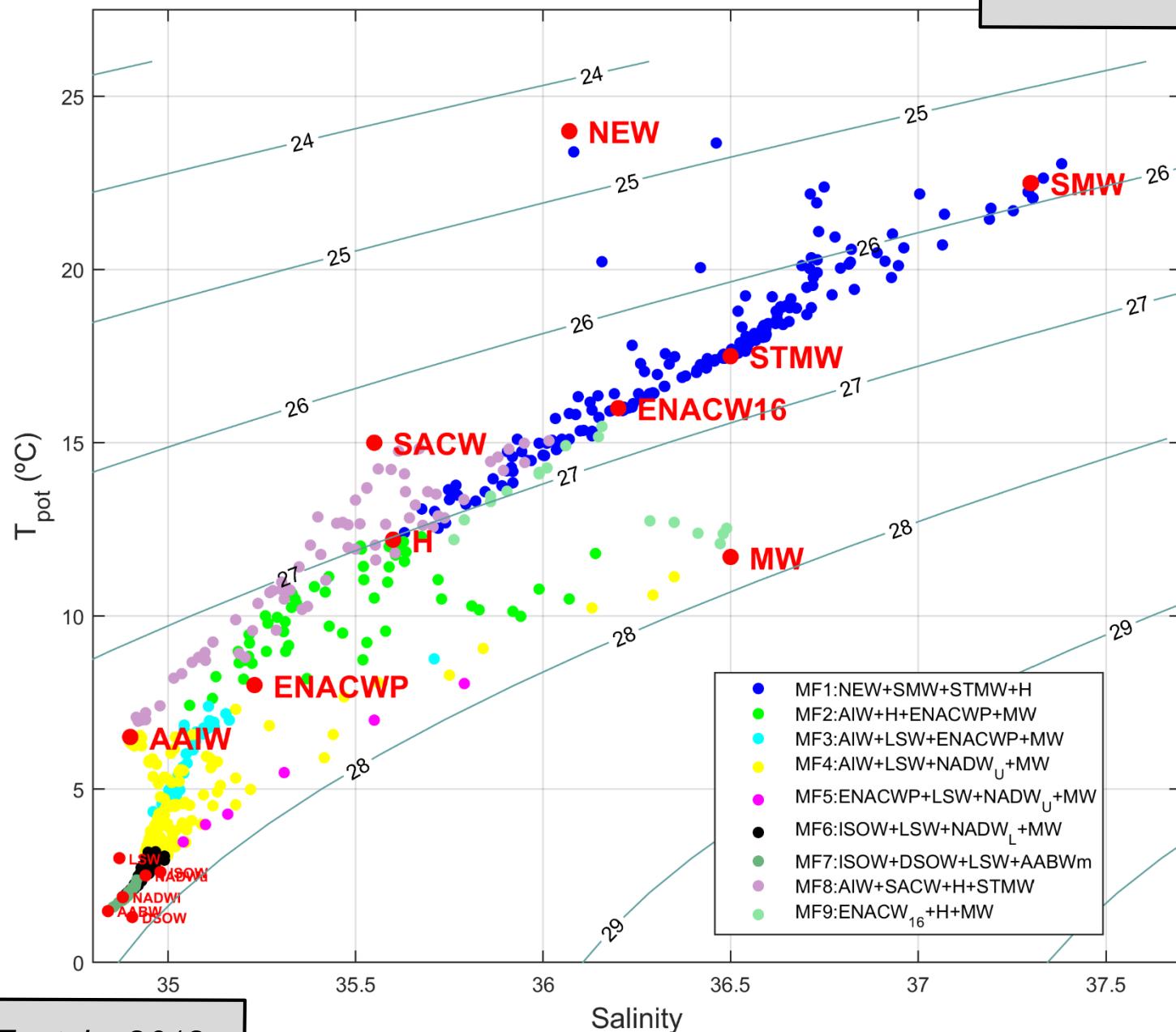


solapadas

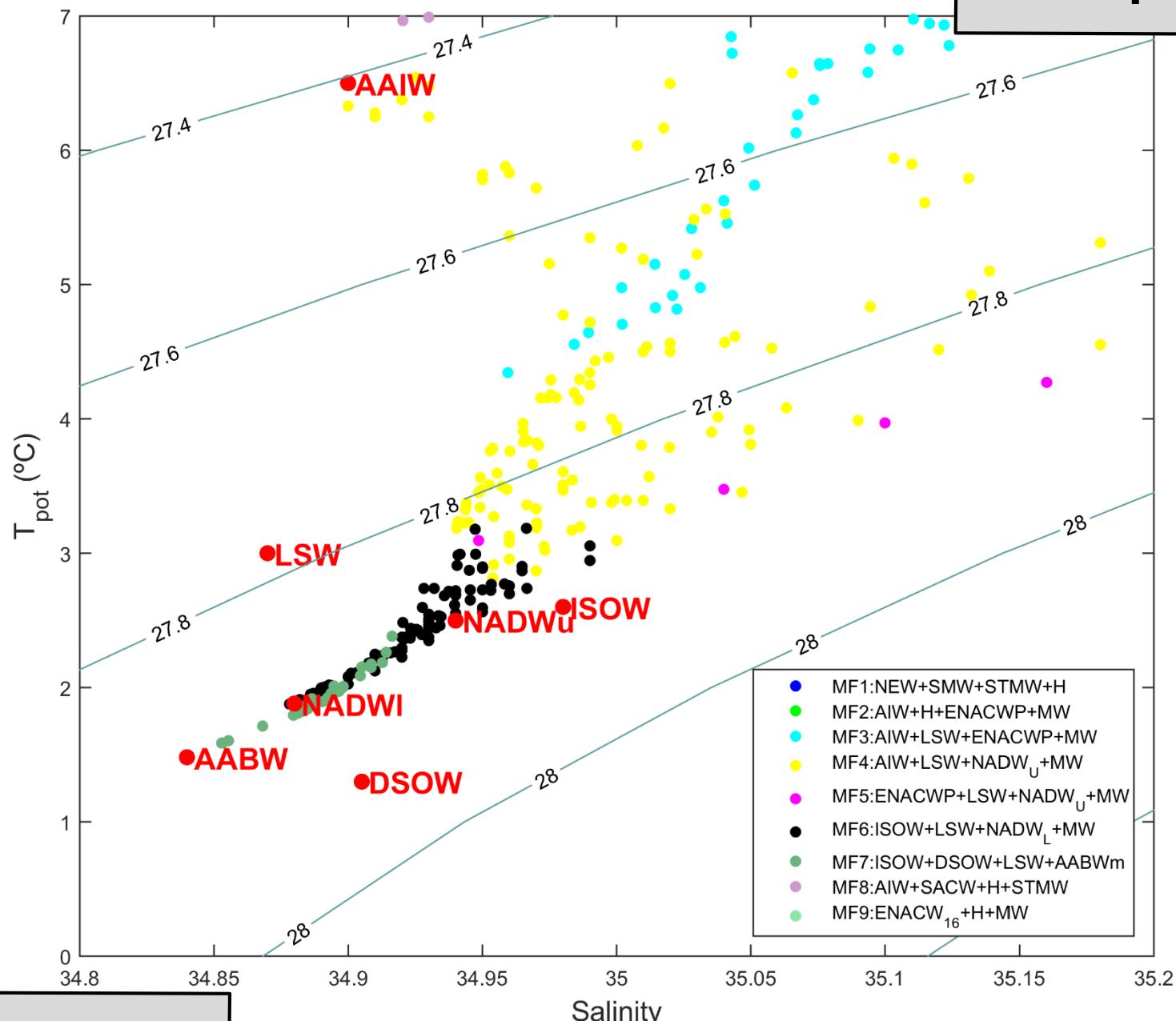
Posibles figuras de mezcla			
NEW	SMW	STMW	H
AAIW	H	ENACWP	MW
AAIW	LSW	ENACWP	MW
AAIW	LSW	NADWu	MW
ENACWP	LSW	NADWu	MW
ISOW	LSW	NADWI	MW
ISOW	DSOW	LSW	AABW
AAIW	SACW	STMW	H
ENACW16	H	MW	NOSWT

