Sulfidic Events in a Shallow Bay of the Central Peruvian Upwelling System

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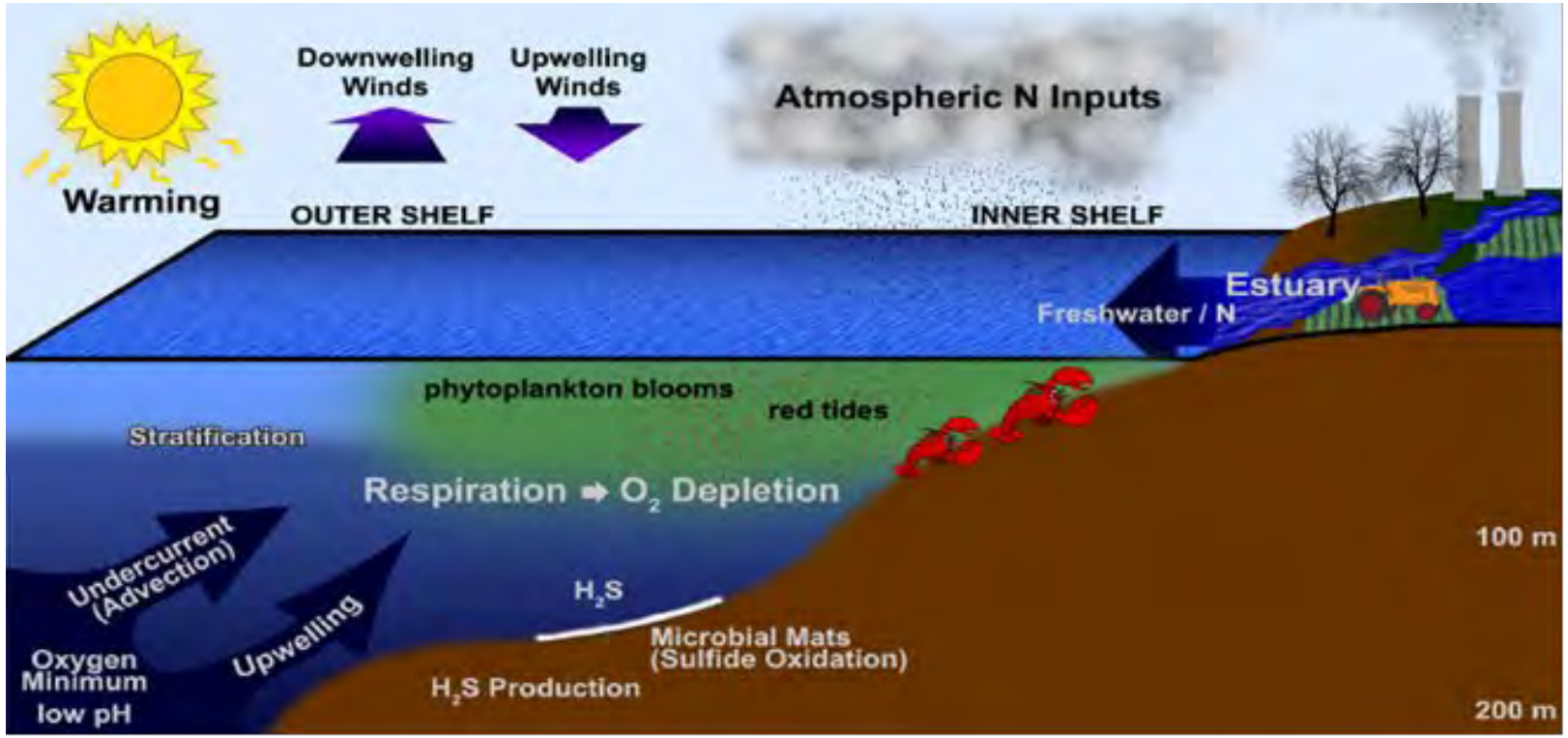
FRANCE

PALEO TRACES

Leibniz-Institut für Ostseeforschung Warnemünde

Gracias...

SULFATE REDUCTION

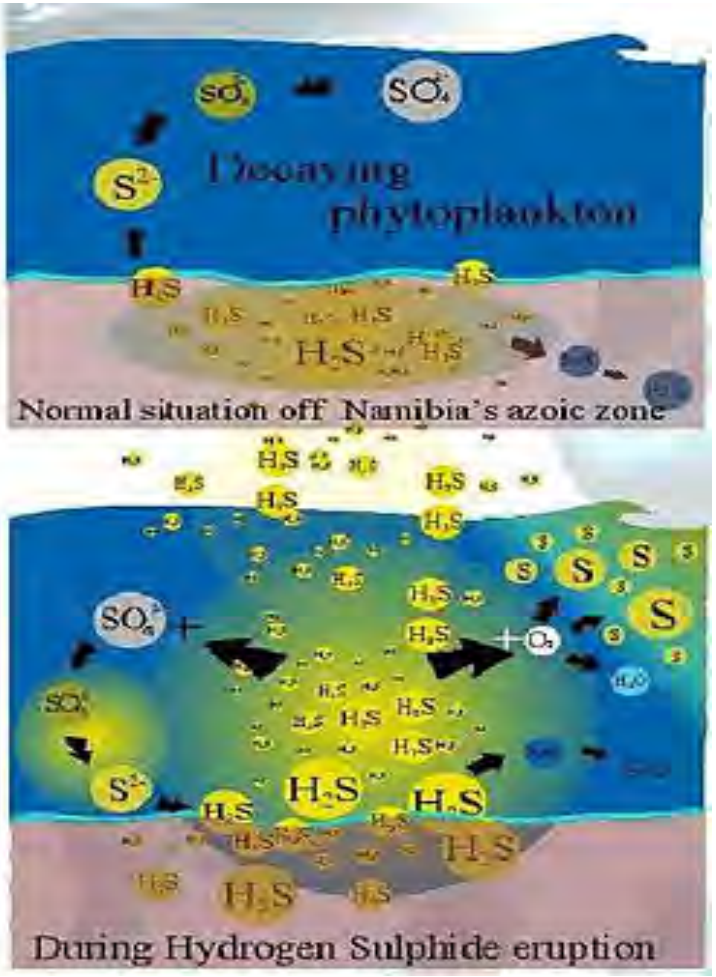


Levin et al., 2009

11% of the liquid primary production is decomposed by sulfate reduction at the top sediments (10 cm).

