MAGDELESA

Design and modeling of Fish Aggregating Devices

CARIFICO Workshop on FAD Fishery Managements

St. Vincent and the Grenadines November 2013

RFM JICA FAO FIAT PANIS COPACO Western Central Atlantic Fishery Commission l'Europe s'engage avec les Antilles-Guyane dans la Grande Caraïbe Ifremer PROGRAMME INTERREG CARAÏBES

Ocean currents are crucial in the behavior of FADs, and therefore in their design.

We will begin with a look at ocean currents in our region.

Then we will look at the main features of FADs to propose a design.

Finally, we will use the 'DCP' software to model a FAD, and analyze its behavior.

1. Ocean currents

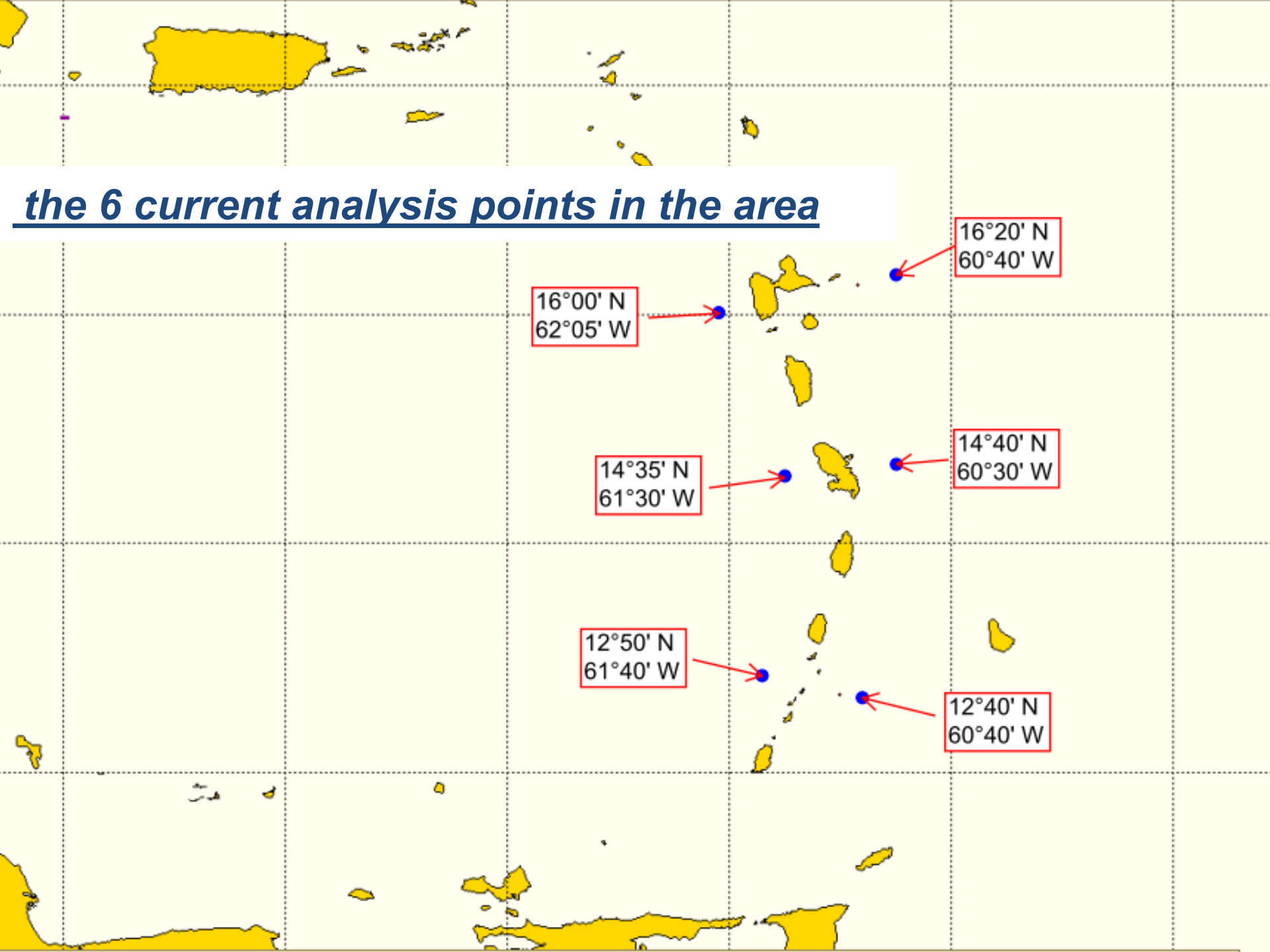
The ocean currents data are from Mercator Ocean

they are taken from:

Global Ocean Physics Analysis and Forecast updated Daily

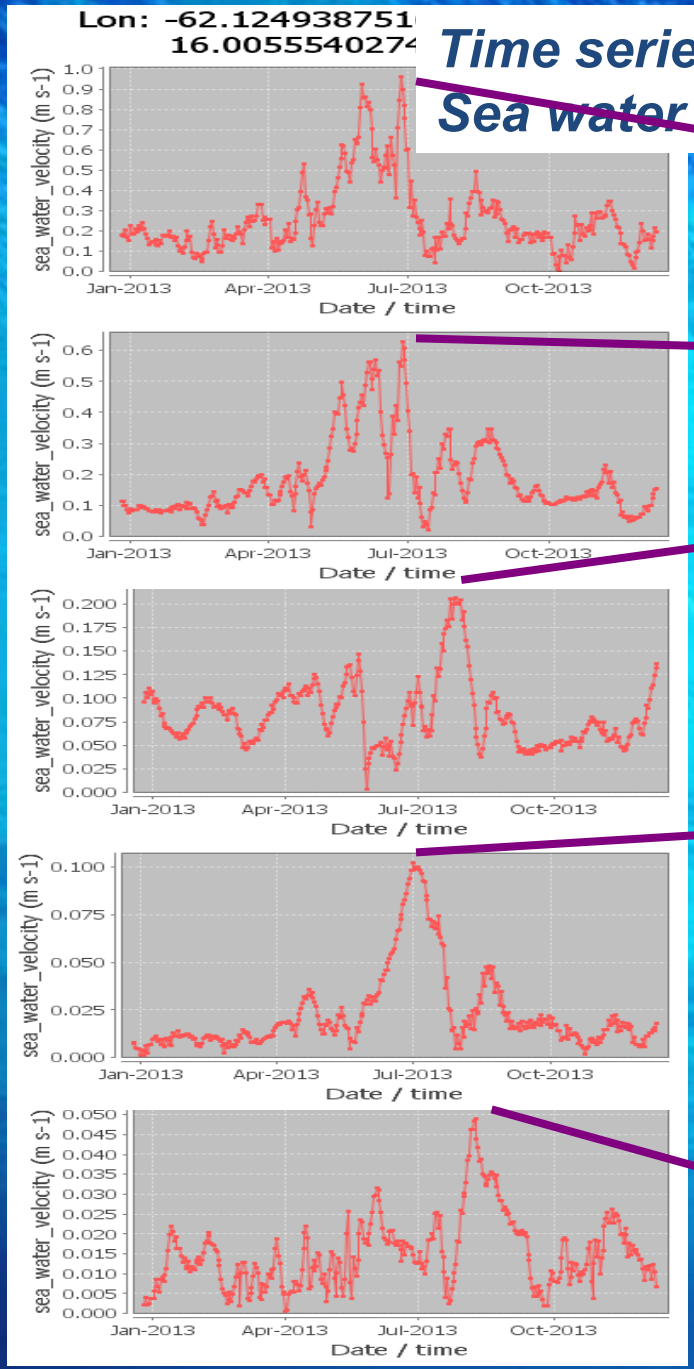
Mercator Ocean is owned by these agencies

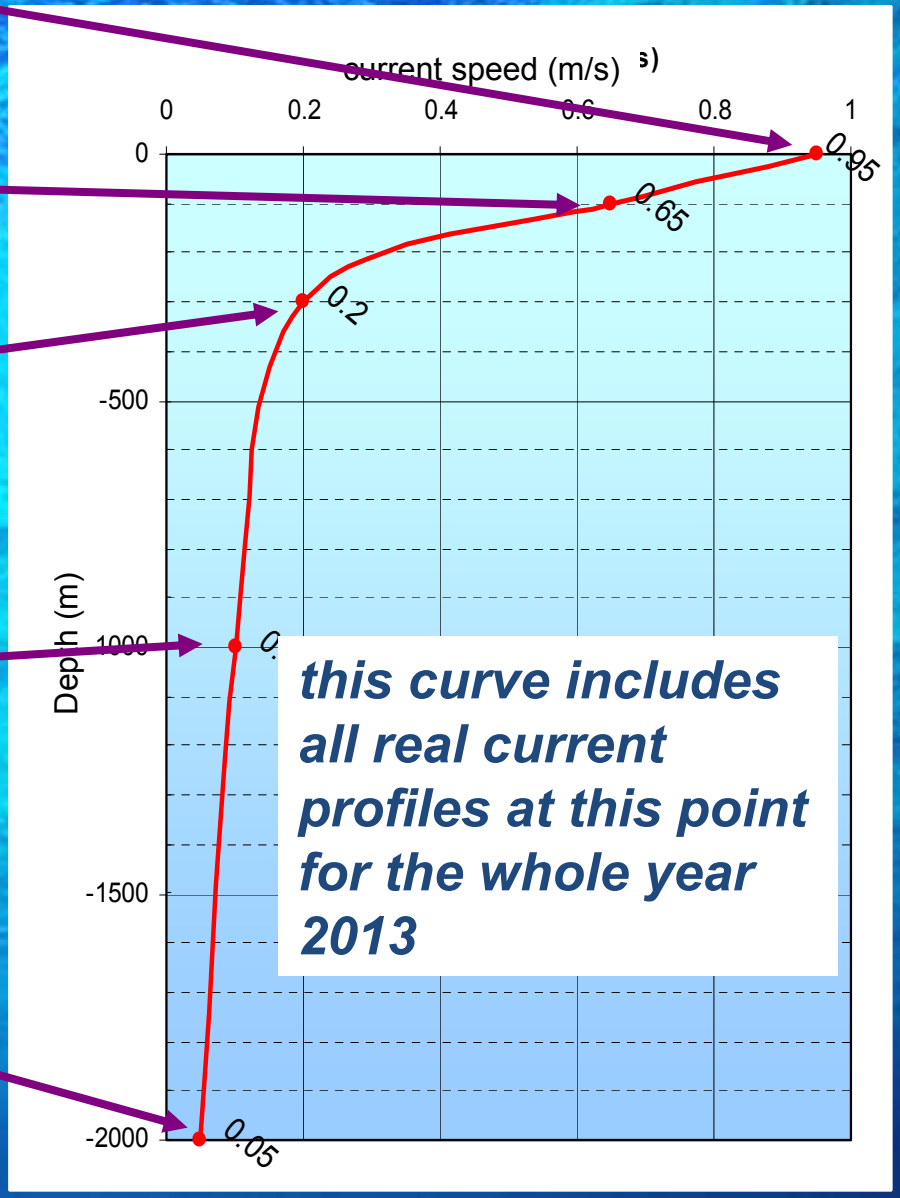
the 6 current analysis points in the area