Tabla de propiedades de las SWT									
wm	Tpot	Sal	SiO4	NO3	PO4	O2	Alk	Ct	O20
AABWm	1.48	34.84	66.5	24.2	1.67	240	2352	2202	240
DSOW	1.3	34.905	8	10.4	0.7	315	2310	2200	305
NADWI	1.88	34.88	48.5	21.9	1.5	242	2349	2203	242
LSW	3	34.87	7.8	15.8	1.07	285	2301	2118	295
ISOW	2.6	34.98	9	15.4	1.09	280	2290	2099	295
NADWu	2.5	34.94	30	18.8	1.31	258	2327	2160	258
MW	11.7	36.5	7.7	10.3	0.62	209	2411	2151	209
AA	6.5	34.9	21.2	33	2.15	102	2315	2210	120
ENACWP	8	35.23	11	18	1.1	200	2320	2112	200
H	12.2	35.6	4.4	12.4	0.74	200	2338	2107	210
STMW	17.5	36.5	0	2	0	200	2386	2112	200
NEW	24	36.07	1	1	0.02	200	2395	2076	190
SMW	22.5	37.3	0	0	0	205	2442	2110	180
SACW	15	35.55	4.8	24.2	1.44	65	2322	2221	60
ENACW16	16	36.2	0.5	3	0.25	220	2320	2112	221

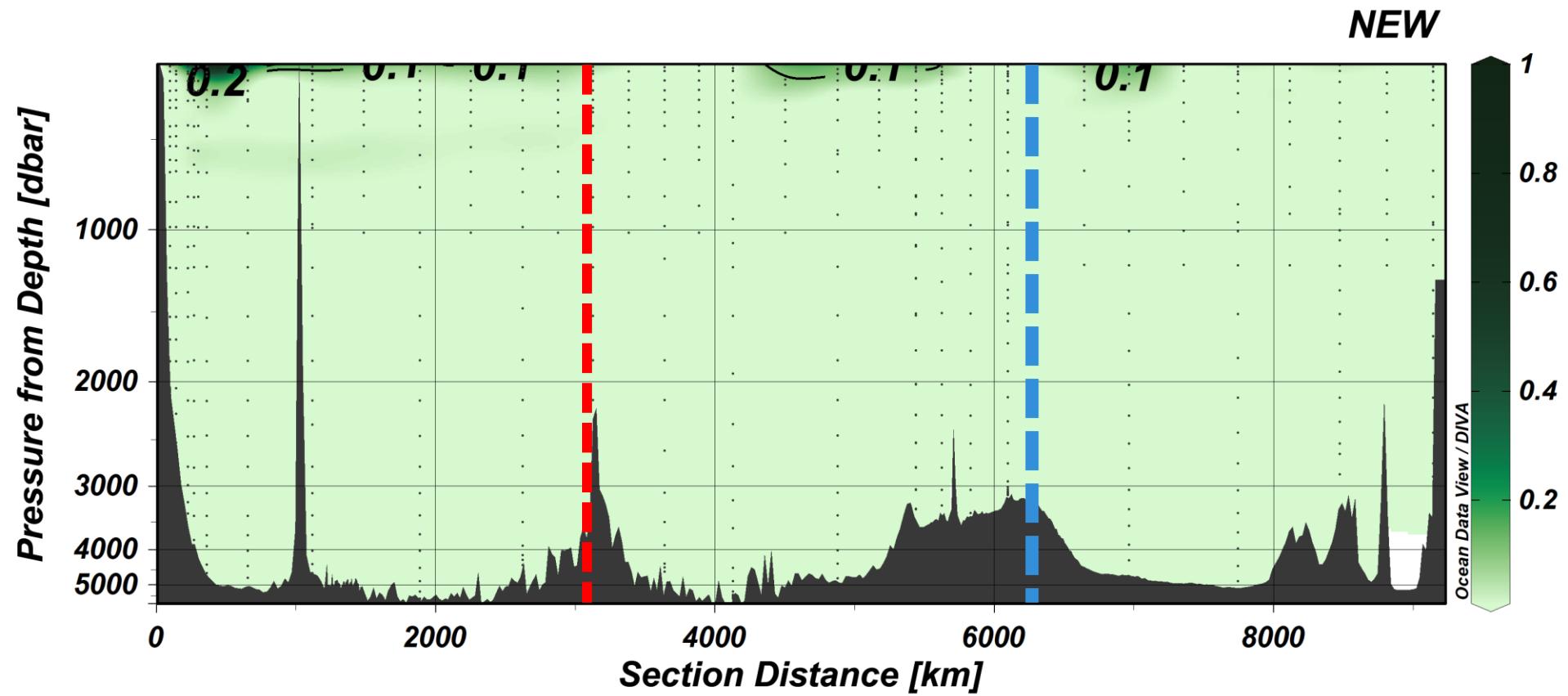
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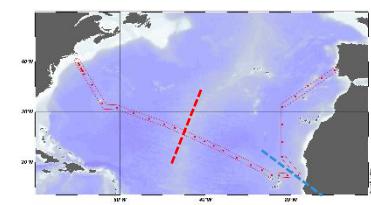
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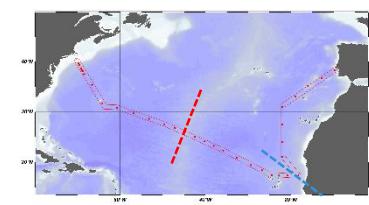
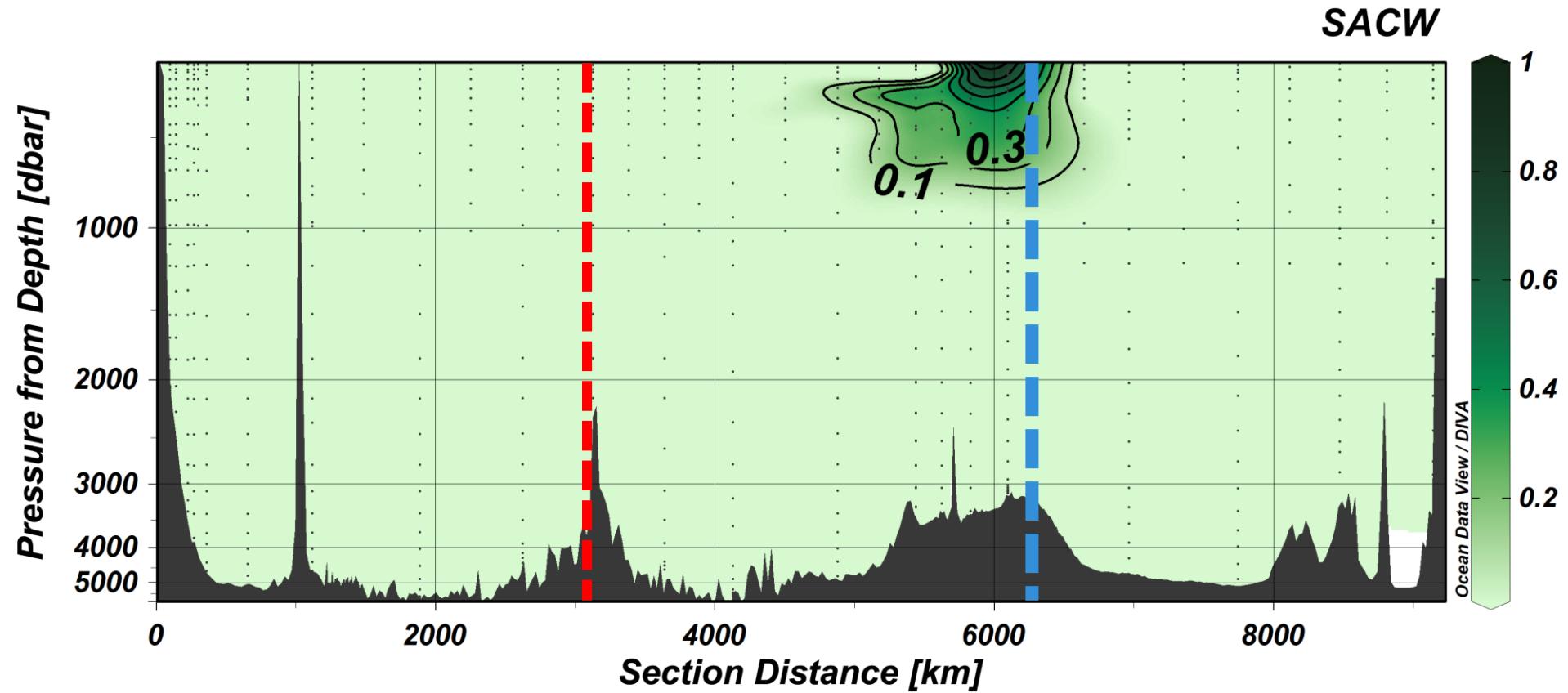
## Resultados OMP