Jorgensen 1982

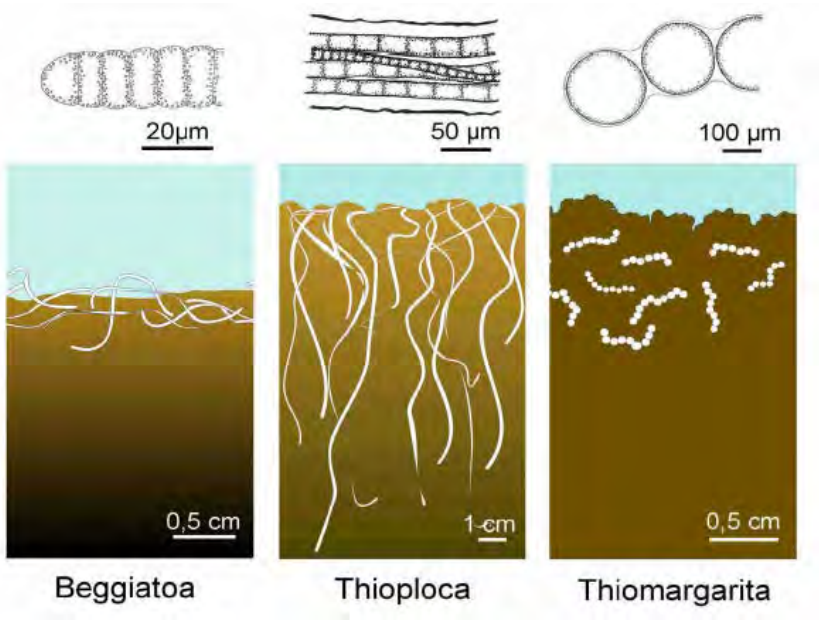
CRIPTIC SULFUR CYCLE



NO_3^- and NO_2^- to NH_4^+ Reduction ⟶ **Oxidation H2S** to **SO_4^{2-}** via **elemental sulphur (S_0)**
Steady-State prevent H2S accumulation

Inorganic carbon rich sediments with high rates of microbial sulphate reduction and underlying **oxygen-depleted** bottom waters, DNRA is an important **sulphide detoxifying mechanism** and coupling the **benthic and pelagic sulphur and nitrogen cycles**.

DNRA in Peruvian sediments:
Filamentous and **nitrate-storing Sulphur oxidizing chemolithotrophs** from genera *Beggiatoa* and *Thioploca*.



Jørgensen & Nelson,2004

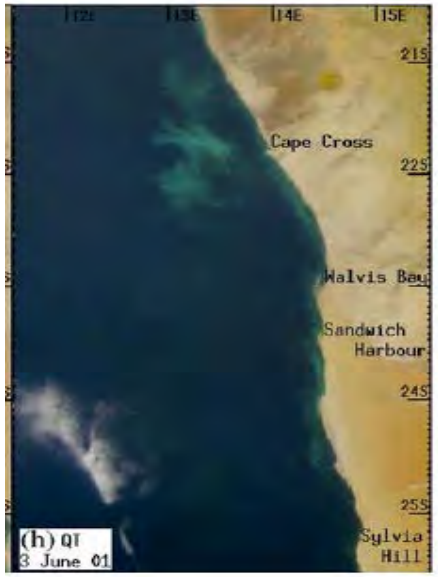
Pieterse & van der Post, 1967.

Reports a “water mass discoloration" attribute to a turquoise discoloration, product of the hydrogen sulfide oxidation and coloidal elemental sulfur formation.

Copenhague et al.,	1953 South Africa
Hart & Currie,	1960 South Africa
Pieterse y van der Post,	1967 South Africa
Bailey et al.,	1991 South Africa
Ferdelman et al.,	1999 South Africa
Emeis et al.,	2000 South Africa
Weeks et al.,	2004 South Africa
Brüchert et al.,	2006 South Africa
Ulloa et al.,	2012 Chile & Peru
Aguirre et al.,	2012 Peru
Shunck et al.,	2013 Peru
Flores et al.	**Present Study**