Time series data for 2013
Sea water velocity

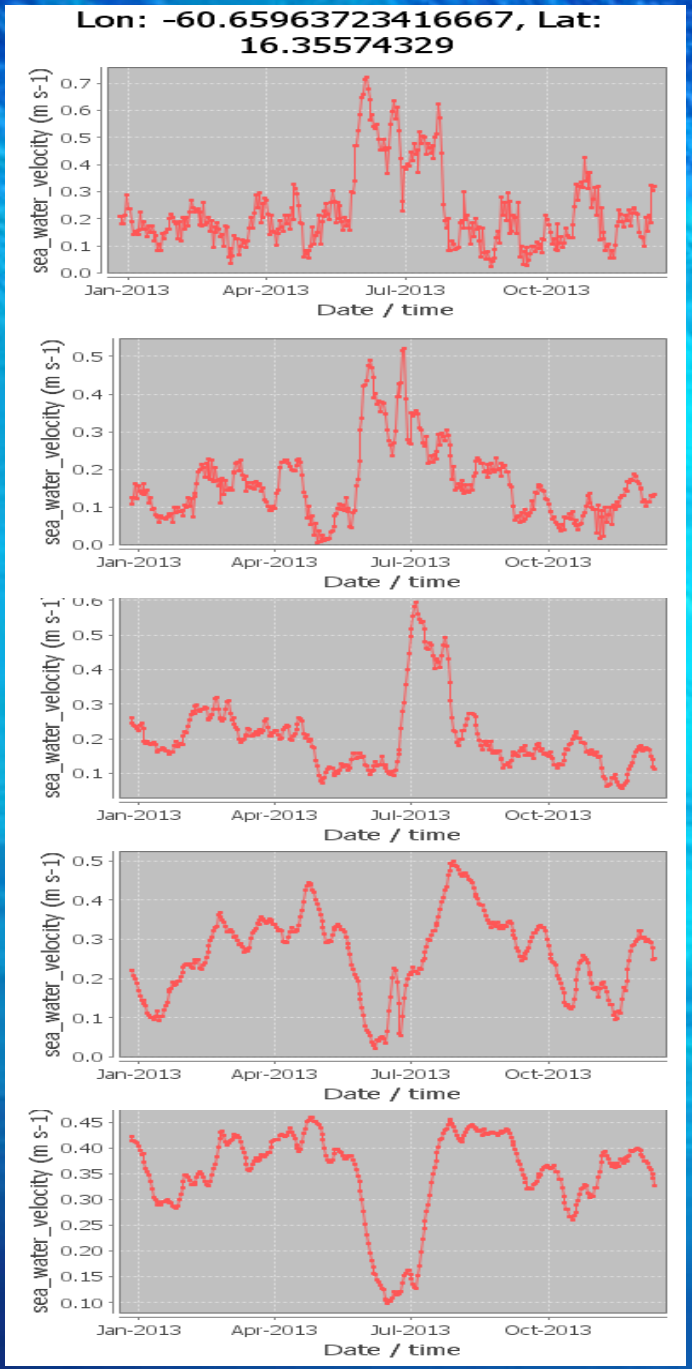
Guadeloupe (downwind)
Maximums currents in 2013





this curve includes all real current profiles at this point for the whole year 2013