*Marcos Fontela, 2019*

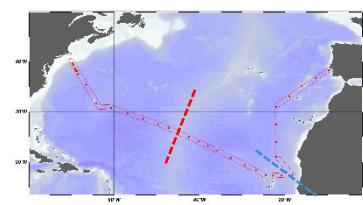
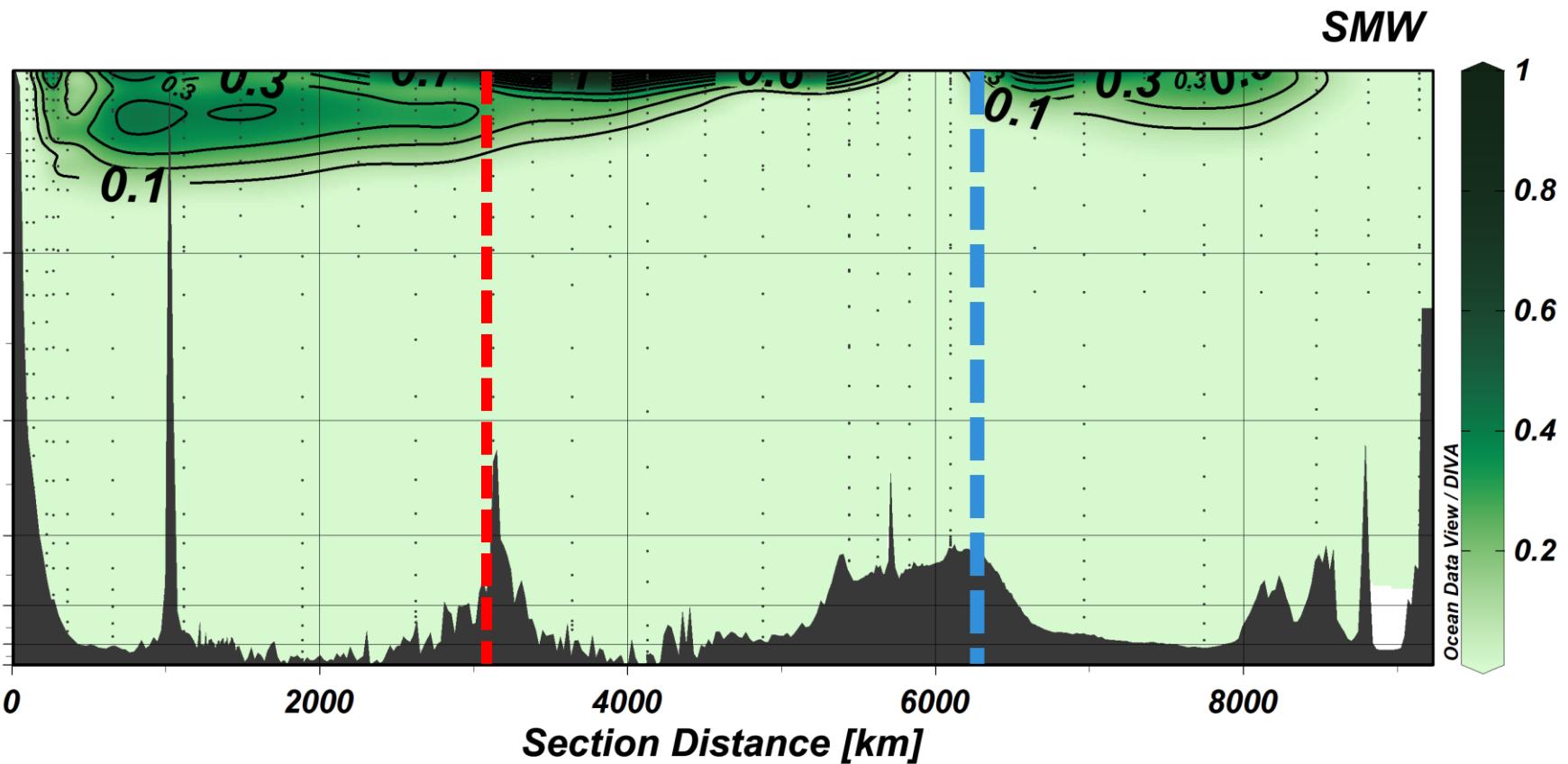


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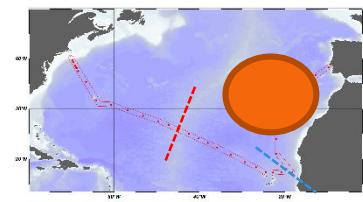
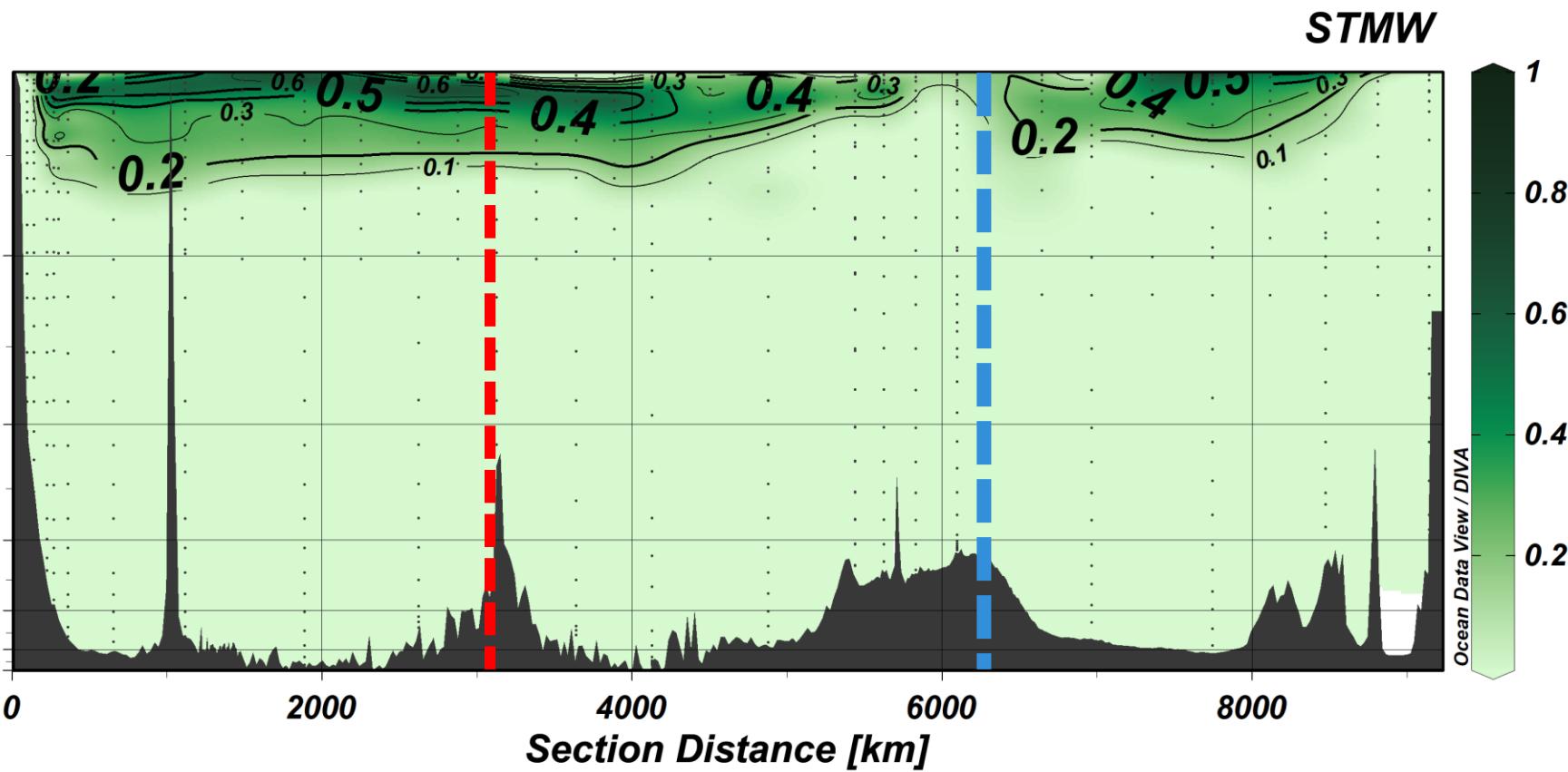


