The Río Magdalena ROFI (Region of Freshwater Influence) project

Joint venture:

KIEL MARINE SCIENCE
CONNECTED RESEARCH

UNIVERSIDAD DEL NORTE

UNIVERSIDAD NACIONAL DE COLOMBIA

LEIBNIZ-INSTITUT FÜR OSTSEEFORSCHUNG WARNEMÜNDE
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UNIVERSIDAD DE ANTIOQUIA

ecopetrol
ENERGÍA PARA EL FUTURO

Daniel Rincón Martínez – Ecopetrol S.A
Oscar álvarez - Universidad del Norte

AGENDA

- ROFI definition
- The Magdalena River overview
- Expressions of the Magdalena ROFI
- Magdalena ROFI and its sedimentary connections
- Deep sea Fan evolution
- MSM112 Rio Magdalena ROFI Expedition

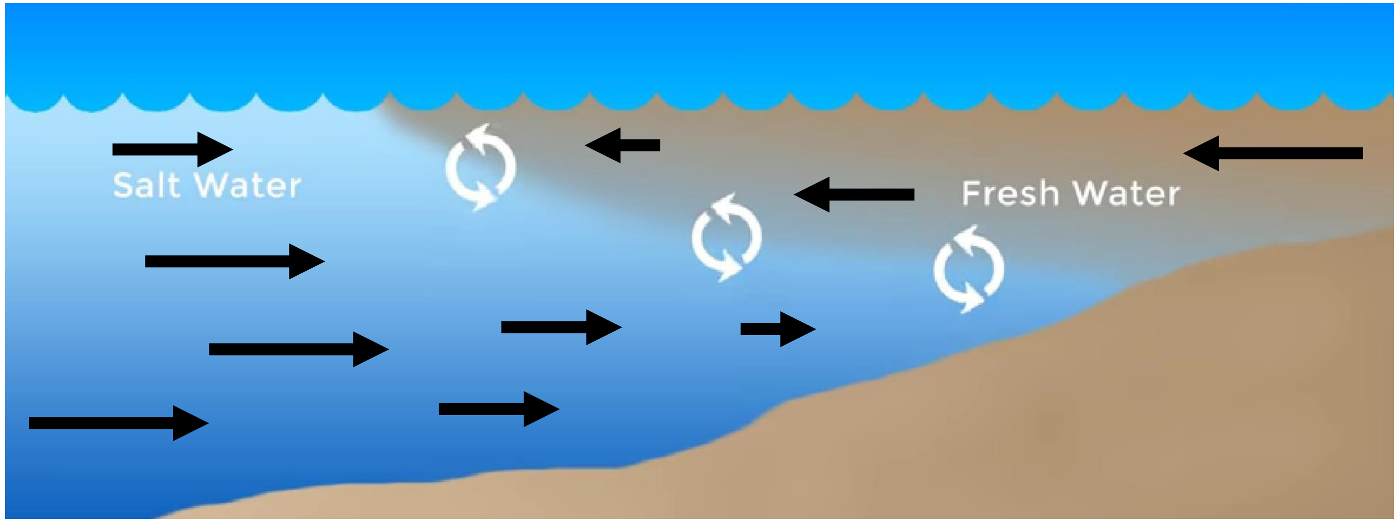
ROFI

Region of freshwater influence (ROFI) is a zone between sea exposure and estuary where local freshwater bouyancy from coastal resource is equal, or exceeds bouyancy of seawater, which has important implications for the structure and dynamics of the water column.

Freshwater input from estuaries that are mixed with suspended materials will give several impact to sea environments.

Run-off input maintain highly nutritive concentration in ROFI zones which induces blooming phytoplankton.

Combination between tides and river buoyancy produces sea organism groups, and higly dispersive water current affects to sea creatures dynamics



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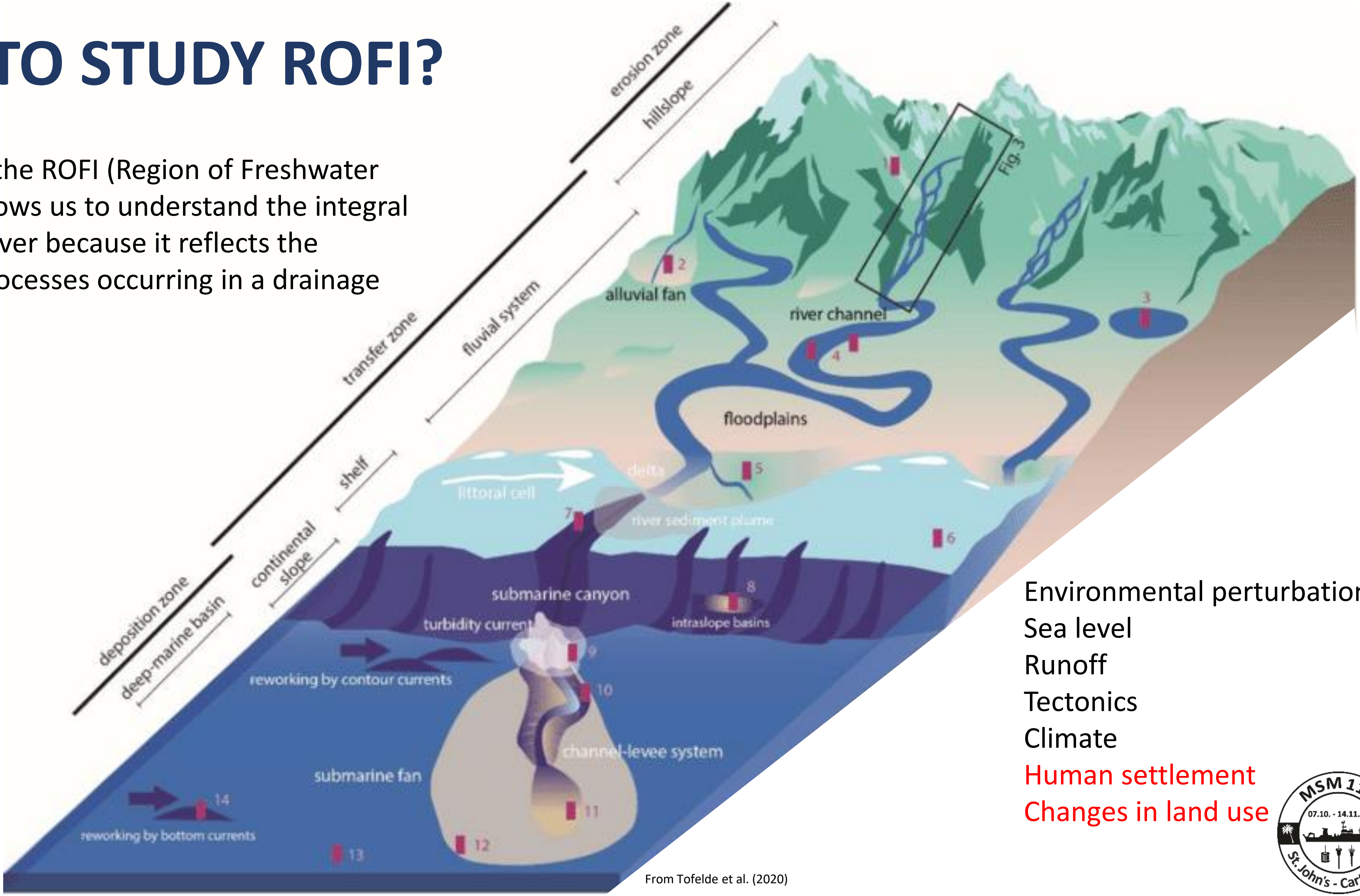
WHY TO STUDY ROFI?

The study of the ROFI (Region of Freshwater Influence) allows us to understand the integral state of the river because it reflects the balance of processes occurring in a drainage basin.



From Tofelde et al. (2020)

Environmental perturbations:
Sea level
Runoff
Tectonics
Climate
Human settlement
Changes in land use

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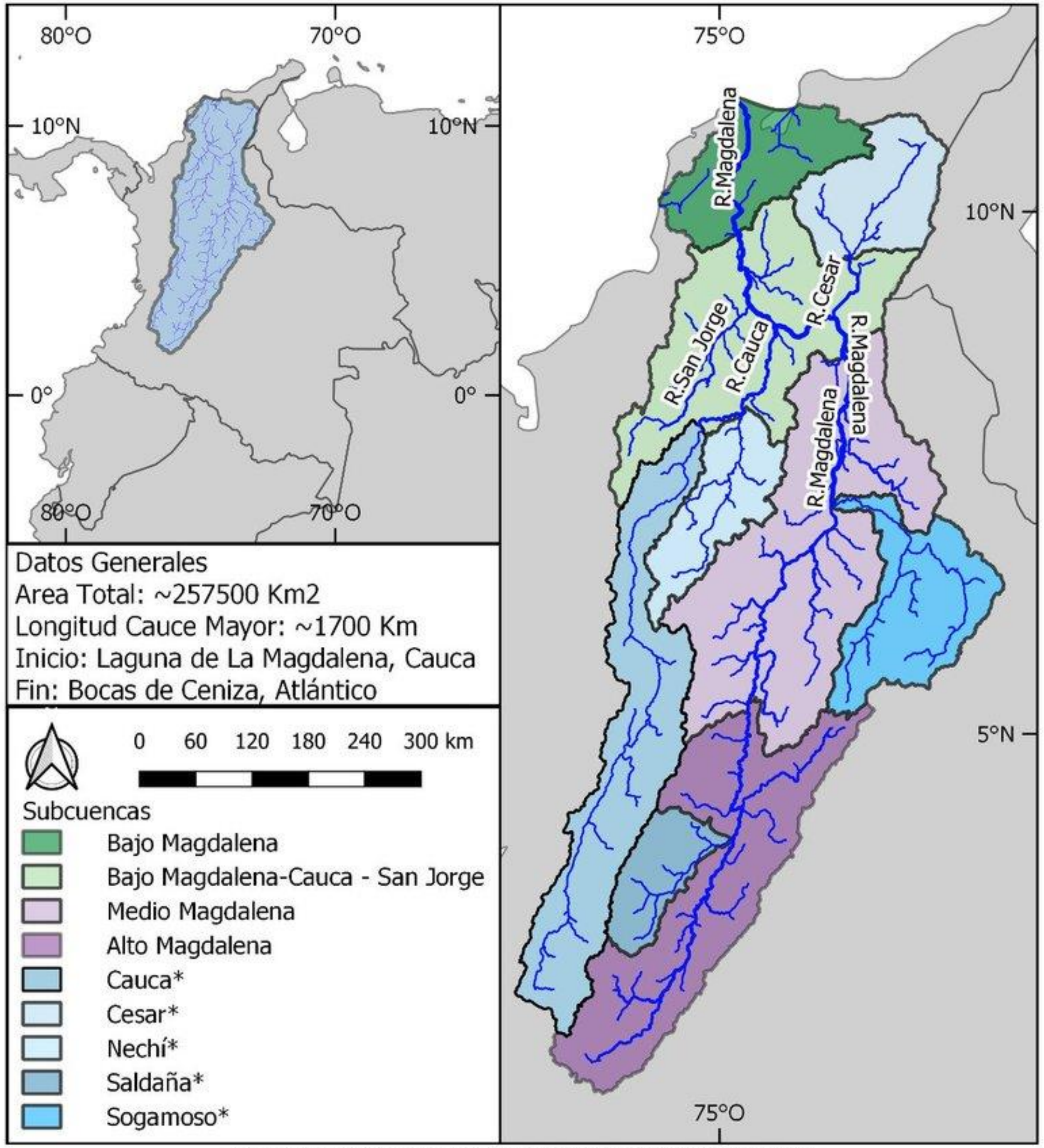
The Magdalena River Basin



Datos Generales
Area Total: ~257500 Km2
Longitud Cauce Mayor: ~1700 Km
Inicio: Laguna de La Magdalena, Cauca
Fin: Bocas de Ceniza, Atlántico

*Cuencas que desembocan en la Gran Cuenca del Magdalena

The Magdalena River dissects Colombia from south to north running between the Central and Eastern Andes Mountain.

The drainage basin area measures 257,440 km^2, covering 24 % of the national territory.

The catchment constitutes Colombia's most important region due to its economic and environmental value:

Hosts more than 30 million inhabitants, around 80% of the country's population, and accounts for 86% of the Gross Domestic Product and generates 75% of the country's agricultural production

Currently Magdalena River Basin provides 70% of Colombia's hydropower, equivalent to 49 % of the country's electricity supply.

It also provides drinking water for 38 million people.

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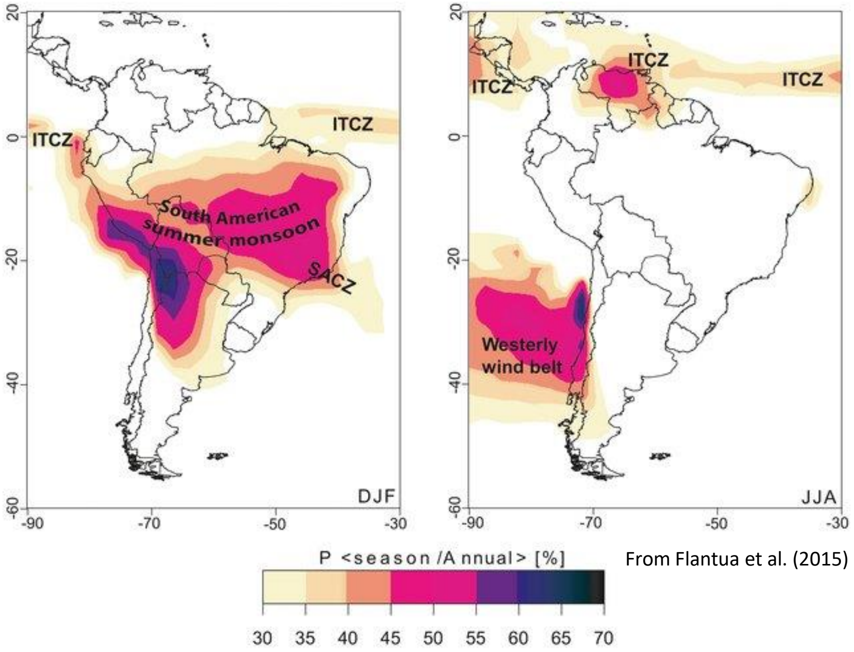
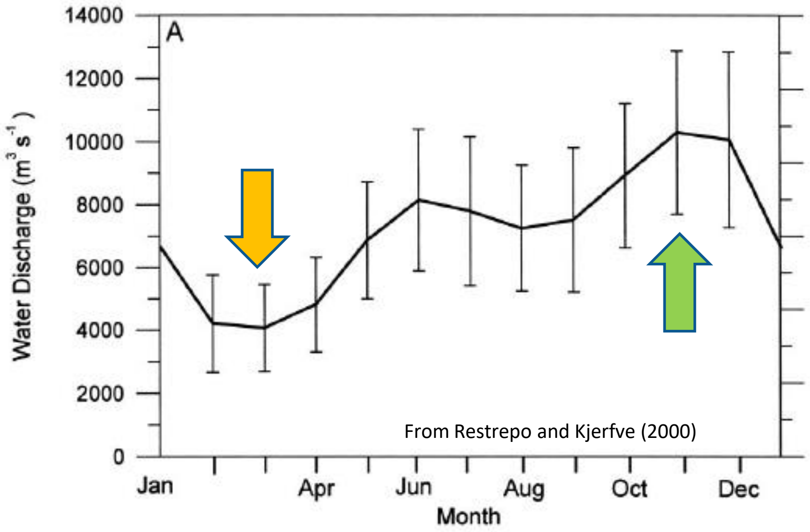
The Magdalena River



From Flantua et al. (2015)

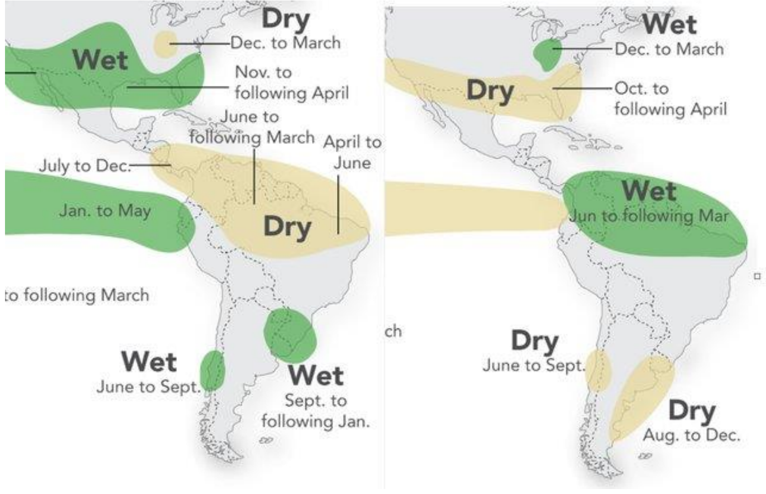
It is one of the world's largest rivers, with a length of 1,612 km and an average discharge volume of 7,154 m^3/s, a minimum of 4,068 m^3/s in March and máxima > 10,000 m^3/s during November.



From Restrepo and Kjerfve (2000)

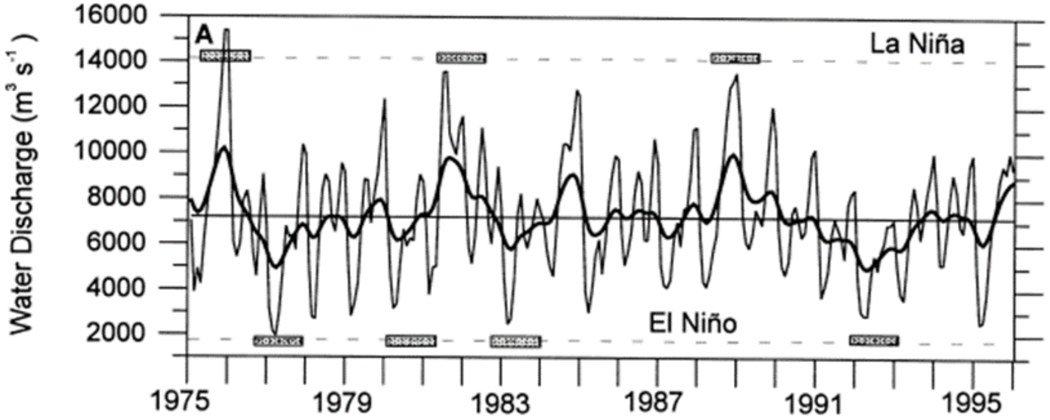
El Niño

La Niña



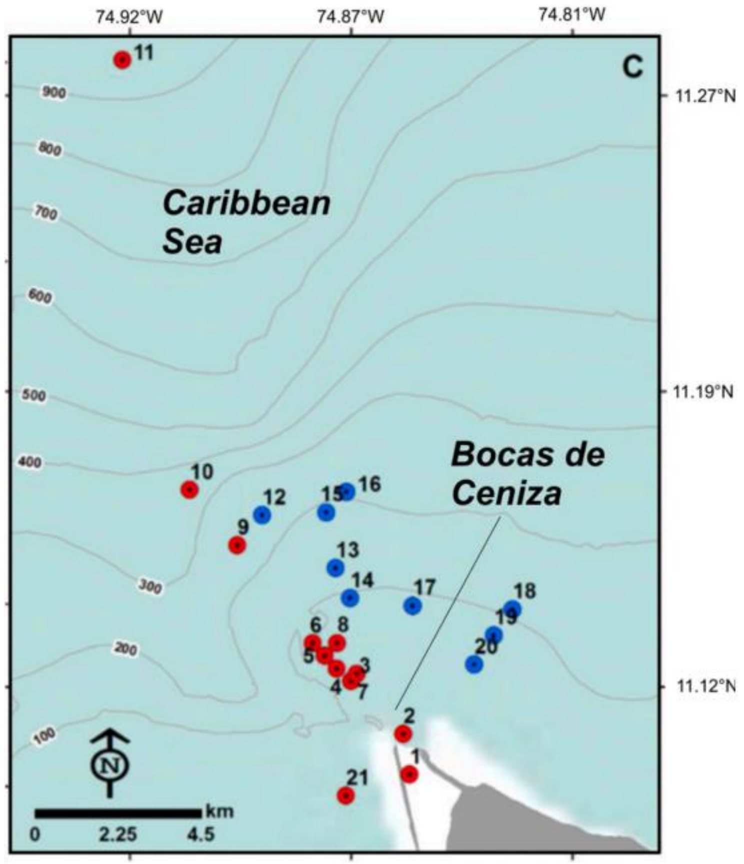
From Muñóz et al. (2016)

El Niño–Southern Oscillation (ENSO) influences the hydro-climatological conditions of the Magdalena River basin, with extended periods of low precipitation (droughts) during El Niño events and prolonged rains (floods) during La Niña events.

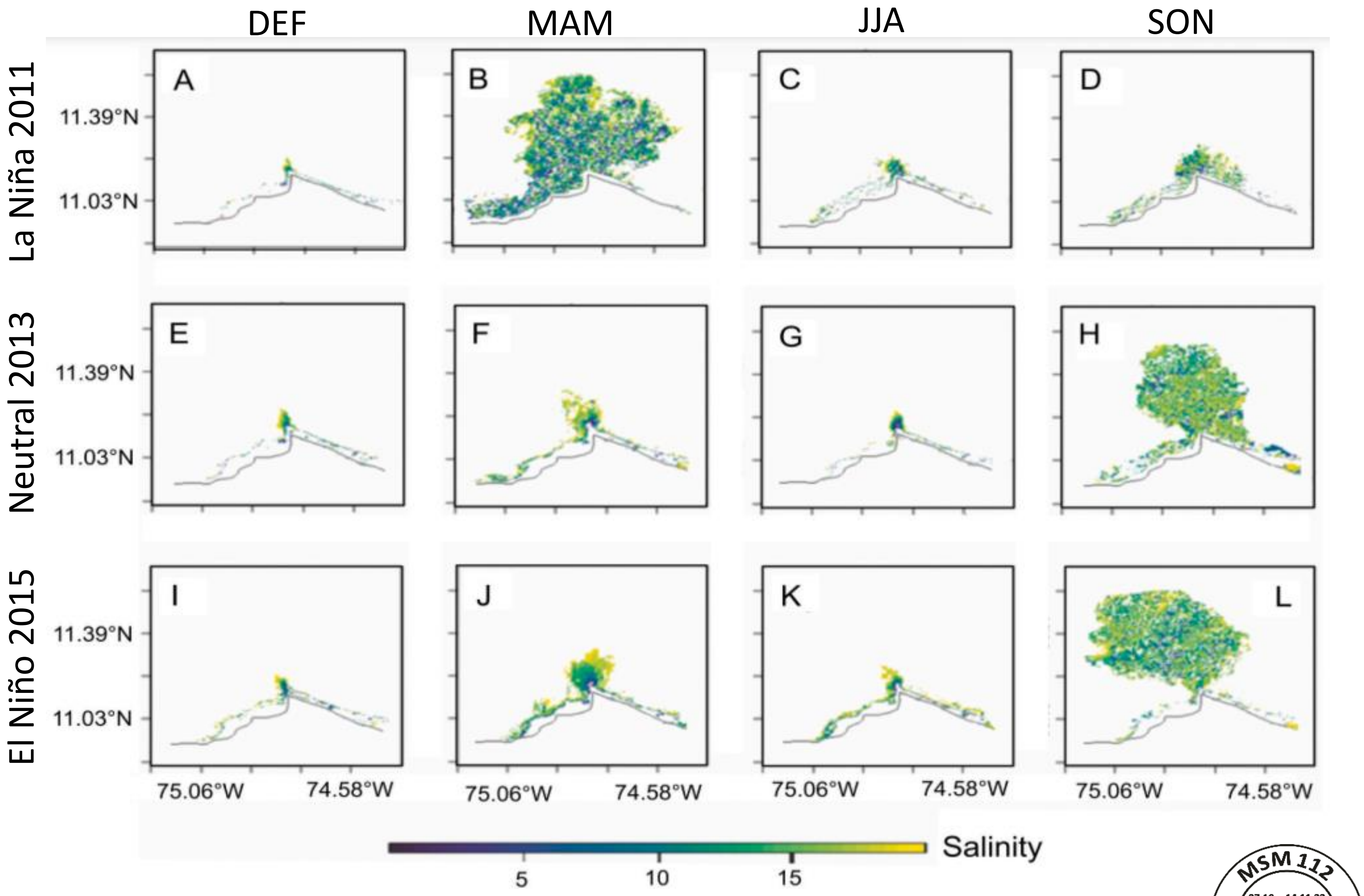


From Restrepo and Kjerfve (2000)

Magdalena River ROFI - Salinity

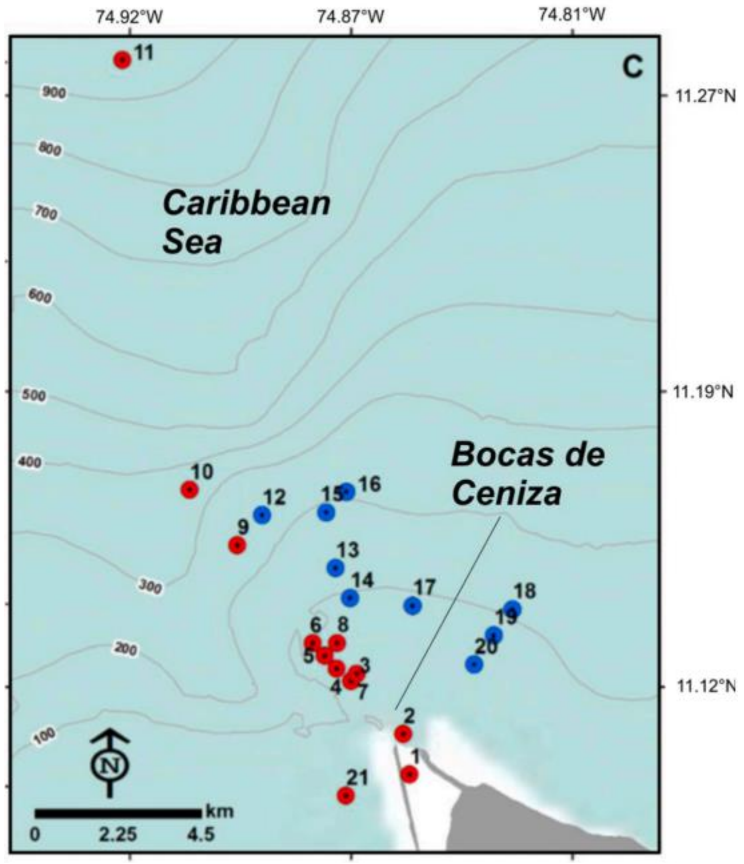


From Torregroza-Espinosa et al. (2020)