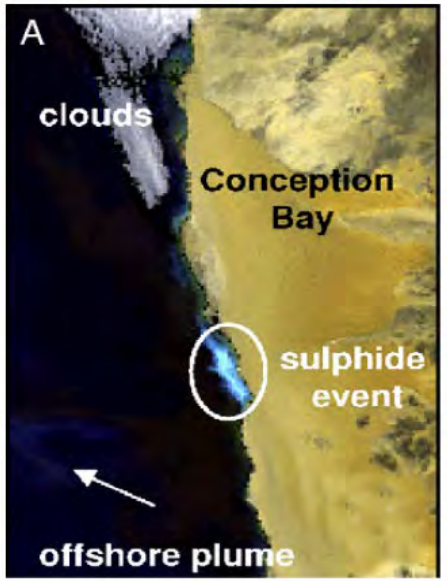
SULFUR PLUMES - NAMIBIA COAST

SeaWiFS-May-jun, 2001



Weeks et al., 2004

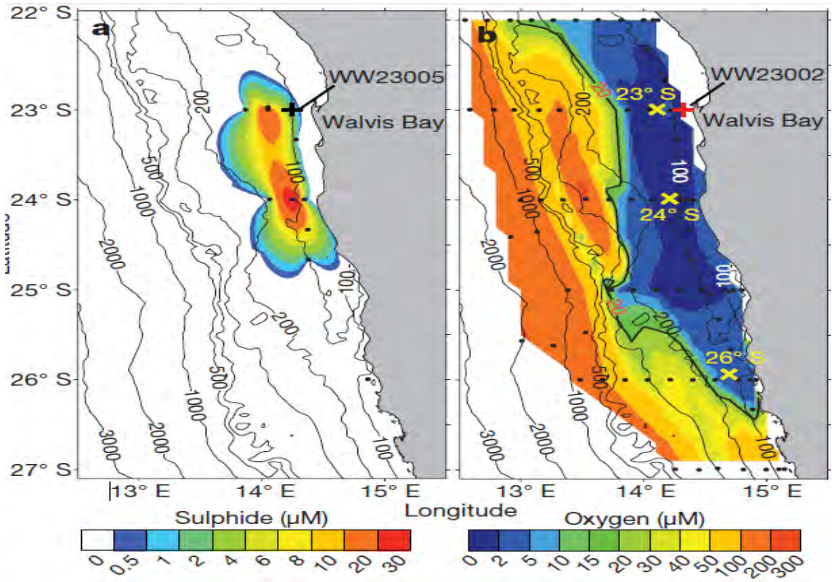
MERIS - 10April-2004



Ohde *et al.*, 2004

EVENT-2005

Currie *et al.*, 2008



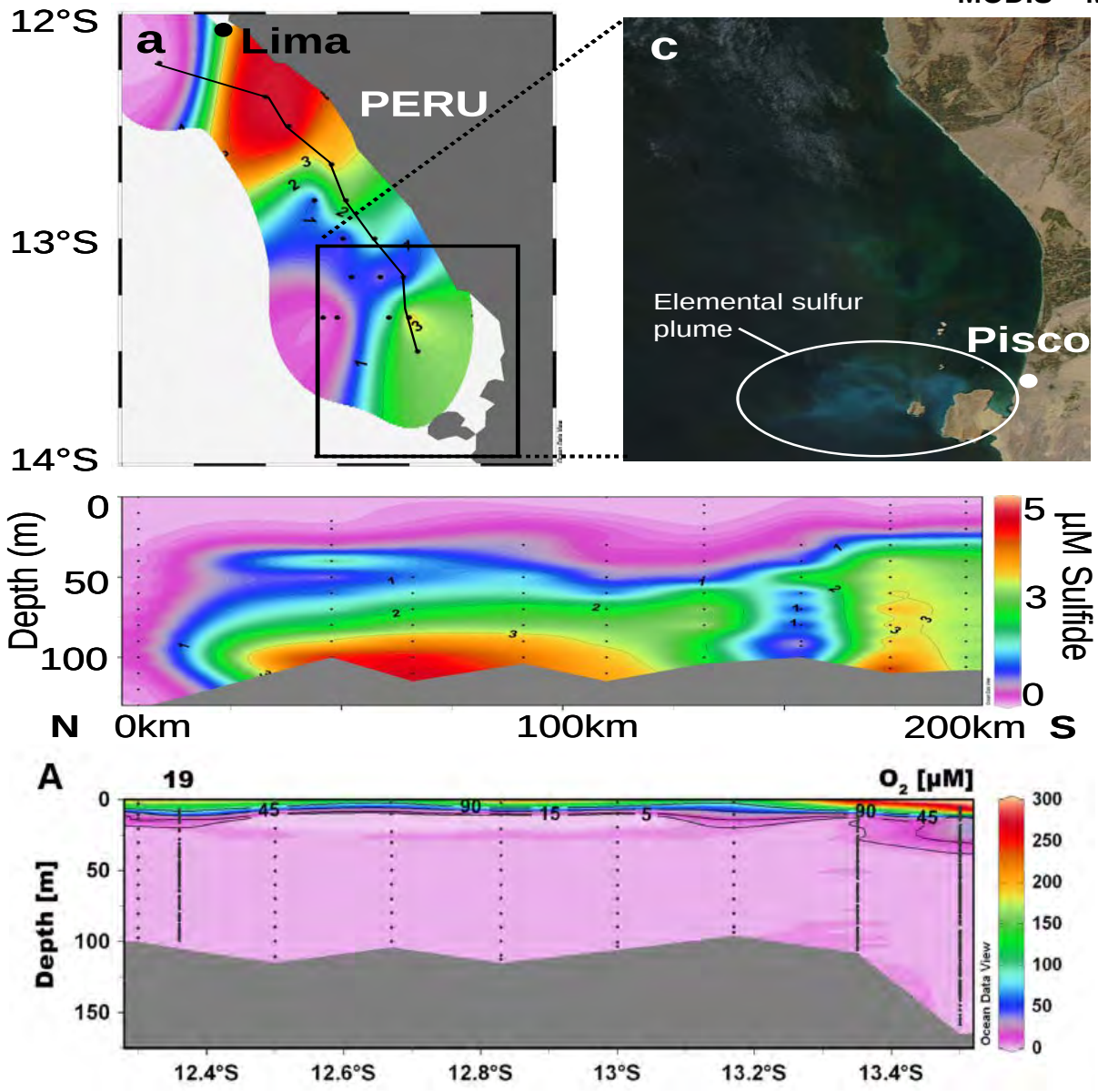
Gaute Lavik et al., 2008

SULFUR PLUMES - PERUVIAN COAST

MODIS – 12-14 April-2004

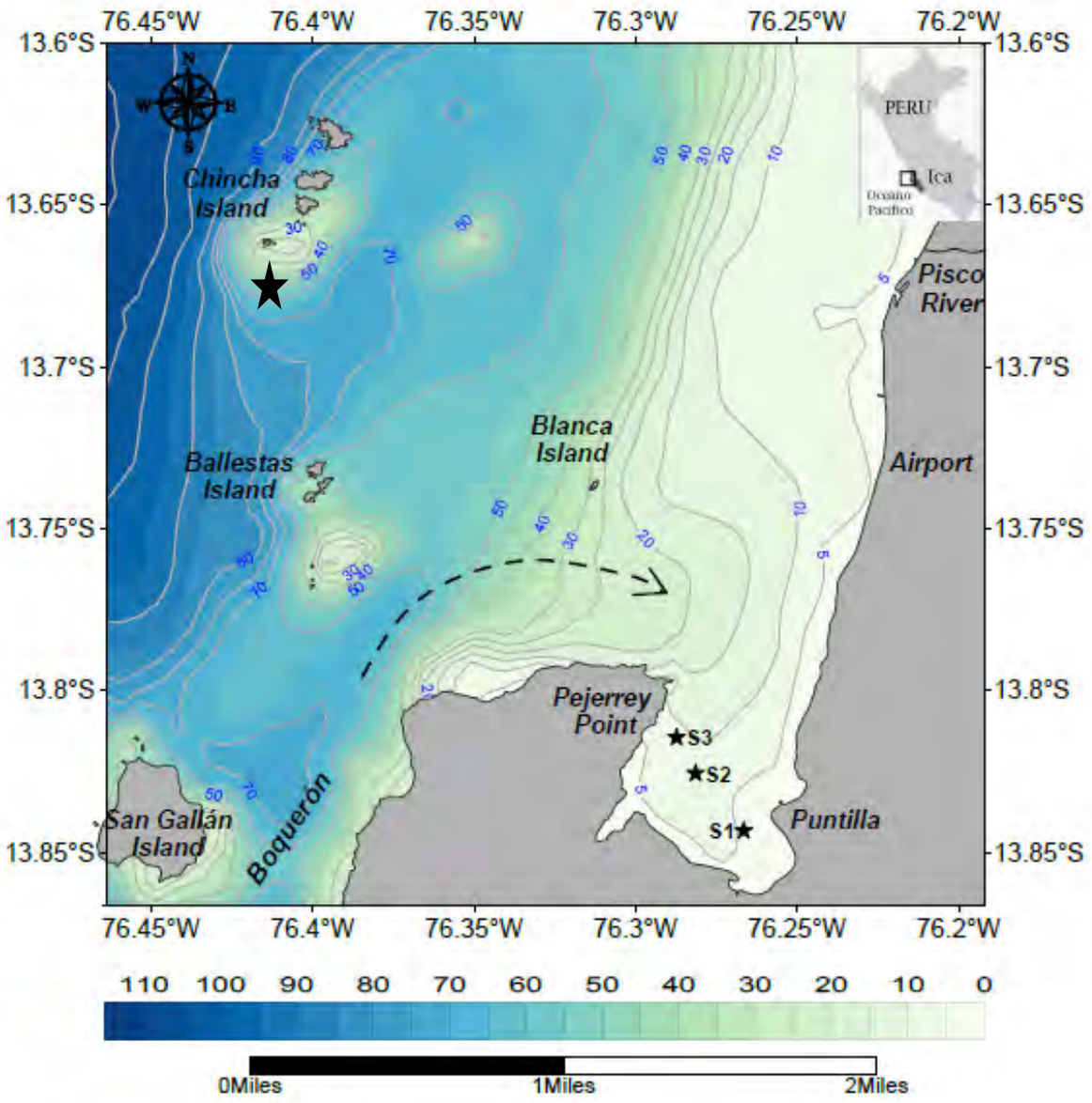
Karhu et al., 2004

MODIS – Mai-2009



Schunk et al., 2013

PARACAS BAY


76.45°W
76.4°W
76.35°W
76.3°W
76.25°W
76.2°W
13.6°S
13.65°S
13.7°S
13.75°S
13.8°S
13.85°S
N
W
E
S
PERU
Ica
Océano Pacífico
Chincha Island
Ballestas Island
Blanca Island
Pisco River
Airport
Pejerrey Point
S3
S2
S1
Puntilla
San Gallán Island
Boquerón
110 100 90 80 70 60 50 40 30 20 10 0
0Miles
1Miles
2Miles