# Resultados OMP

Pressure from Depth [dbar]



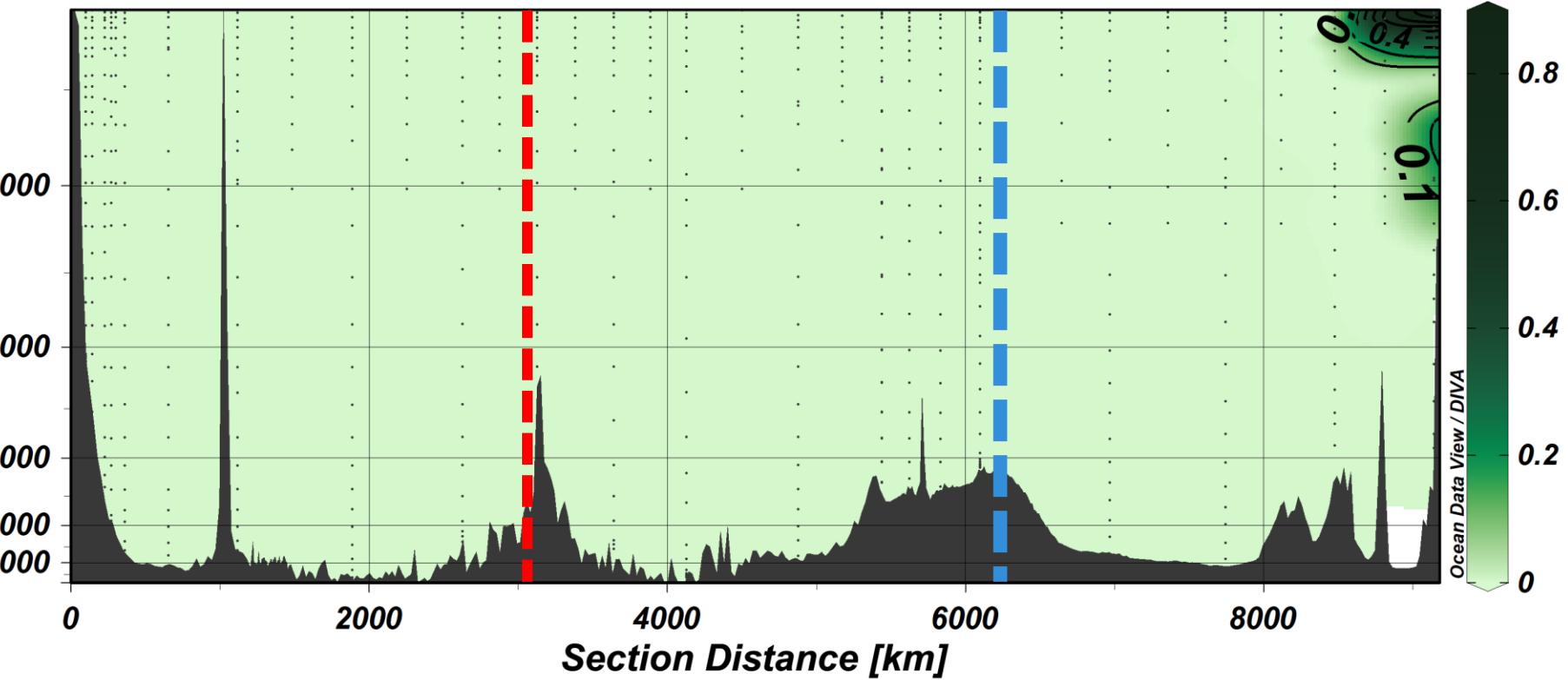
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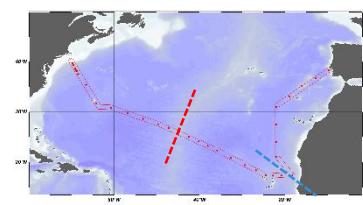
# Resultados OMP

ENACW16

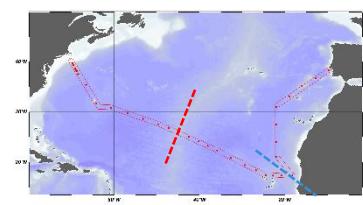
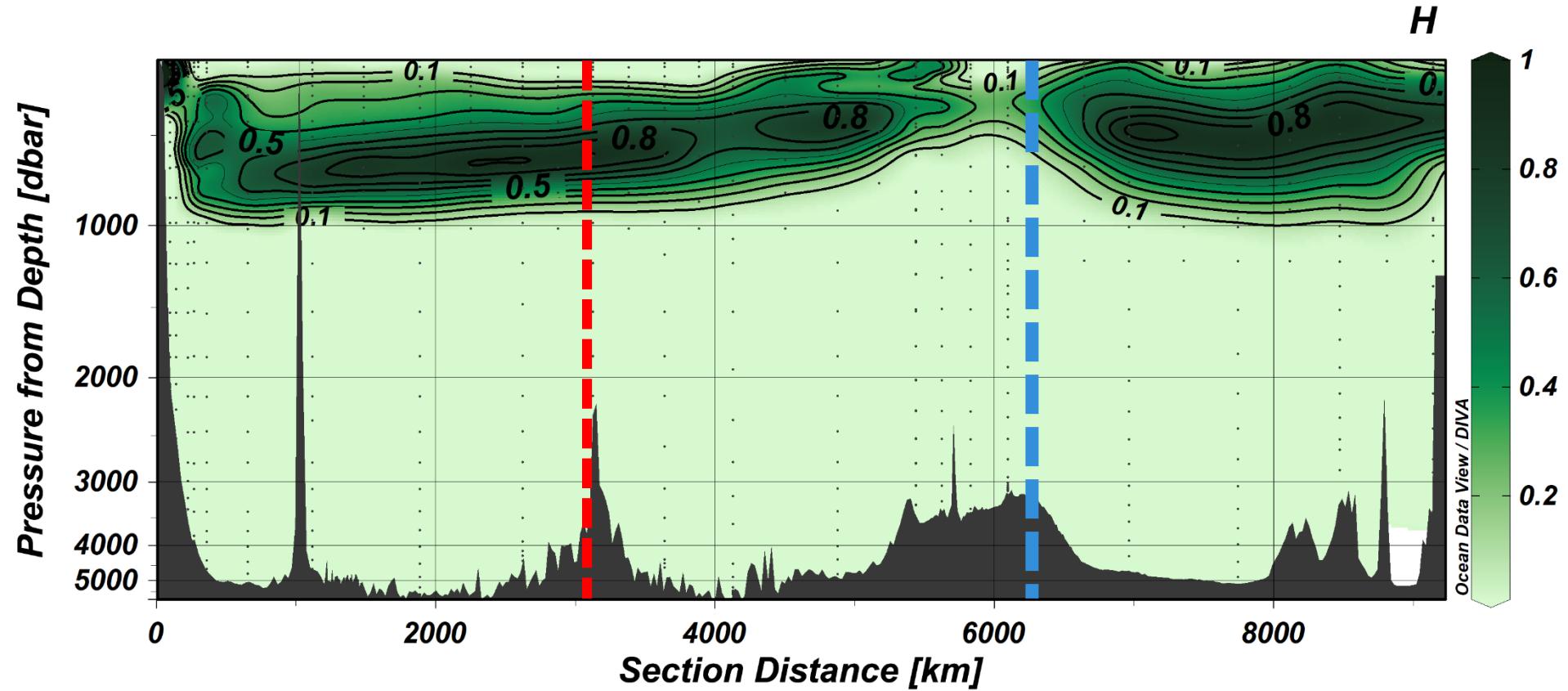
Pressure from Depth [dbar]