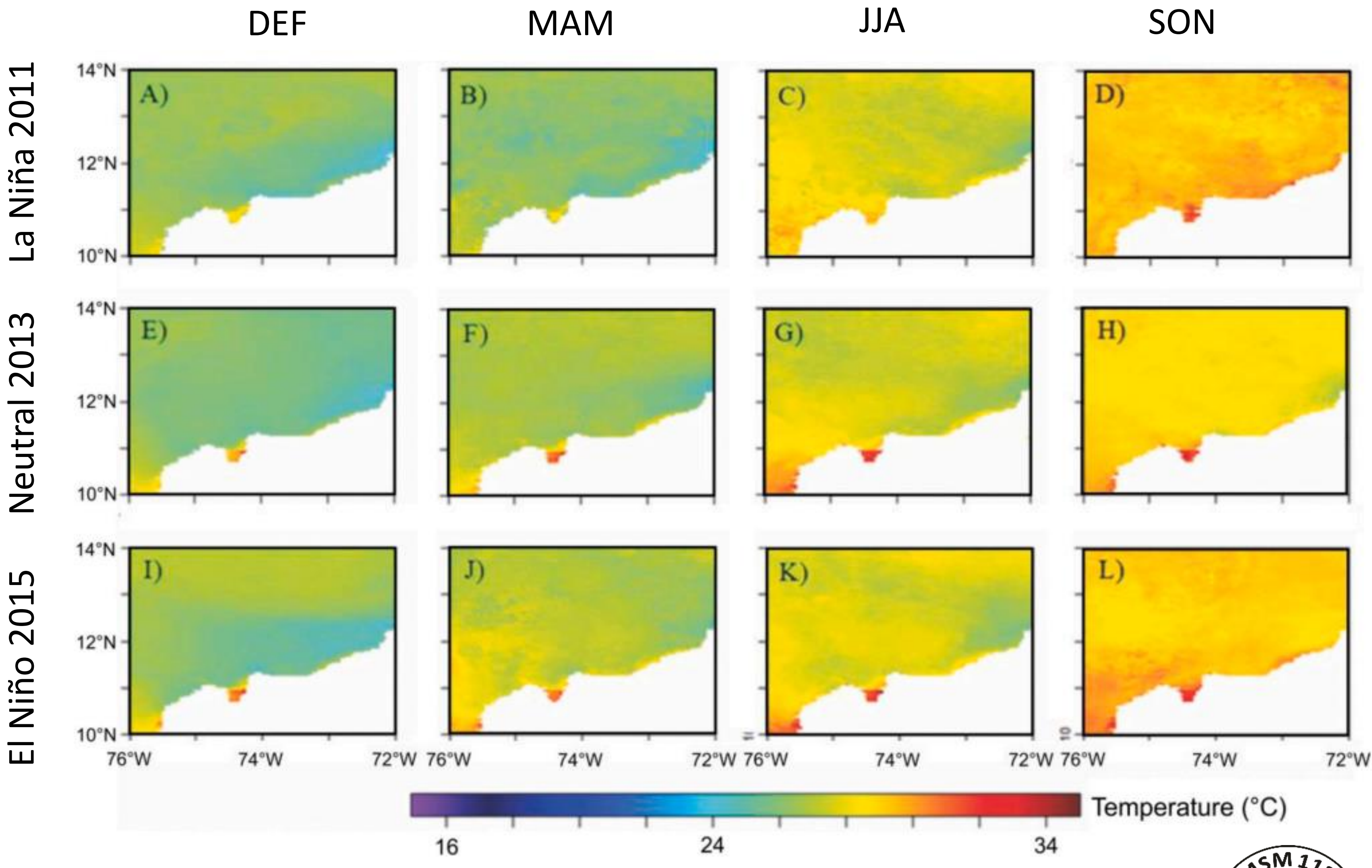


In the neutral year 2013 and El Niño year 2015, the largest freshwater river plume area of influence was observed in SON, during the wet season.

Magdalena River ROFI - Temperature

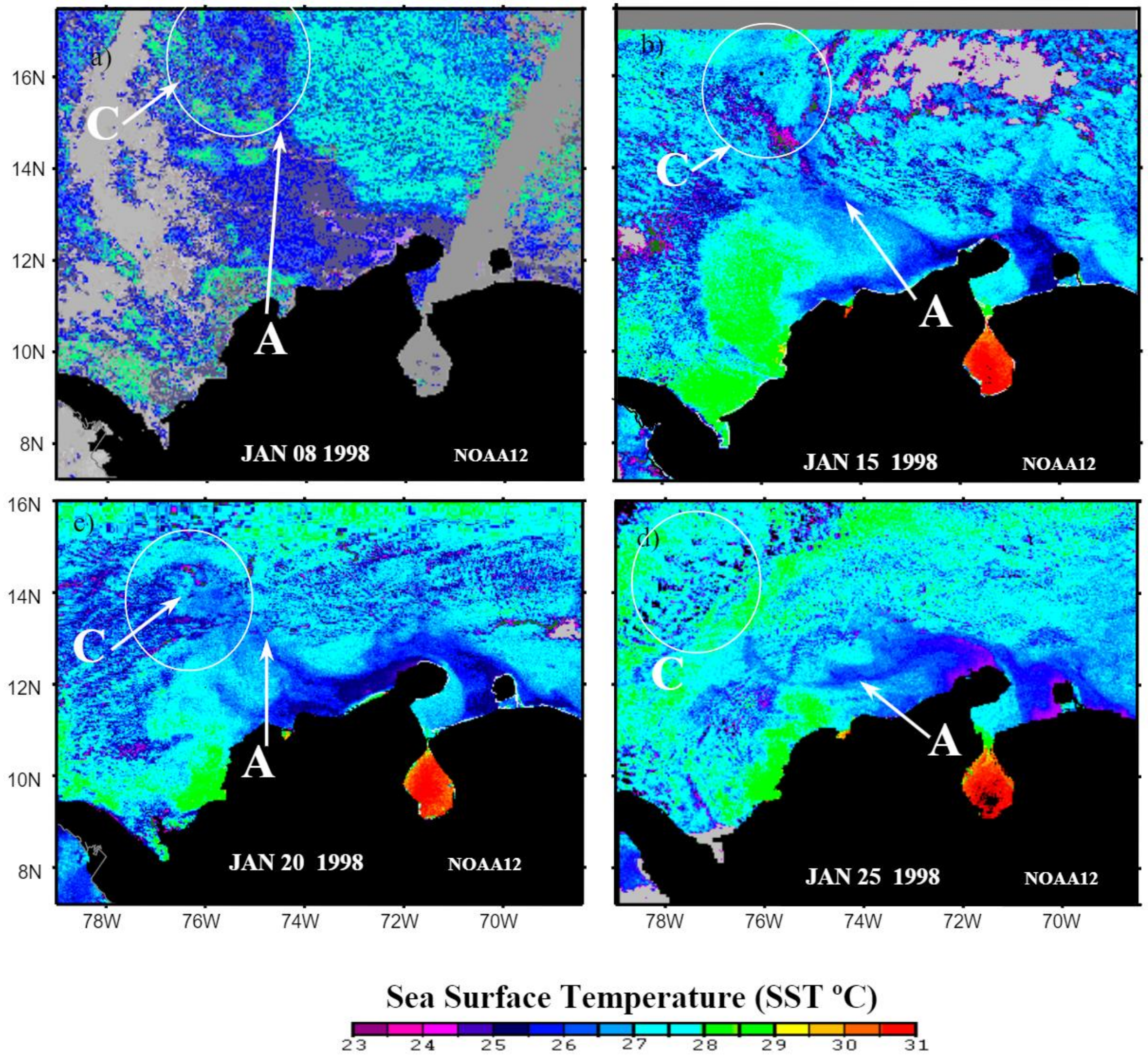


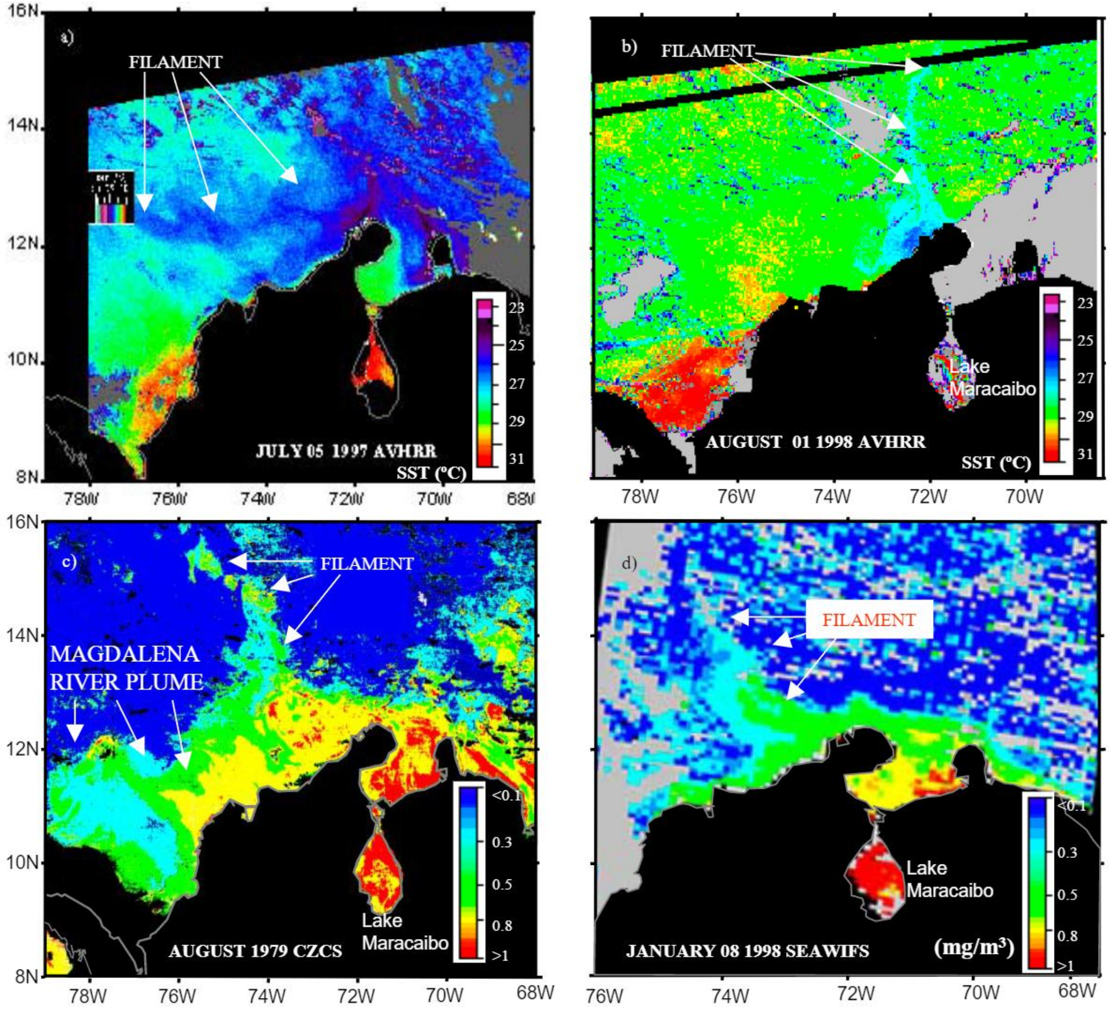
From Torregroza-Espinosa et al. (2020)



A strong influence of cold waters (~25 ◦C) moving westward from the Guajira Peninsula was observed along the littoral zone in months DJF.

Magdalena River ROFI vs. Guajira Upwelling System





From Andrade (2000)

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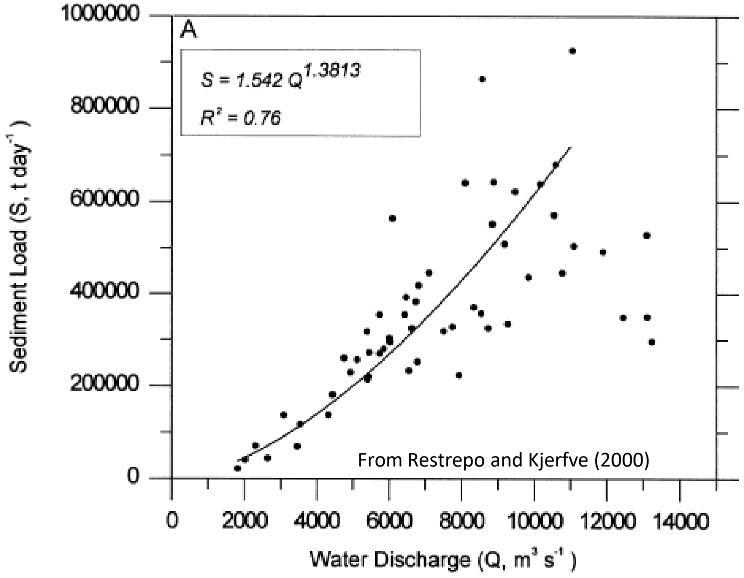
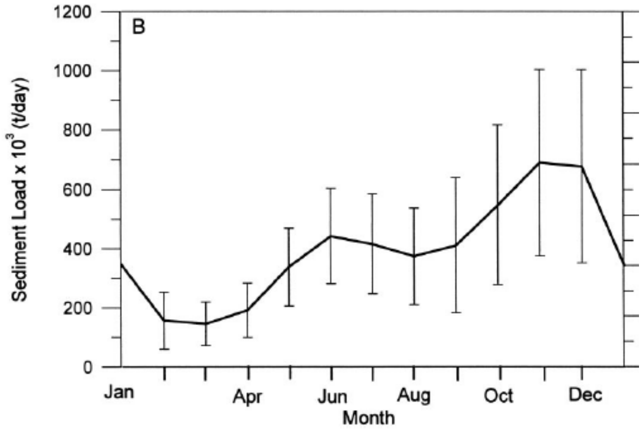
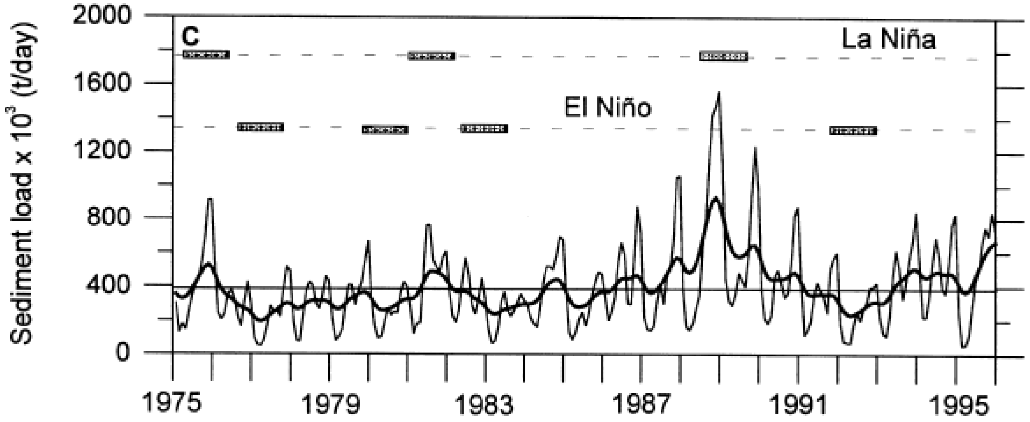
Magdalena River Suspended sediment load

The river accumulates one of the highest global sediment yields (144 Mt /yr) and the largest in South America (Restrepo 2008). This sediment load estimate implies that the river provides 89% of the total sediment flux into the Caribbean from the three main Andean rivers of Colombia.



From Restepo and Kjerfve (2000)



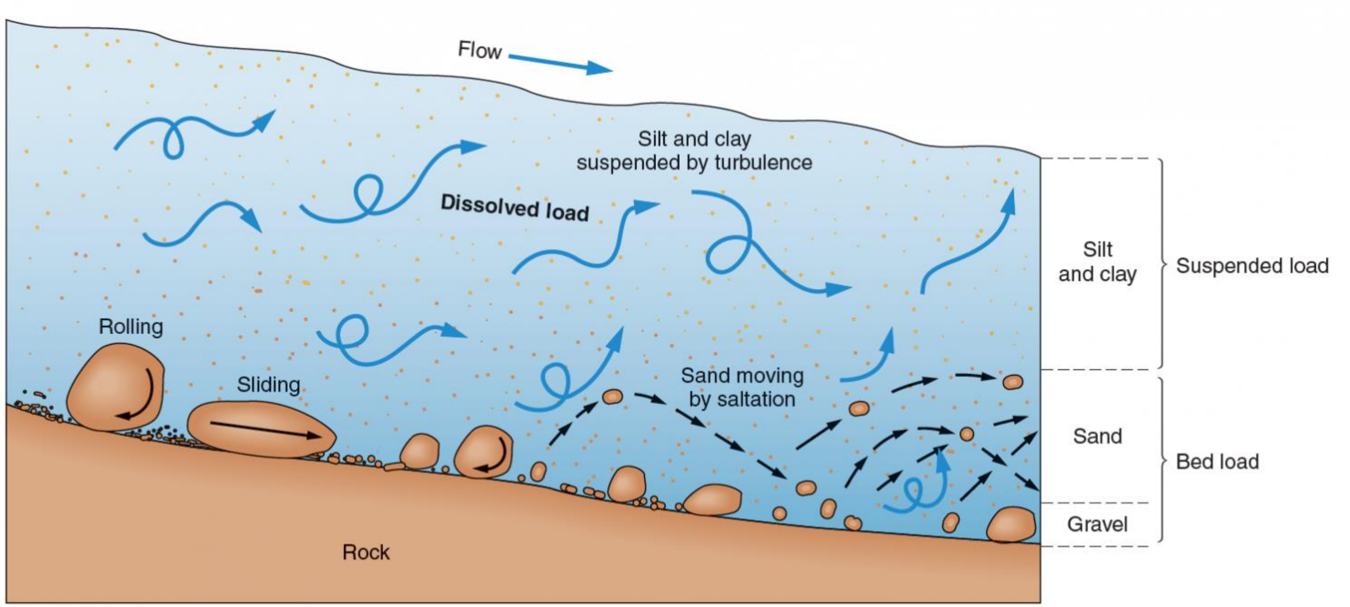


Restrepo and Kjerfve (2000) had pointed out that the ENSO was able to explain up to 54% (r^2: 0.74) of the interannual variability in suspended sediment load (SSL) in the Magdalena River, with high SSL during La Niña and low SSL during El Niño.

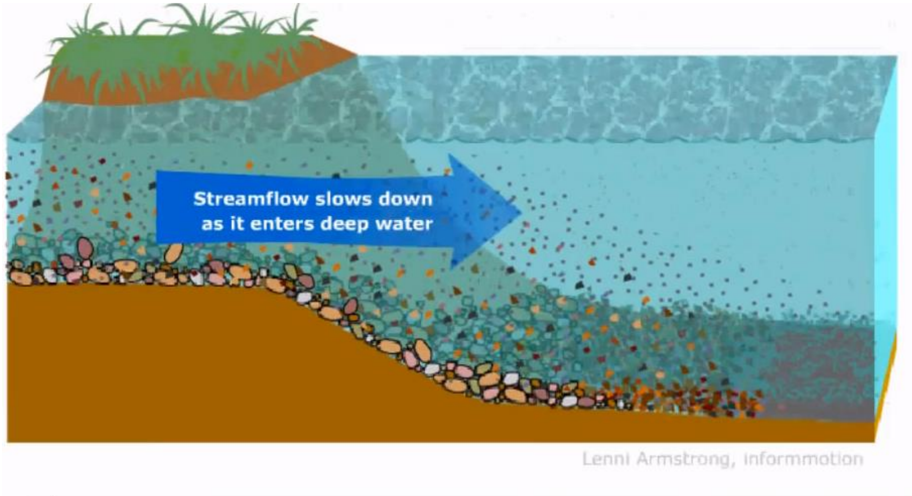
Sediment transported as suspended load is fine grained.

Causes the stream to appear “muddy”

Transporting sediments



Generally, the bedload transport rate of a stream is about 5–25% of that of suspension load



Lenni Armstrong, informmotion

Suspension: Fine material such as clay and sediment transported within the stream flow but not dissolved

Traction: large boulders and pebbles transported rolling and sliding along stream bed

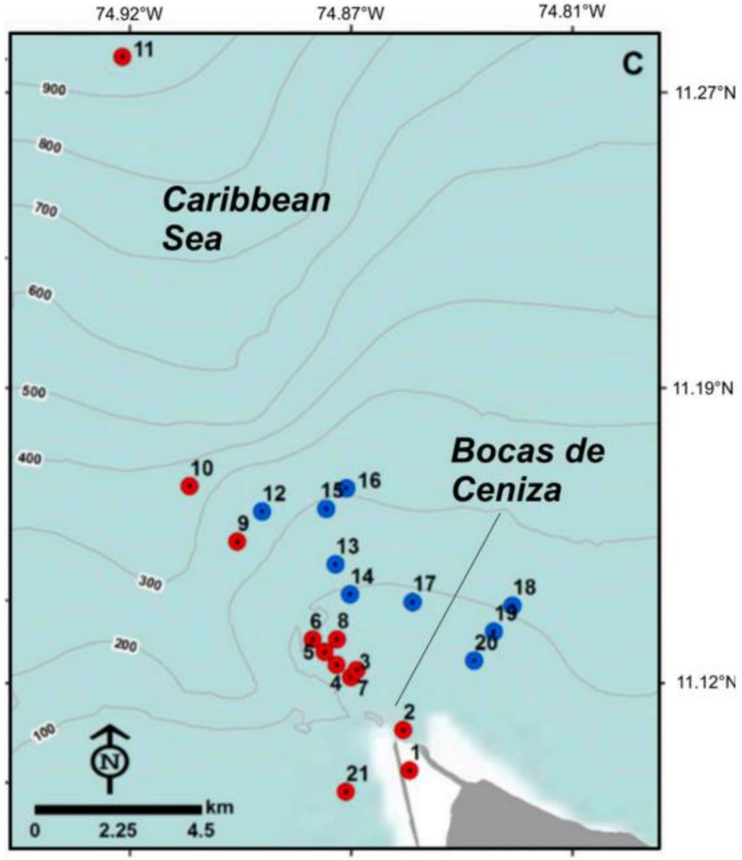
Saltation: Small stones, pebble and silt transported by bouncing along stream bed

The steeper the river thalweg, the larger the particles that will be transported

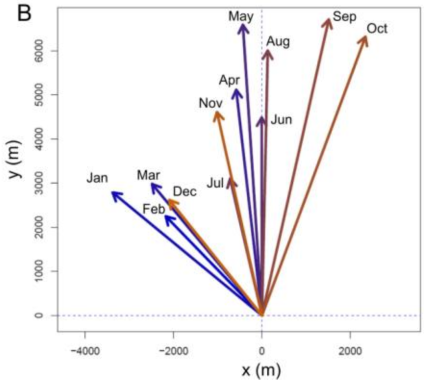
The stronger the current, the larger the particles that will be transported