Guadeloupe (windward)
Maximum currents in 2013



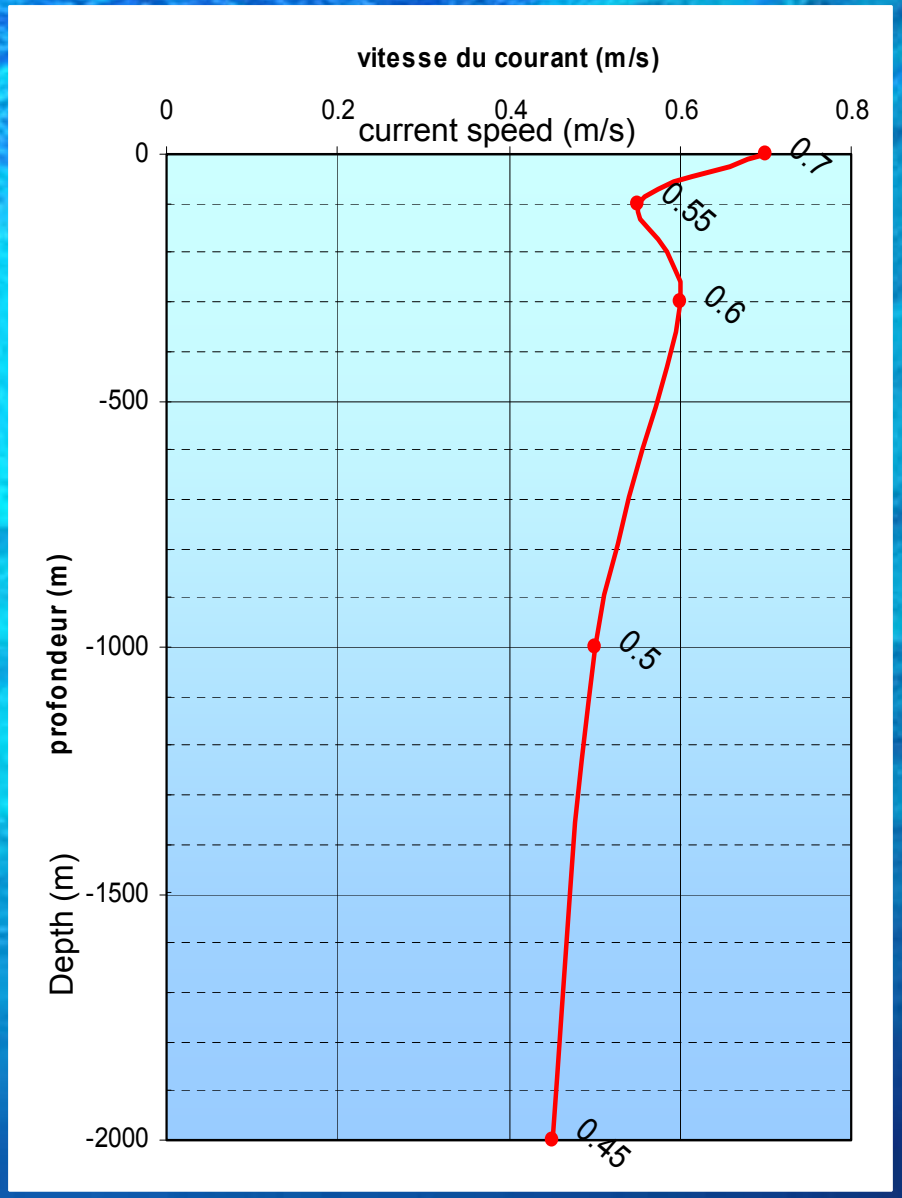
surface

-100 m

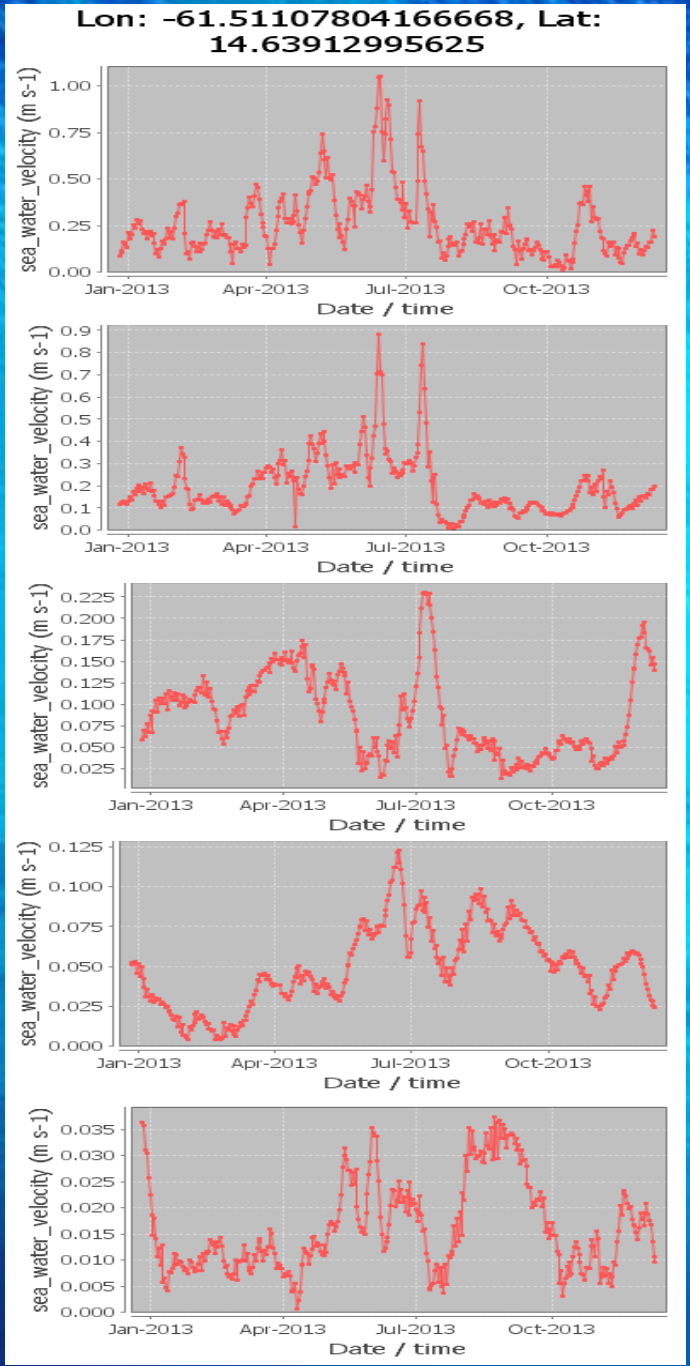
-300 m

-1000 m

-2000 m



Martinique (downwind)
Maximum currents in 2013



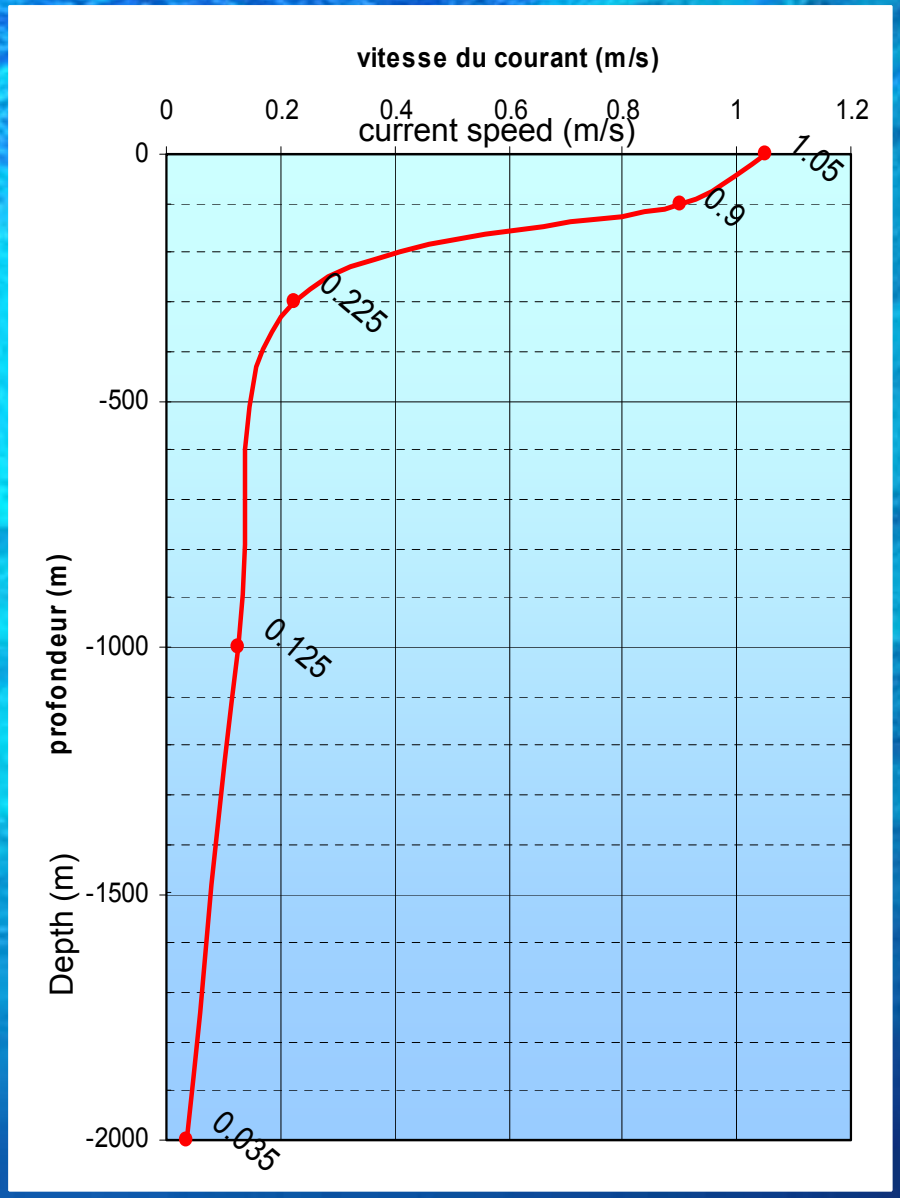
surface

-100 m

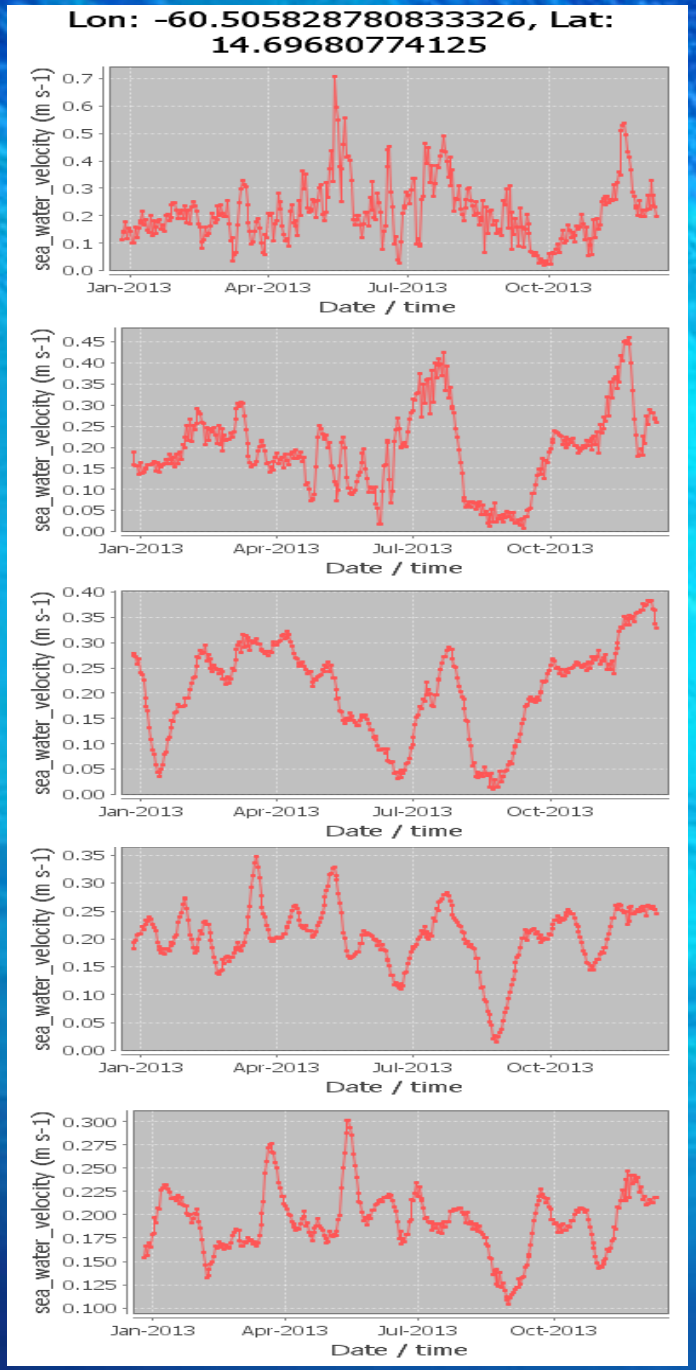
-300 m

-1000 m

-2000 m



Martinique (windward)
Maximum currents in 2013



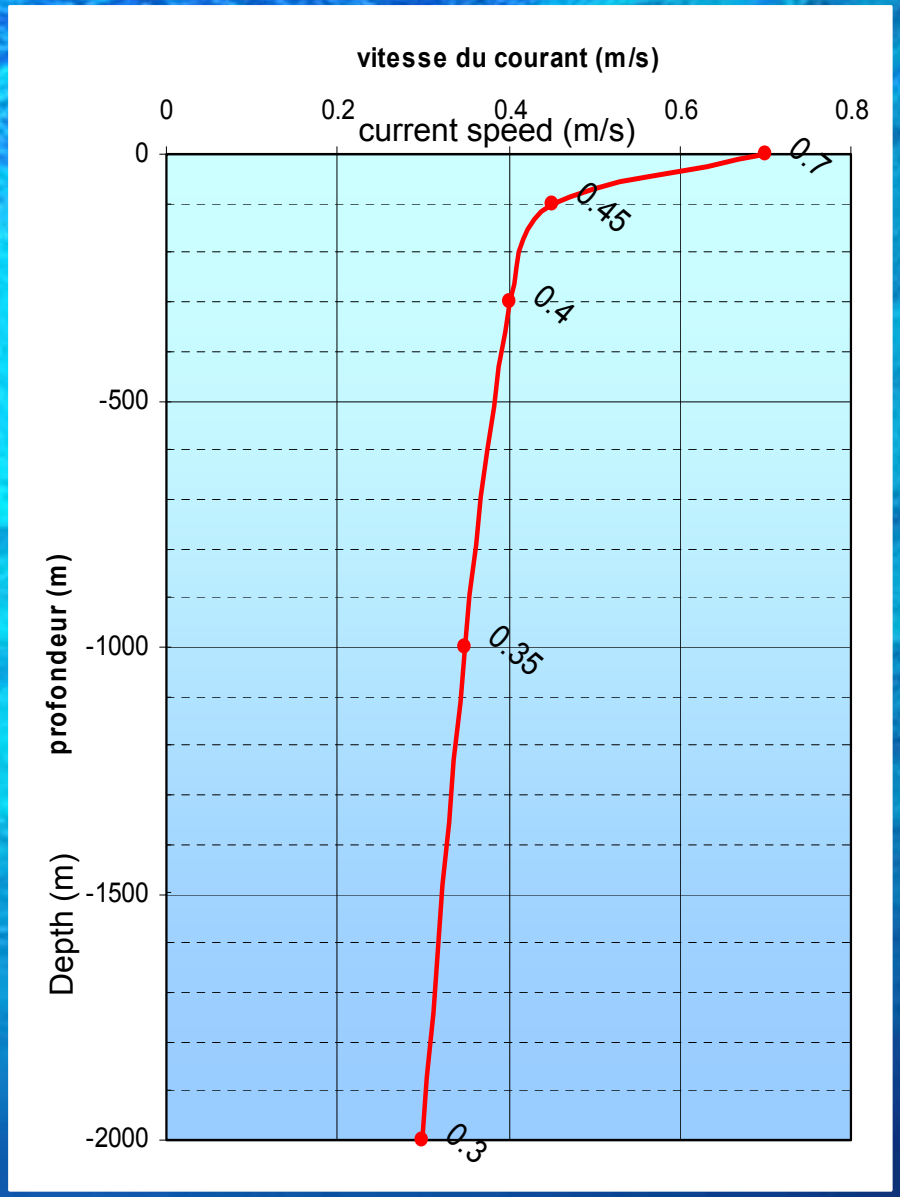
surface

-100 m

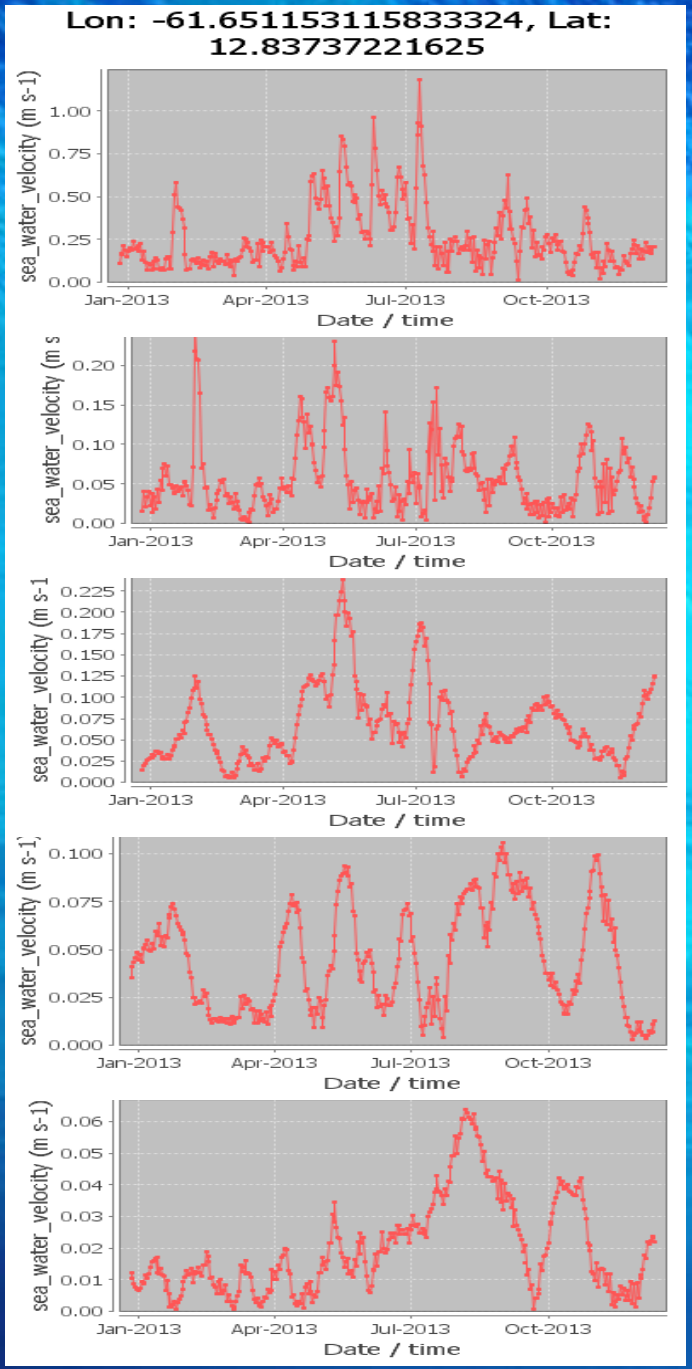
-300 m

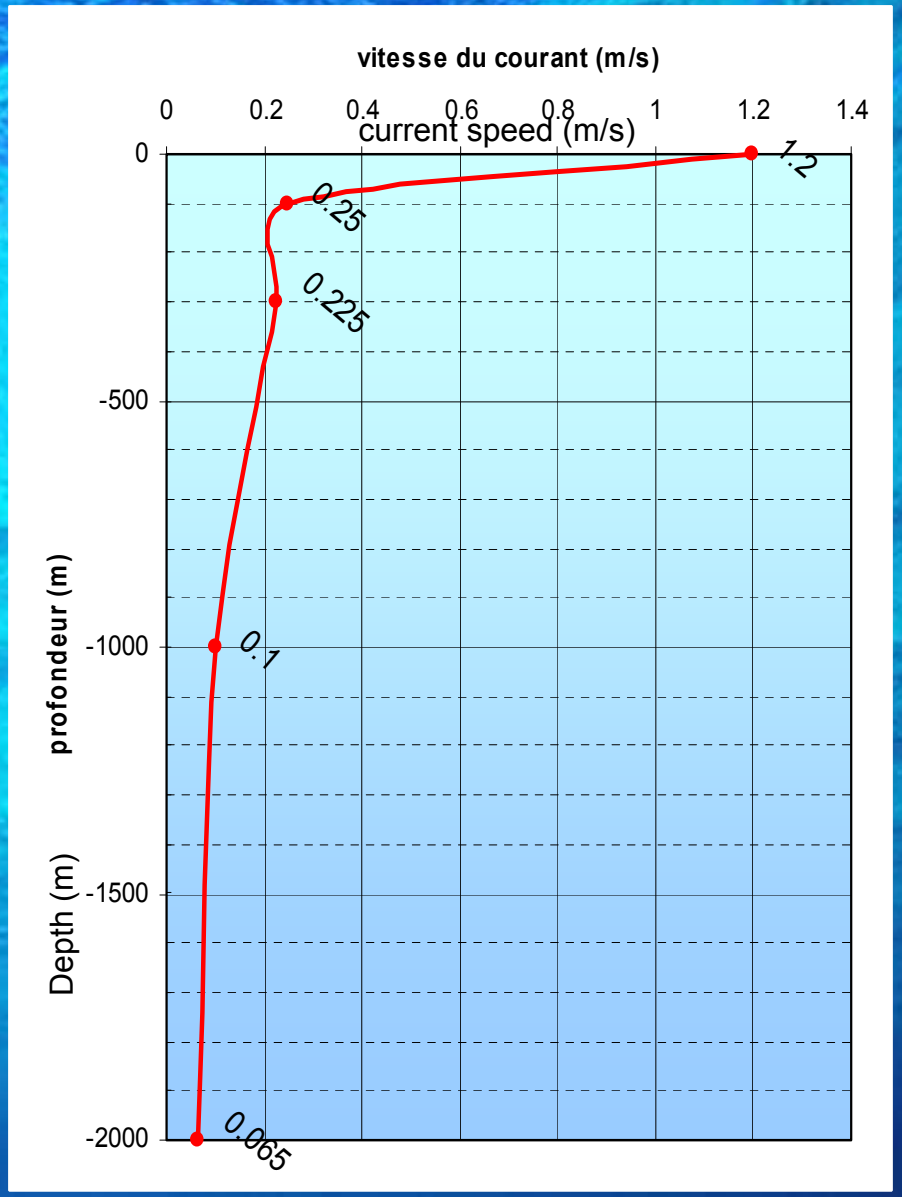
-1000 m

-2000 m

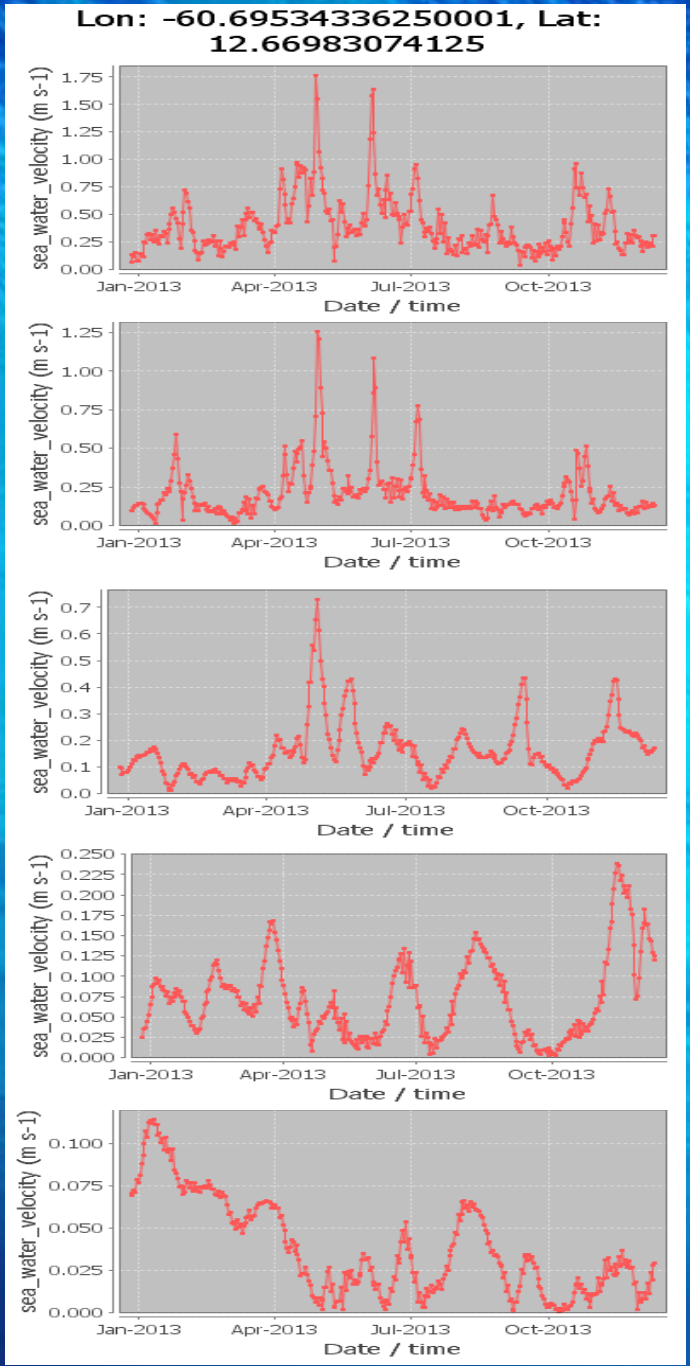


The Grenadines (downwind)
Maximum currents in 2013





The Grenadines (windward) maximum currents in 2013