Ocean Data View / DIVA

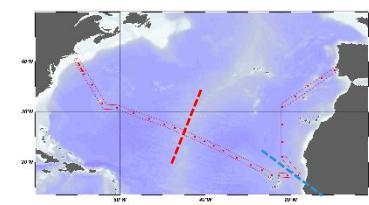
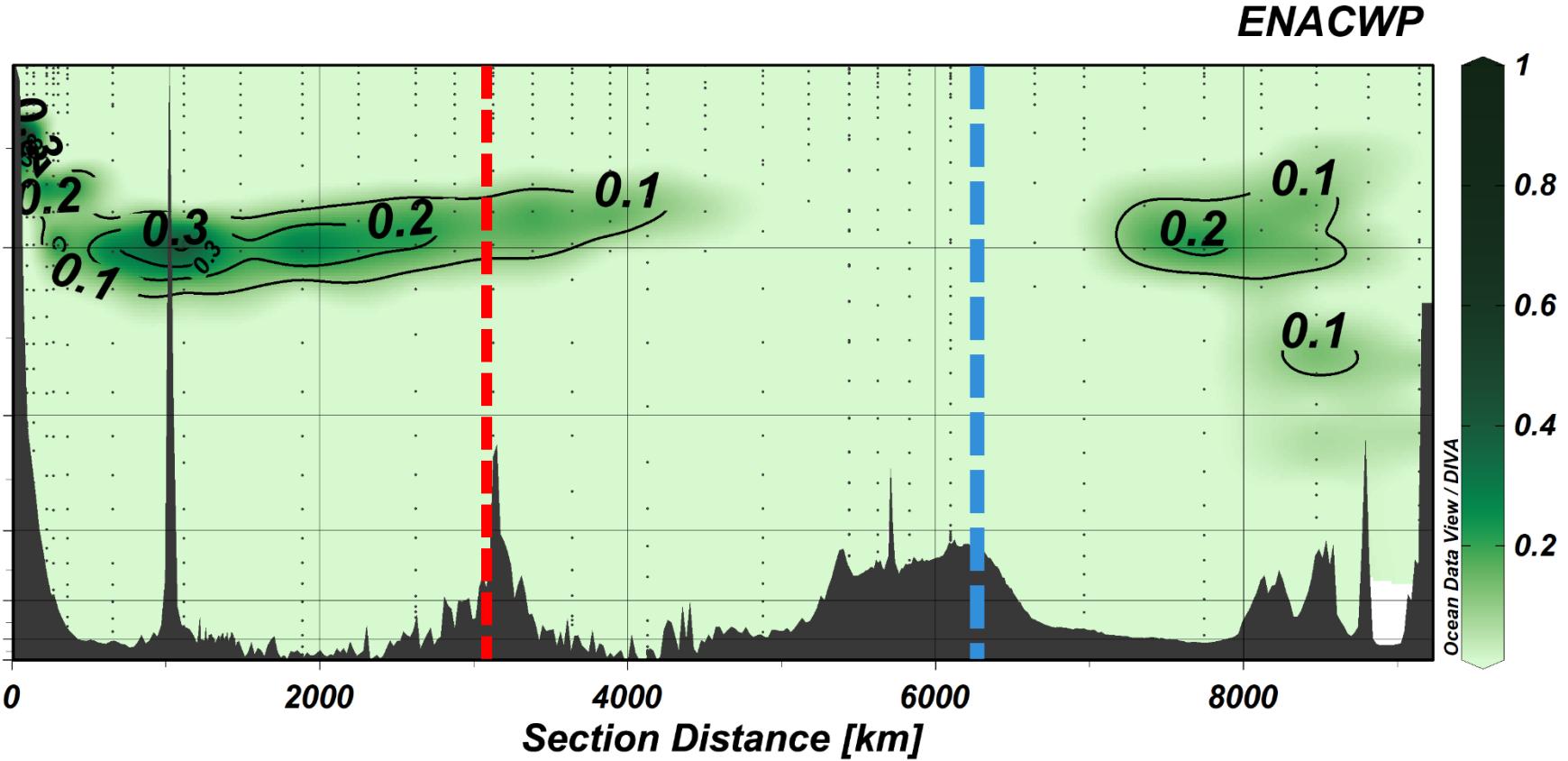


# Resultados OMP

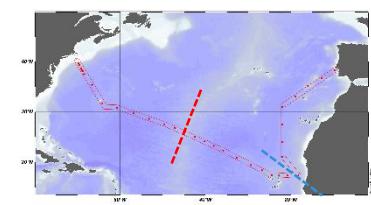
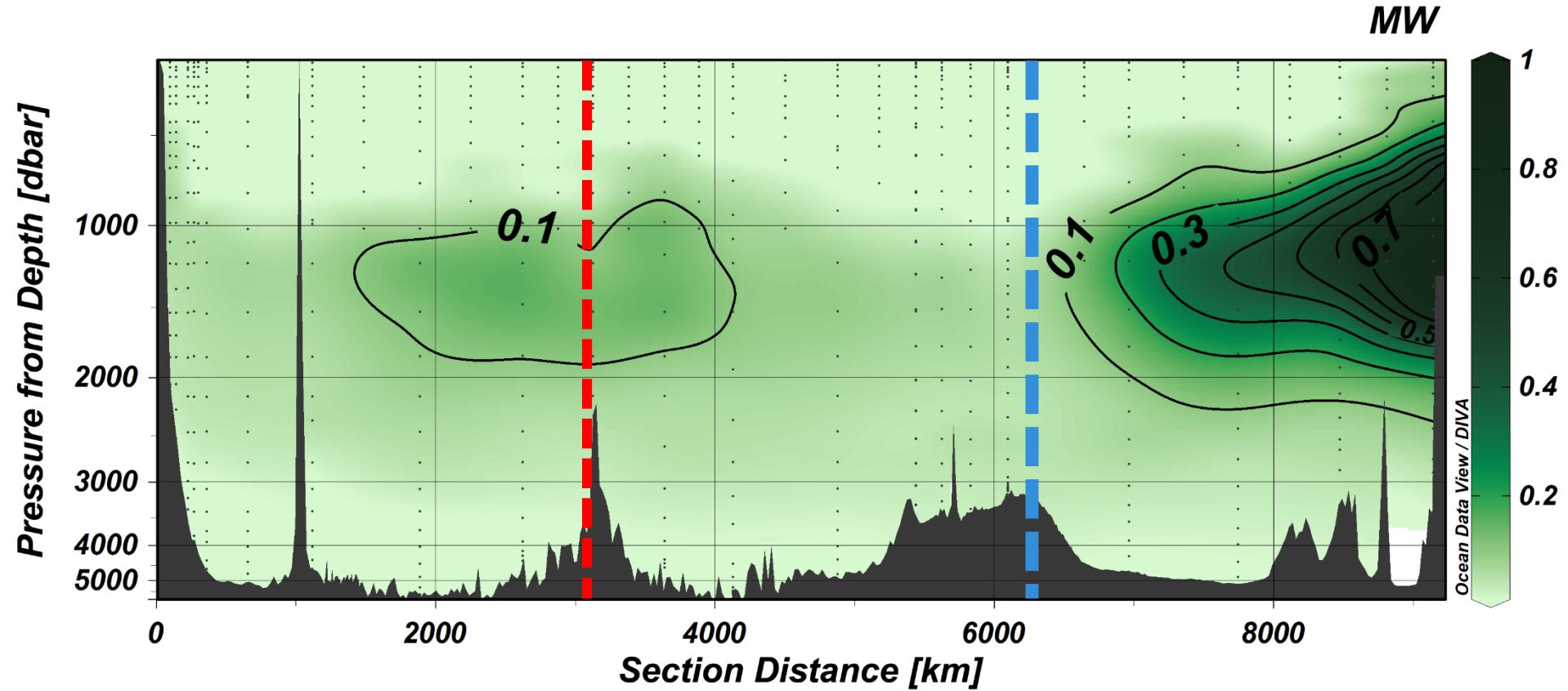