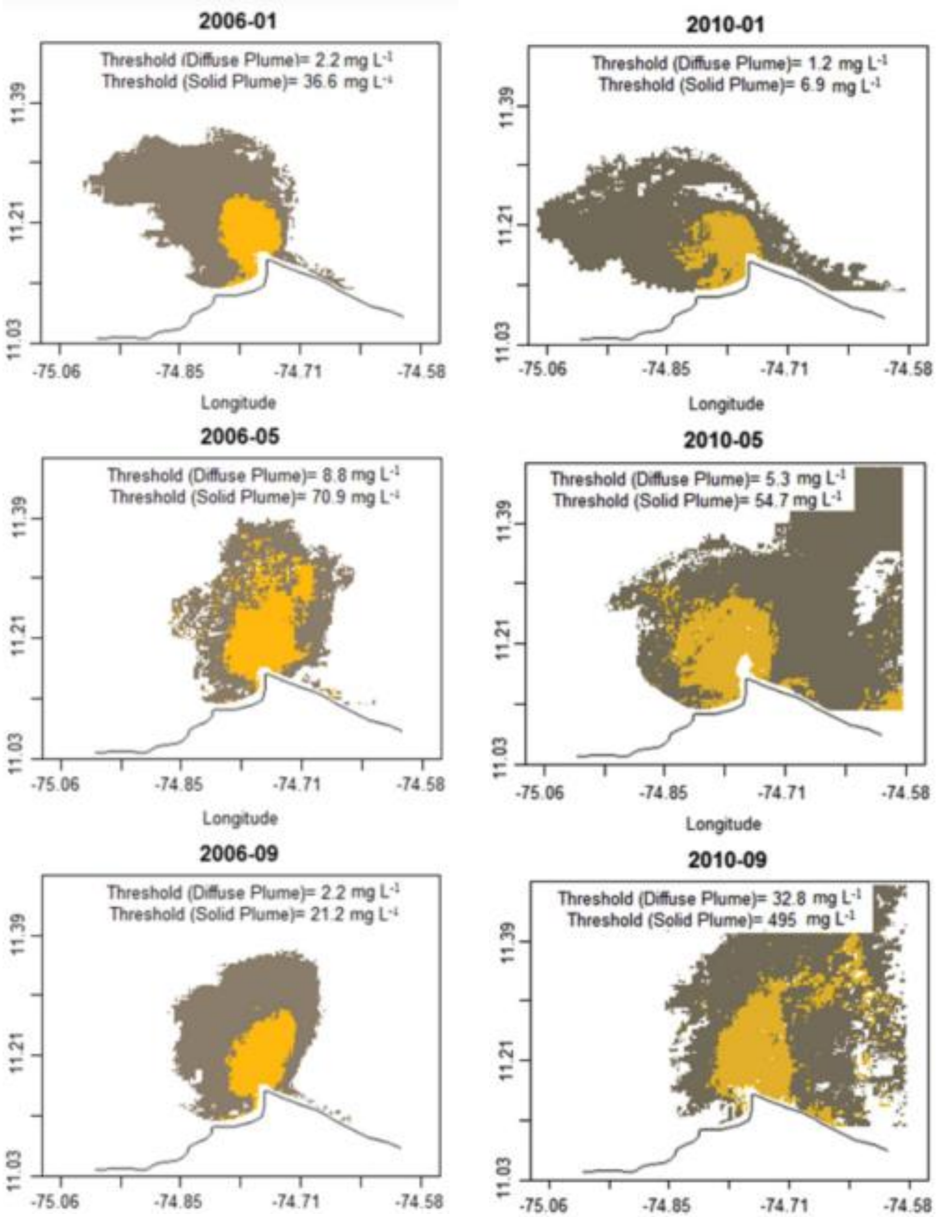
The stronger the current, the farther the particles will be transported

Magdalena River ROFI – Sediment plume



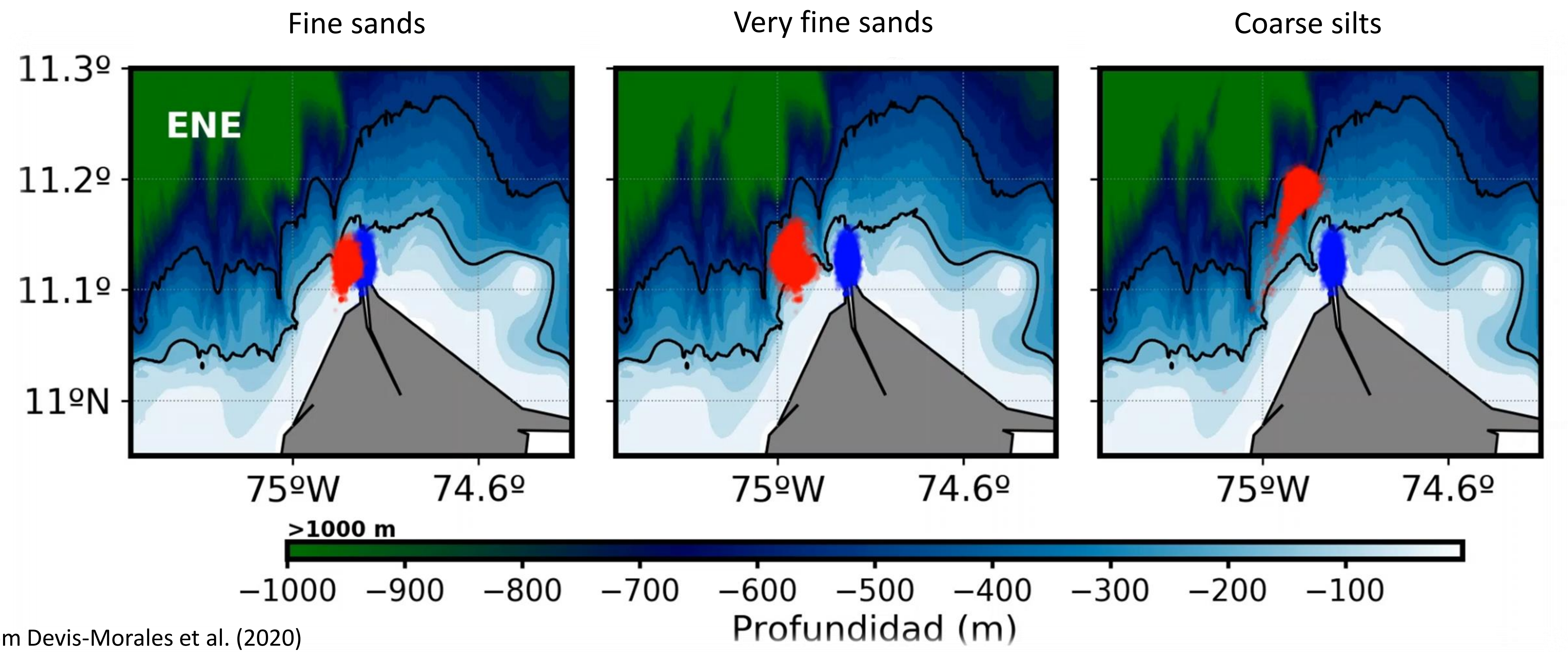
Tomado de Torregroza-Espinosa et al. (2020)





La pluma sólida se extiende a distancias máximas de 6,5 km, con mayores extensiones en mayo y septiembre-octubre

Sediment transport offshore Magdalena river mouth



From Devis-Morales et al. (2020)

Seasonal simulations with SedimentDrift®. Seafloor bathymetry from GEBCO-2019 (isodepths at 200 and 500 m).

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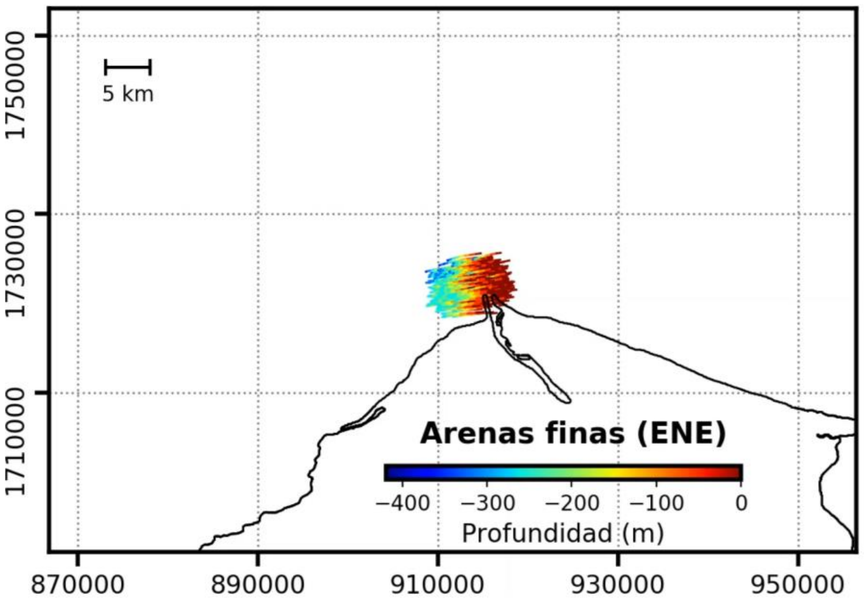
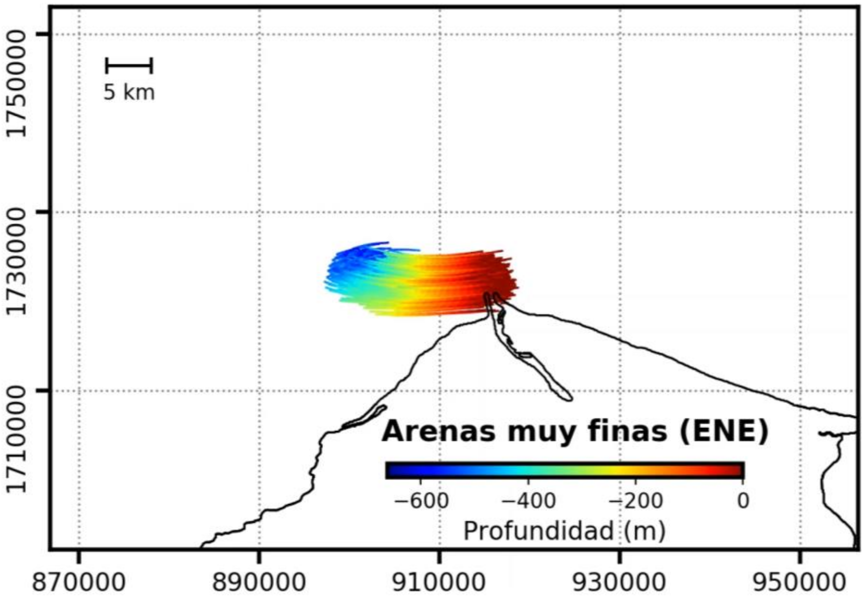
Trajectory of released particles

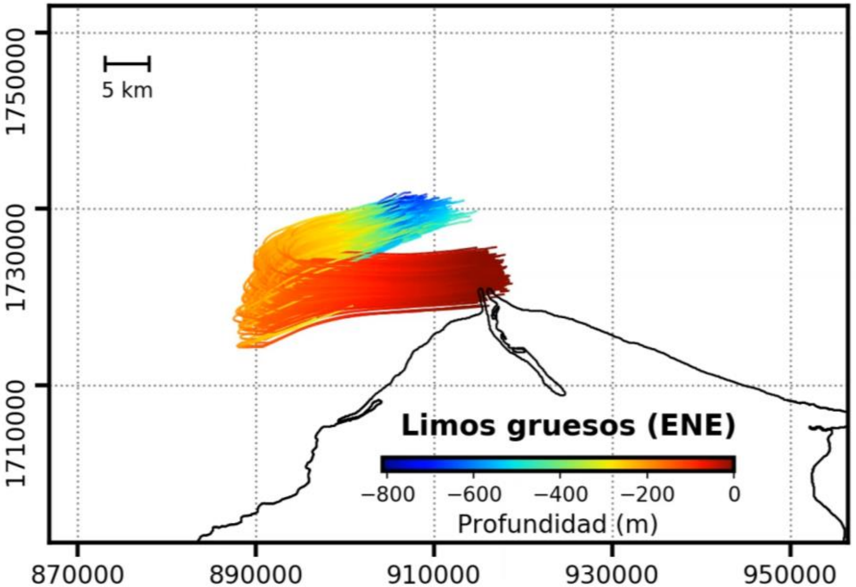


The fine sands take about 5-6 hours to reach the bottom, located around 250-300 m deep.

From Devis-Morales et al. (2020)



Very fine sands take between 12 and 22 hours to settle to the bottom (reaching depths of up to 400 m).



Coarse silt can take more than 5-7 days to reach the seafloor. In some cases, this type of sediment remains suspended very close to the bottom for several hours or even days before settling completely.

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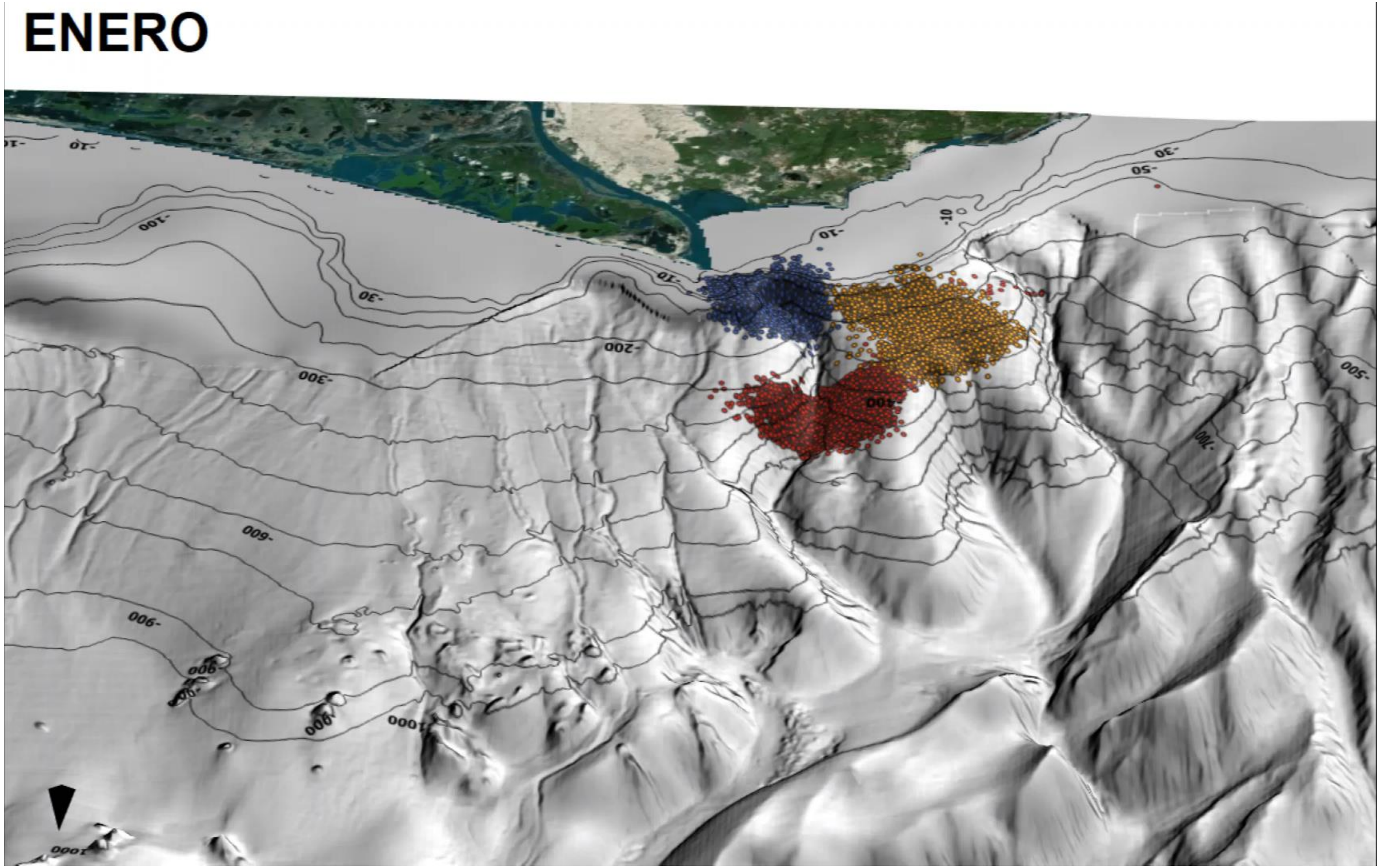
Building the modern Magdalena deep-sea fan

North

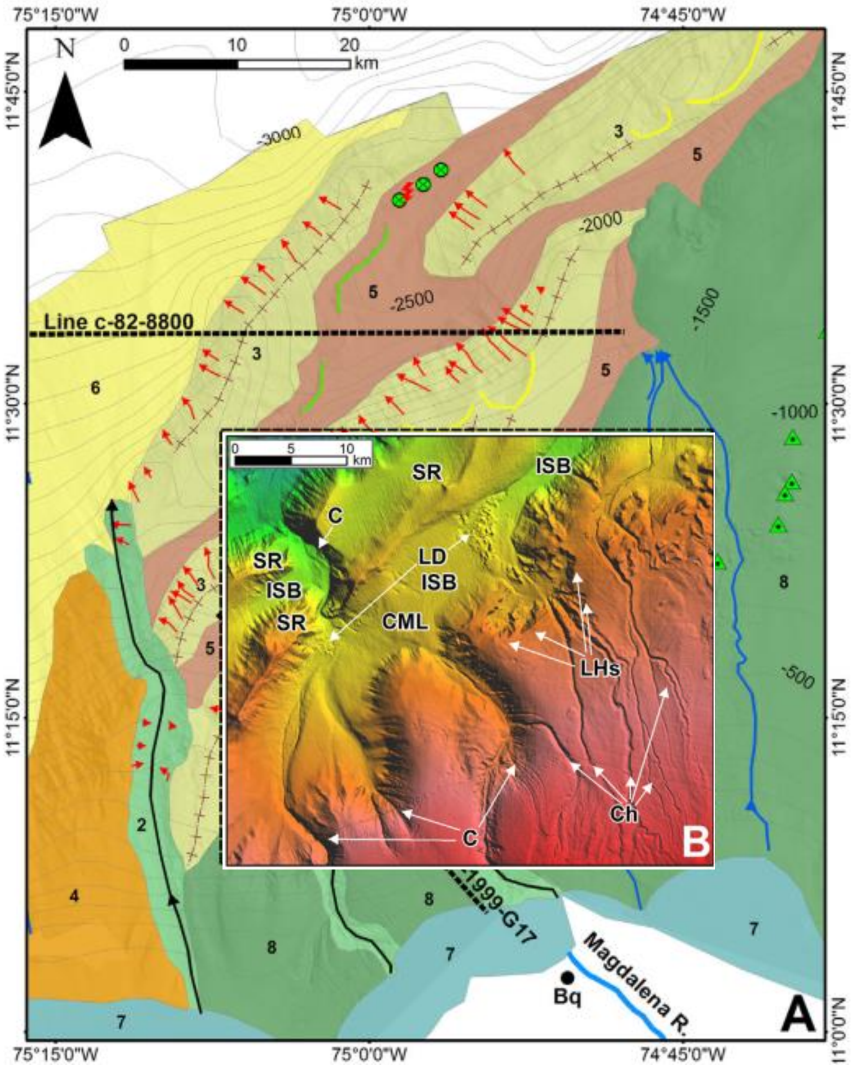


South

Blue (FS), yellow (VFS), red (CSt).

From Devis-Morales et al. (2020)

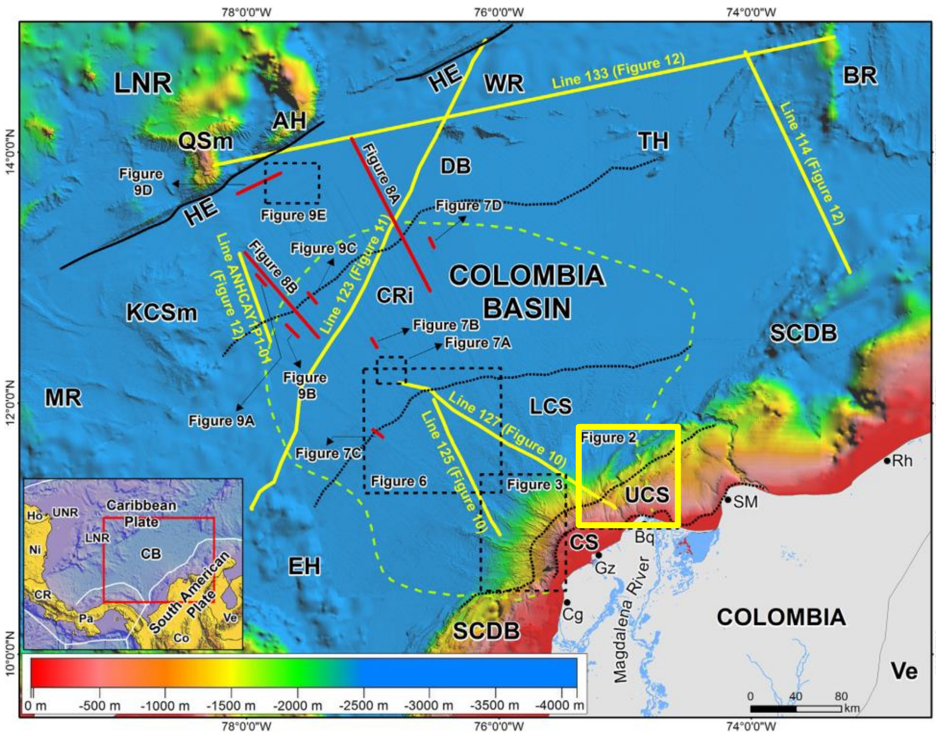
Building the modern Magdalena upper fan



From Idárraga-García et al. (2019)

Clear river connection

The development and evolution of this canyon system has been controlled by the presence of structural highs related to the Southern Caribbean Deformed Belt. These positive relief features reach heights of ~1000 m above the surrounding seafloor and act as barriers that control both the path of the canyons and the formation of small-scale circular/elongated basins that are recipients of much of the sediment carried by the canyons



From Idárraga-García et al. (2019)

Four NS to NNW-SSE trending submarine canyons associated with a narrow continental shelf

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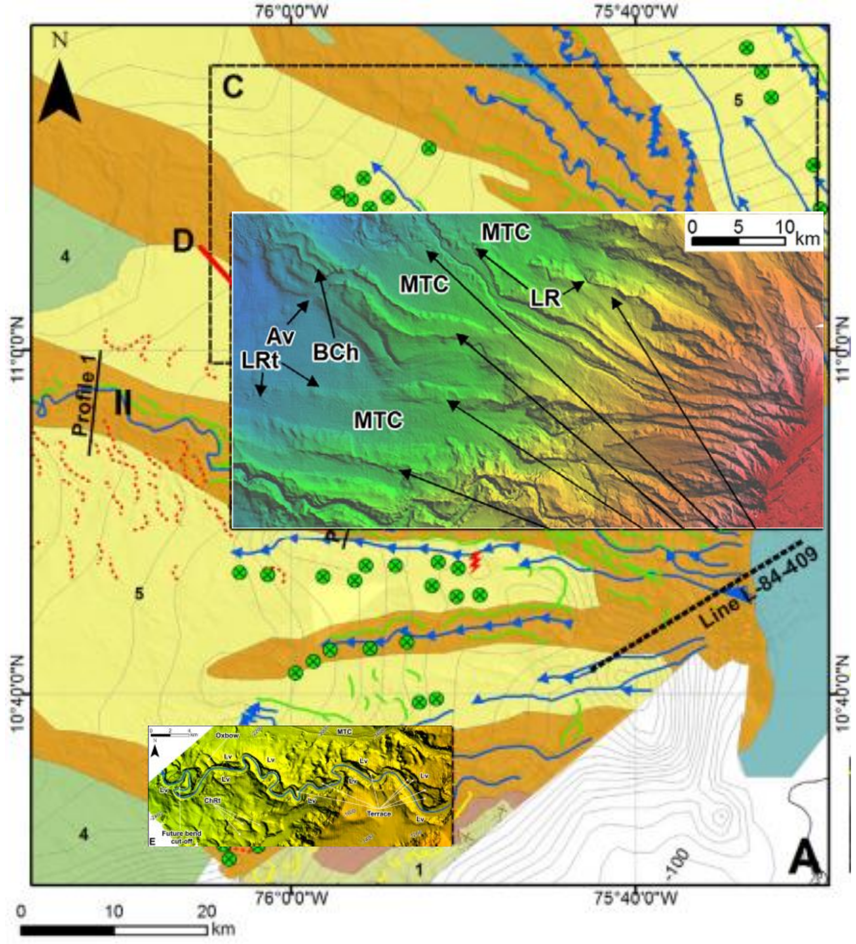
An ancient Magdalena upper fan?



From Idárraga-García et al. (2019)

1	Canyon-mouth lobe	4	Channel-Levee complex	7	Continental shelf	→	Channel thalweg
2	Canyon	5	Intra-slope basin	8	Continental slope	→	Gully
3	Structural ridges	6	Mass transport complexes			—	Levee-related slide scar

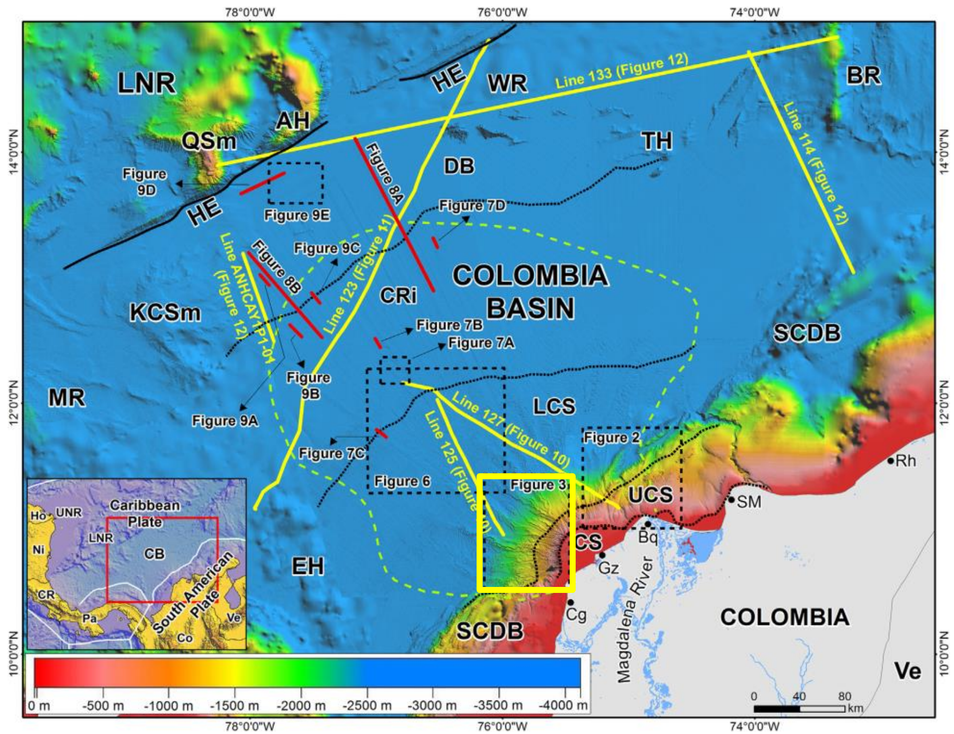
—	Slide scar	⊗	Levee remnant
+–+	Ridge axis	▲	Mud volcano
→	Canyon thalweg	⚡	Levee rupture

Unclear river connection

Most channels typically evolve in the zone of transition between the continental shelf and the toe of the continental slope. Channels start as gullies, which merge downslope to become channel-levee systems.