SULFIDIC EVENTS DURING EL NIÑO EVENT 2015

Intense
Sulfidic Event

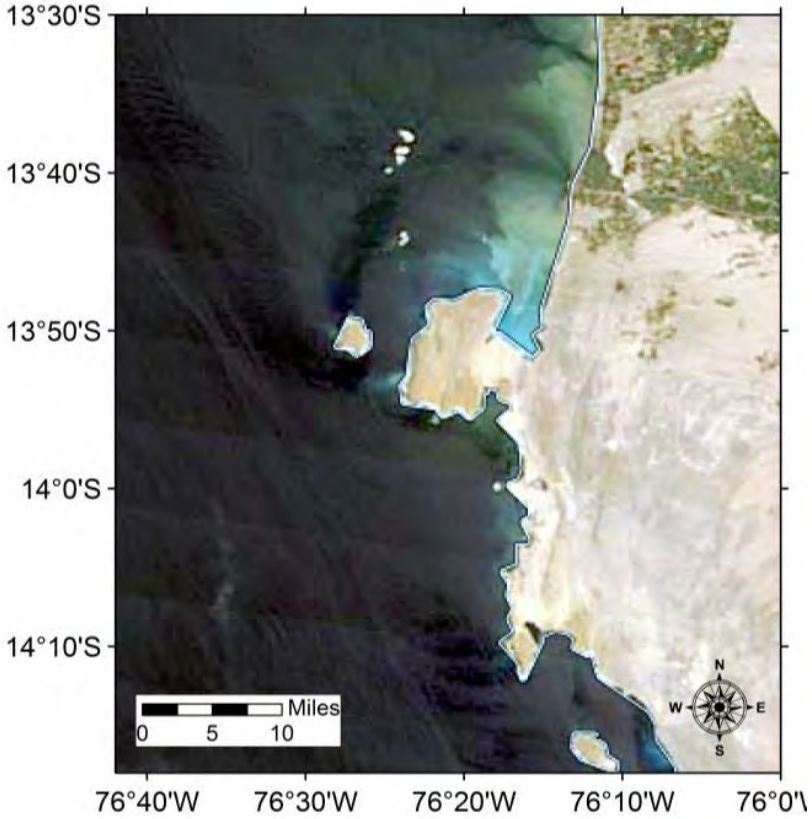
23 – 31 March
Massive fisheries mortality

3-month time series
11 April – 07 June

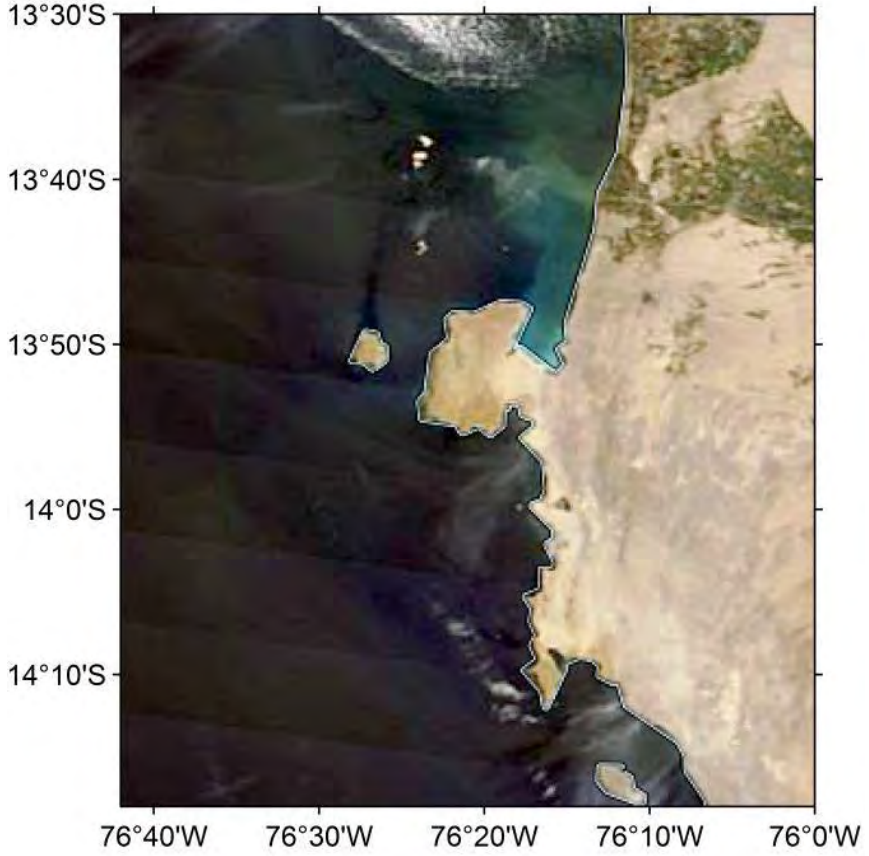
Short-term
Sulfidic Event

18 April

Intense
Sulfidic Event

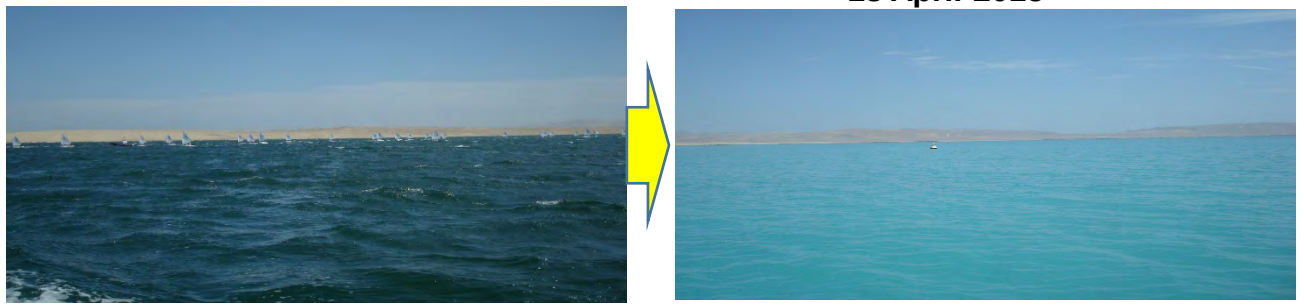


Short-term
Sulfidic Event



18 April-2015

Normal Conditions



Sulfidic Event

MODIS – March 2017

MONTHLY ASCAT WINDS VARIATION (January-September 2015)