# Resultados OMP

Pressure from Depth [dbar]

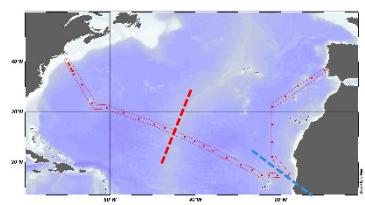
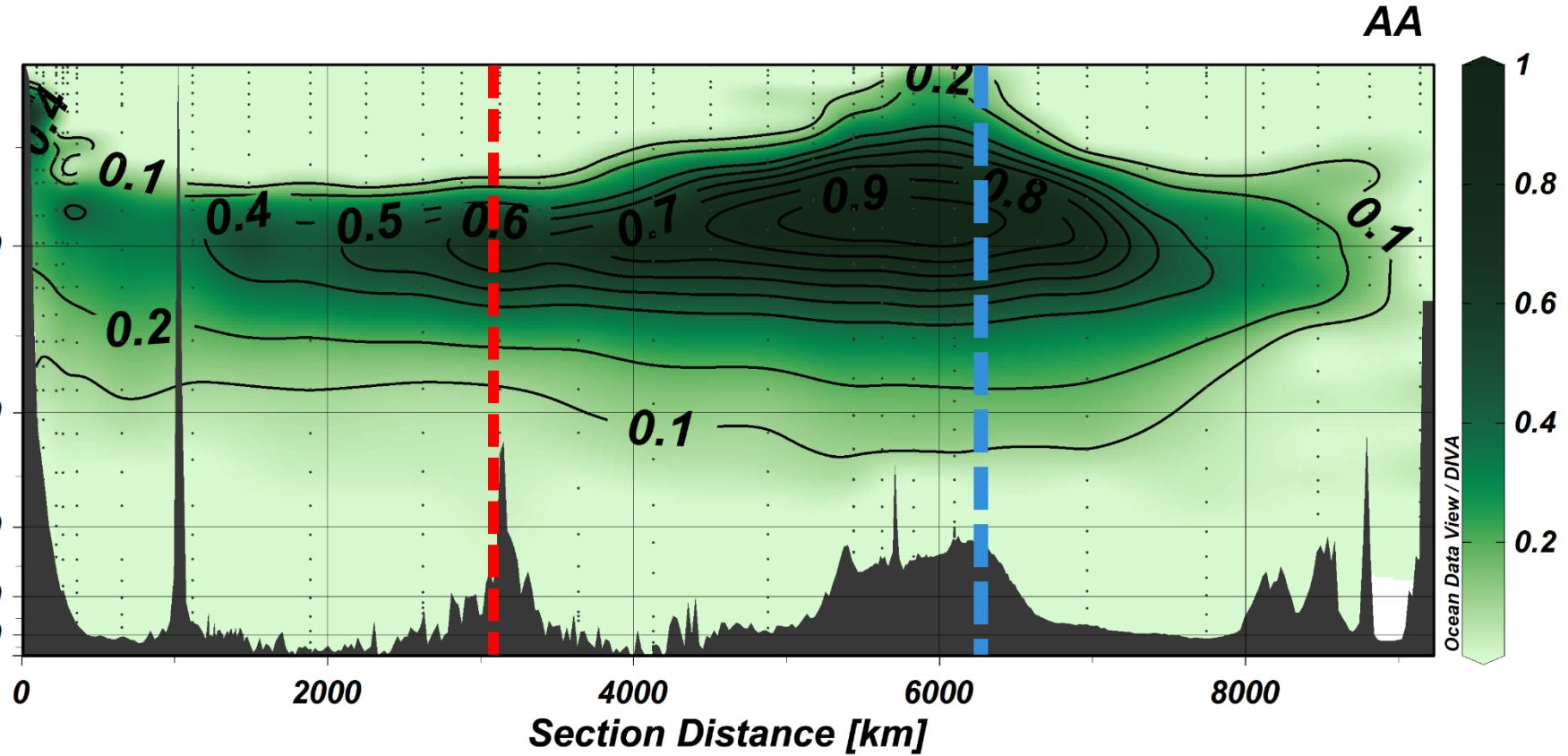


# Resultados OMP



# Resultados OMP

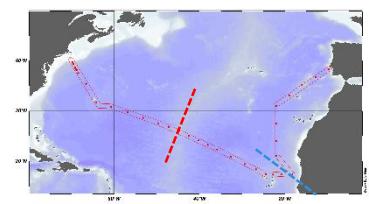
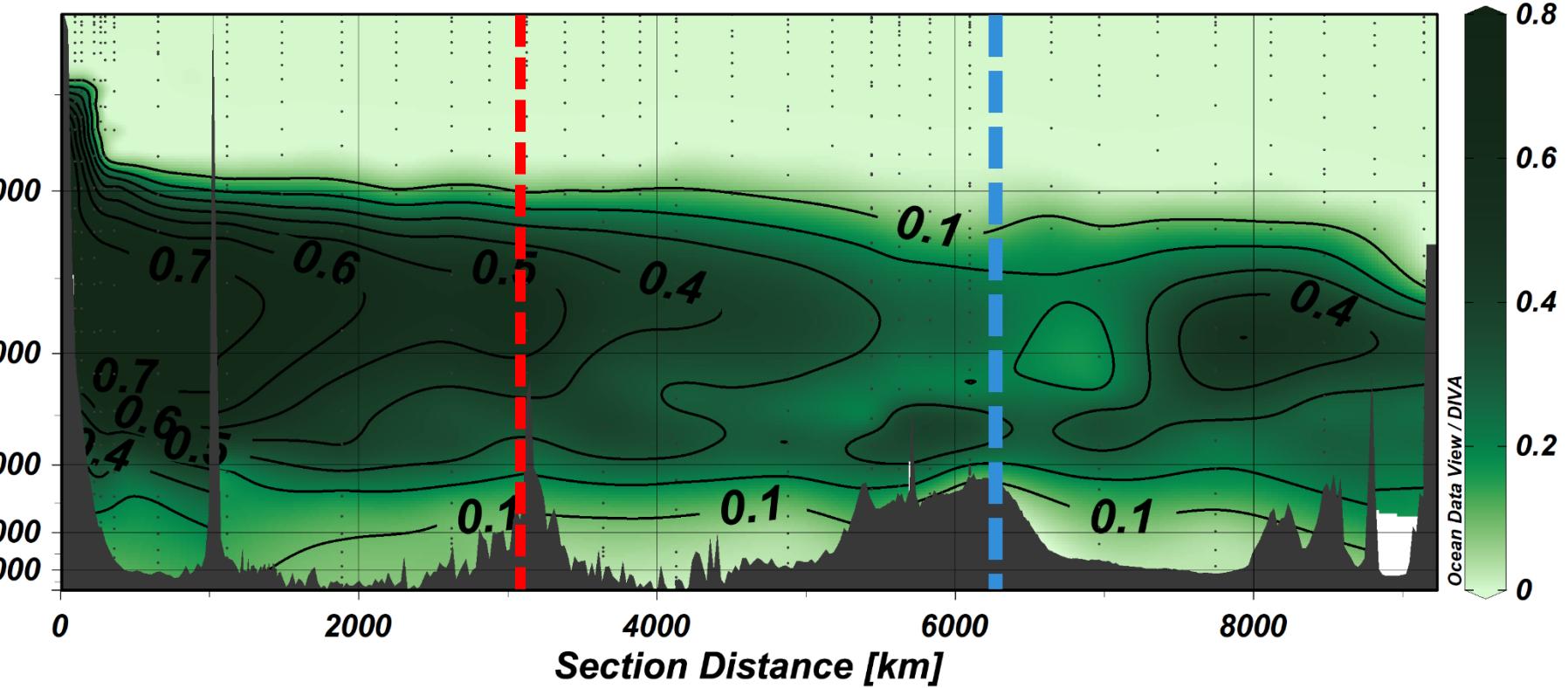
Pressure from Depth [dbar]