Commonly, these channels are partially destroyed by tongue-like MTCs, associated with mass failures starting near the edge of the shelf.

Mass transport deposits are filling and eroding the tectonic relief, smoothing slope topography



From Idárraga-García et al. (2019)

A series of channel-levee complexes and extensive mass transport complexes (MTC) with a radial pattern originates at the slope break

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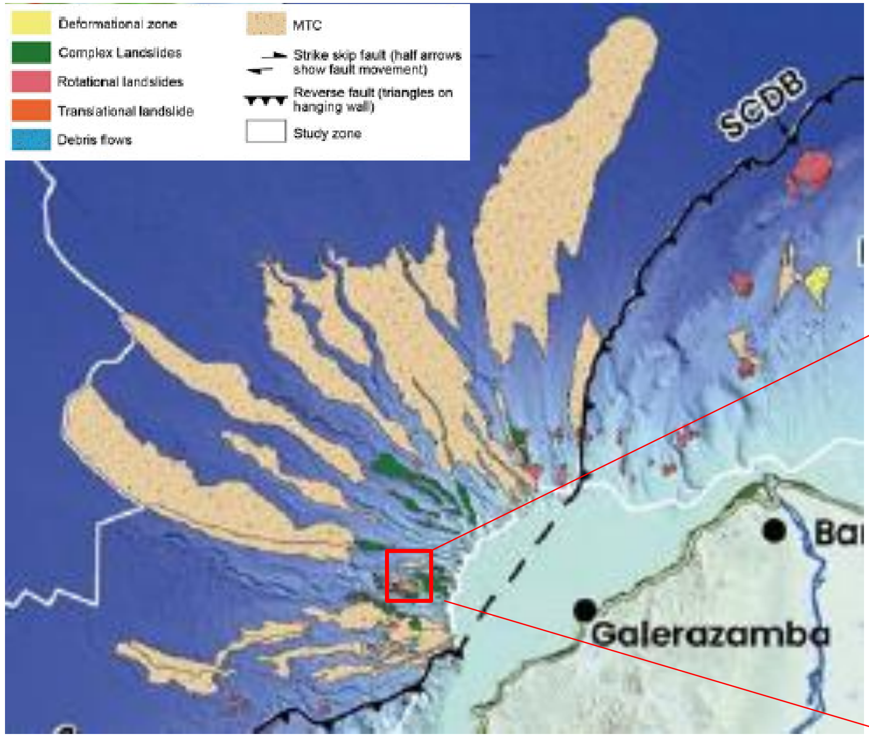
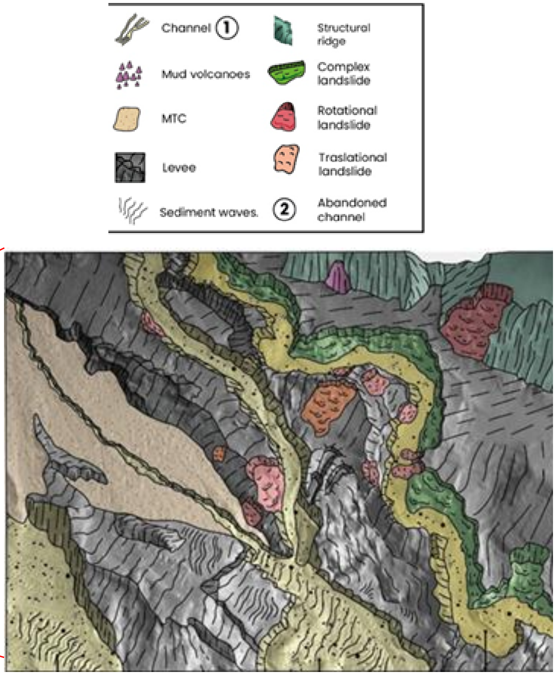
An ancient Magdalena upper fan?

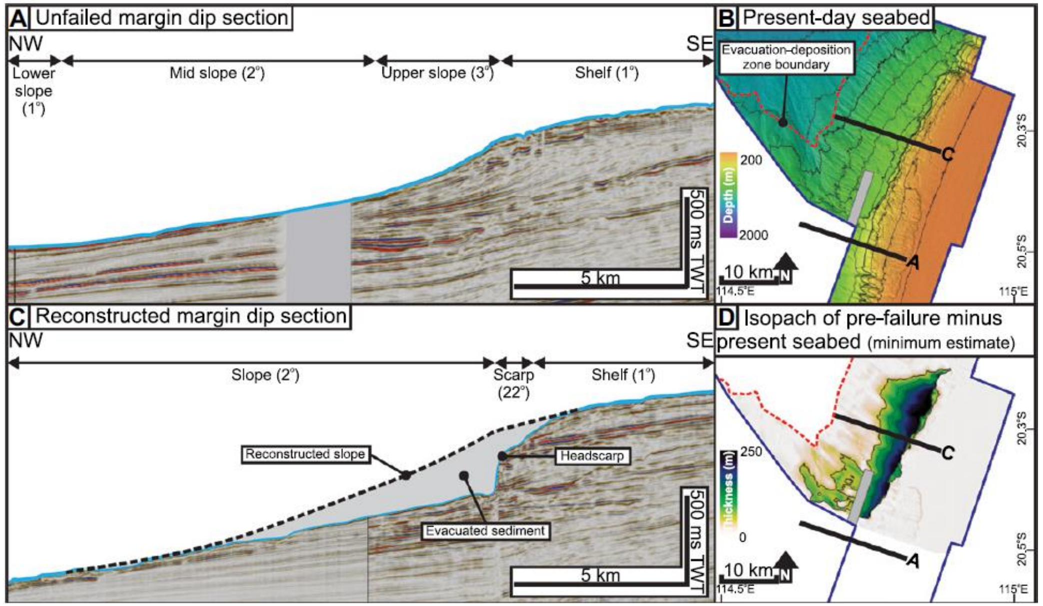


From Mateus et al. (in press)

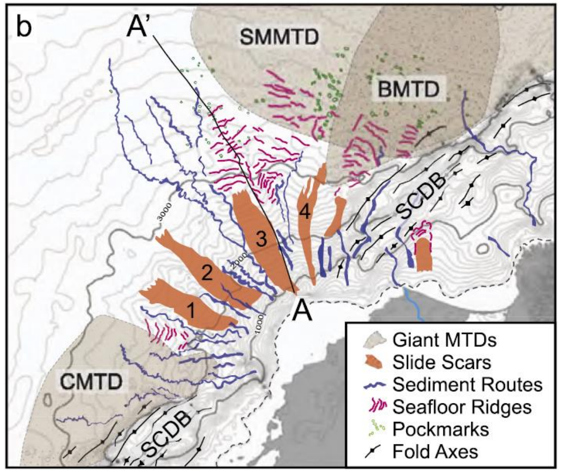
Extreme slope instability



From Mateus et al. (in press)



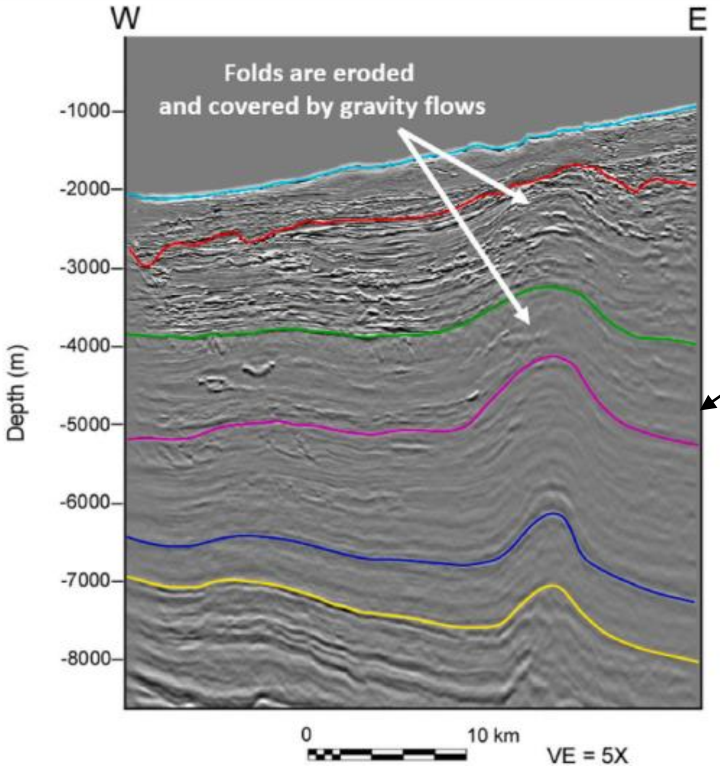
From Nugraha et al. (2022)



From Leslie and Mann (2016)

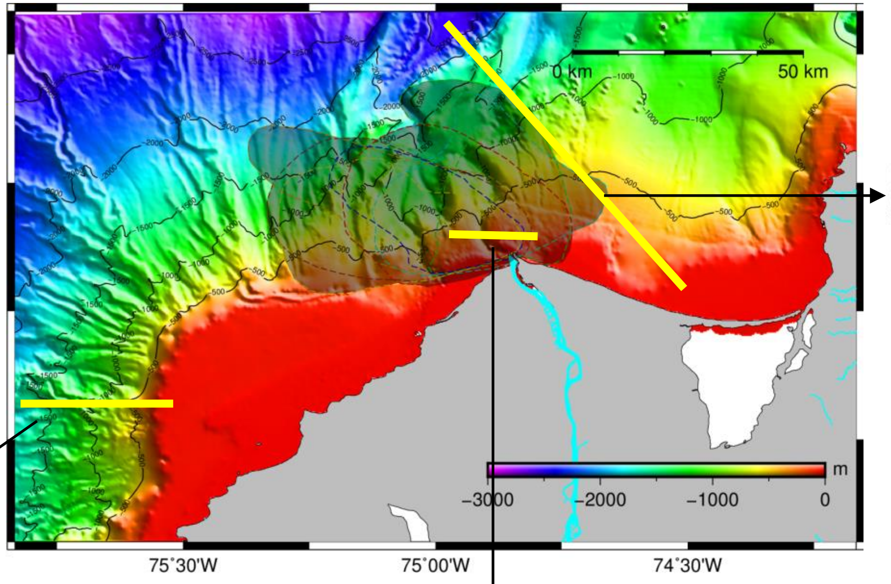
The lengths and widths of MTCs exceed 150 km and 25 km, respectively, in the continental rise. These highly erosive flows may have the ability to smooth and modify the relief of the continental slope and bottom of the Colombia Basin and their deposits cover areas that reach 1,540 km^2 and have been reported with sizes of up to 34,700 km^2 in the subsurface.

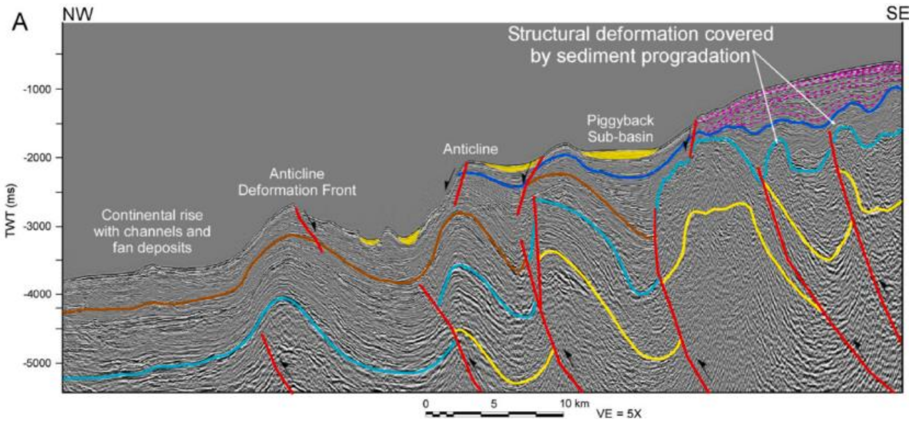
Ancient vs. Modern upper fan



From Naranjo-Vesga et al. (2022)

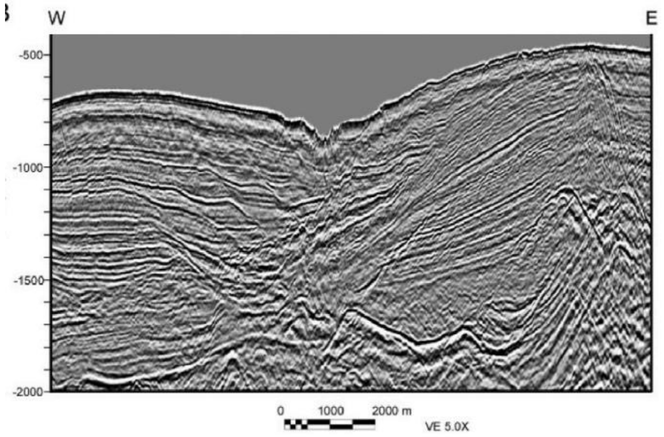
A “false” appearance of low structural deformation, when in reality the fold belt has been degraded and buried

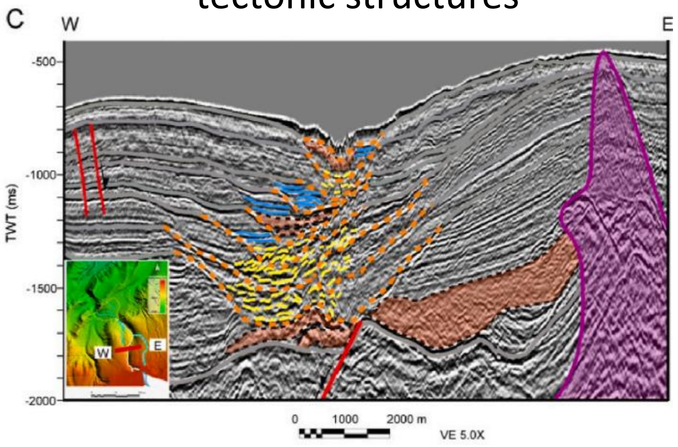




From Naranjo-Vesga et al. (2022)

High sediment input from the Magdalena River enables filling of the piggyback sub-basins between the anticlines, and the progradation of sediments, thereby burying the tectonic structures

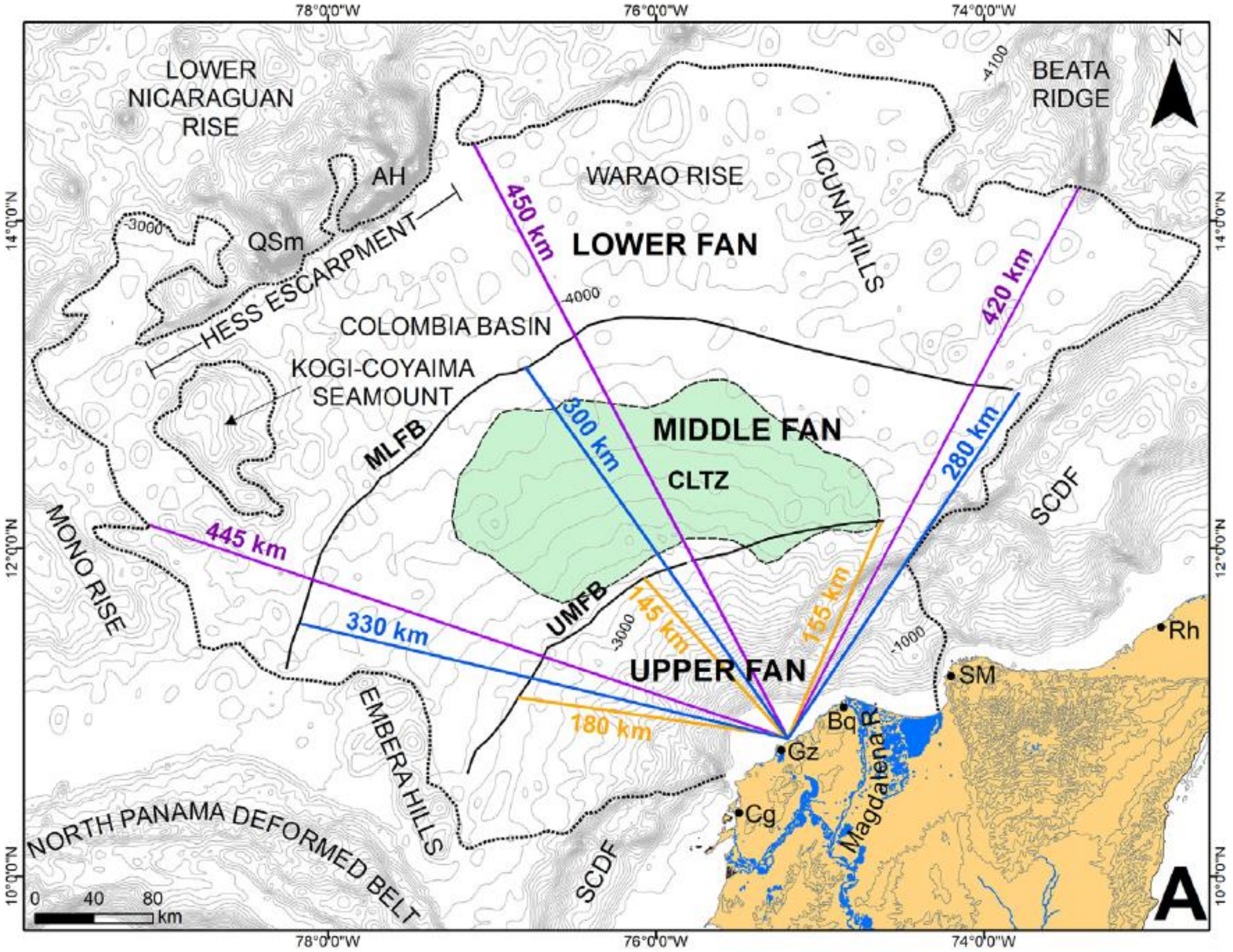




From Naranjo-Vesga et al. (2022)

The Magdalena canyon has sectors with prevalent vertical aggradation (~1000 m).

Modern Magdalena Deep-sea Fan

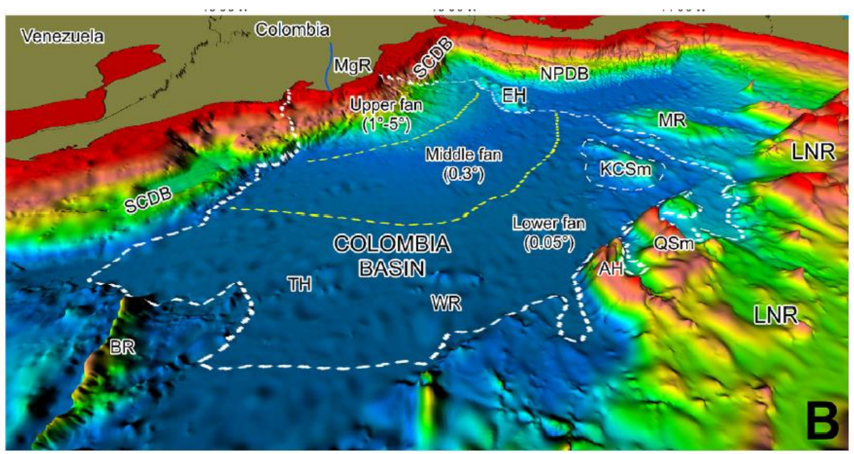


An area of ~ 237,000 km^2, which puts it among the World's largest submarine fans.

Amazon Fan: ~ 330.000 km^2

Congo Fan: ~ 300.000 km^2

Mississippi Fan: ~ 300.000 km^2



From Idárraga-García et al. (2019)

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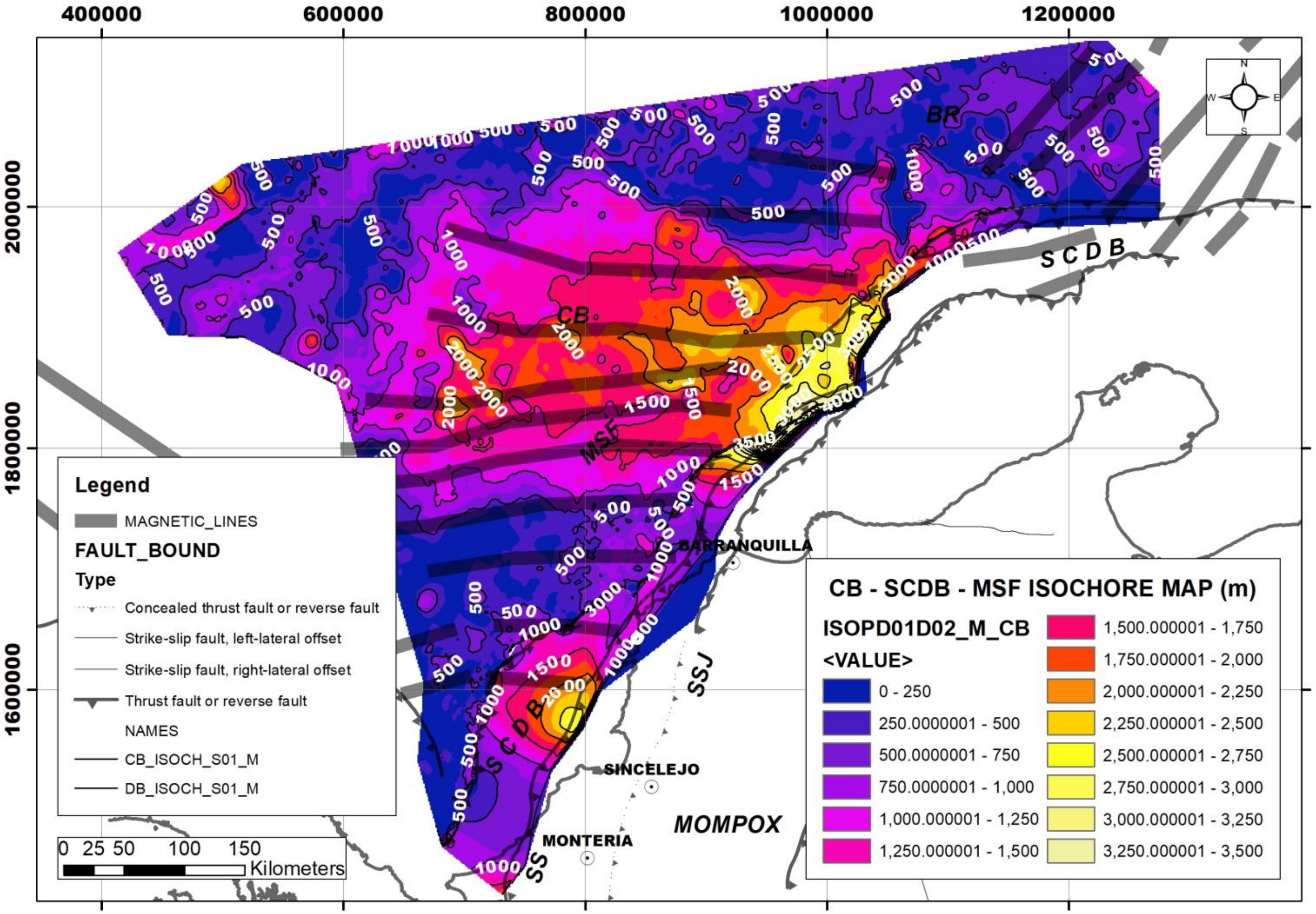
Magdalena Deep-sea Fan evolution



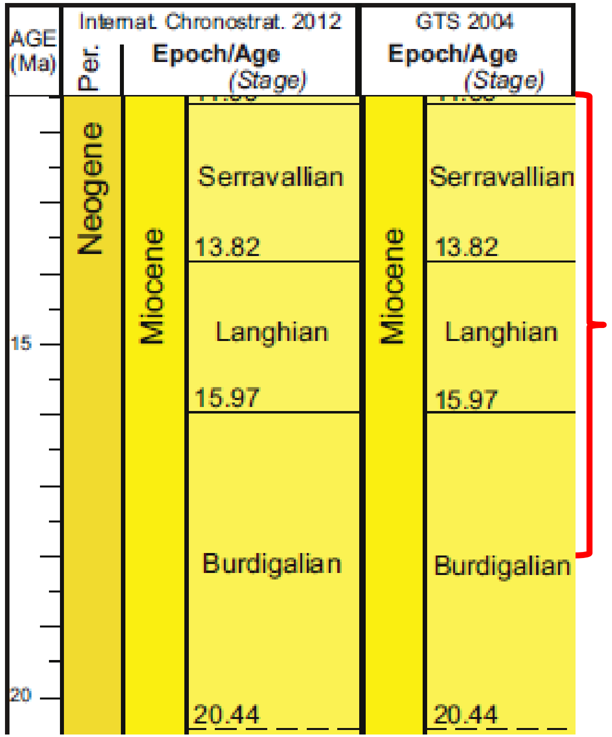
From López et al. (2021)

This sequence marks the beginning of the great sedimentary contributions in the CB area, provided by the South American continent