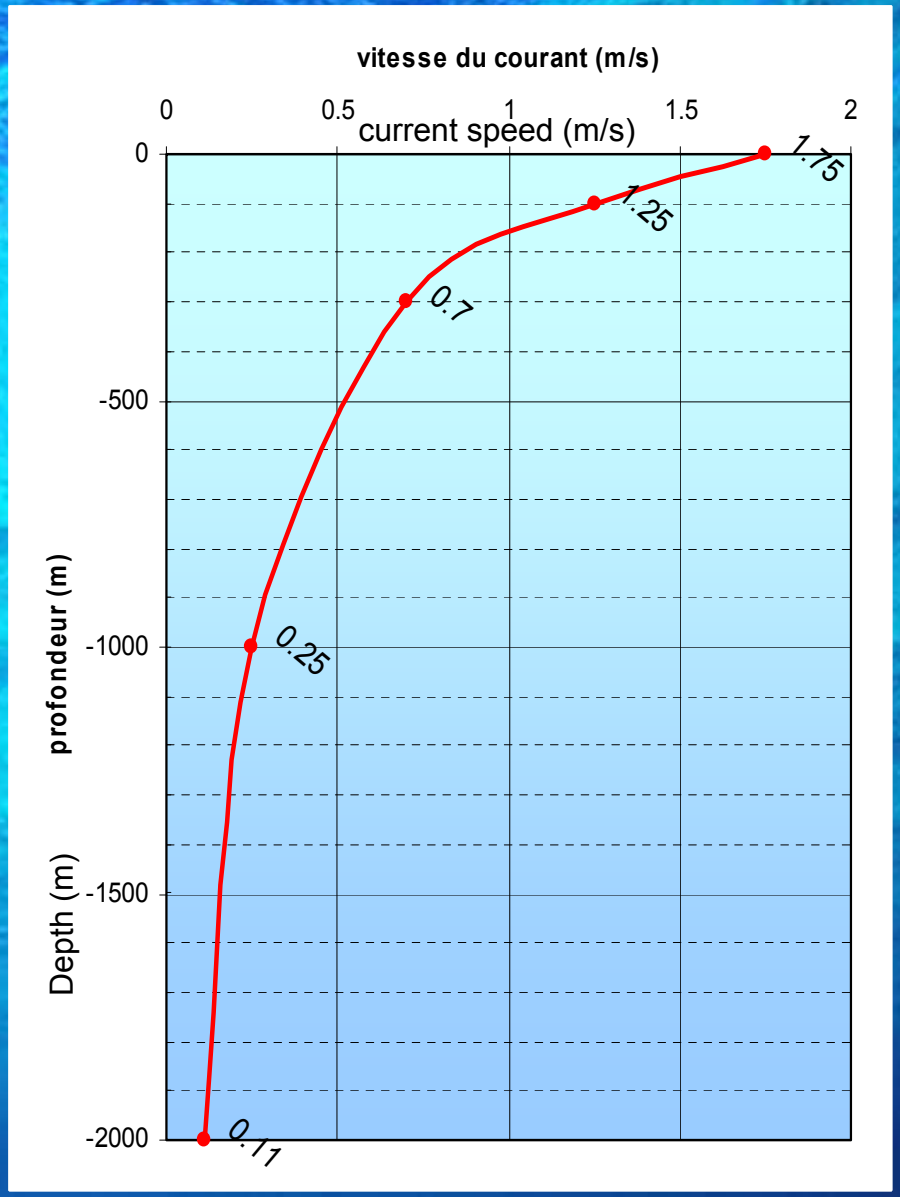
surface

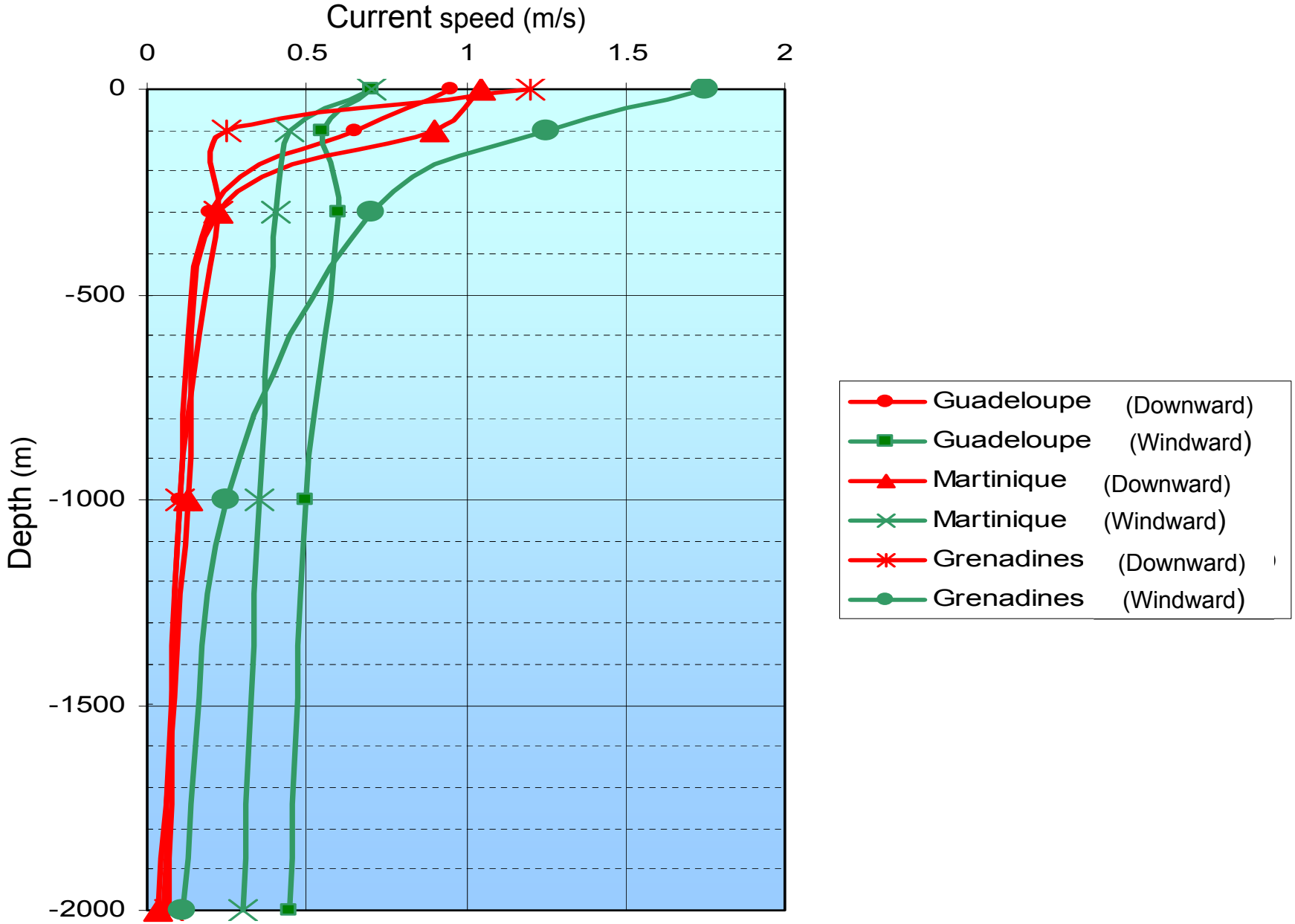
-100 m

-300 m

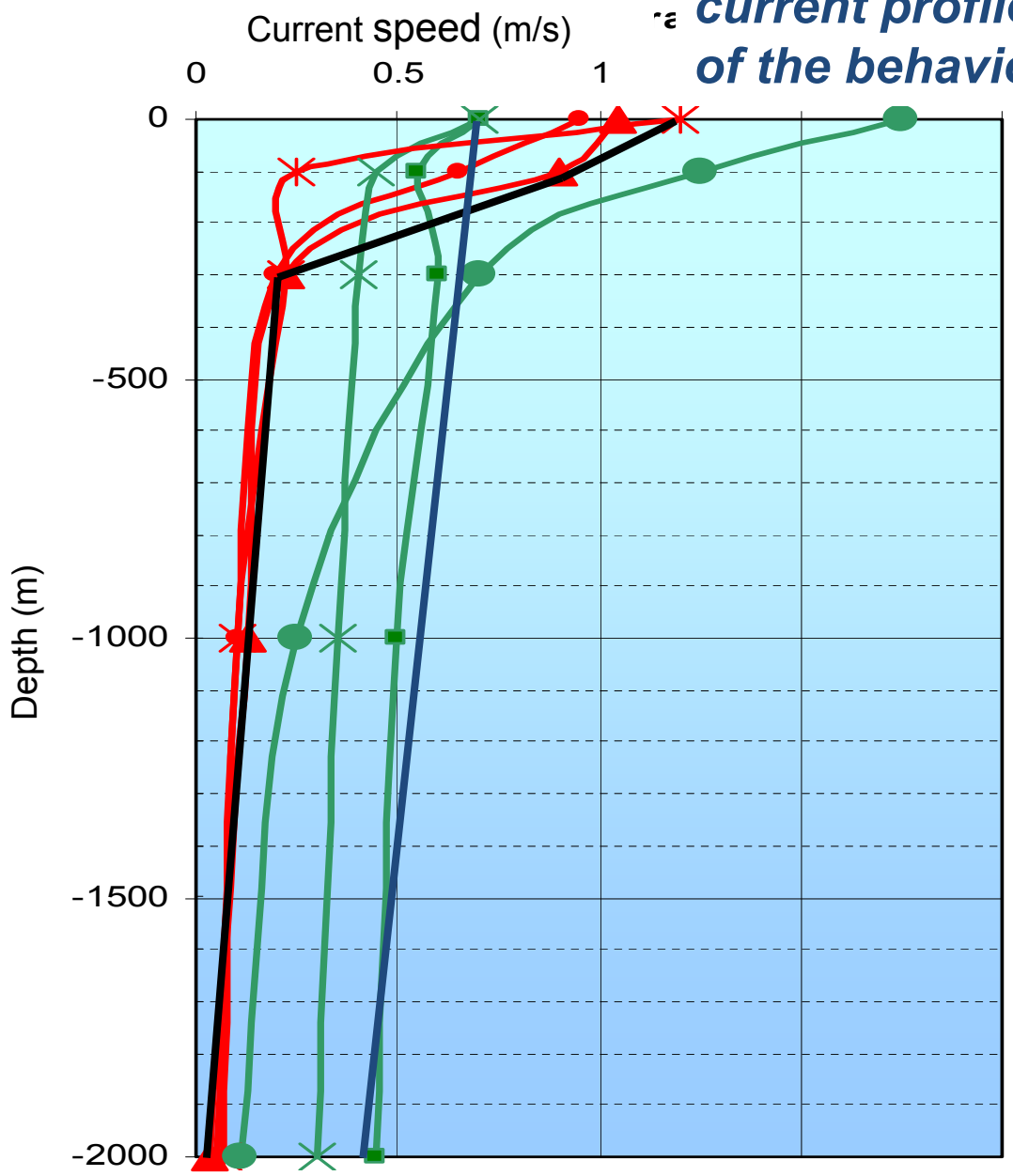
-1000 m

-2000 m




Current speed (m/s)
0
0.5
1
1.5
2
0
-500
-1000
-1500
-2000
Depth (m)
Guadeloupe (Downward)
Guadeloupe (Windward)
Martinique (Downward)
Martinique (Windward)
Grenadines (Downward)
Grenadines (Windward)

current profiles to be used for analysis of the behavior of FADs in the region

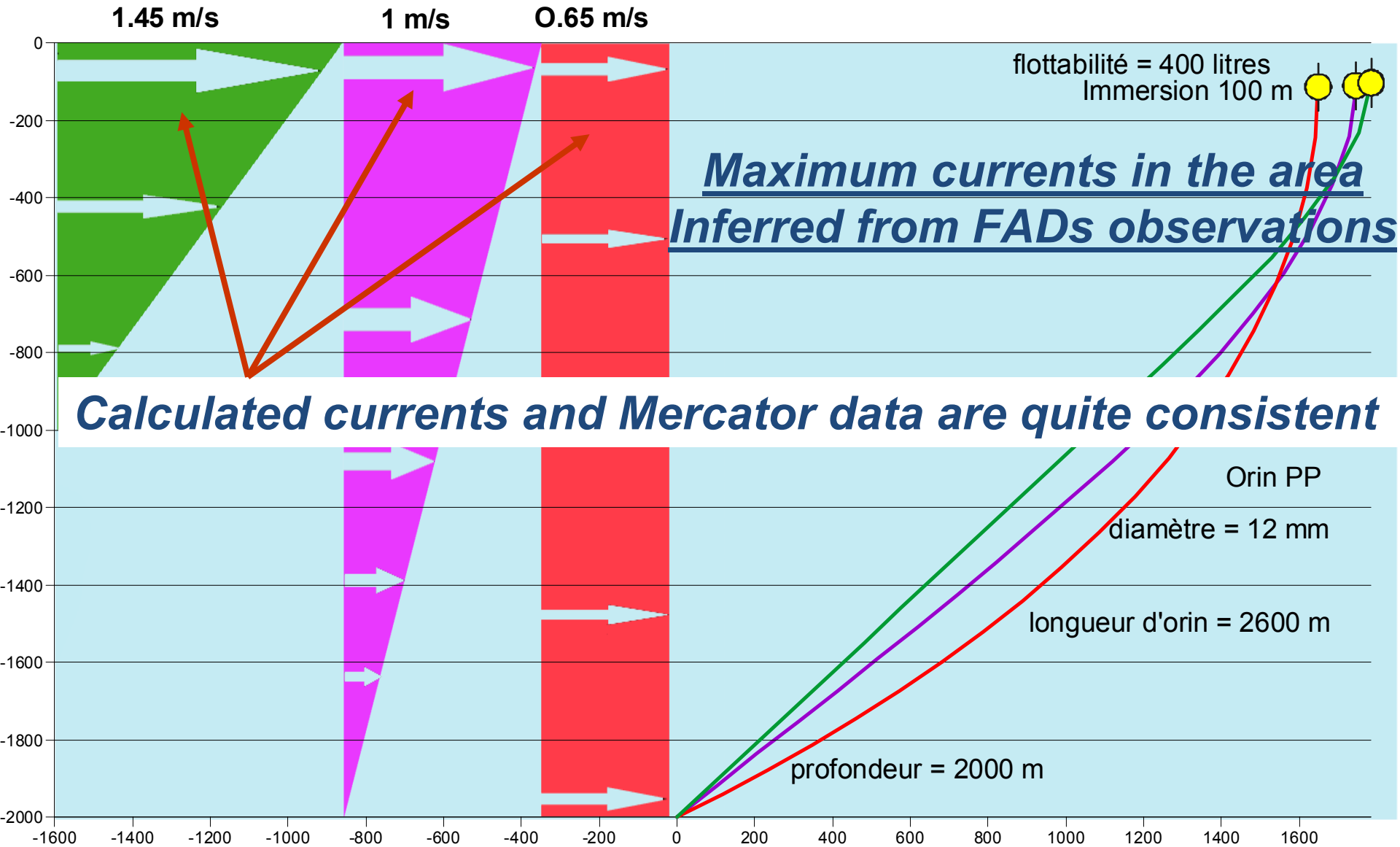


All downwards areas	
depth	current speed
(m)	(m/s)
surface	1.2
-100	0.9
-300	0.25
bottom	0.1

Martinique and Guadeloupe (windwards)	
depth	current speed
	(m/s)
surface	0.7
bottom	0.5

The Grenadines (windwards)	
depth	current speed
(m)	(m/s)
surface	1.75
-100	1.25