Summer

Minimal: 0,26 m/s
Maimal: 7,31 m/s
Mean: 3,89 m/s

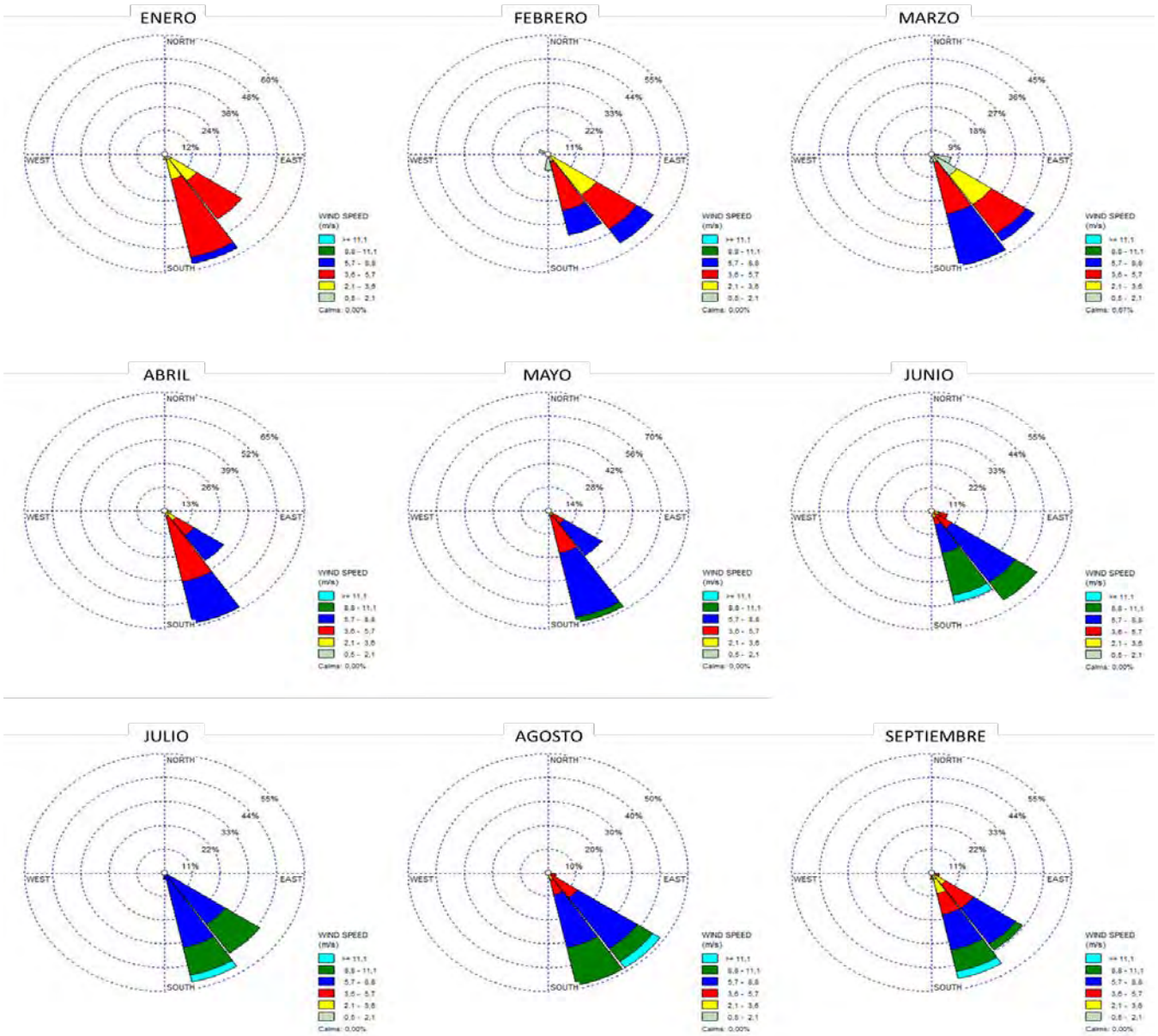
4 calm days (16 al 19-03) <0,5 m/s

Spring

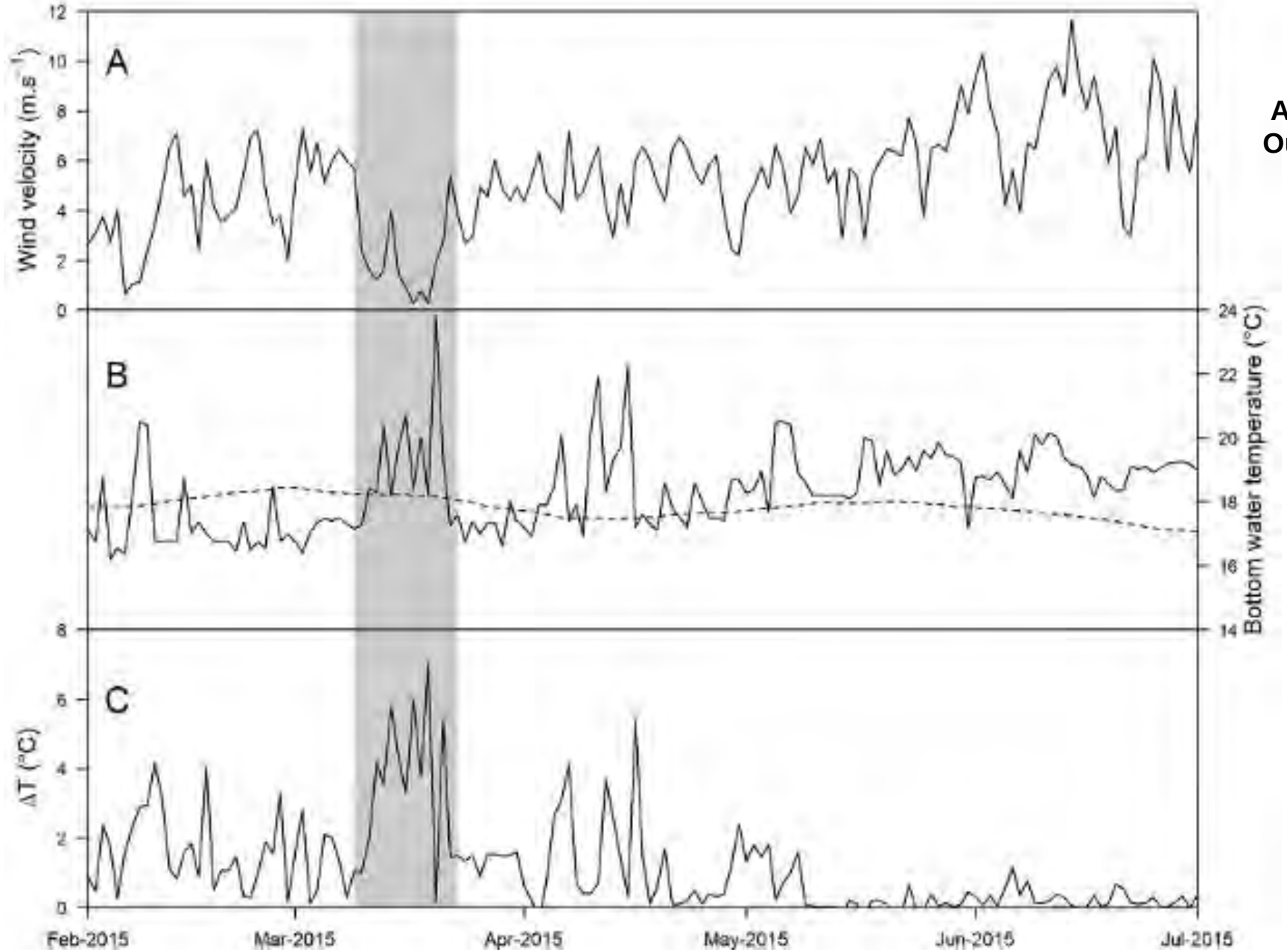
Minimal: 0,22 m/s
Maximal: 11,66 m/s
Mean: 5,85 m/s

IWinter

Minimal:0,47 m/s
Maximal de12,50 m/s
Mean: 6,95 m/s



MONTHLY WINDS AND TEMPERATURE VARIATION (February-July 2015)