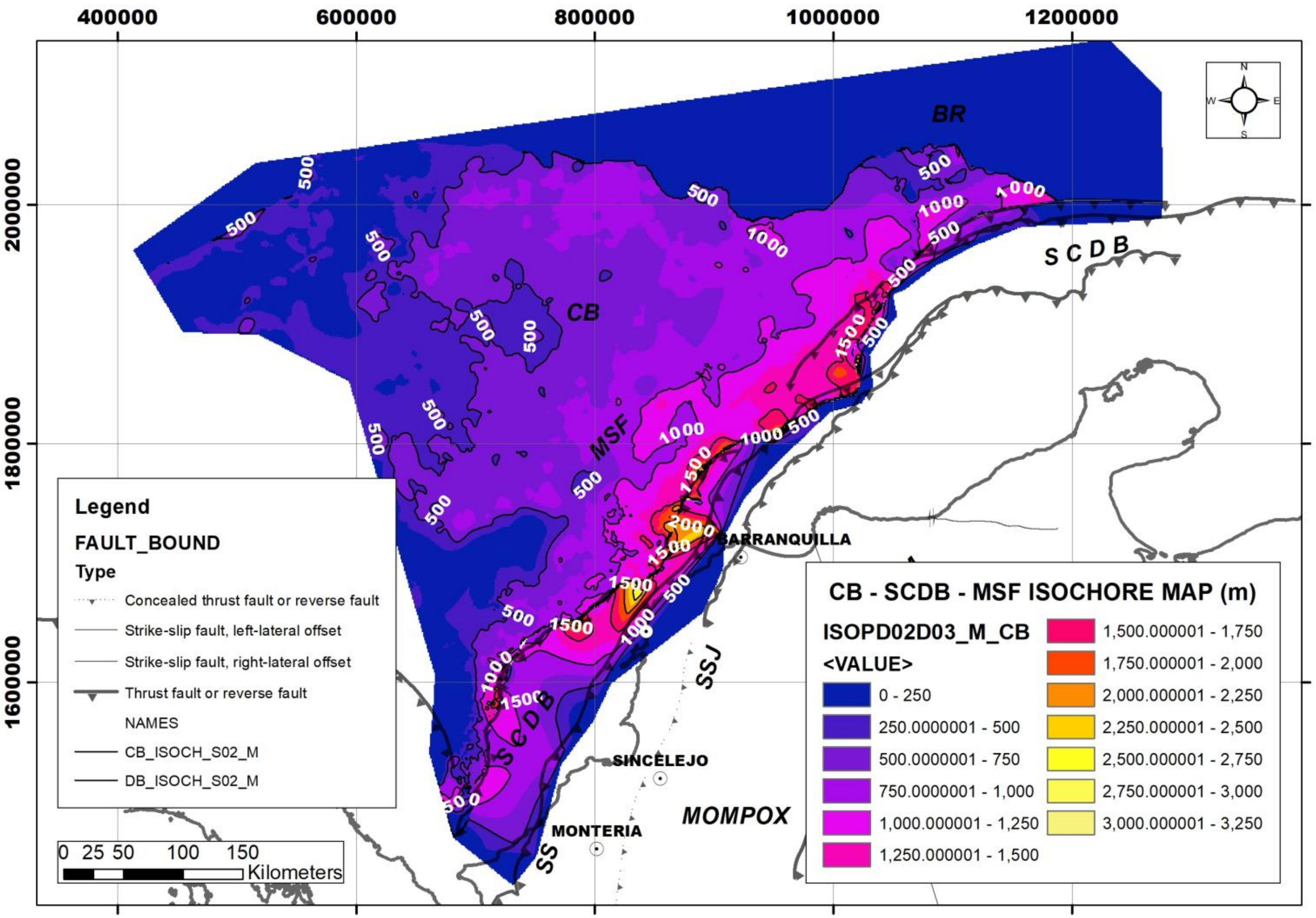
SO1: 17.91 My to 11.62 Ma (6.92 My)

The accumulated sediment volumes during this time interval, lead to estimate a rate of 1.34×10^{14} Tons/My (~134 MTons/year) or 49,697 km^3/My

About the same sedimentary transport rate of the Magdalena River 144 MTon/y



Magdalena Deep-sea Fan evolution



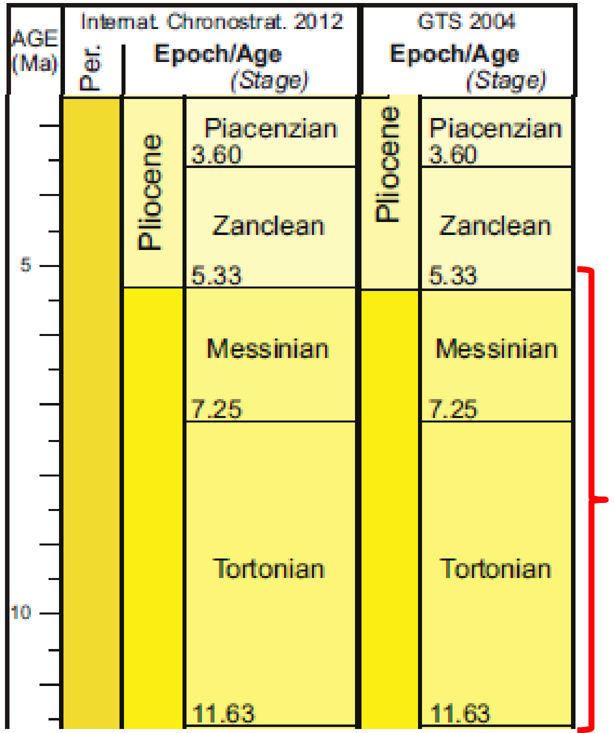
From López et al. (2021)

The arrival of the proto-Magdalena River close to its modern Fan occurred in late Miocene - early Pliocene times.

SO2: 11.6 My to 5.01 Ma (6.5 My)

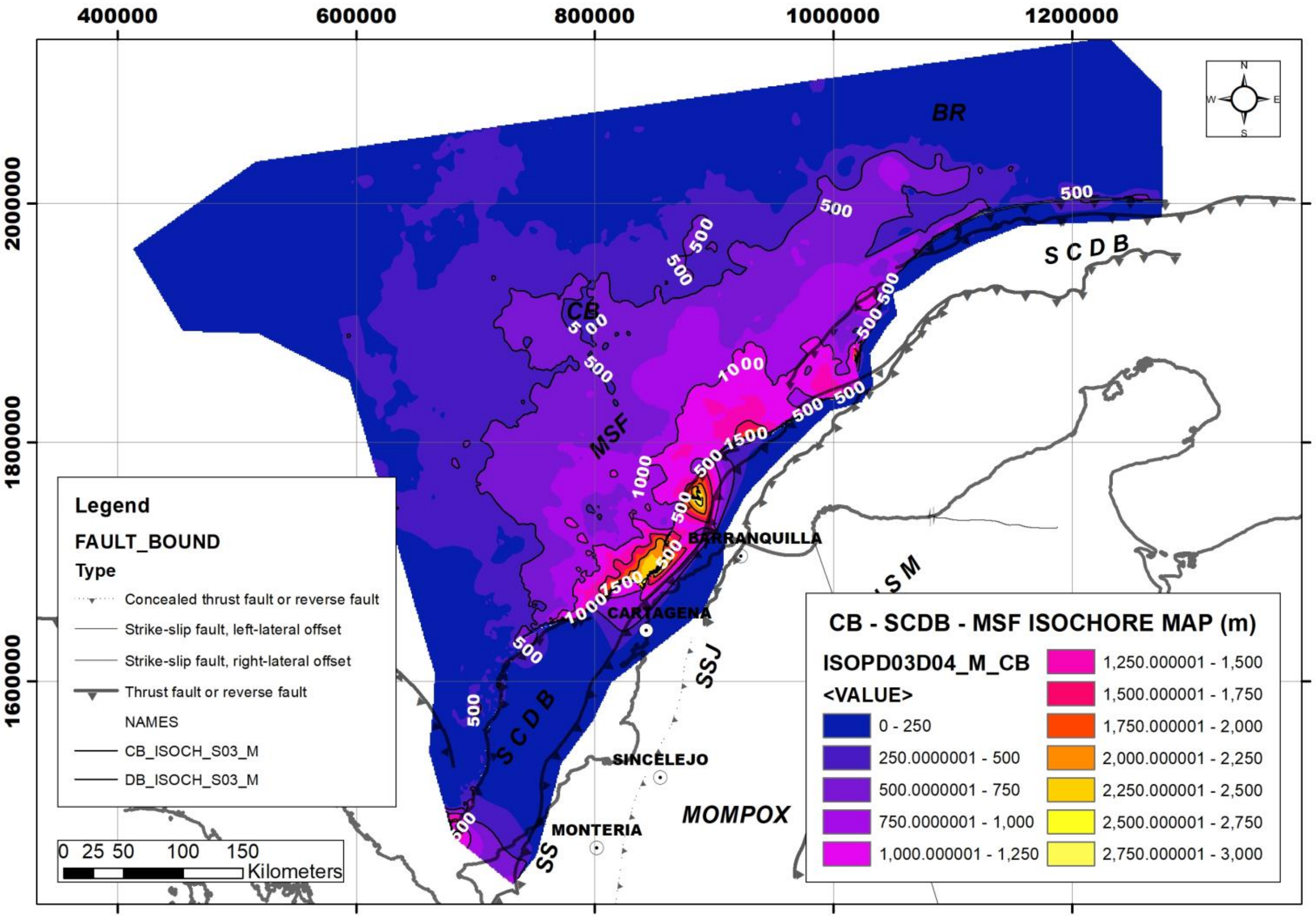
The accumulated sediment volumes during this time interval, lead to estimate a rate of 5.46 x 10^{13} Tons/My (~55 MTons/year) or 20,200 km^3/My

Third of the current sedimentation rate of the Magdalena River (144 MTon/y)



AGE (Ma)	Per.	Internat. Chronostrat. 2012 Epoch	Internat. Chronostrat. 2012 Age (Stage)	GTS 2004 Epoch	GTS 2004 Age (Stage)
		Pliocene	Piacenzian 3.60	Pliocene	Piacenzian 3.60
5			Zanclean 5.33		Zanclean 5.33
			Messinian 7.25		Messinian 7.25
10			Tortonian 11.63		Tortonian 11.63

Magdalena Deep-sea Fan evolution



From López et al. (2021)

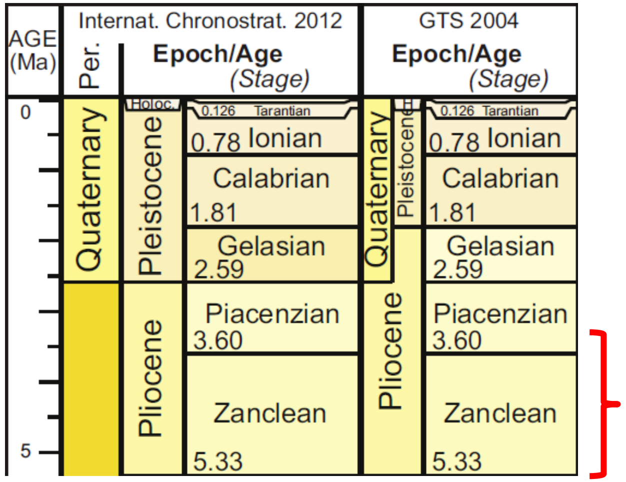
Accumulated after the union of the Cauca and Magdalena rivers hydrographic basins

SO3: 5.01 My to 3.52 Ma (1.49 My)

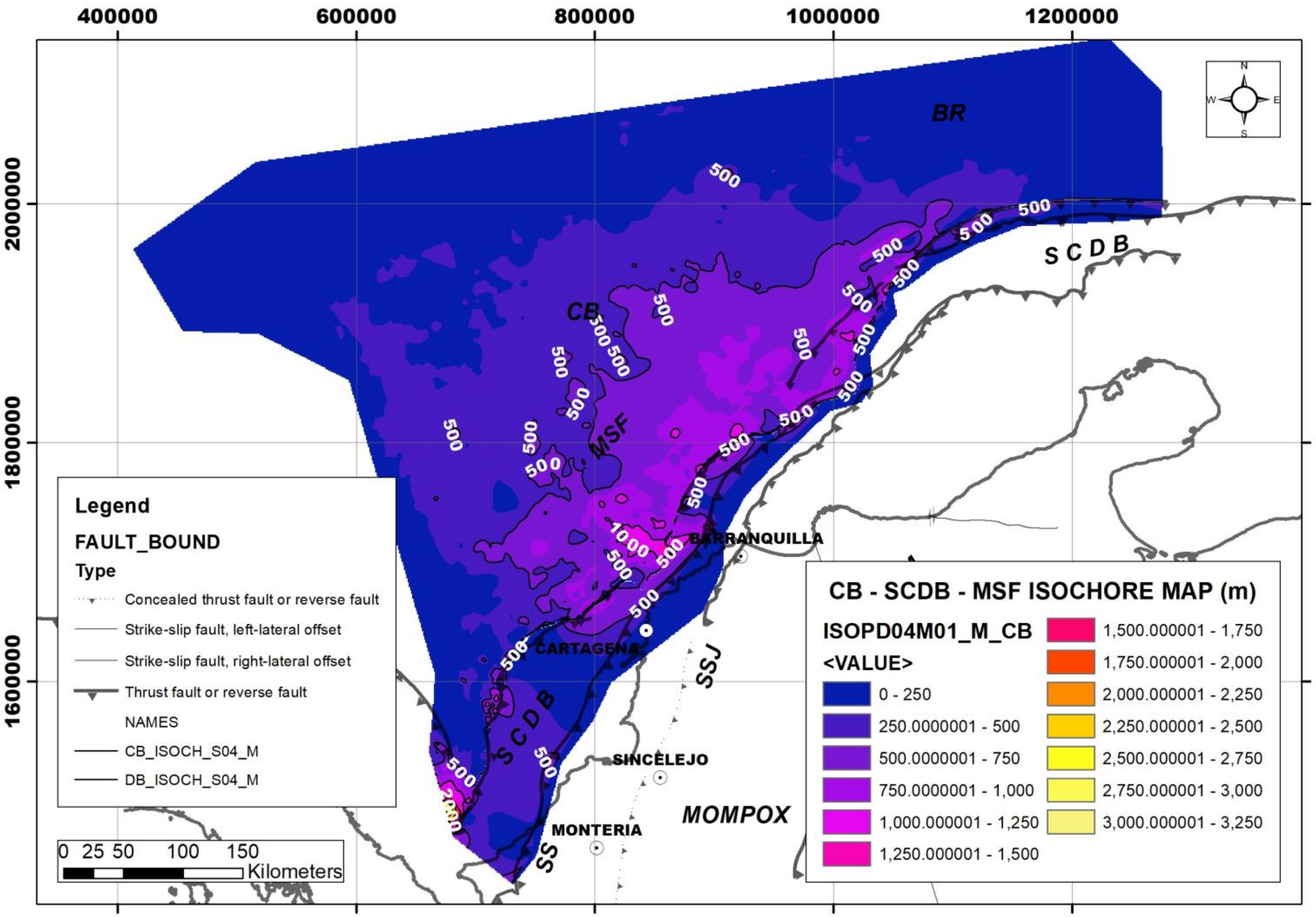
Fan shape: less than 100 km wide, less than 200 km long, and NW direction of ejection

The accumulated sediment volumes during this time interval, lead to estimate a rate of 1.55 x 10^{14} Tons/My (~155 MTons/year) or 57,463 km^3/My

Three times greater than the previous sequence S02 (~55 MTons/year)



Magdalena Deep-sea Fan evolution



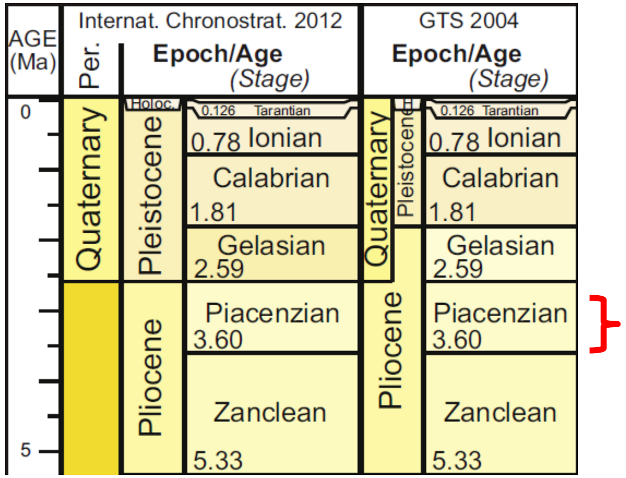
From López et al. (2021)

SO4: 3.52 My to 2.70 My (0.82 My)

Fan shape: an elongated lobe shape, more than 300 km wide and less than 200 km long, arranged along the SCDB.

This sedimentary volume was accumulated at rates of 1.74x10^{14} Tons/My (~174 Mtons/y) or 64,526 km^3/My

Slight increase compared to previous SO3, exceeding current rate (144 MTon/y).



Seismic data of the north of MSF suggests the presence of a giant (>3000 km^3) MTC more than 100 km long and ~40-200 m thick, named Barranquilla (Leslie and Mann, 2019)

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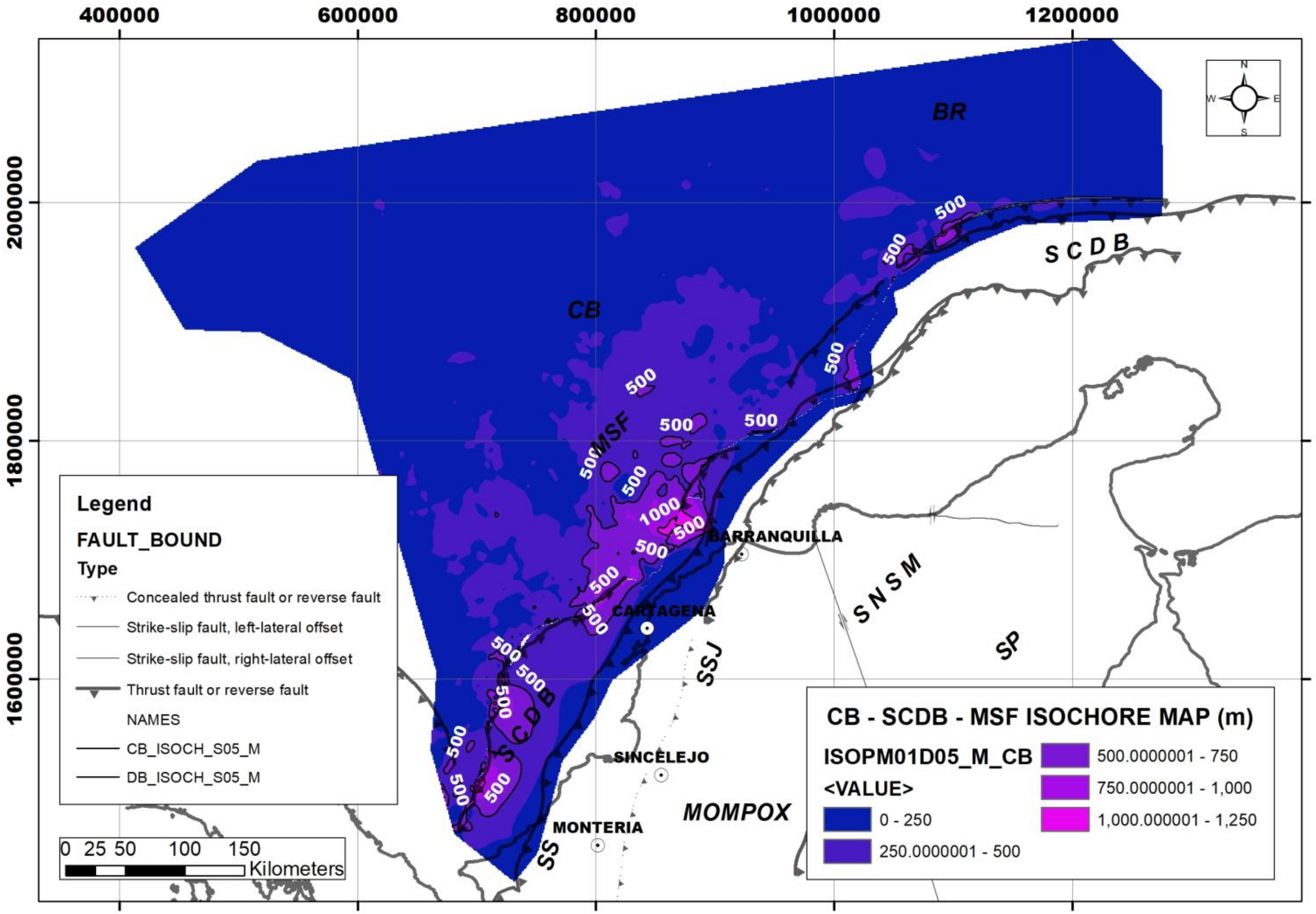
St. John's - Cartagena

Magdalena Deep-sea Fan evolution



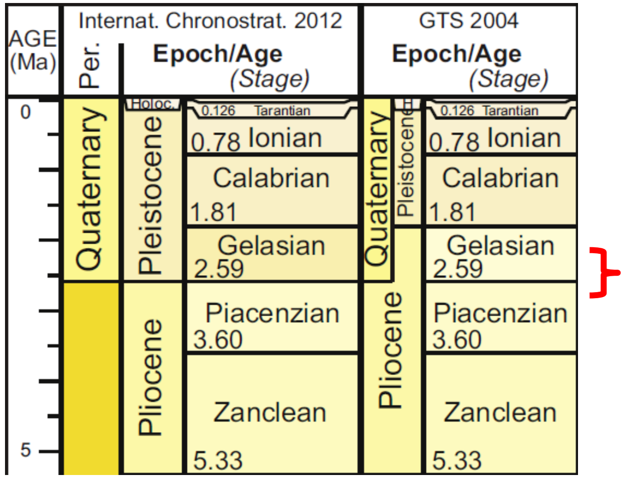
From López et al. (2021)

SO5: 2.70 to 2.36 Ma (0.34 My)

Fan shape: slight lobular elongated shape, which decreases towards the CB area.

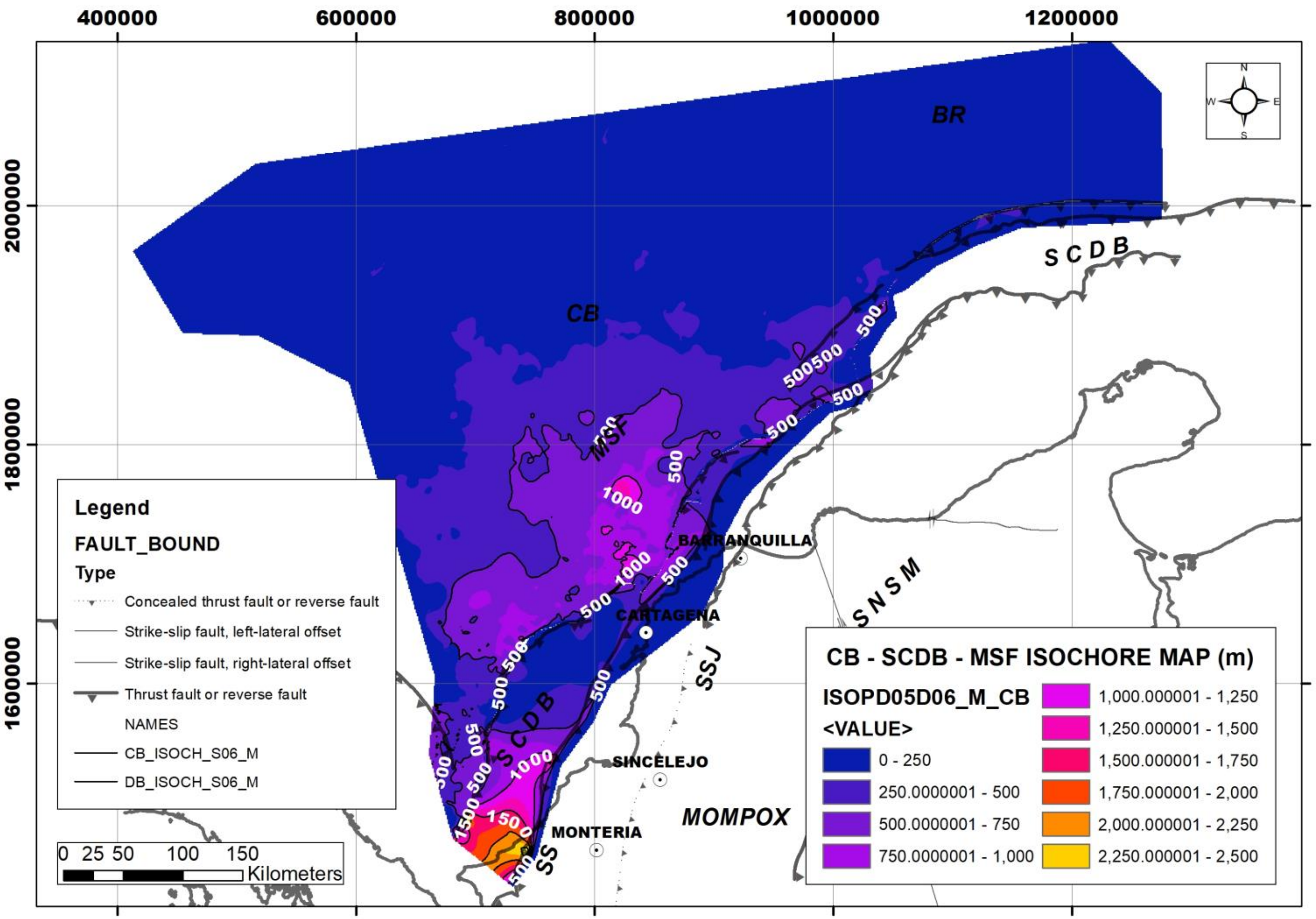
This sedimentary volume accumulated at rates of 2.95x10^{14} Tons/My (~295 MTons/year) or 109,137 km^{3}/My.

Almost twice the estimated sedimentation rates for the previous sequences, doubling the current sedimentation rate (144 MTon/y).