# Resultados OMP

LSW

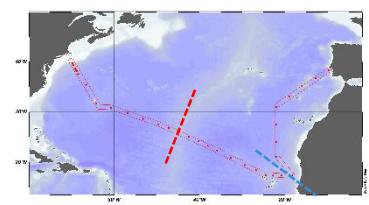
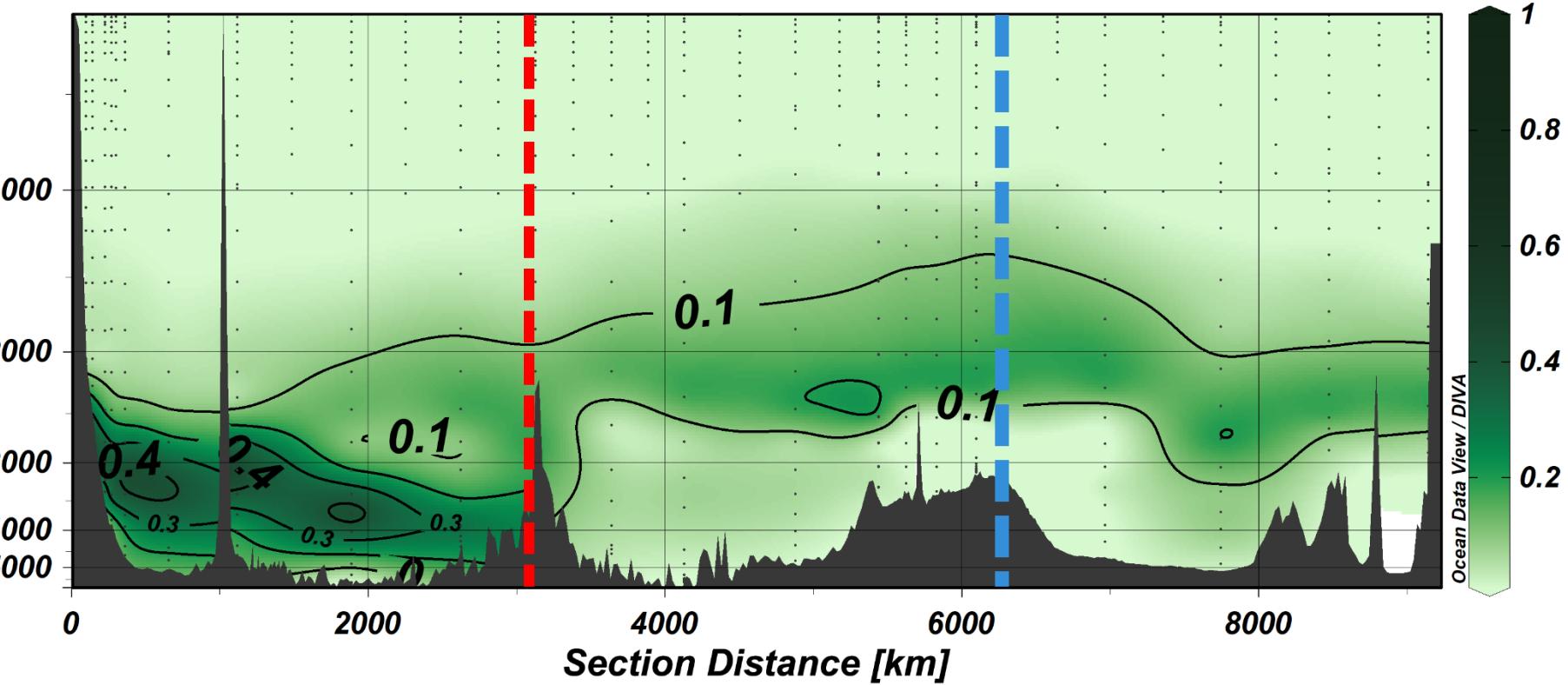
Pressure from Depth [dbar]



# Resultados OMP

ISOW

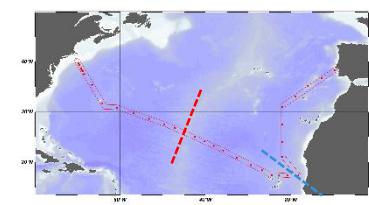
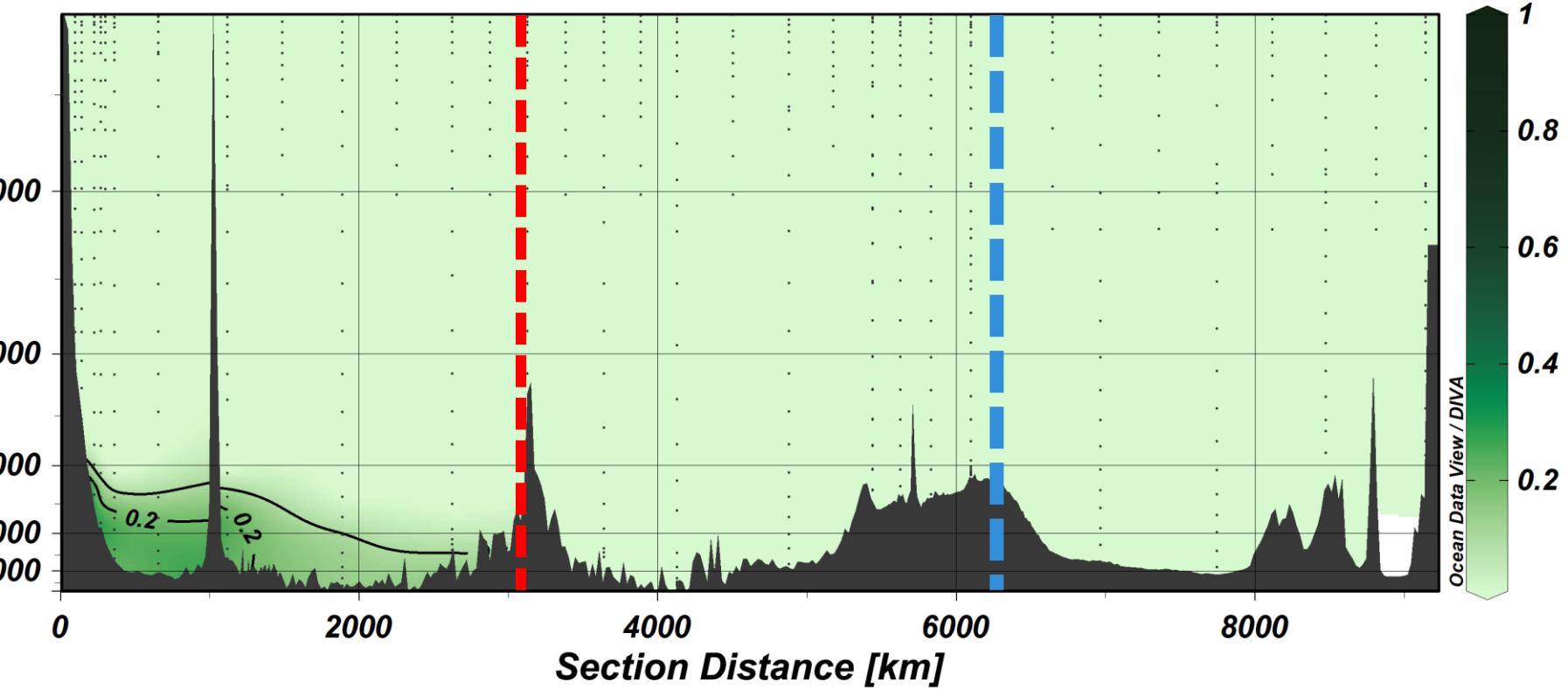
Pressure from Depth [dbar]