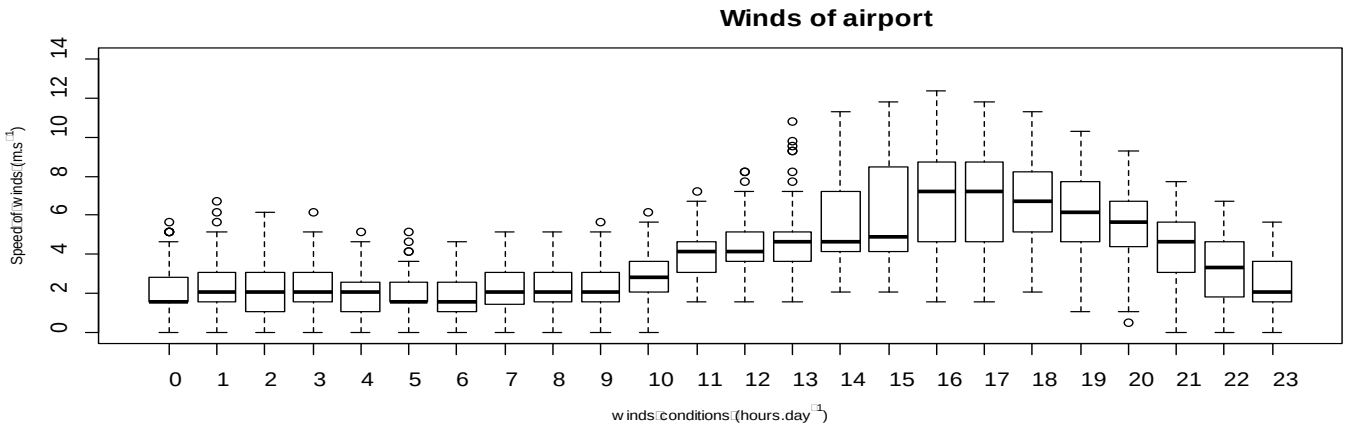


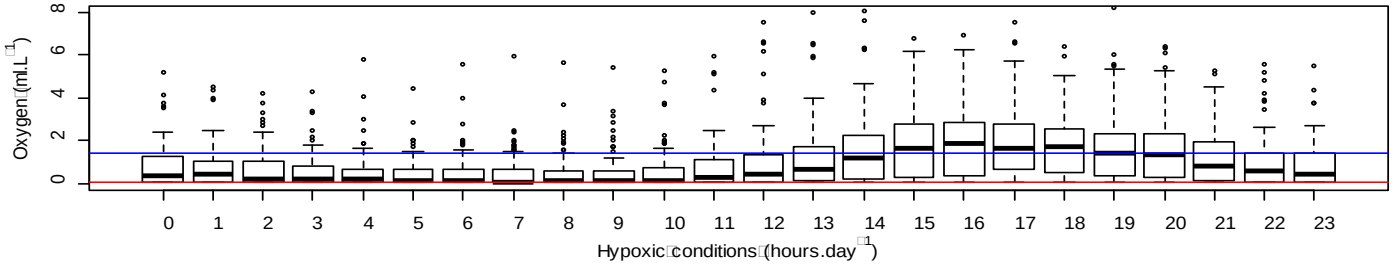
ASCAT Satélite Winds Outside de Bay

Inside de Bay

Inner-Bay

Correlation
Temp vs. O_2 = 0.56

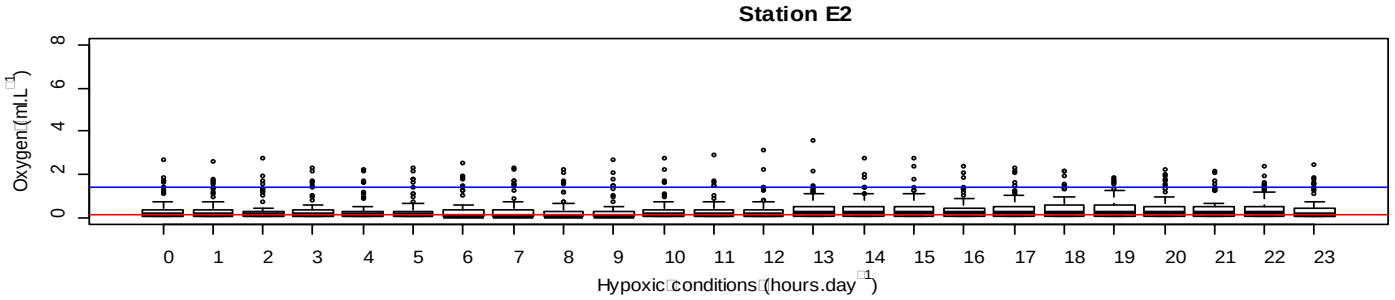




Inner-Bay

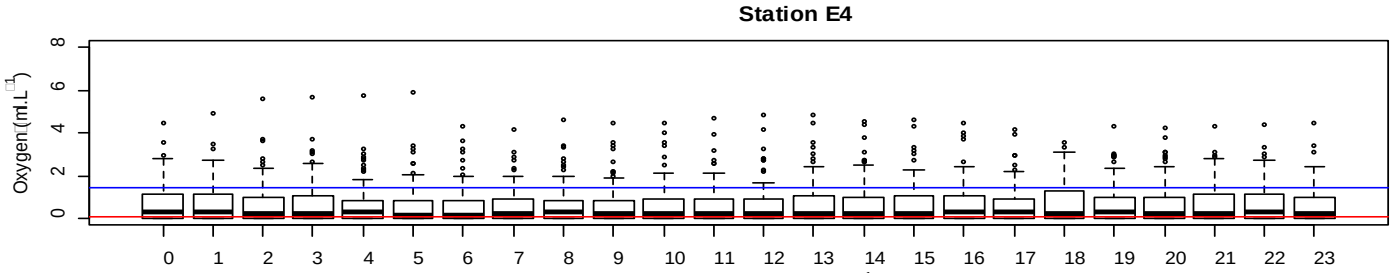
Hipoxic → 1,43 mL/L ~ 63 µM (Middelburg, 2009 Conolly, 2010)

Microxic → 0.1 mL/L ~ 4 µM (Naqvi et al., 2006)