AGE (Ma)	Internat. Chronostrat. 2012			GTS 2004		
	Per.	Epoch	Age (Stage)	Per.	Epoch	Age (Stage)
0	Quaternary	Holoc.		Quaternary	H	
		Pleistocene	0.126 Tarantian		Pleistocene	0.126 Tarantian
			0.78 Ionian			0.78 Ionian
			Calabrian 1.81			Calabrian 1.81
			Gelasian 2.59		Pliocene	Gelasian 2.59
		Pliocene	Piacenzian 3.60			Piacenzian 3.60
5			Zanclean 5.33			Zanclean 5.33

Magdalena Deep-sea Fan evolution



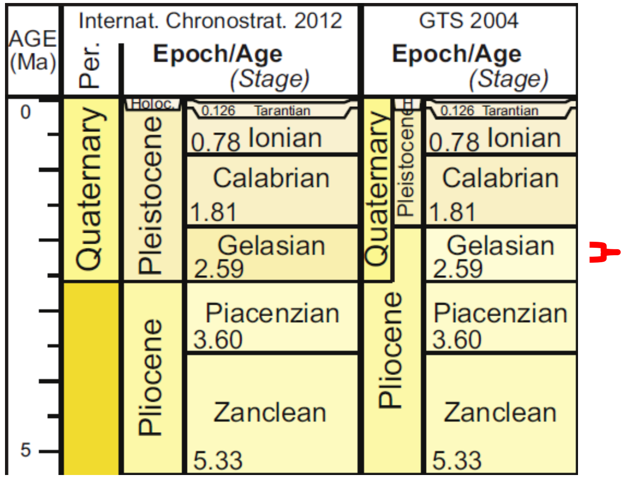
From López et al. (2021)

SO6: 2.36 My to 2.21 My (0.15 My)

Fan shape: a slightly elongated lobe shape, less than 100 km wide and about 200 km long

This sedimentary volume accumulated at rates of 8.03x10^{14} Ton/My (~803 MTons/year) or 297,251 km^3/My.

Maximum sedimentation rate, six times greater than the current sedimentary rate (144 MTon/y)



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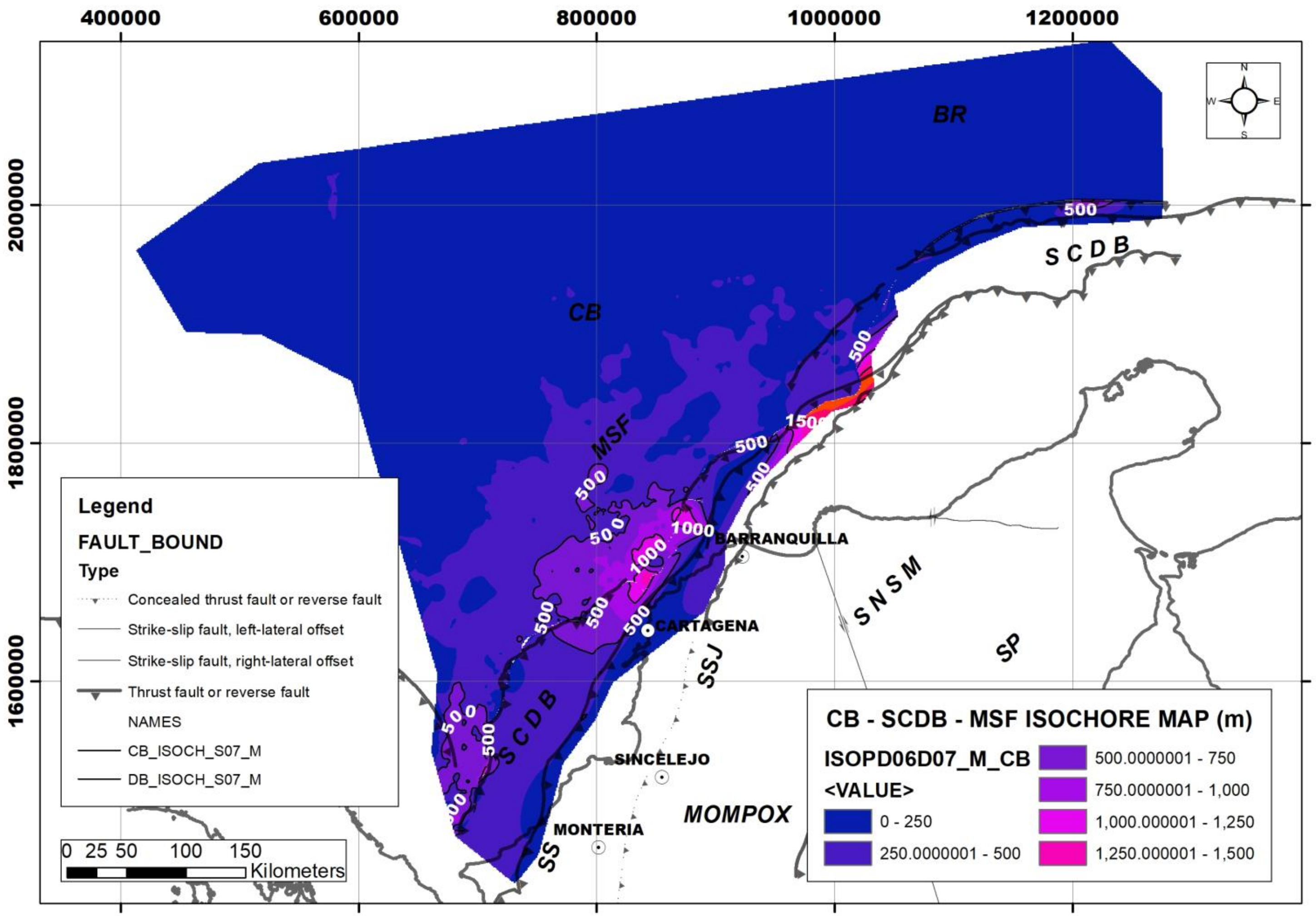
Magdalena Deep-sea Fan evolution



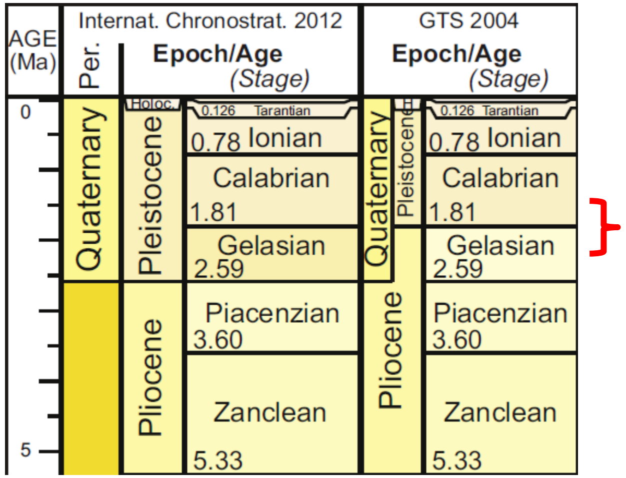
From López et al. (2021)

SO7: 2.21 to 1.69 Ma (0.52 My)

Fan shape: a small, slightly elongated lobe, less than 100 km wide and long, which towards the central part of the CB and the SCDB decrease to 500 m, and less to the north.

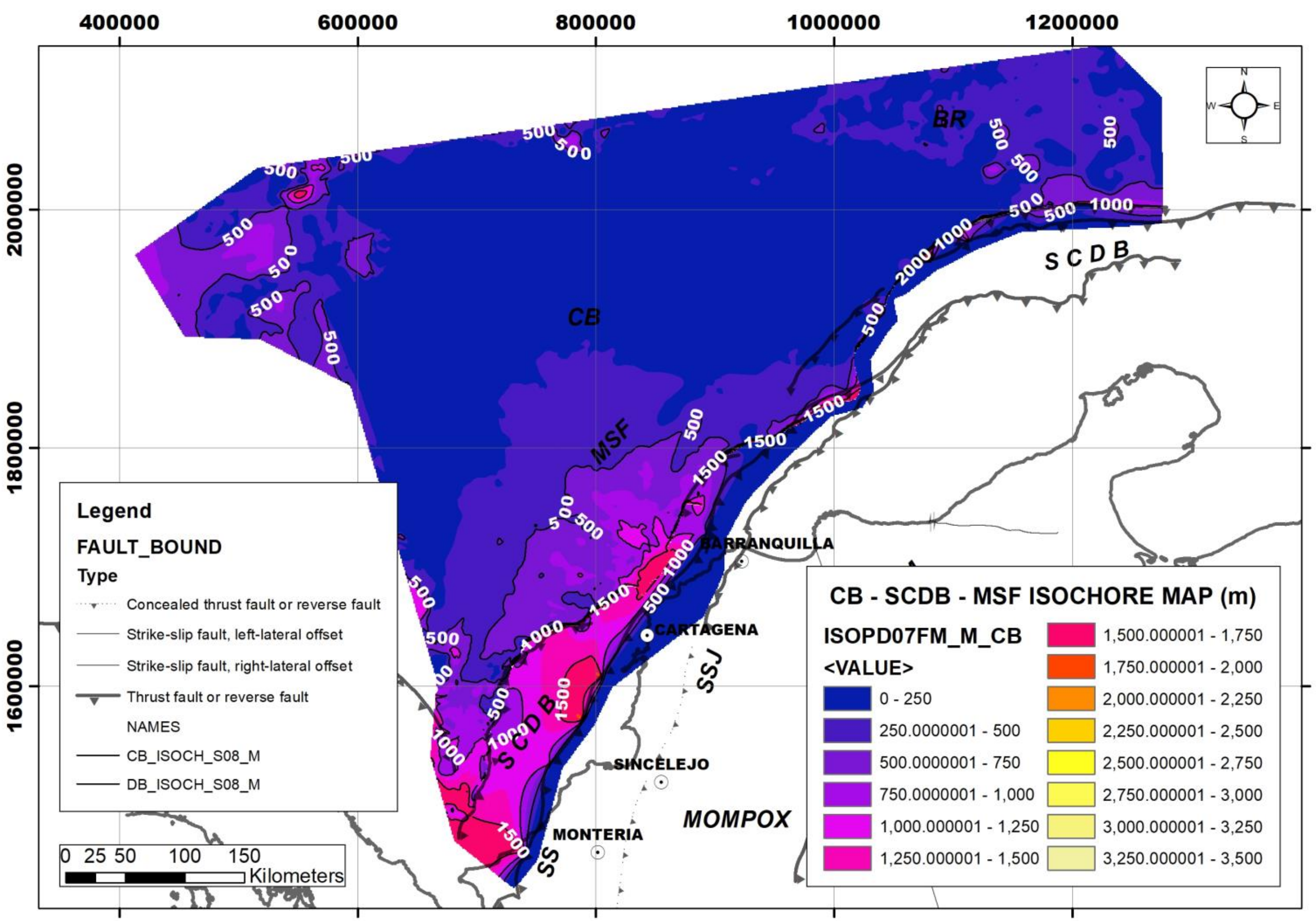
This sedimentary volume accumulated at rates of 1.65 x 10^{14} Tons/My (~165 Tons/year) or 61,033 km^3/My.

Very similar to the rates registered during the accumulation of sequences S03 and S04.



AGE (Ma)	Internat. Chronostrat. 2012 Per.	Internat. Chronostrat. 2012 Epoch	Internat. Chronostrat. 2012 Epoch/Age (Stage)	GTS 2004 Per.	GTS 2004 Epoch	GTS 2004 Epoch/Age (Stage)
0	Quaternary	Holoc.	0.126 Tarantian	Quaternary	Pleistocene	0.126 Tarantian
		Pleistocene	0.78 Ionian			0.78 Ionian
			Calabrian 1.81			Calabrian 1.81
			Gelasian 2.59		Pliocene	Gelasian 2.59
		Pliocene	Piacenzian 3.60			Piacenzian 3.60
5			Zanclean 5.33			Zanclean 5.33

Magdalena Deep-sea Fan evolution



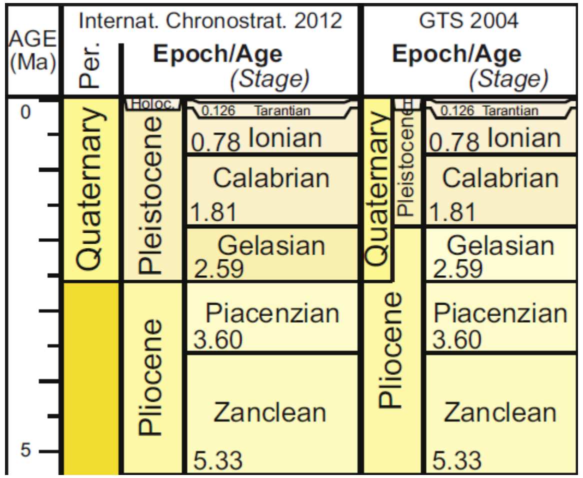
From López et al. (2021)

SO8: < 1.69 Ma (1.69 My)

Fan shape: an elongated lobe shape and depocenters included in the SCDB, to the west of the Sinu mountain range.

This sedimentary volume accumulated at rates of 1.01×10^{14} Tons/My (~101 MTons/year) or 37,272 km^3/My.

Less than the rate measured during the recent one (144 MTon/y)



AGE (Ma)	Internat. Chronostrat. 2012			GTS 2004		
	Per.	Epoch	Age (Stage)	Per.	Epoch	Age (Stage)
0	Quaternary	Holoc.	0.126 Tarantian	Quaternary	H	0.126 Tarantian
		Pleistocene	0.78 Ionian		Pleistocene	0.78 Ionian
			Calabrian 1.81			Calabrian 1.81
			Gelasian 2.59			Gelasian 2.59
		Pliocene	Piacenzian 3.60		Pliocene	Piacenzian 3.60
5			Zanclean 5.33			Zanclean 5.33

MSM112 - Magdalena ROFI

EL TIEMPO

COLOMBIA | BOGOTÁ MEDELLÍN CALI BARRANQUILLA SANTANDER BOYACÁ LLANO MÁS CIUDADES

Compartir

Preparan expedición científica colombo-alemana en el delta del río Magdalena

21 de agosto 2022

MSM 112
07.10. - 14.11.22
St. John's - Cartagena

Goals

1. Assess the extension and dynamics of a tropical river plume: dimensions, stability, extent, mixing conditions, structure of the salt wedge, total suspended solids (TSS), and pycnocline dynamics and turbulent processes.

2. Quantify past and modern sedimentary connections between the river mouth, delta and adjacent coastal zones with a focus on human impact on morphological changes and nutrients and pollutants balance.

3. Explore the hypothesis of a possible interaction between the RM ROFI and La Guajira Upwelling system

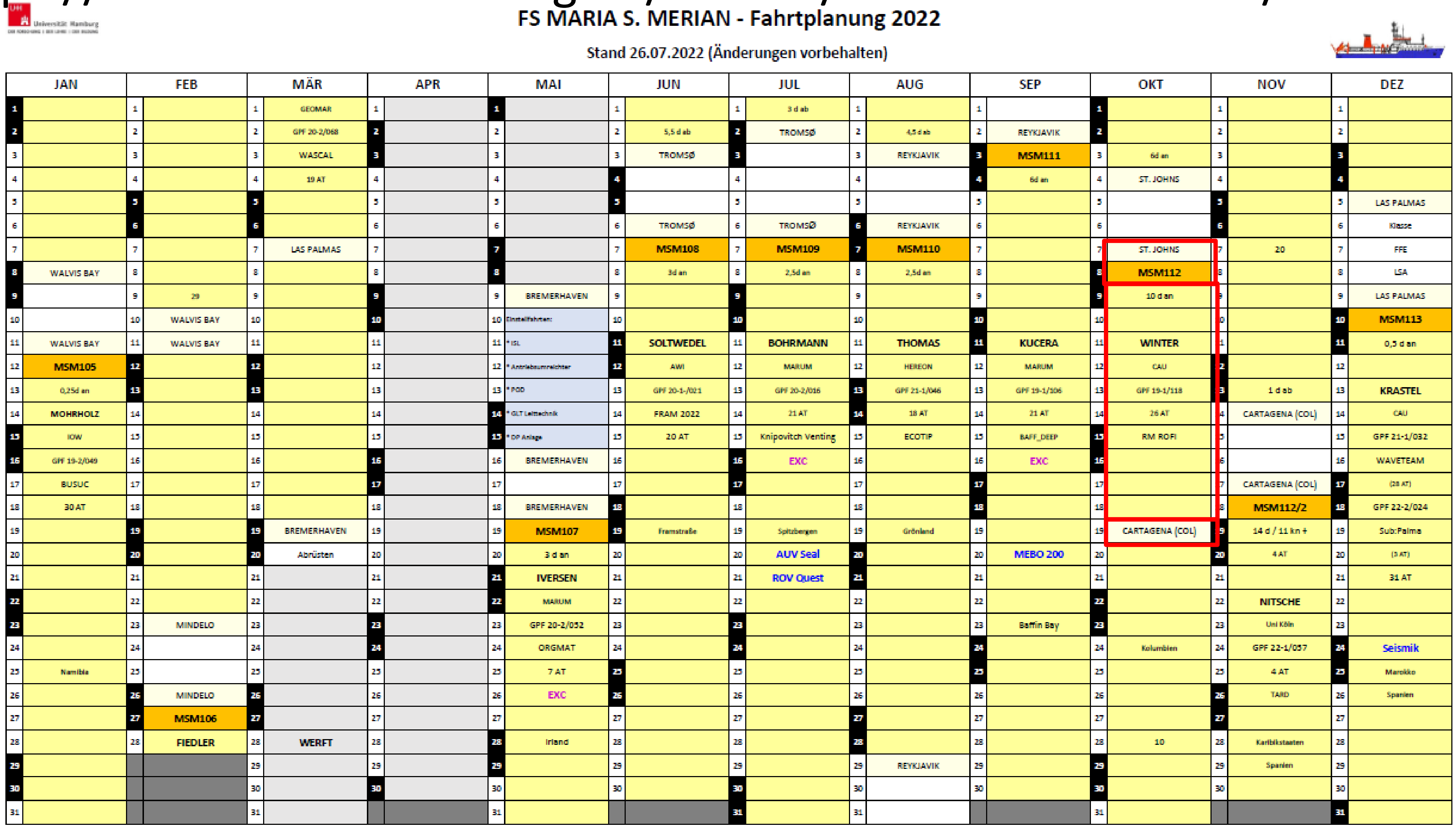
The Maria S. Merian (MSM112)

The youngest of the German research fleet.
Also called the "Blue Angel“.

Year of construction:	2006
Length:	94,8 m
Beam:	19,2 m
Nautical Crew:	21 Persons
Scientists:	**23 Persons**

Schedule

https://www.ldf.uni-hamburg.de/merian/dokumente-merian/msm2022.pdf



FS MARIA S. MERIAN - Fahrtplanung 2022

Stand 26.07.2022 (Änderungen vorbehalten)

	JAN	FEB	MÄR	APR	MAI	JUN	JUL	AUG	SEP	OKT	NOV	DEZ
1			GEOMAR				3 d ab					
2			GPF 20-2/068			5,5 d ab	TROMSØ	4,5 d ab	REYKJAVIK			
3			WASCAL			TROMSØ		REYKJAVIK	MSM111	6d an		
4			19 AT						6d an	ST. JOHNS		
5												LAS PALMAS
6						TROMSØ	TROMSØ	REYKJAVIK				Klasse
7			LAS PALMAS			MSM108	MSM109	MSM110		ST. JOHNS	20	FFE
8	WALVIS BAY					3d an	2,5d an	2,5d an		MSM112		LSA
9		29			BREMERHAVEN					10 d an		LAS PALMAS
10		WALVIS BAY			Einstellfahrten:							MSM113
11	WALVIS BAY	WALVIS BAY			* ISL	SOLTWEDEL	BOHRMANN	THOMAS	KUCERA	WINTER		0,5 d an
12	MSM105				* Antriebsumrichter	AWI	MARUM	HEREON	MARUM	CAU		
13	0,25d an				* POD	GPF 20-1-/021	GPF 20-2/016	GPF 21-1/046	GPF 19-1/106	GPF 19-1/118	1 d ab	KRASTEL
14	MOHRHOLZ				* GLT Leittechnik	FRAM 2022	21 AT	18 AT	21 AT	26 AT	CARTAGENA (COL)	CAU
15	IOW				* DP Anlage	20 AT	Knipovitch Venting	ECOTIP	BAFF_DEEP	RM ROFI		GPF 21-1/032
16	GPF 19-2/049				BREMERHAVEN		EXC		EXC			WAVETEAM
17	BUSUC										CARTAGENA (COL)	(28 AT)
18	30 AT				BREMERHAVEN						MSM112/2	GPF 22-2/024
19			BREMERHAVEN		MSM107	Framstraße	Spitzbergen	Grönland		CARTAGENA (COL)	14 d / 11 kn +	Sub:Palma
20			Abrüsten		3 d an		AUV Seal		MEBO 200		4 AT	(3 AT)
21					IVERSEN		ROV Quest					31 AT
22					MARUM						NITSCHE	
23		MINDELO			GPF 20-2/052				Baffin Bay		Uni Köln	
24					ORGMAT					Kolumbien	GPF 22-1/057	Seismik
25	Namibia				7 AT						4 AT	Marokko
26		MINDELO			EXC						TARD	Spanien
27		MSM106										
28		FIEDLER	WERFT		Irland					10	Karibikstaaten	
29								REYKJAVIK			Spanien	
30												
31												

26 days

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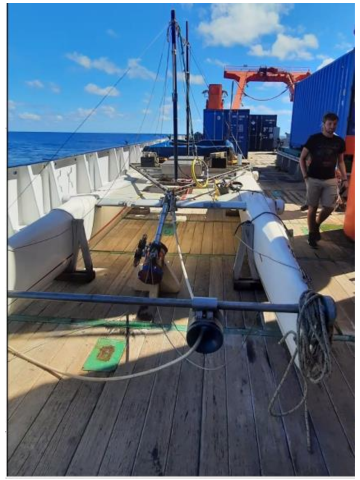
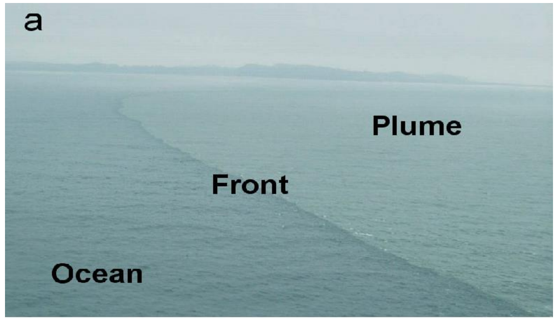
Research questions and approaches

Extension and dynamics of the river plume

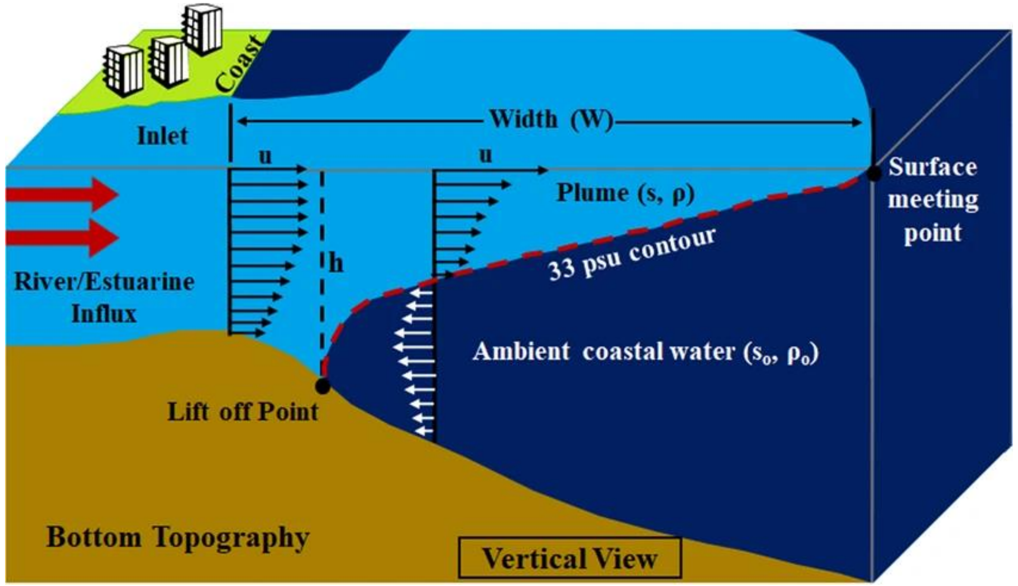

IOW Kat 1200 kHz ADCP & CTD Chain



Catamaran Acoustic Doppler current profiler (ADCP)



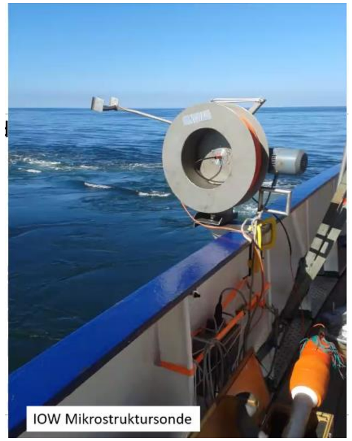
Offshore spreading of the plume over the ambient coastal.



From Seena et al. (2019)


Tidal and plume dynamics: ADCP Lander SedObs mit Pop-Up Bojen in ~30m: Upward 600kHz, 12kHz ADCP, LISST 100X, CTD, downward 1200kHz ADCP


CTD


IOW Mikrostruktursonde

Plume extent:

- What is the extension of the Magdalena River plume when comparing properties of salinity, sediments, and other characteristics? What are the dynamics and turbulent processes at the pycnocline?
- What is the spatial structure and dynamics of the mixing zone, salt wedge and turbidity maximum zone of the Magdalena River in tidal time scales?