-300	0.75
-1000	0.25
bottom	0.1

Observations of FADs and the Ifremer software "DCP" allowed to infer the maximum theoretical currents in the area



2.main features of FADs

Main features of FADS are:

A. Buoyancy
B. Weight of anchoring
C. Length and characteristics of the mooring line

A. Buoyancy

It is the capacity of a body to stay afloat (or not)

It's a force* which must be expressed in Newton .... Let us simplify !

We will express buoyancy in liters and establish it as the difference of body volume in dm3 and weight in kg.

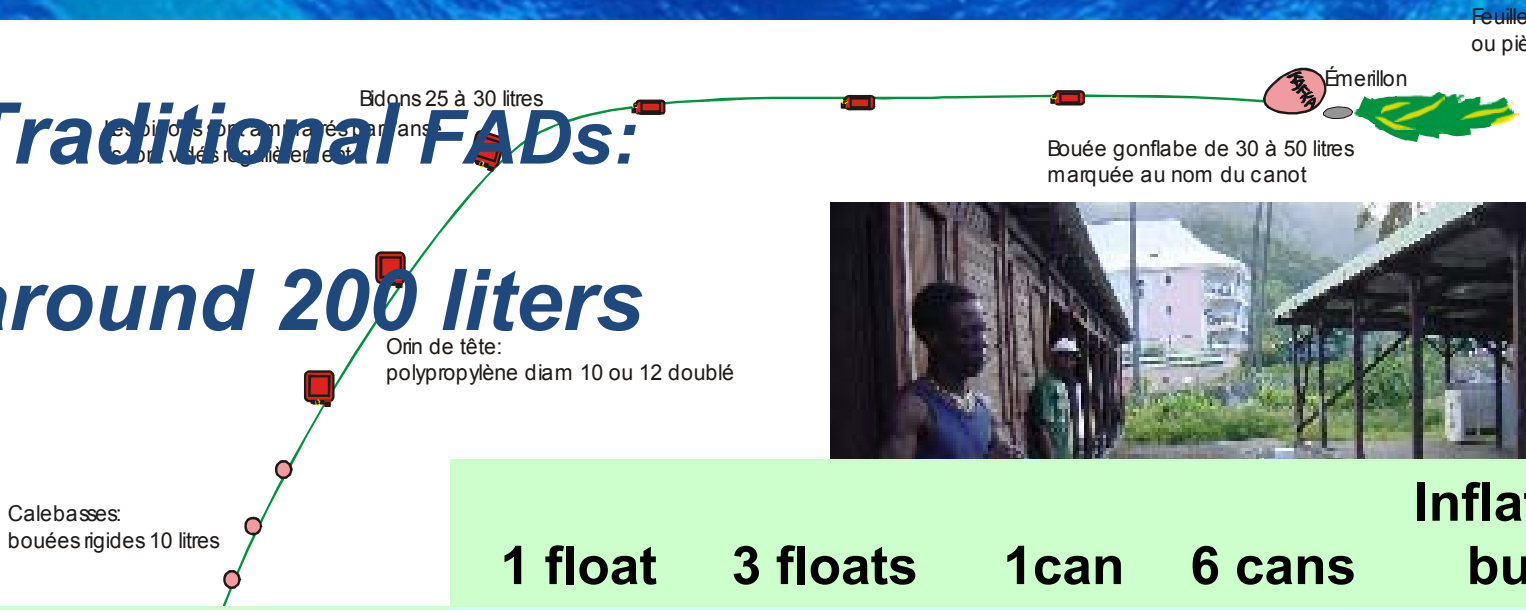
Let us remember that a body of one liter of buoyancy can keep on the surface a load of one kilogram

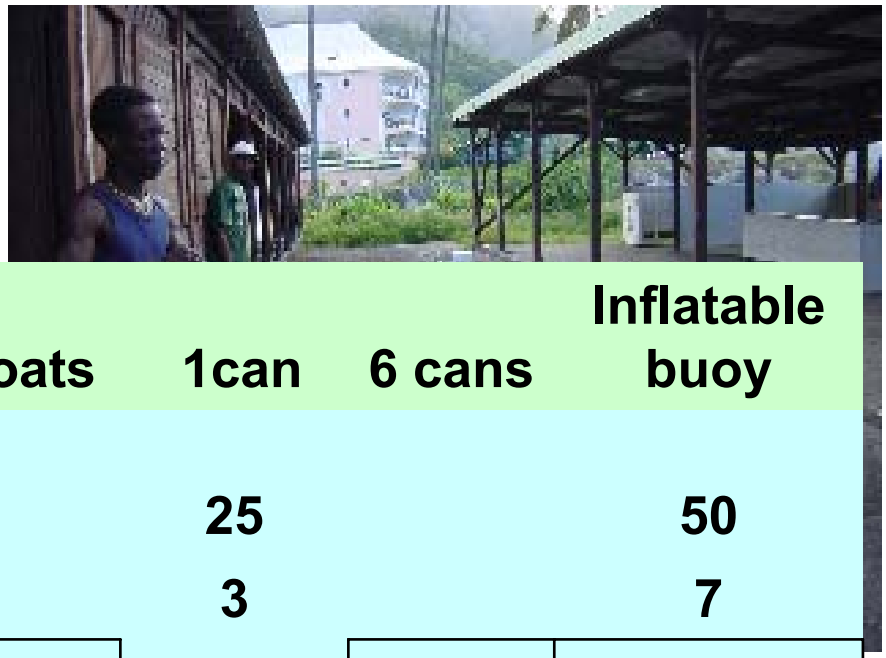
some examples :