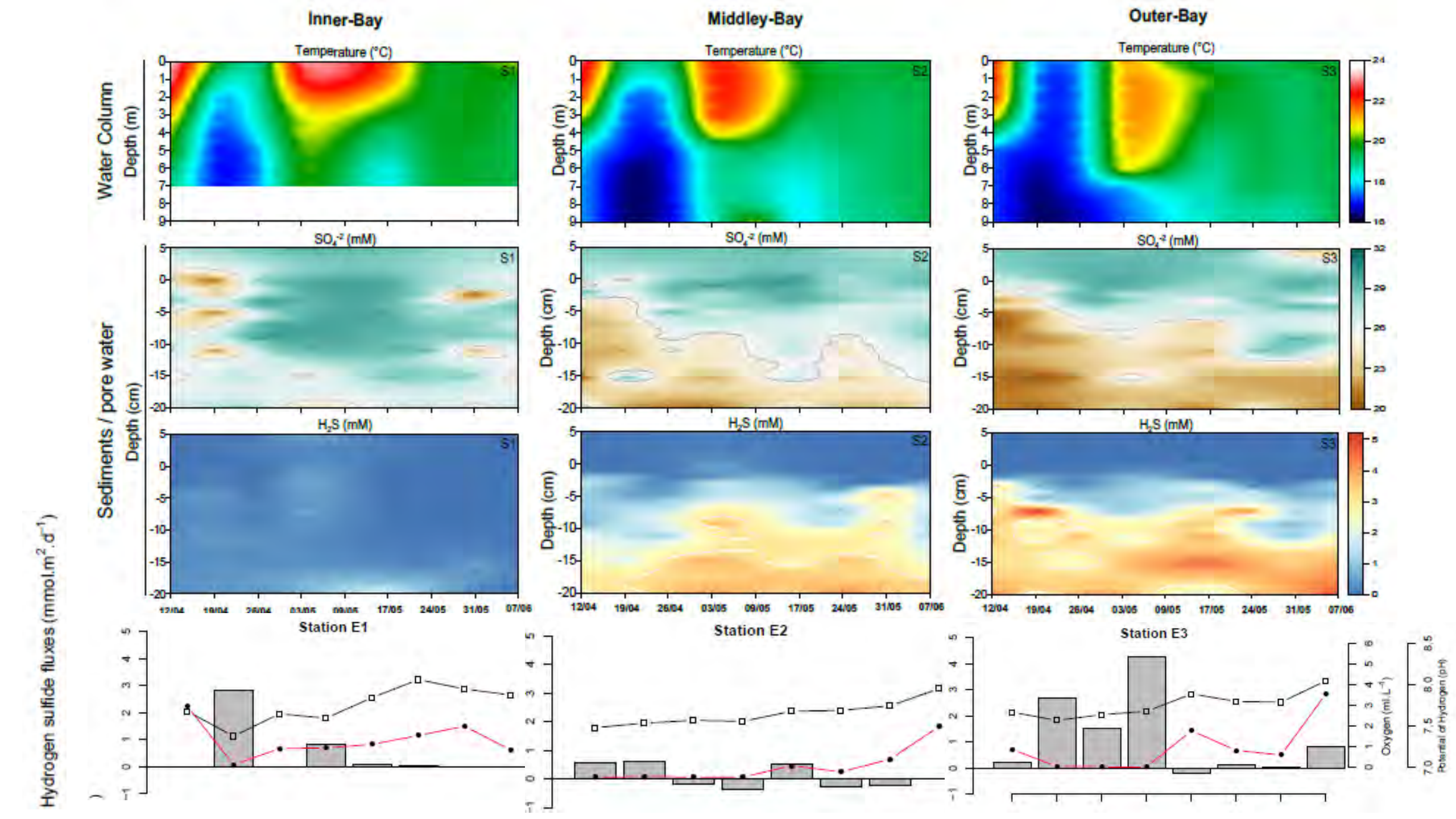


Middle-Bay

1.43 ml/L
0.1 ml/L



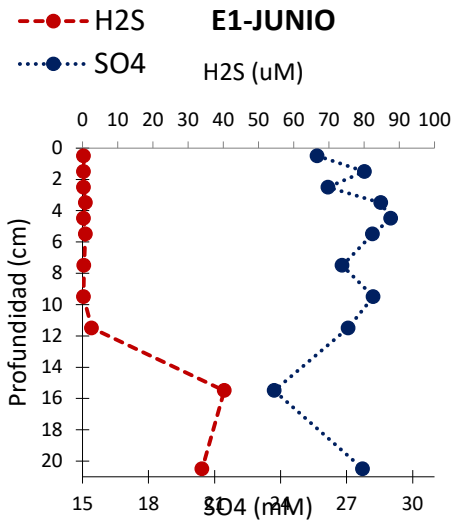
Outer-Bay

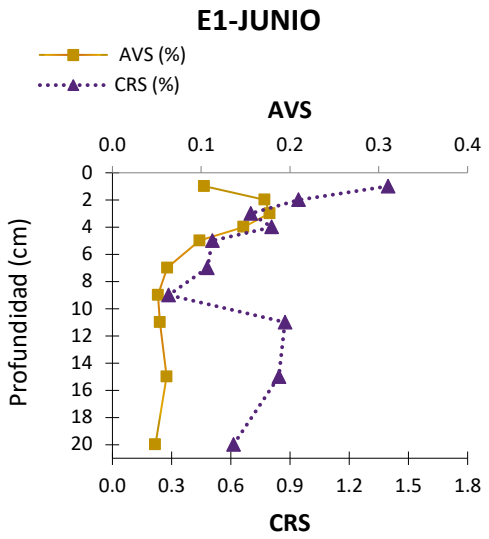

Inner-Bay
Middley-Bay
Outer-Bay
Water Column
Sediments / pore water
Depth (m)
Depth (cm)
Temperature (°C)
SO4-2 (mM)
H2S (mM)
S1
S2
S3
12/04
19/04
26/04
03/05
09/05
17/05
24/05
31/05
07/06
Station E1
Station E2
Station E3
Hydrogen sulfide fluxes (mmol.m-2.d-1)
Oxygen (ml.L-1)
Potential of Hydrogen (pH)

Area	Winds (m/s)	O_{22} (ml/l)	H_2S (mM)	H_2S Difusive Flux ($mmol.m^2.d^{-1}$)	Author
Namibia (23-28ºS)	-	0.7	-	-	Weeks et al., 2004
Namibia (23ºS)				11.4	Buchert et al. 2006
Namibia (23-24.5ºS)		-	0.05-0.25	8	Lavik et al., 2009
Peru (12-13ºS), 100 m			4.2	-	Schunck et al., 2013
Perú (12ºS), 70 m	5 Atypical Conditions 1		4	12.6	Dale et al., 2016 Sommer et al., 2016
Paracas Bay (13ºS) 10 m **Short-term** **Sulfidic event**	**<10** **Prevailed 2-0.5**	**1.4** **Microxic Prevailed 0.1**	**5.6**	**4**	**Present Study**