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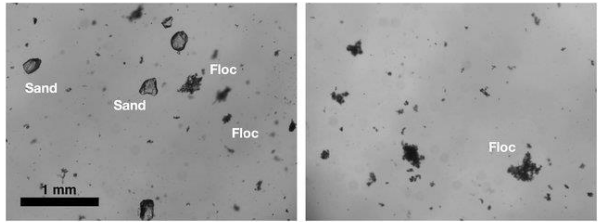
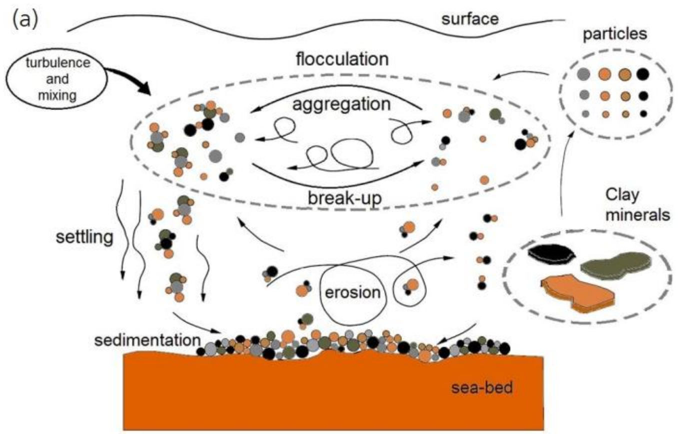
Research questions and approaches

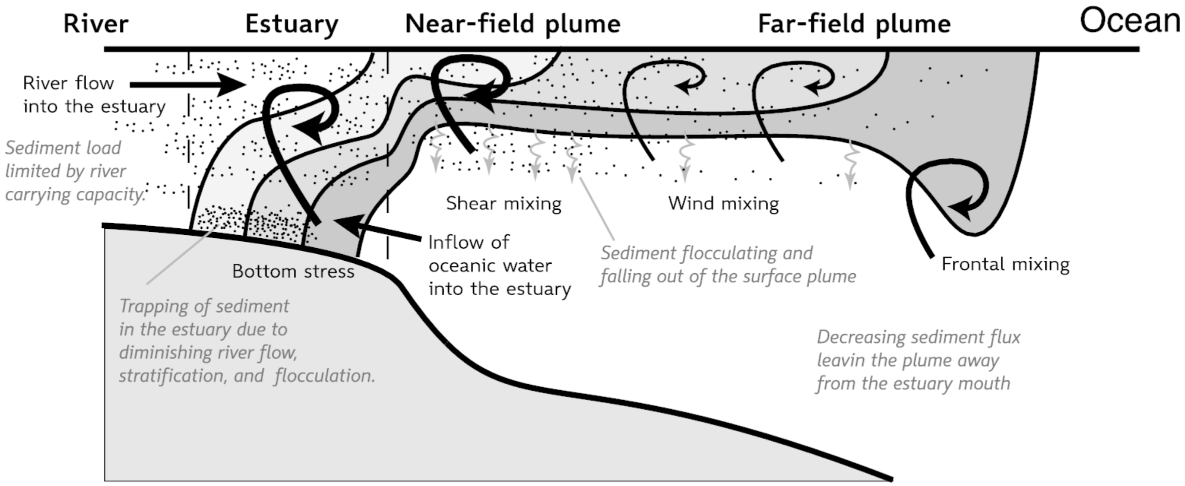
Extension and dynamics of the river plume



In situ Floc camera



From Wang and Andutta (2012)



From Hetland and Hsu (2013)

Water samples

In situ laser particle sizer

Suspended sediments:

- How are hydrodynamics and transport quantities coupled along the water column?
- How do aggregate sizes reflect local hydrodynamics?

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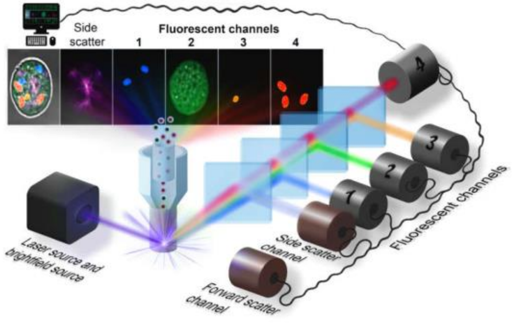
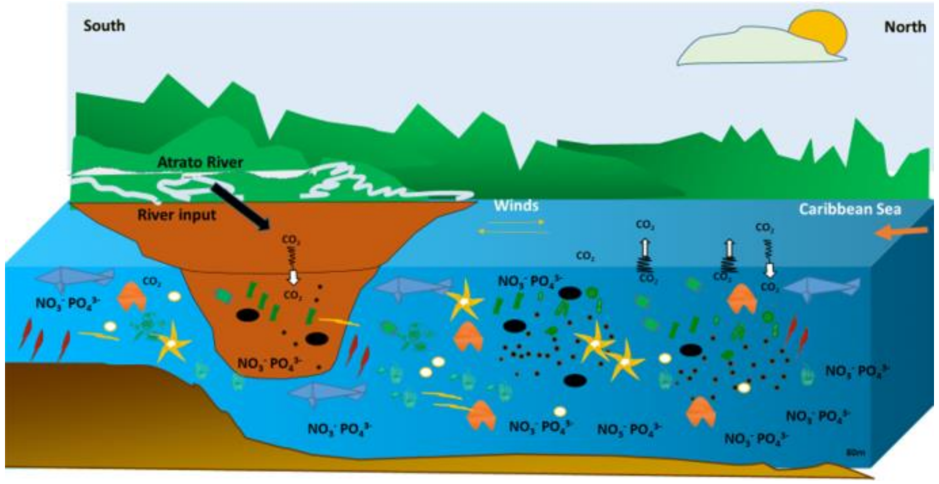
Research questions and approaches

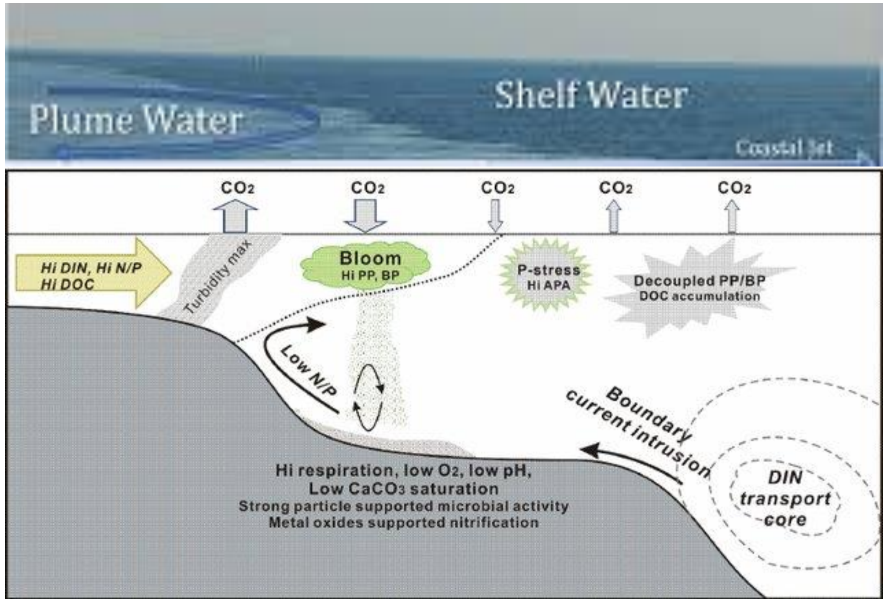
Extension and dynamics of the river plume



Water samples

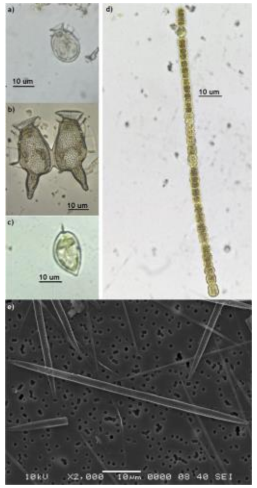


From Córdoba-Mena et al. (2020)



From Liu et al.(2014)

Water samples



Phytoplankton

From Córdoba-Mena et al. (2020)

Biochemical processes in the water column:

- What is the effective role of fluvial inputs on nutrients and contaminant dispersal and deposition in the ROFI system?
- What is the spatial distribution of phytoplankton and zooplankton functional groups in the upper section of the water column in the Magdalena River ROFI?
- What is the relation of phytoplankton abundance with chlorophyll and seston concentration levels, as possible estimators of primary productivity in the study area?

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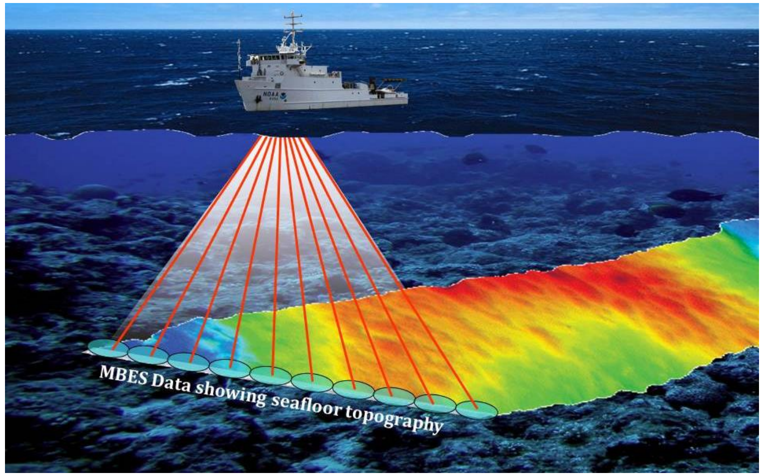
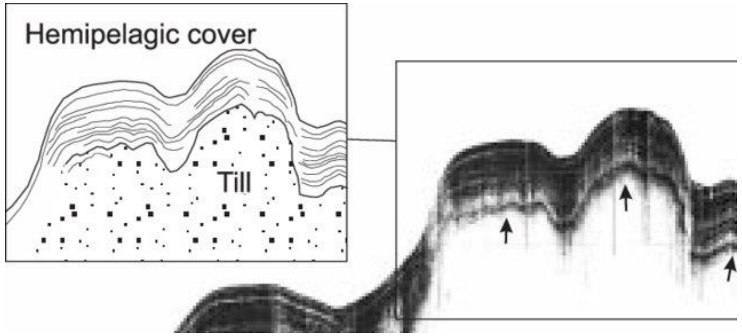
Research questions and approaches

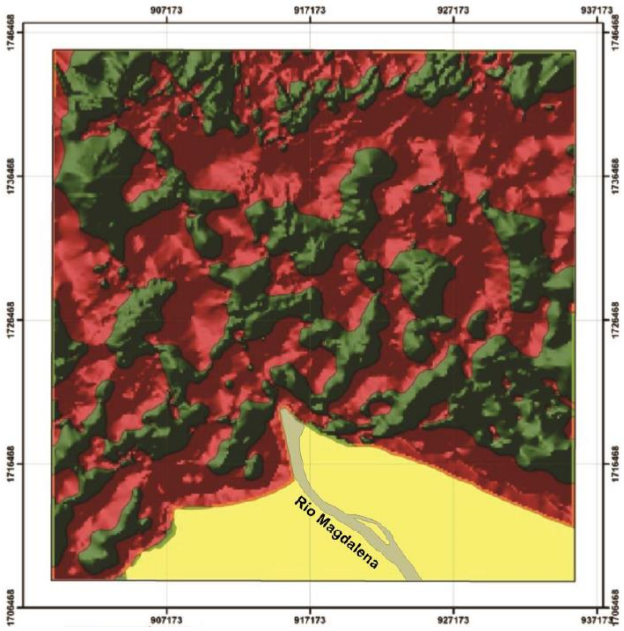
Past and modern sedimentary connections

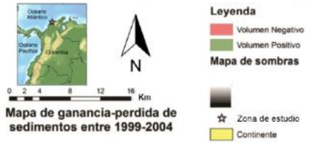


multibeam echo sounder (bathymetry and sidescan option)

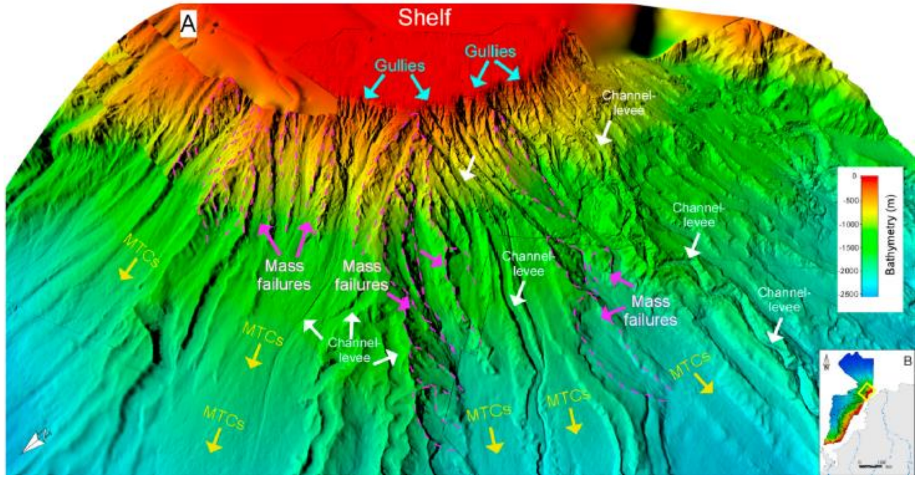


Parametric sonar (parasound or SES).





From Madrid (2017)



From Naranjo-Vesga et al. (2022)

Biochemical processes in the water column:

- What are main geomorphological features and sedimentological characteristics of the river mouth, the active delta and the abandon delta lobes?
- What are the migration rates of the river bed forms during the time scale of the observations?

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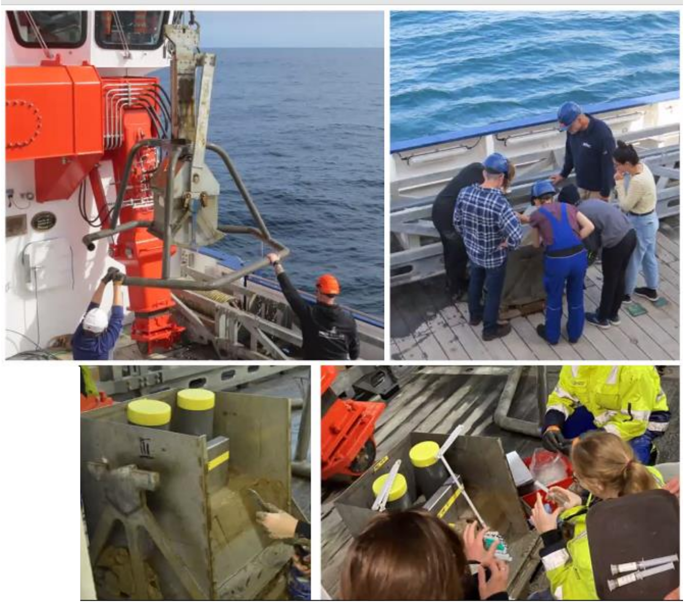
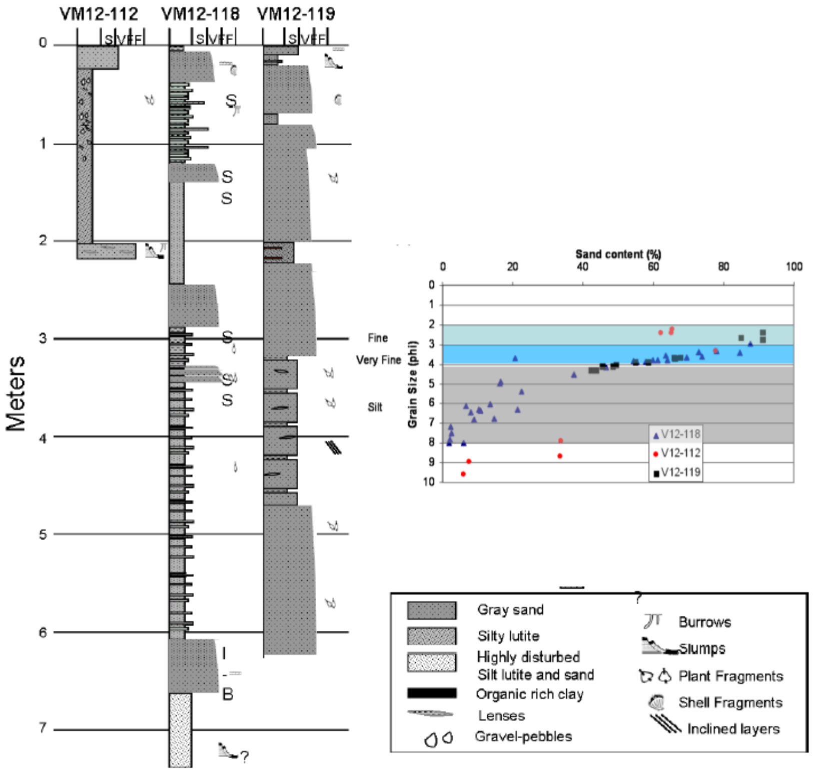
Research questions and approaches

Past and modern sedimentary connections

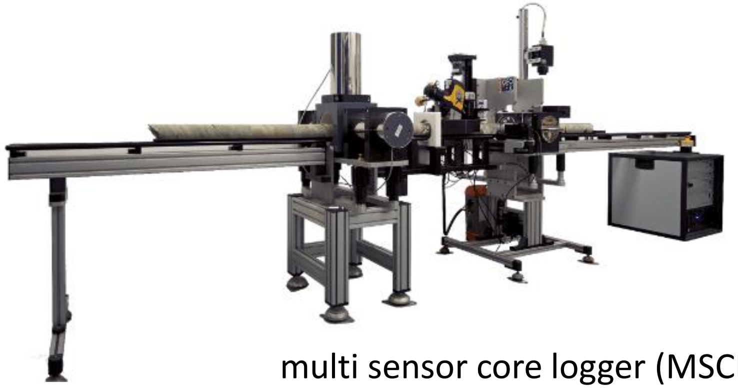


Giant box corer

Gravity corer sedimentology



From Romero (2009)



multi sensor core logger (MSCL)

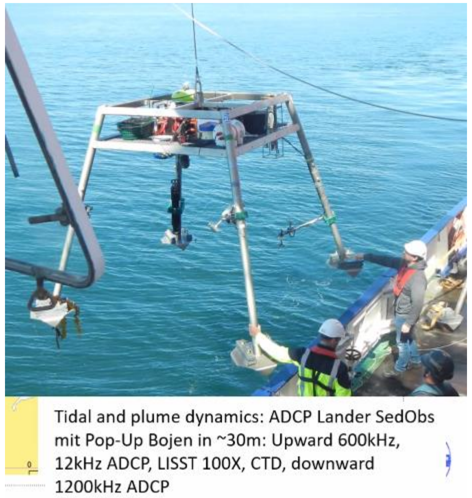
Sedimentology:

- How is the link between fluvial inputs, turbidity currents and turbidity deposits (e.g. hyperpycnal flows) and their importance on fan deposition?
- Can we record the history of human interventions in terms of pollution.

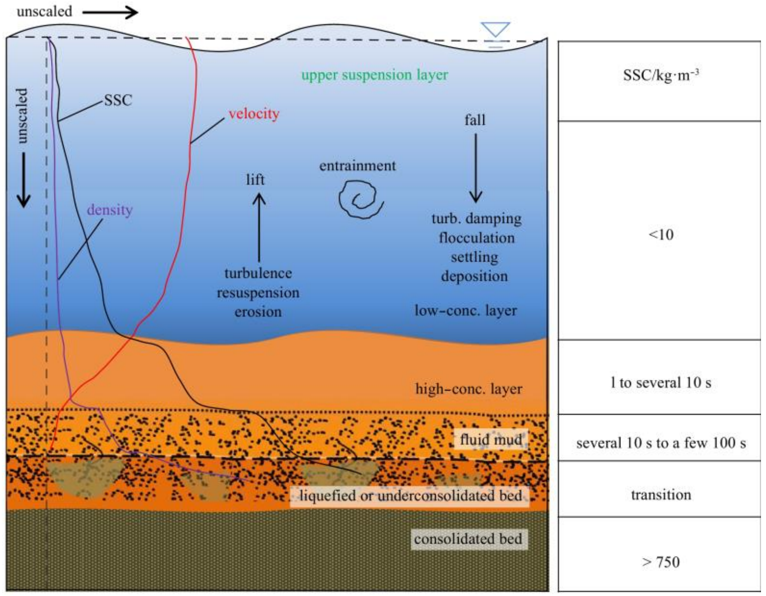
Research questions and approaches

Past and modern sedimentary connections

Giant box corer



Tidal and plume dynamics: ADCP Lander SedObs mit Pop-Up Bojen in ~30m: Upward 600kHz, 12kHz ADCP, LISST 100X, CTD, downward 1200kHz ADCP



From Wen et al. (2020)

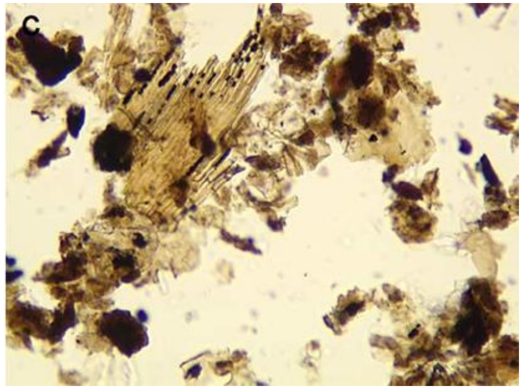
Near bed processes:

- How are bed sediments linked to suspended load? Which fraction of the bed sediments is mobilized and suspended into the (lower) water column?
- When during the tidal cycle are the seafloor features in dynamic states and when are they stable?
- How do the magnitude and frequency of turbulent events relate with waves, currents, small-scale bed morphology, bed sedimentology and benthic assemblages?

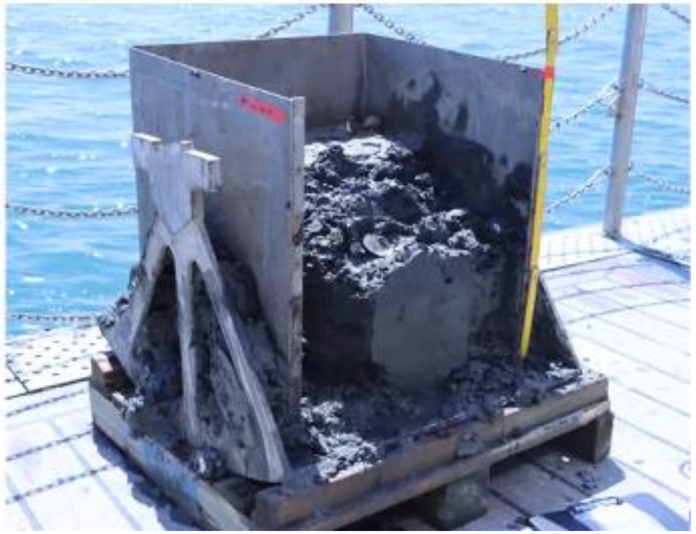
Research questions and approaches

Past and modern sedimentary connections

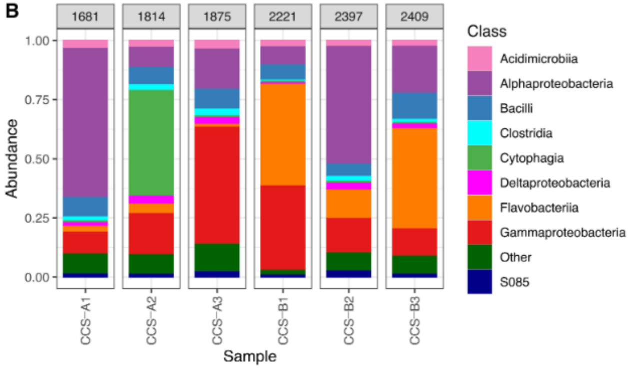
LECO



Organic petrology

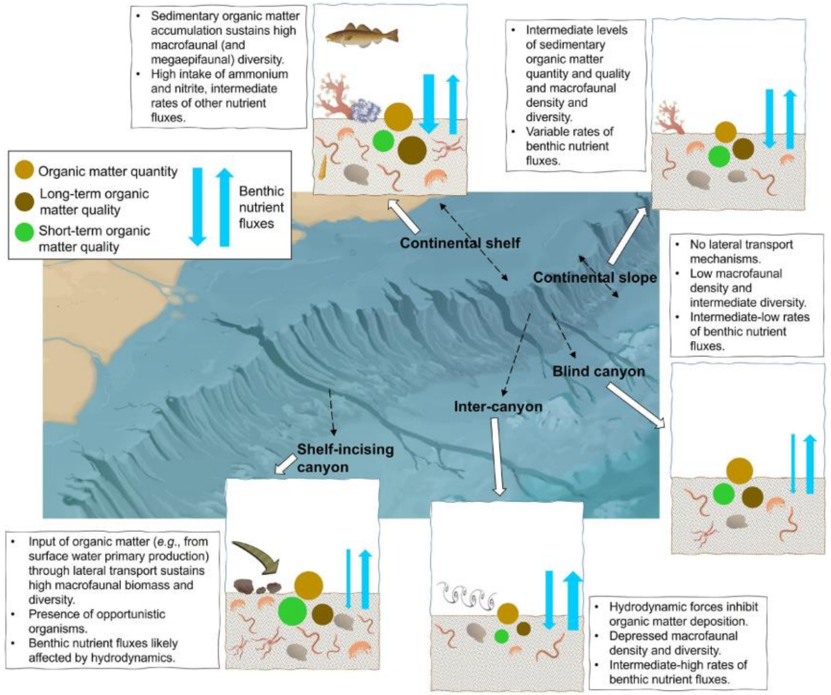


Giant box corer



Bacteria abundance

From Rivera Franco et al. (2021)



- Sedimentary organic matter accumulation sustains high macrofaunal (and megaepifaunal) diversity.
- High intake of ammonium and nitrite, intermediate rates of other nutrient fluxes.