# Resultados OMP

DSOW

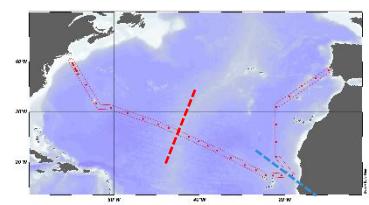
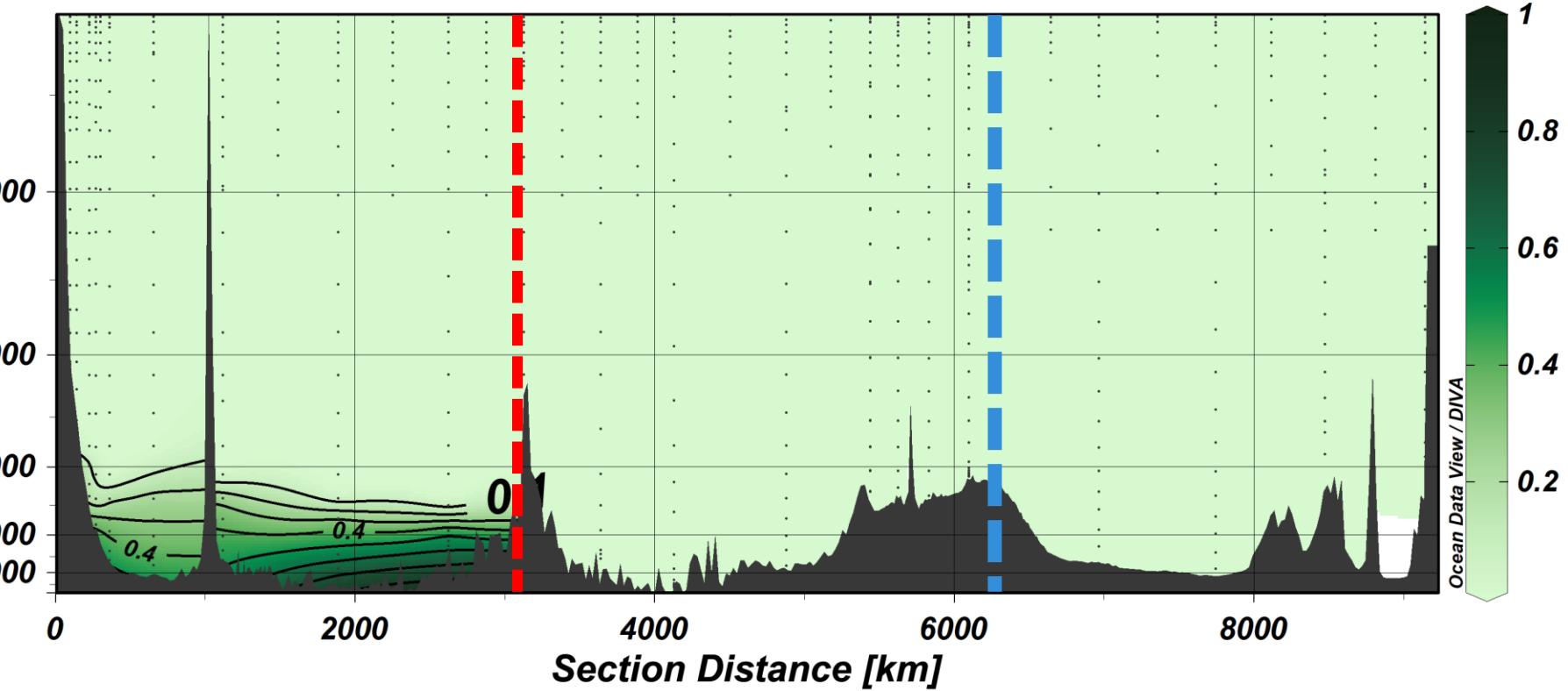
Pressure from Depth [dbar]



# Resultados OMP

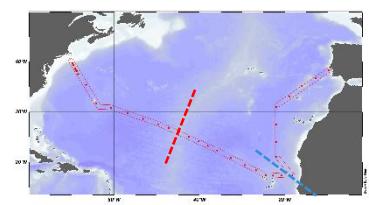
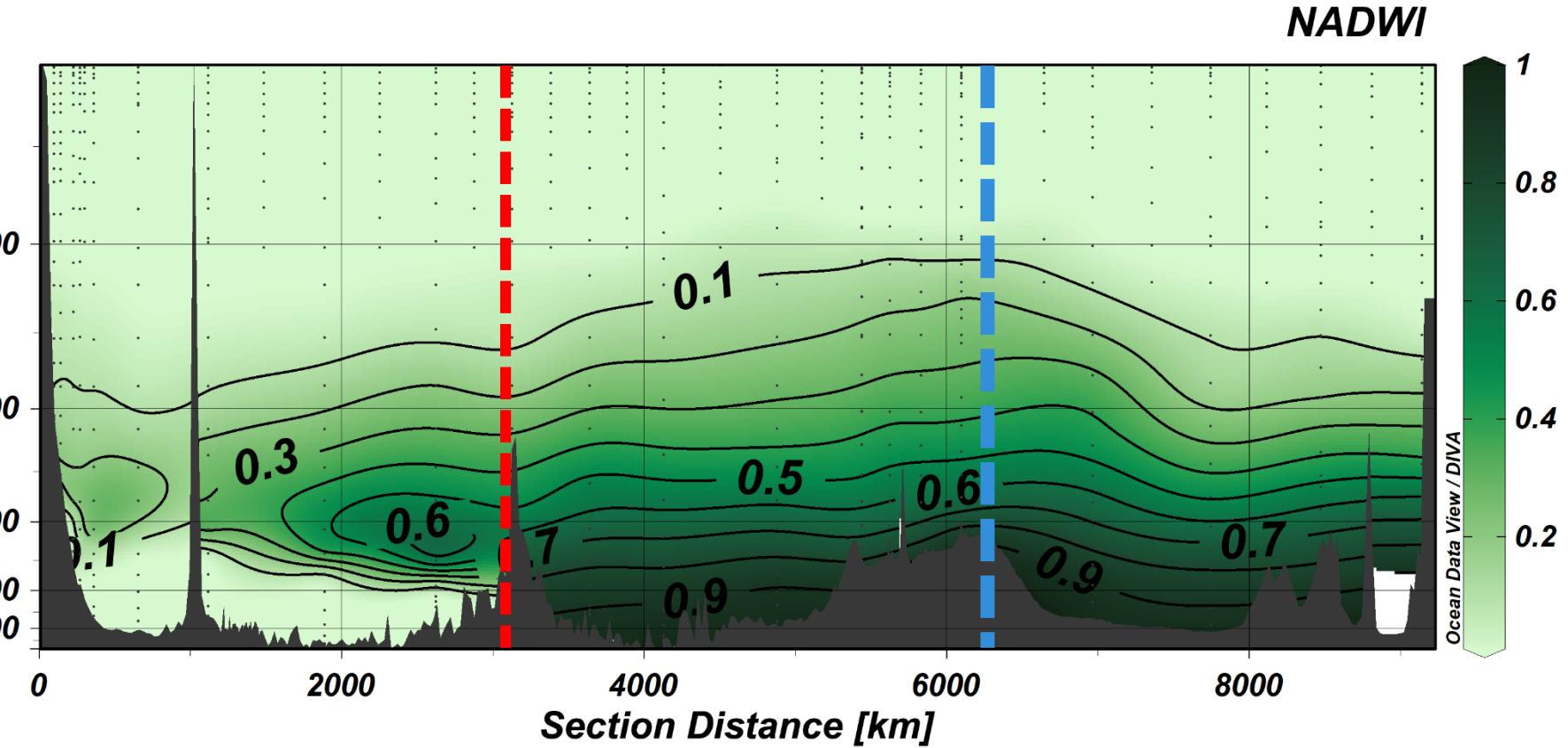
AABW

Pressure from Depth [dbar]



# Resultados OMP

Pressure from Depth [dbar]



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