*see Archimedes

Traditional FADs:

around 200 liters

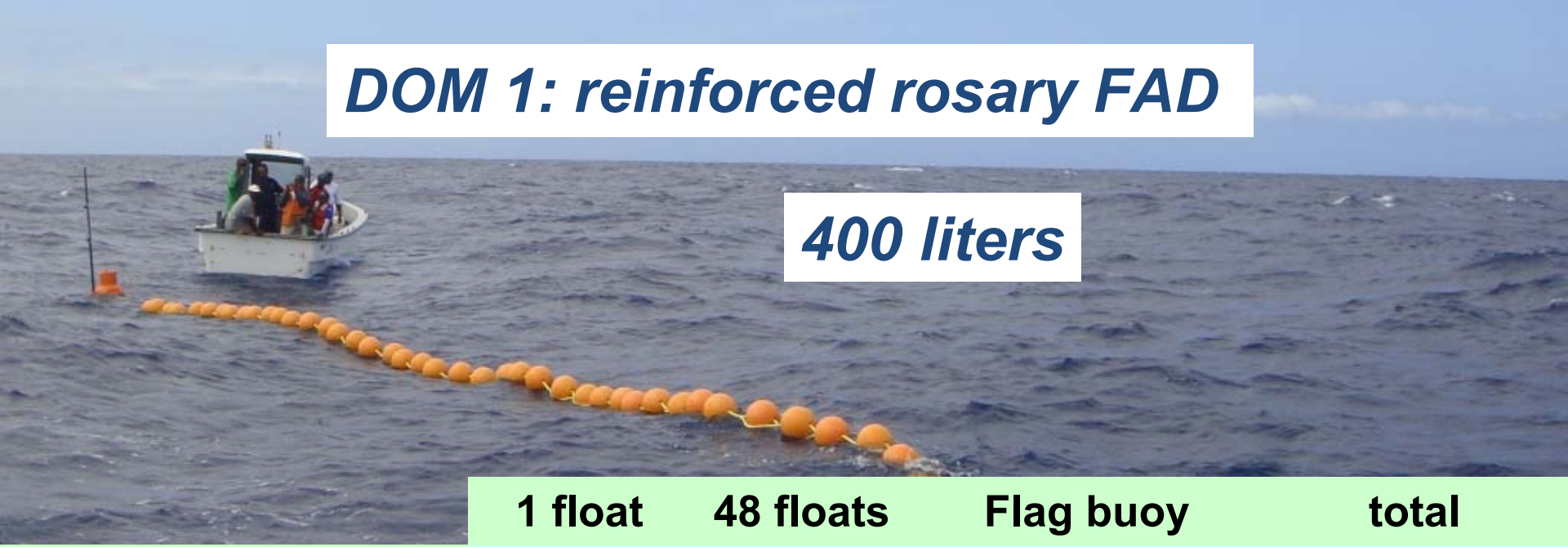




	1 float	3 floats	1can	6 cans	Inflatable buoy
volume (dm3)ou (litres)	11		25		50
weight (kg)	3		3		7
buoyancy (dm3)ou (litres)	8	24	22	132	43

Artisanal Fad buoyancy (litres)	199

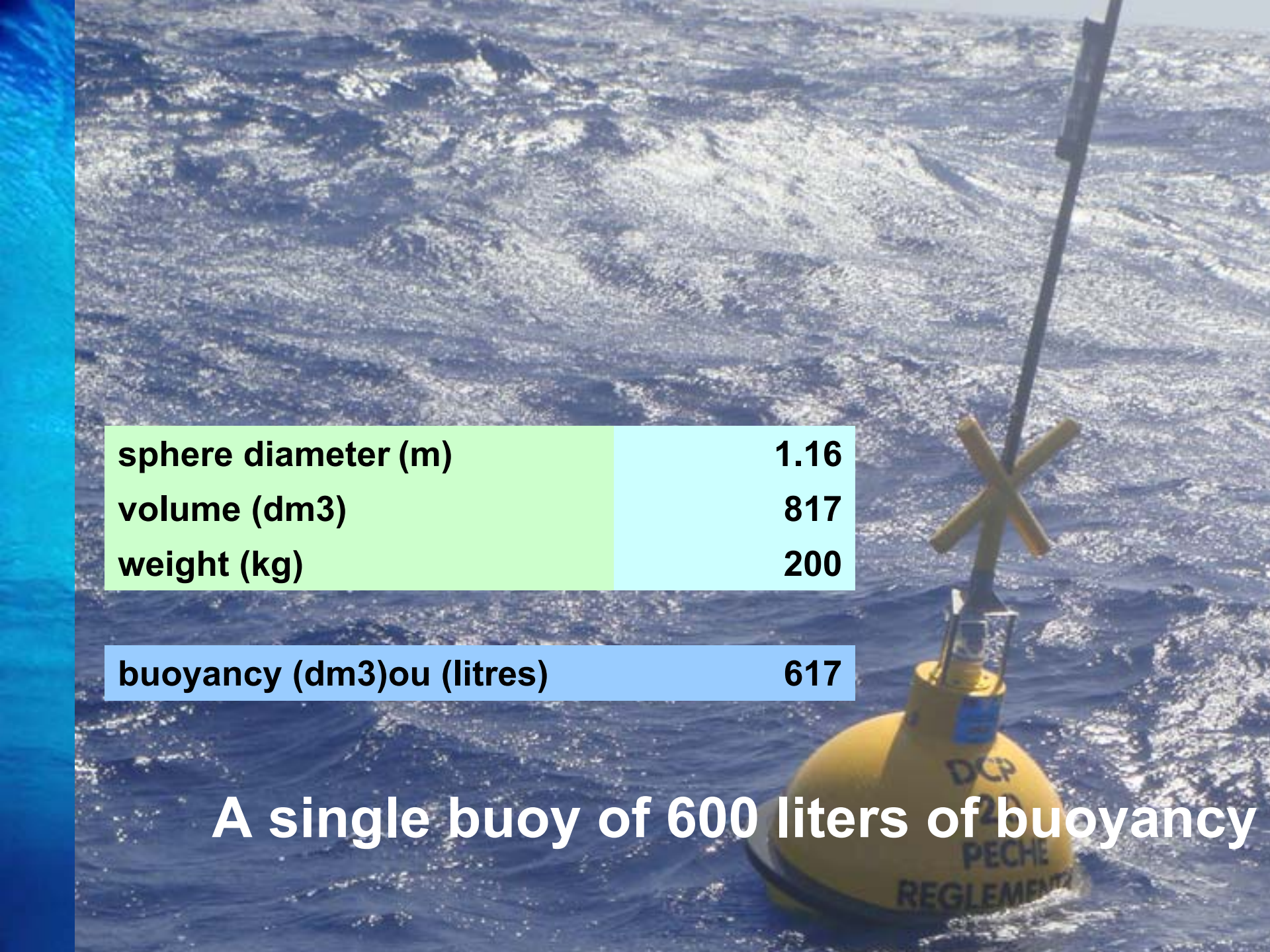
DOM 1: reinforced rosary FAD



400 liters

	1 float	48 floats	Flag buoy	total
volume (dm3) or (liters)	11		80	
weight (kg)	3		50	
buoyancy (dm3) or (liters)	8	384	30	414

Weight in water of the cable between floats (kg)	9
DOM 1 buoyancy (litres)	405

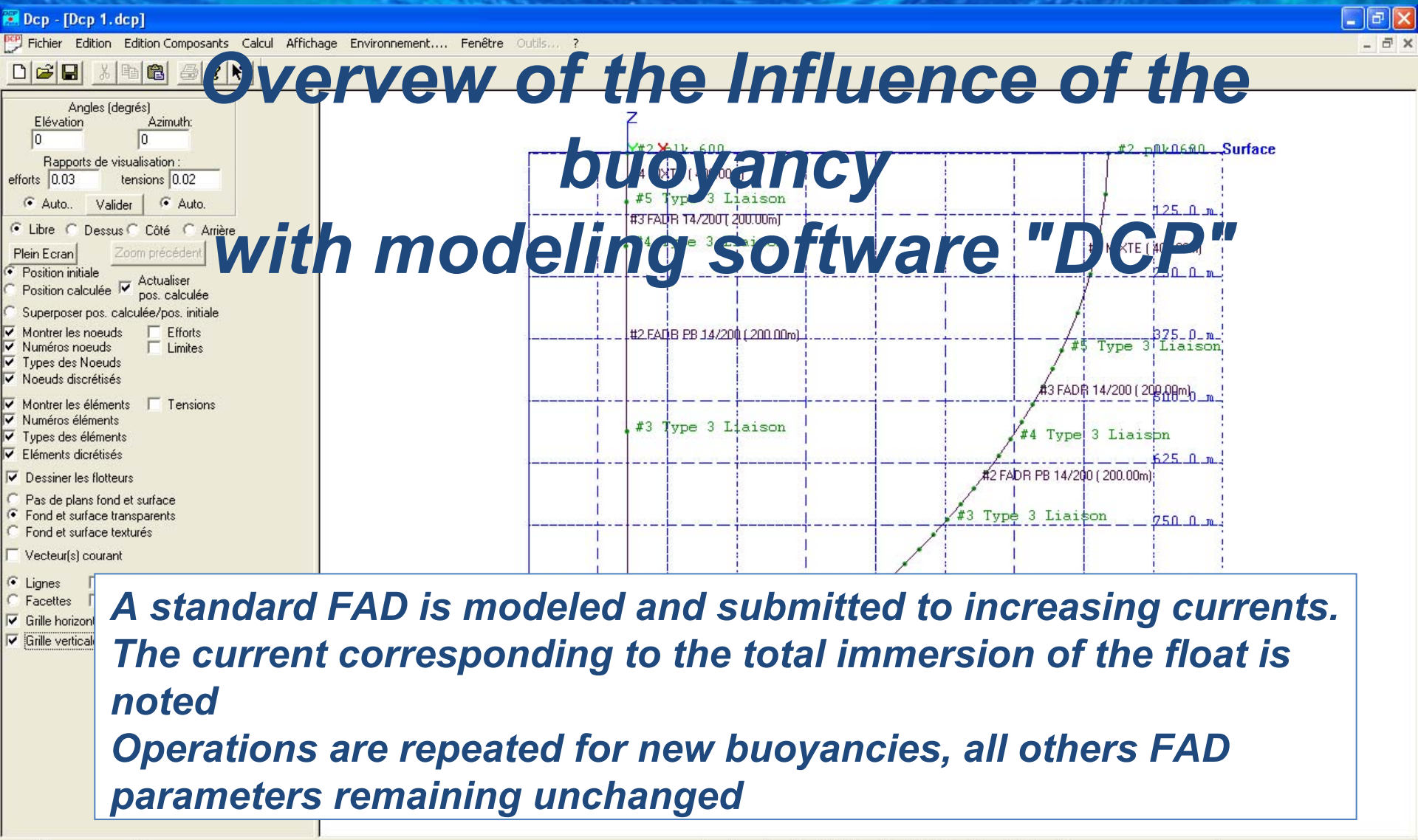


sphere diameter (m)	1.16
volume (dm3)	817
weight (kg)	200

buoyancy (dm3)ou (litres)	617

A single buoy of 600 liters of buoyancy

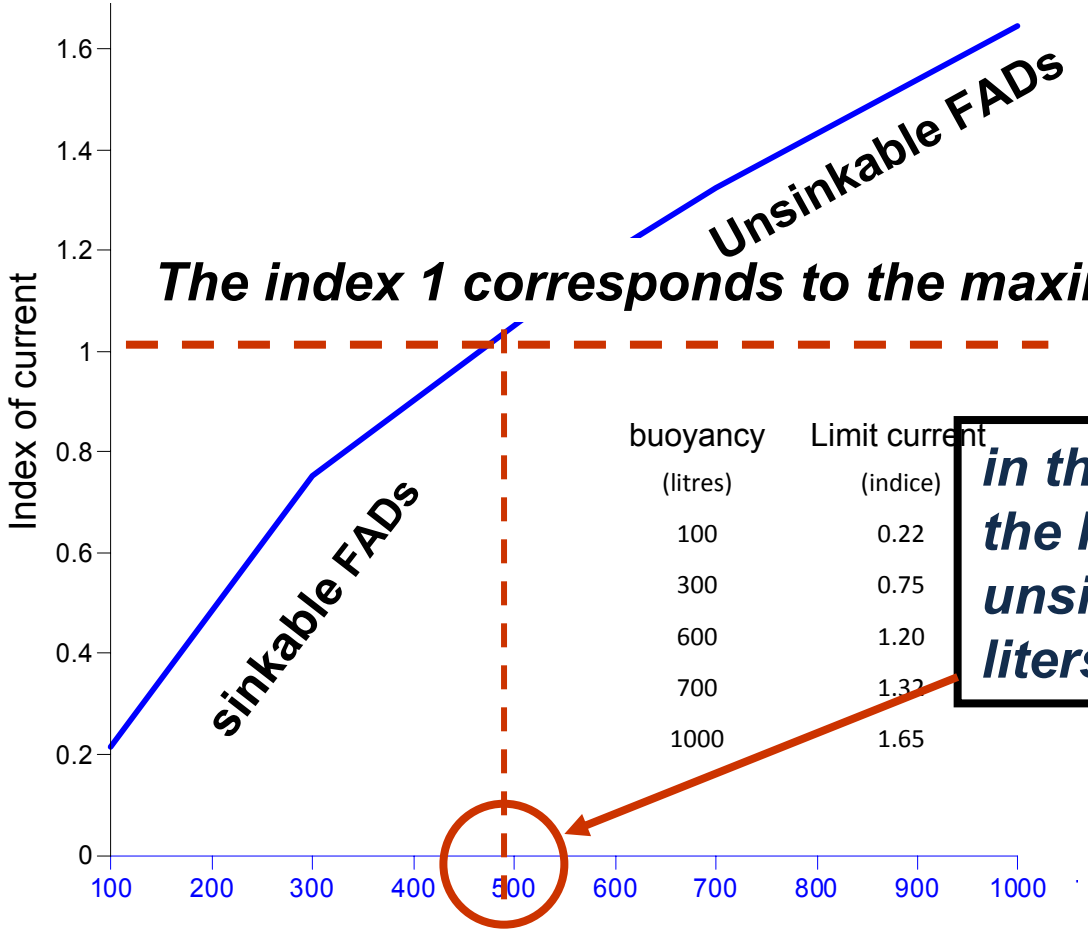
Overvew of the Influence of the buoyancy with modeling software "DCP"