- Intermediate levels of sedimentary organic matter quantity and quality and macrofaunal density and diversity.
- Variable rates of benthic nutrient fluxes.

- No lateral transport mechanisms.
- Low macrofaunal density and intermediate diversity.
- Intermediate-low rates of benthic nutrient fluxes.

- Input of organic matter (*e.g.*, from surface water primary production) through lateral transport sustains high macrofaunal biomass and diversity.
- Presence of opportunistic organisms.
- Benthic nutrient fluxes likely affected by hydrodynamics.

- Hydrodynamic forces inhibit organic matter deposition.
- Depressed macrofaunal density and diversity.
- Intermediate-high rates of benthic nutrient fluxes.

From Miata and Snelgrove (2021)

Biochemical processes in bed sediments:

- What is the geographical pattern of organic matter from the continental margin to the deep ocean? How efficient is its burial at different sedimentological settings?
- What are the main bacteria communities of the Magdalena sediments? What can their evolution during the last million years tell us about paleoceanographic conditions?

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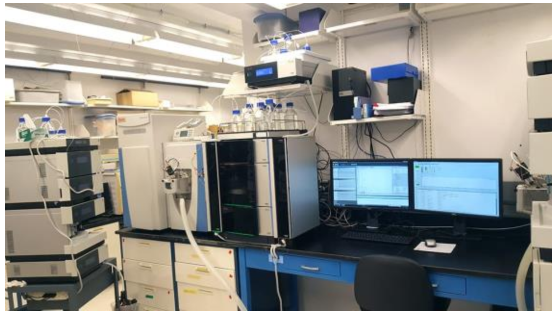
St. John's - Cartagena

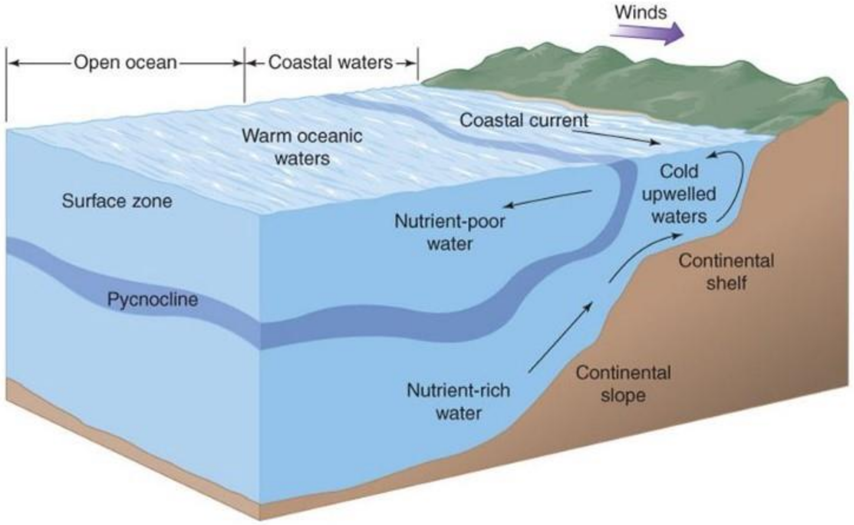
Research questions and approaches

Past and modern sedimentary connections



Mass spectrometer

Water samples

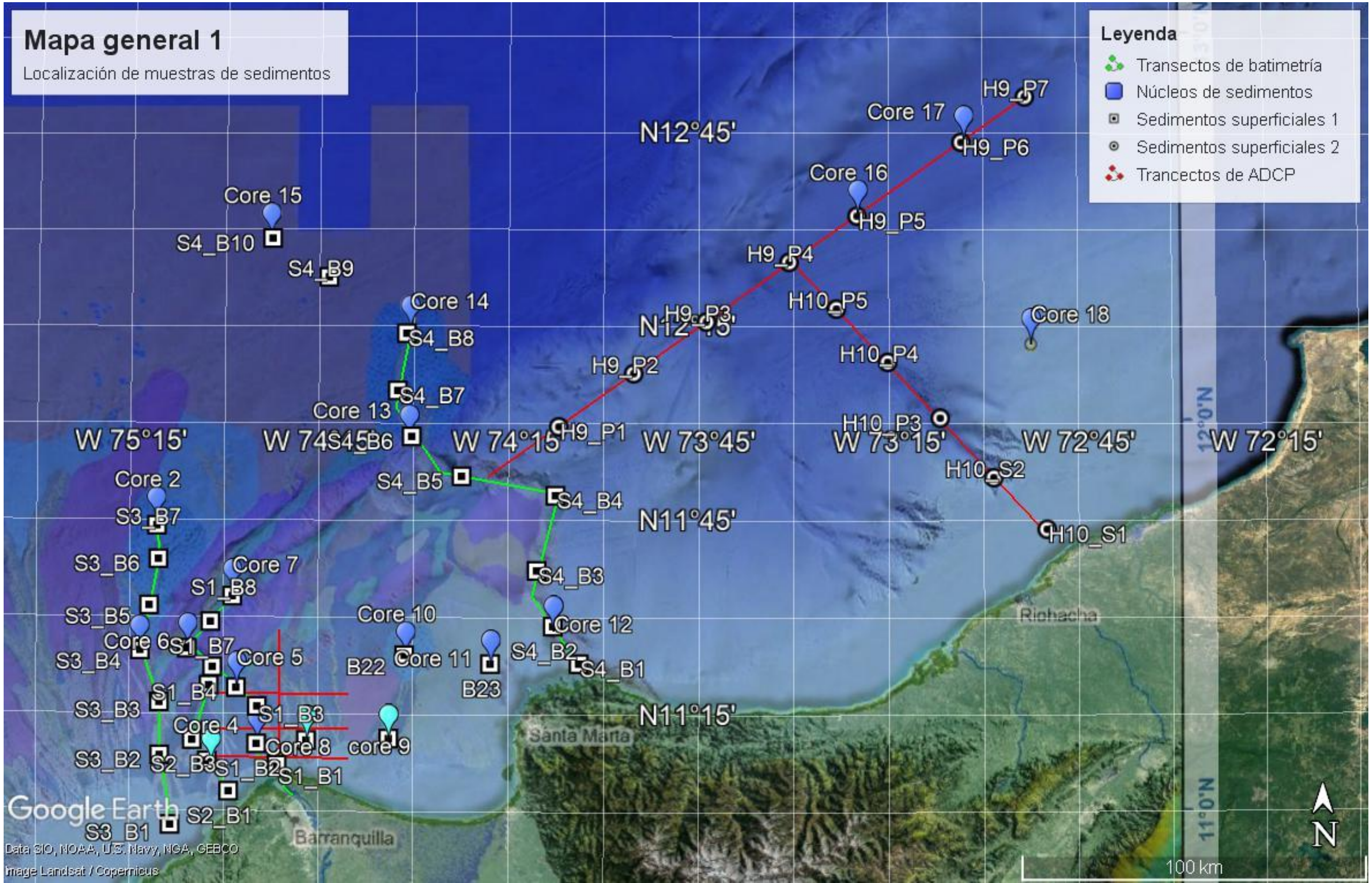


Coastal upwelling in the Northern Hemisphere

Connectivity between the RM ROFI and La Guajira Upwelling:

- Which are the sedimentary and geochemical evidences and the time scale of the interaction between the Magdalena River water masses and La Guajira upwelling?
- How do conditions of sediment production and preservation vary between the shelf, slope and deep basin, related to the upwelling variability?

Work program



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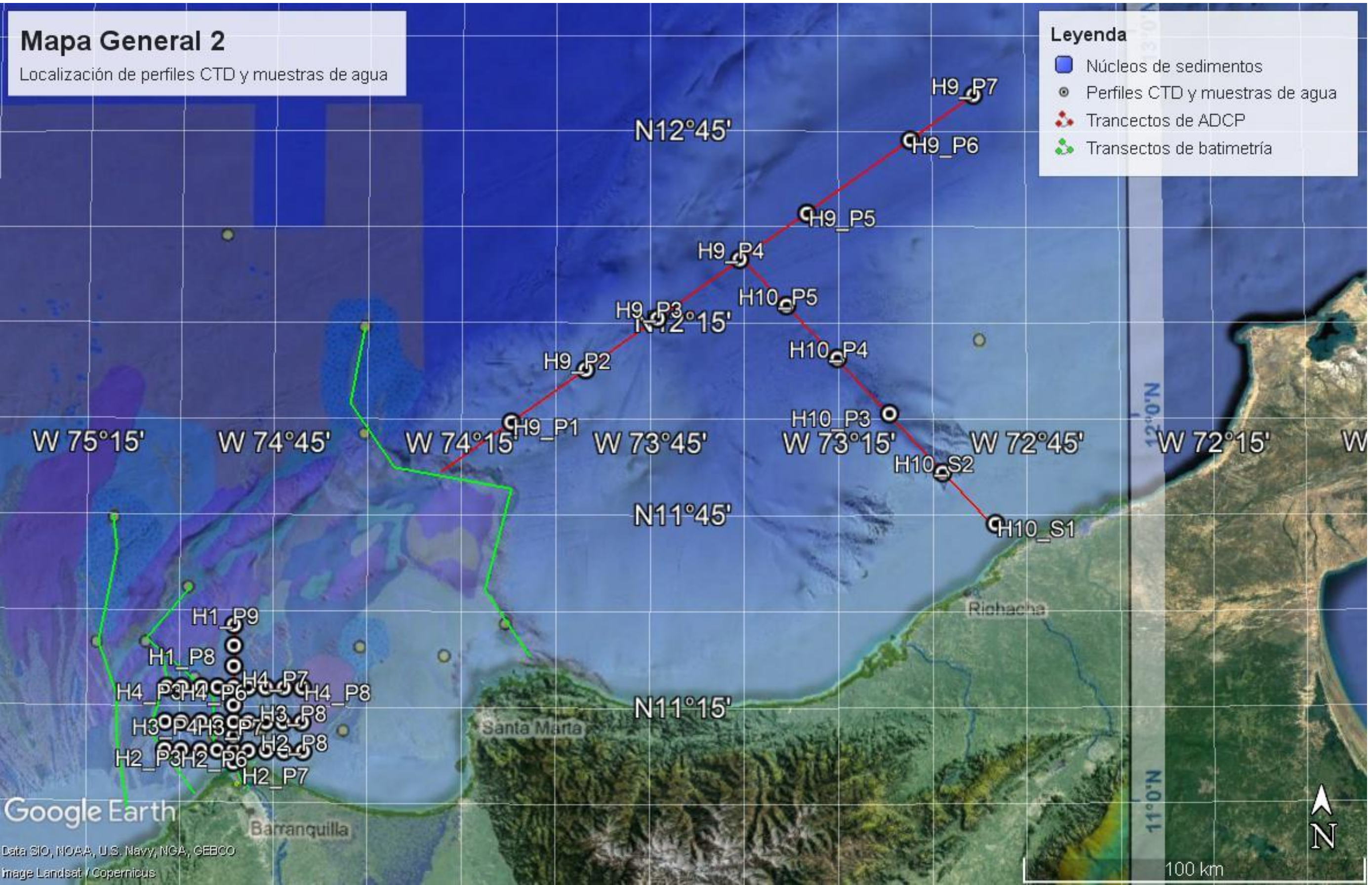
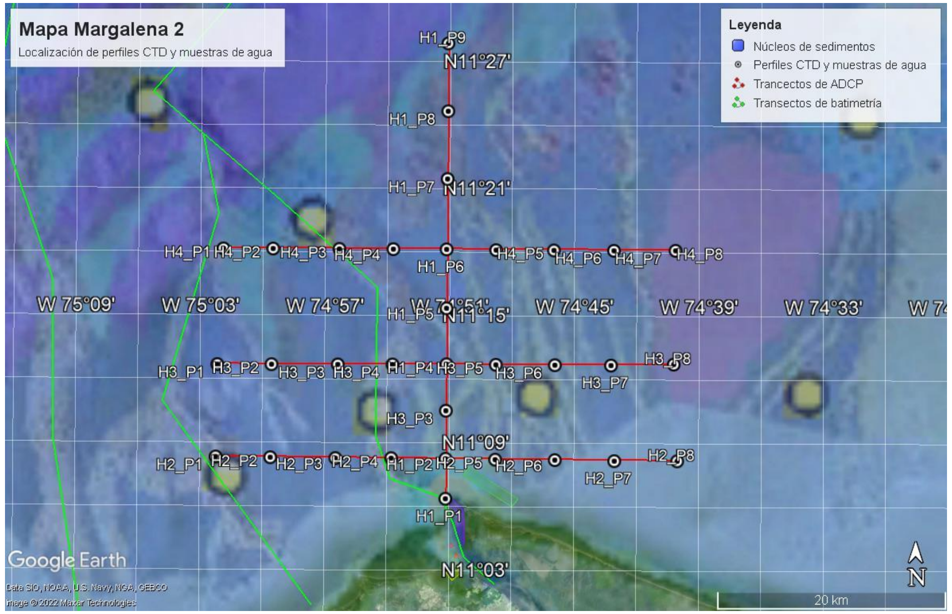
Work program

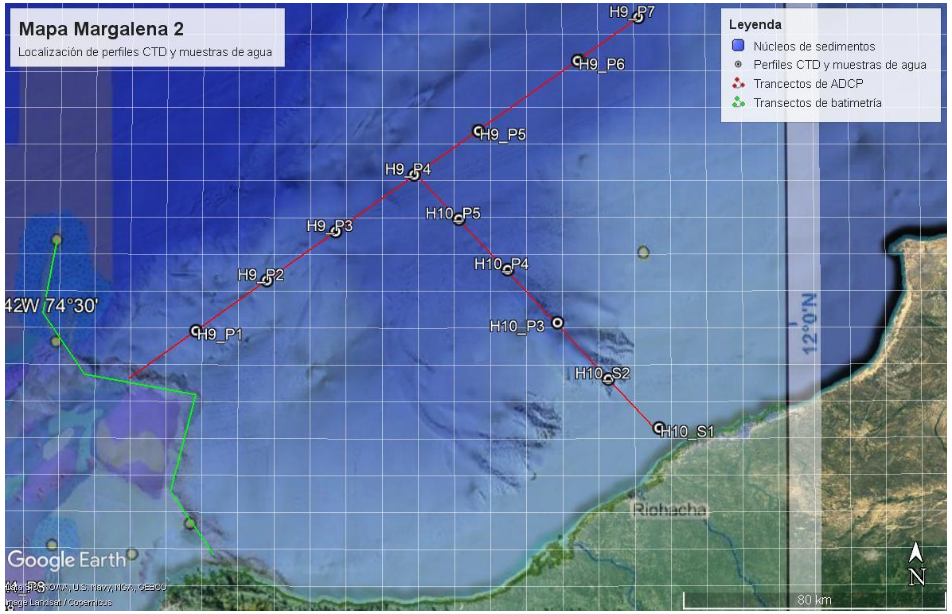
Hydrodynamic monitoring

6 ADCP transects
- 4 in Magdalena Deep-sea fan
- 2 in La Guajira Basin

45 CTD profiles and water quality







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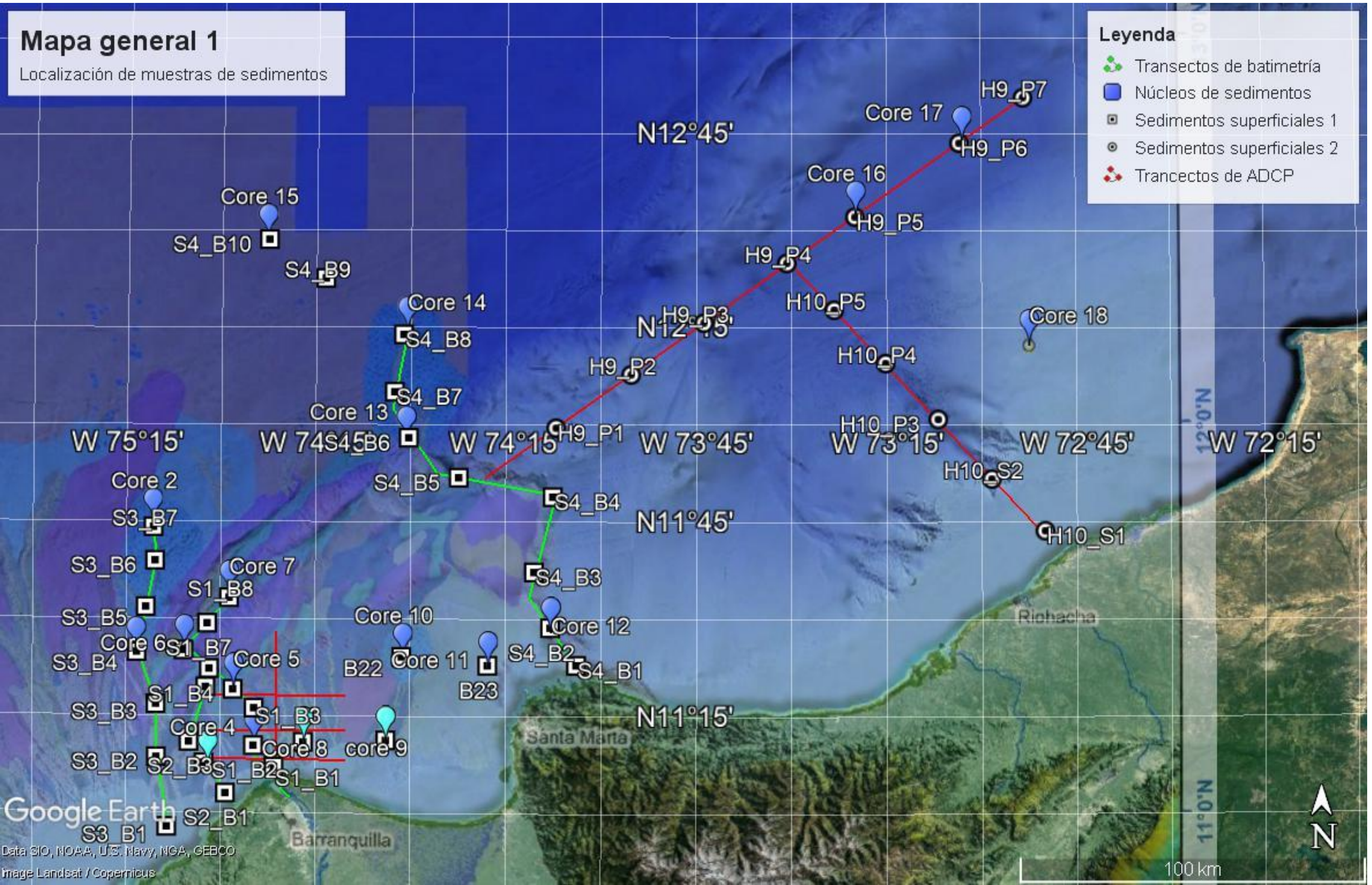
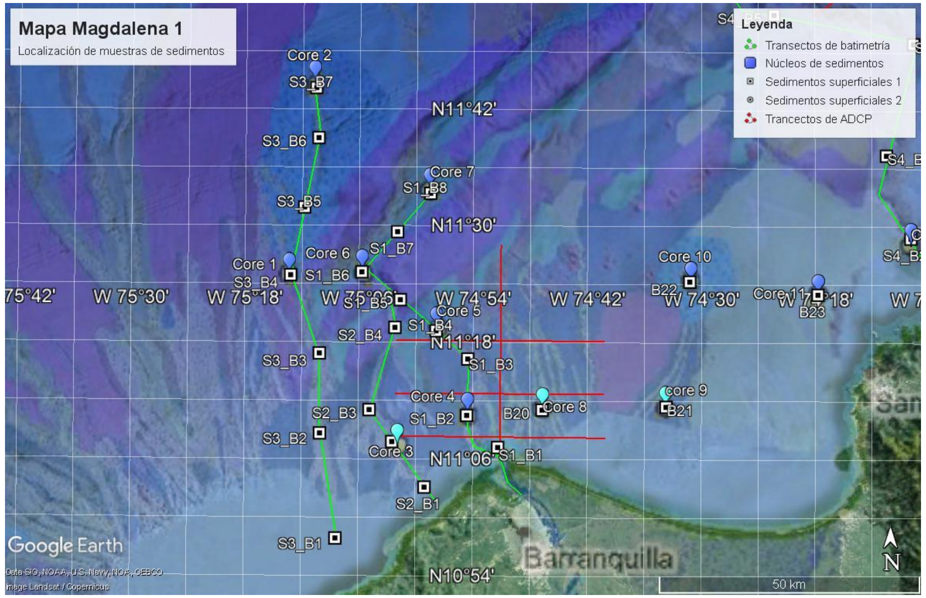
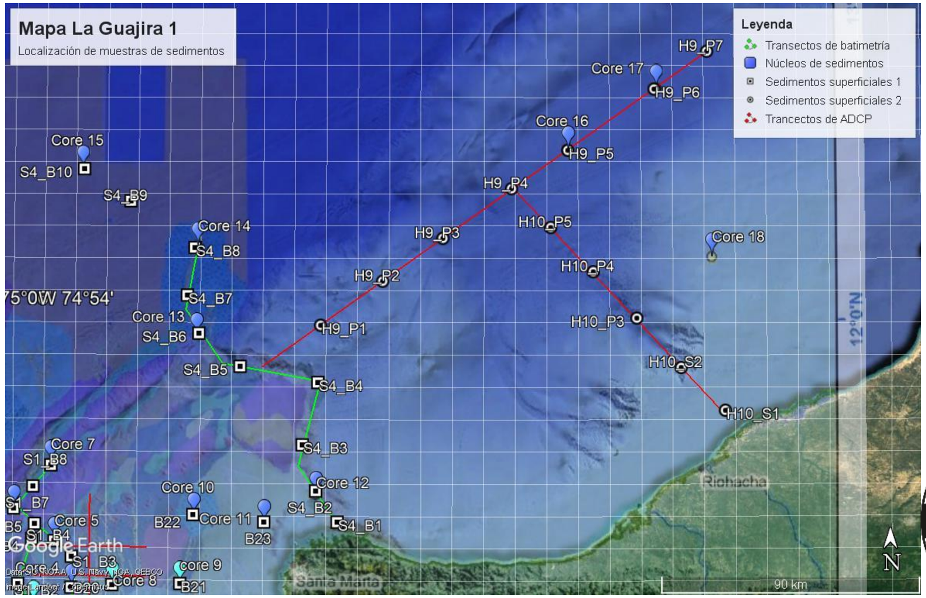
Work program

Sedimentology sampling

4 MBES y sub-bottom profiles
3 in Magdalena Deep-sea fan
1 in La Aguja Canyon
40 samples of Surface sediments
18 gravity cores (up to 10 m)







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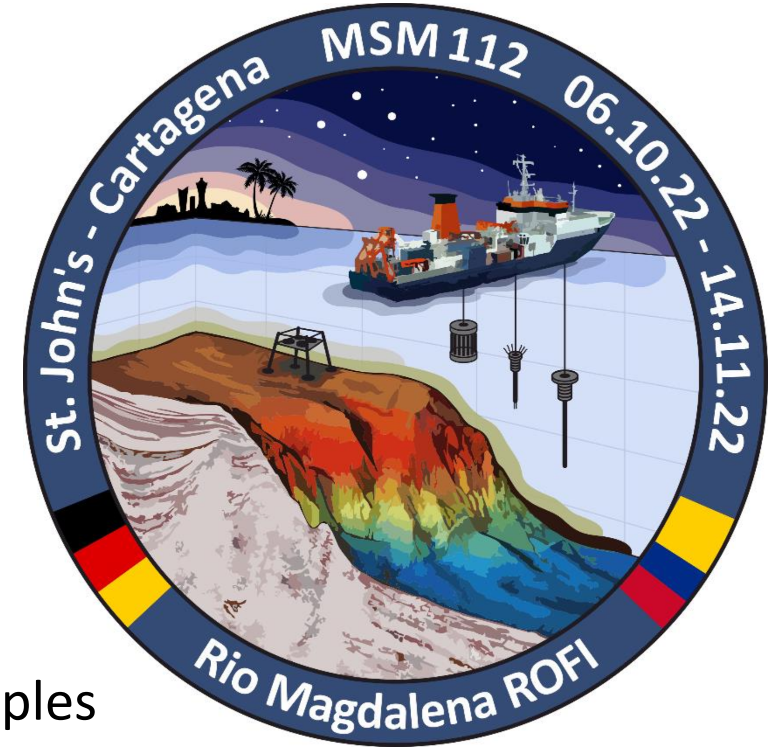
The Río Magdalena ROFI project

Land-Sea Interaction of the major tributary of the Caribbean Sea

- MSM112
- 23 researchers
- 6 institutions
- 26 days
- > 1500 km
- about 5000 km^2 ROFI
- 18 sediment cores
- 40 Surface sediment samples
- 45 physical and biochemical profiles



KIEL MARINE SCIENCE
CONNECTED RESEARCH

LEIBNIZ-INSTITUT FÜR OSTSEEFORSCHUNG WARNEMÜNDE
IOW

UN
UNIVERSIDAD DEL NORTE

UNIVERSIDAD DE ANTIOQUIA

UNIVERSIDAD NACIONAL DE COLOMBIA

ecopetrol
ENERGÍA PARA EL FUTURO

Prof. Dr. Christian Winter

Dr. Oscar Álvarez

Technical WORKSHOPS

ANH

#LaNUEVAENERGÍA

2022 ANH TECHNICAL TALKS

The Río Magdalena ROFI project:
Land-Sea Interaction of the major tributary of the Caribbean Sea

DANIEL RINCÓN, PHD

FRIDAY, SEPTEMBER 23RD 2022 8:00 a.m. – 9:00 a.m.