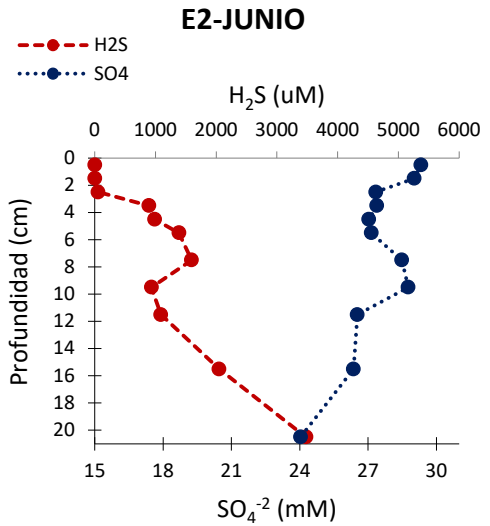
NORMAL SYSTEM

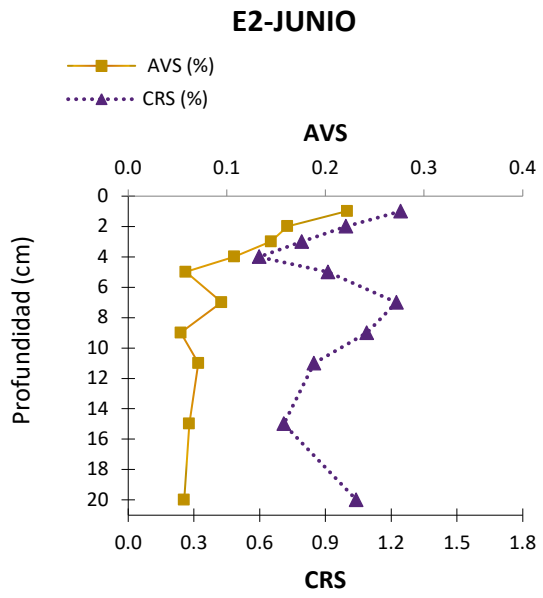
Inner-Bay



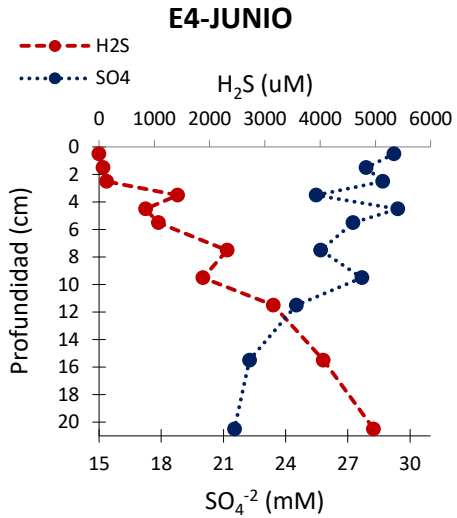


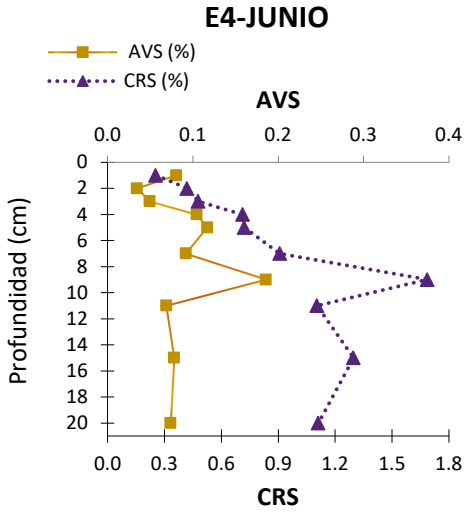
Middle-Bay





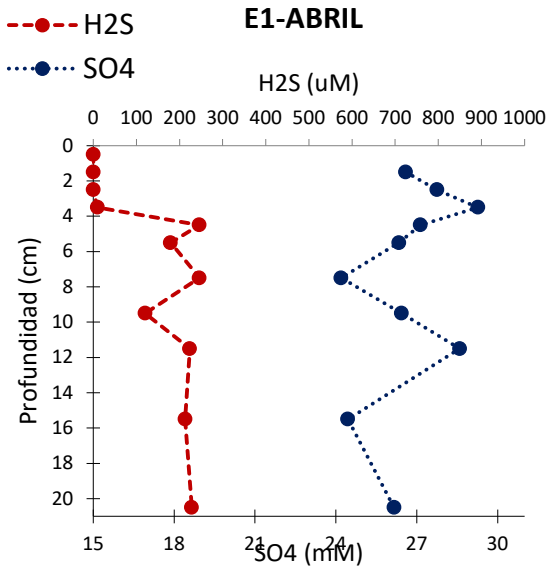
Outer-Bay

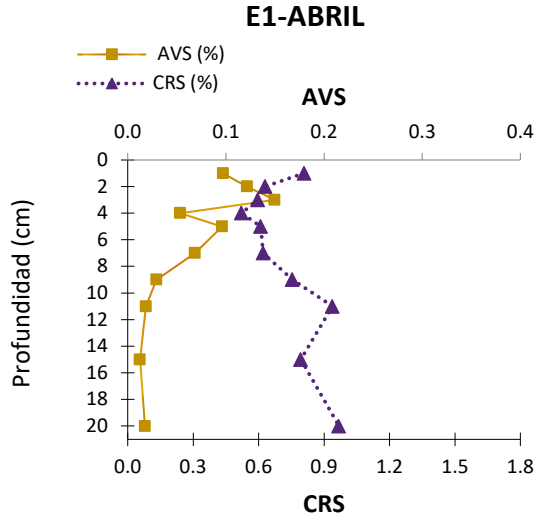




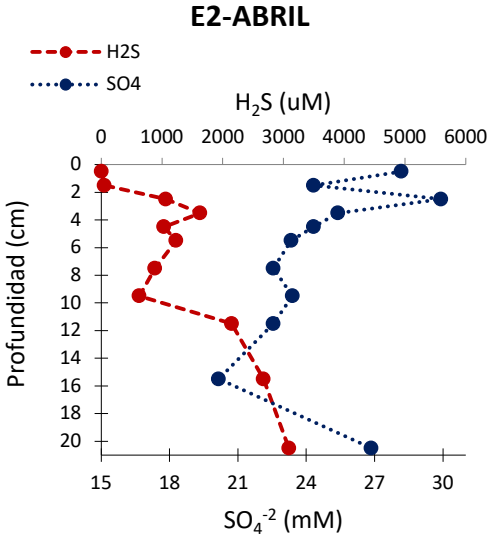
SHORT-TERM SULFIDIC EVENT

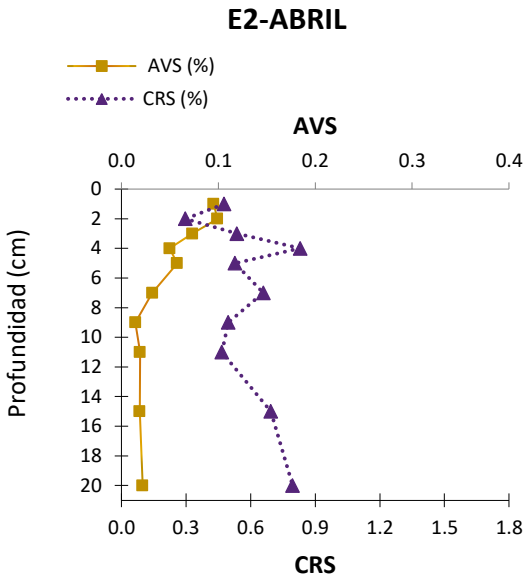
Inner-Bay



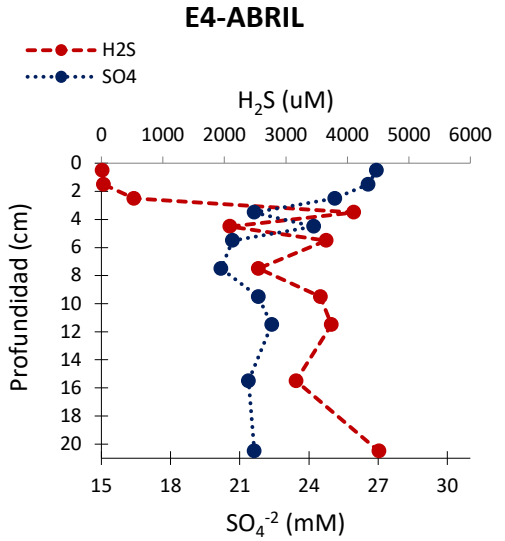


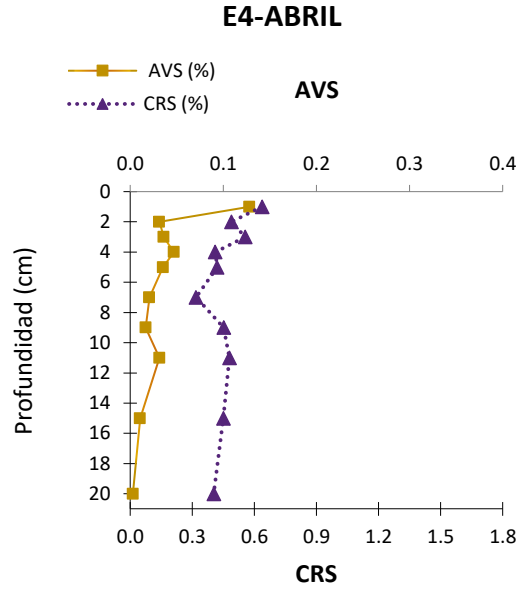
Middle-Bay





Outer-Bay





CONCEPTUAL MODEL