A standard FAD is modeled and submitted to increasing currents. The current corresponding to the total immersion of the float is noted

Operations are repeated for new buoyancies, all others FAD parameters remaining unchanged

obviously, the greater the buoyancy is , the better an FAD resists currents



buoyancy (litres)	Limit current (indice)
100	0.22
300	0.75
600	1.20
700	1.32
1000	1.65

in the selected area, the FAD becomes unsinkable for 480 liters buoyancy

But this is not without consequences, particularly on the weight of the anchoring

B. Anchoring weight

For block anchoring, without chains or anchors

General rule:
Weight in water of the anchoring must be 130% of the FAD buoyancy

***weight in water* : Ww**

The weight in water of à body is the body weight decreased by the buoyant force

the buoyant force = body volume (V) multiplied by sea water density (Dw)

body weight(W) =its volume(V) multiplied by its density (Dmat)

Therefore **Ww= (V*(Dmat))-(V*(Dw))**

Ww=V*(Dmat-Dw)

Or **Ww= W(1-(Dw/Dmat))**

characteristic	formula	type of FAD			
		PLK600	DOM1	artisanal FAD	small artisanal FAD
FAD bouyancy (liters)		600	400	200	120
anchoring block weight in water (kg)	= buoyancy * 1.3	780	520	260	156
anchoring block weight in air (concrete density = 2.1) (kg)	= buoyancy * 1.3 / (1-(1.025/2.1))	**1524**	**1016**	**508**	**305**
block volume (m3)	= weight in air / 2100	0.726	0.484	0.242	0.145
block side (cm)	= (ROOT(volume /height)) * 1000	110	90	70	60
block height (cm)		60	60	50	40
anchoring block weight in air (steel density = 7.8) (kg)		898	599	299	180

C. Length and characteristics of the rope

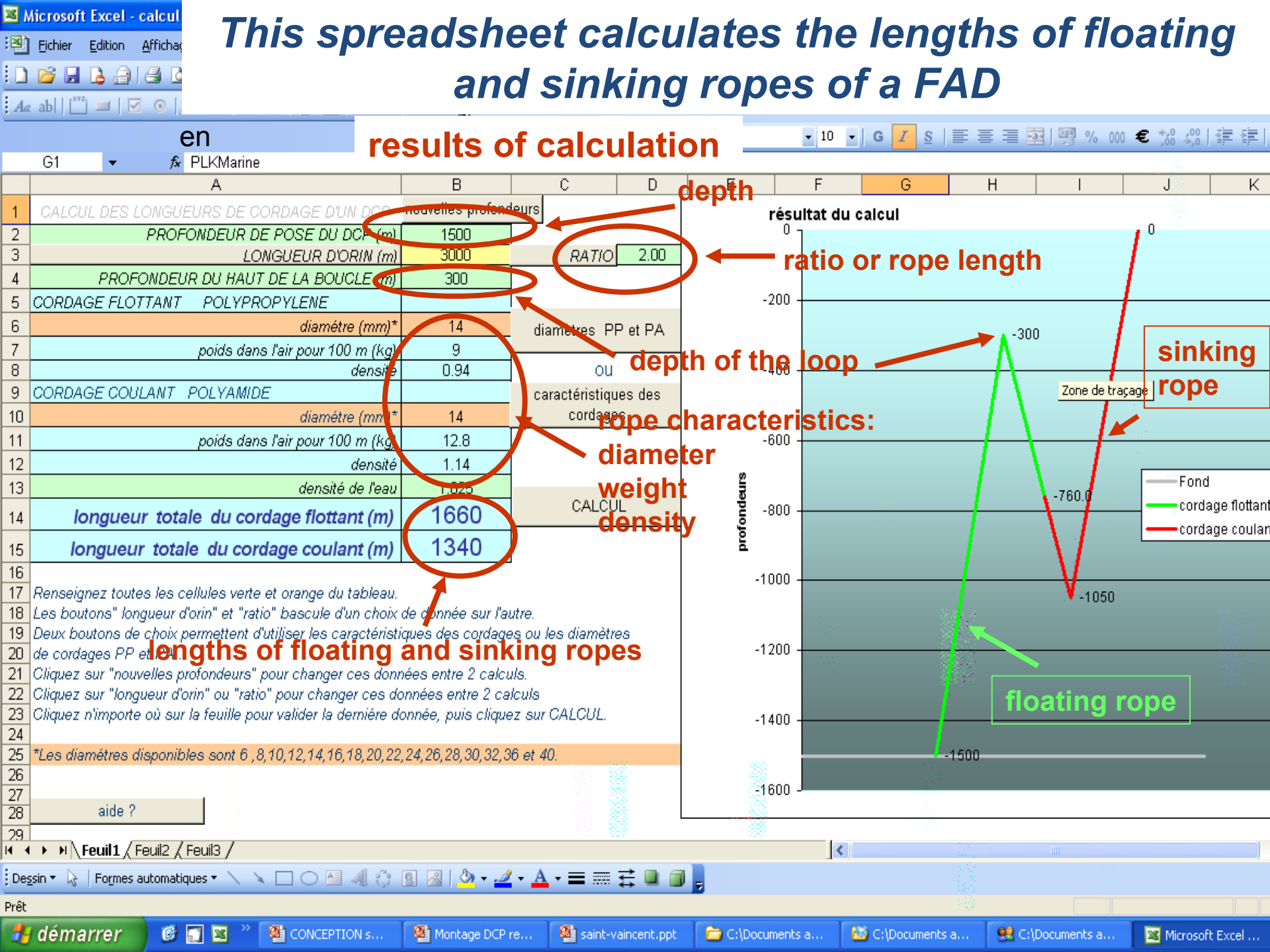
The excess length ratio is the ratio of length of the rope and depth
Ex: 2000 m of rope for 1000 m depth, ratio is 2

Basic rule
When there is no current:
no length of rope should come floating on the surface
no length of rope should come touching the bottom

This rule necessarily implies :
The buoyancy of the lower part of the mooring line is positive (floating rope)
The buoyancy of the upper part of the mooring line is negative (sinking roope)
The ratio of excess length should be between 1 and 3

Usually 1.2 < ratio < 2

This spreadsheet calculates the lengths of floating and sinking ropes of a FAD

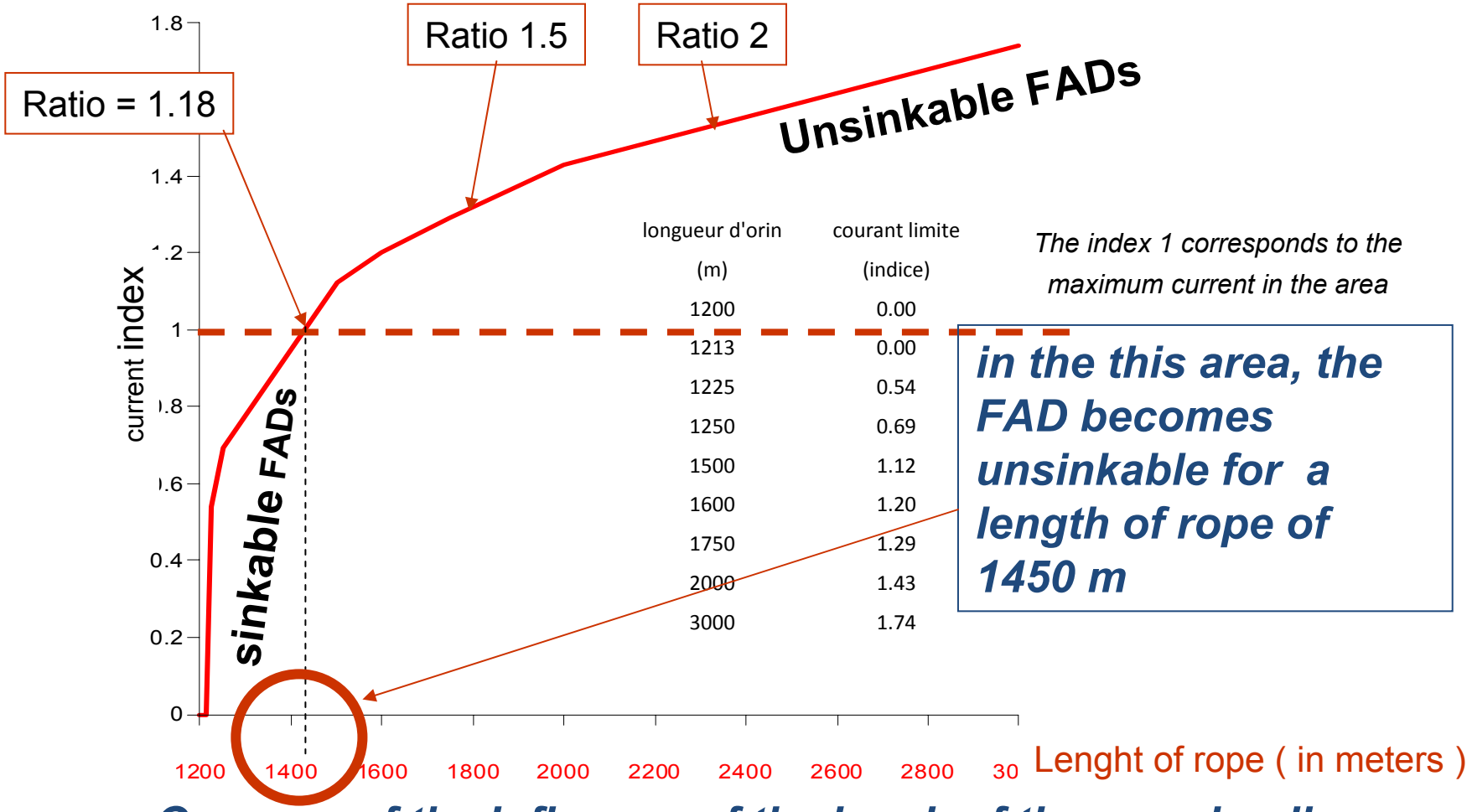


				notations	formules
1					
PROFONDEUR DE POSE DU DCP (m)			1500	P	
2					
LONGUEUR D'ORIN		(m)	3000	LT	
3					
DENSITE DE L'EAU			1.025	De	
4					
RATIO DE SURLONGUEUR			2		
(rapport entre la longueur d'orin et la profondeur)					
(usuellement entre 1.3 et 3 pour un)					
5					
PROFONDEUR DU HAUT DE BOUCLE		(m)	300	Phb	
(sans courant)					
6					
LONGUEUR DE LA BOUCLE		(m)	1500		= LT-P
LONGUEUR DU BRAS DE BOUCLE		(m)	750	Lb	= (LT-P)/2
7					
CARACTERISTIQUE DES CORDAGES					
A. CORDAGE FLOTTANT					
poids dans l'air pour 100 m	(PP de 14 mm)	(kg)	9	PAf	
densité			0.94	DMf	
B. CORDAGE COULANT					
poids dans l'air pour 100 m	(PA de 14 mm)	(kg)	12.8	PAc	
densité			1.14	DMc	
7					
POIDS DANS L'EAU DU METRE DE CORDAGE FLOTTANT		(kg)	-0.0081383	pf	= (Paf*(1-(De/DMf)))/100
POIDS DANS L'EAU DU METRE DE CORDAGE COULANT		(kg)	0.01291228	pc	= (Pac*(1-(De/DMc)))/100
8					
REPARTITION DES CORDAGES DANS LE BRAS DE BOUCLE					
longueur de cordage flottant dans le bras de boucle		(m)	460.044863	Lf	= Lb*(pc/(-pf+pc)) car on a : - Lf*pf = Lc*pc et Lf+Lc = Lb
longueur de cordage coulant dans le bras de boucle		(m)	289.955137	Lc	= Lb*(-pf/(-pf+pc)) (dans le bras de boucle, la flottabilité du PP égale le poids dans l'eau du PA)
9					
LONGUEUR TOTALE DE CORDAGE FLOTTANT (m)			1660		= P-Phb+Lf
LONGUEUR TOTALE DE CORDAGE COULANT (m)			1340		= Phb+Lb+Lc

details of calculations and formulas

thanks again to Archimedes

For the standard FAD, and increasing currents ,the current corresponding to the total immersion of the float is noted
Operations are repeated for <u>new lengths</u> of the anchoring rope, all other FADs parameters remaining unchanged



longueur d'orin (m)	courant limite (indice)
1200	0.00
1213	0.00
1225	0.54
1250	0.69
1500	1.12
1600	1.20
1750	1.29
2000	1.43
3000	1.74

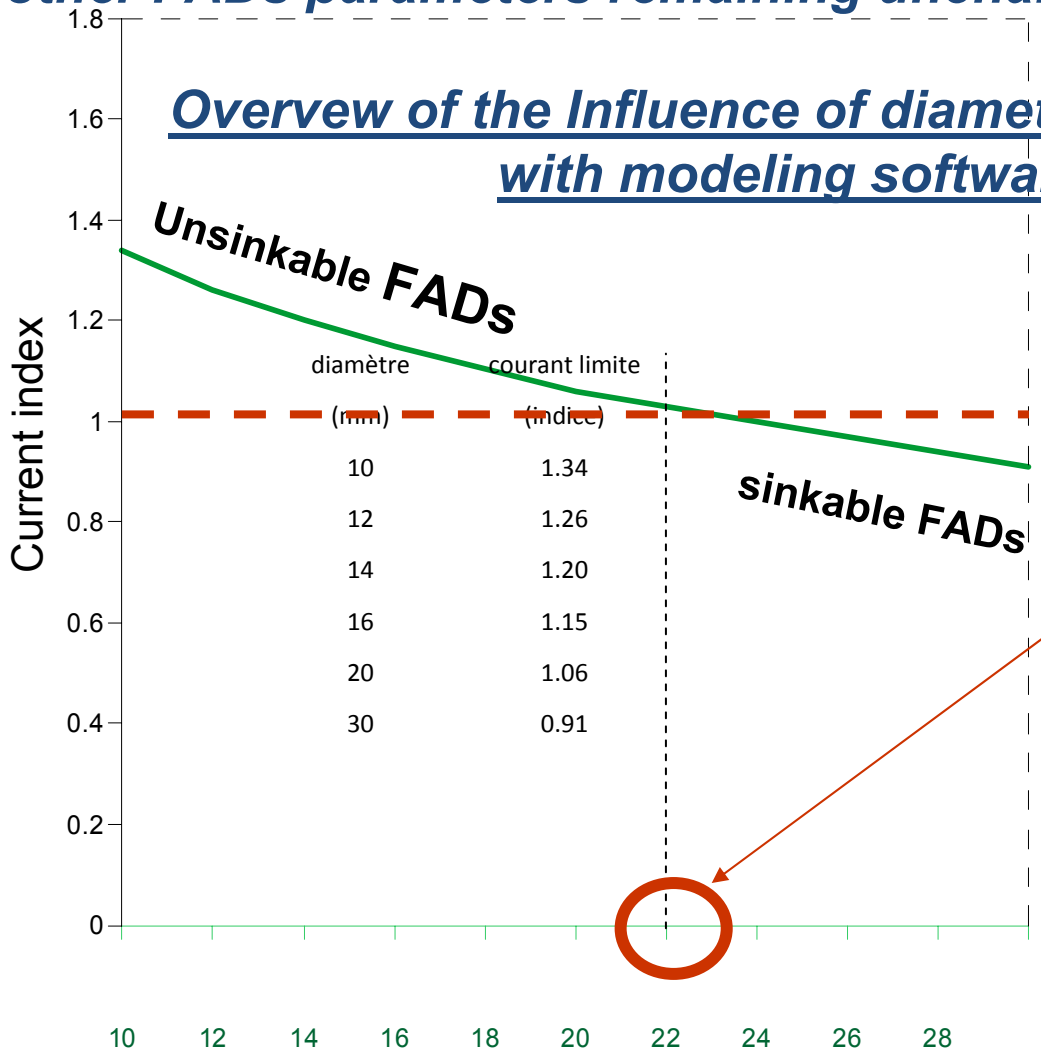
The index 1 corresponds to the maximum current in the area

in the this area, the FAD becomes unsinkable for a length of rope of 1450 m

<u>Overvew of the Influence of the lengh of the mooring line with modeling software "DCP"</u>

For the standard FAD, and increasing currents ,the current corresponding to the total immersion of the float is noted. Operations are repeated for <u>new diameters</u> of the anchoring rope, all other FADs parameters remaining unchanged.

<u>Overvew of the Influence of diameter of the mooring line with modeling software "DCP"</u>



diamètre (mm)	courant limite (indice)
10	1.34
12	1.26
14	1.20
16	1.15
20	1.06
30	0.91

in this area, the FAD stays unsinkable for rope diametre up to 22 mm

A practical example of a FAD design and analysis of its behavior with the Ifremer 'DCP' software

the geo localized ESPACE SUD 2 FAD

located in the Atlantic at 20nm east of Martinique coast

depth: 2100 m

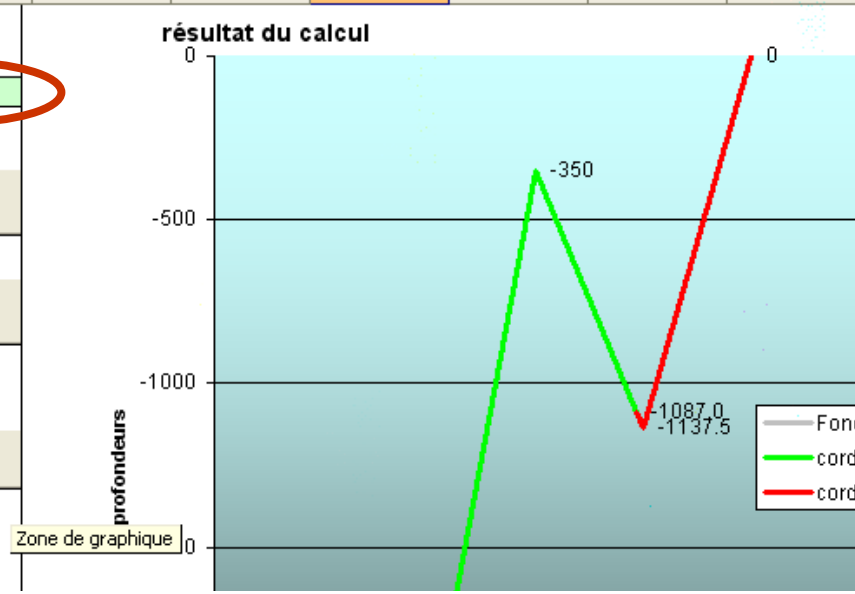
buoyancy 600 liters

Microsoft Excel - calcul des longueurs d'orin (version 5)1.xls

Fichier Edition Affichage Insertion Format Outils Données Fenêtre ?

G1 PLKMarine

	A	B	C	D
1	CALCUL DES LONGUEURS DE CORDAGE D'UN DCP	nouvelles profondeurs		
2	PROFONDEUR DE POSE DU DCP (m)	2100		
3	LONGUEUR D'ORIN (m)	3675	RATIO	1.75
4	PROFONDEUR DU HAUT DE LA BOUCLE (m)	350		
5				
6	CORDAGE FLOTTANT		diamètres PP et PA	
7	poids dans l'air pour 100 m (kg)	9		
8	densité	0.94	ou	
9			caractéristiques des cordages	
10	CORDAGE COULANT			
11	poids dans l'air pour 100 m (kg)	20		
12	densité	2.5		
13	densité de l'eau	1.025		
14	longueur totale du cordage flottant (m)	2487	CALCUL	
15	longueur totale du cordage coulant (m)	1188		
16				
17	Renseignez toutes les cellules verte et orange du tableau			



In our spreadsheet, depth, loop depth , ratio and features ropes are entered.

Lengths of floating and sinking ropes required are obtained

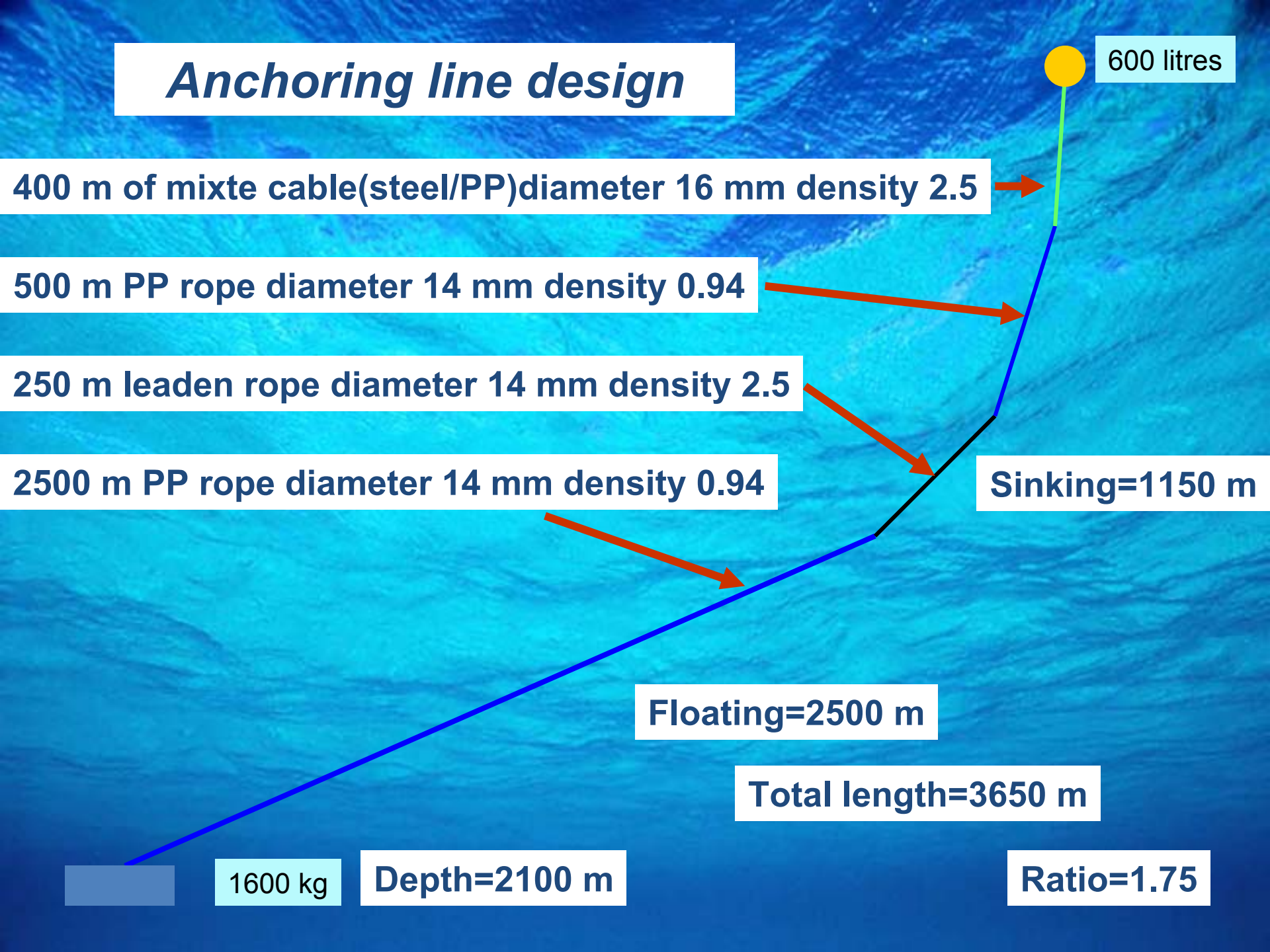
Feuil1 Feuil2 Feuil3

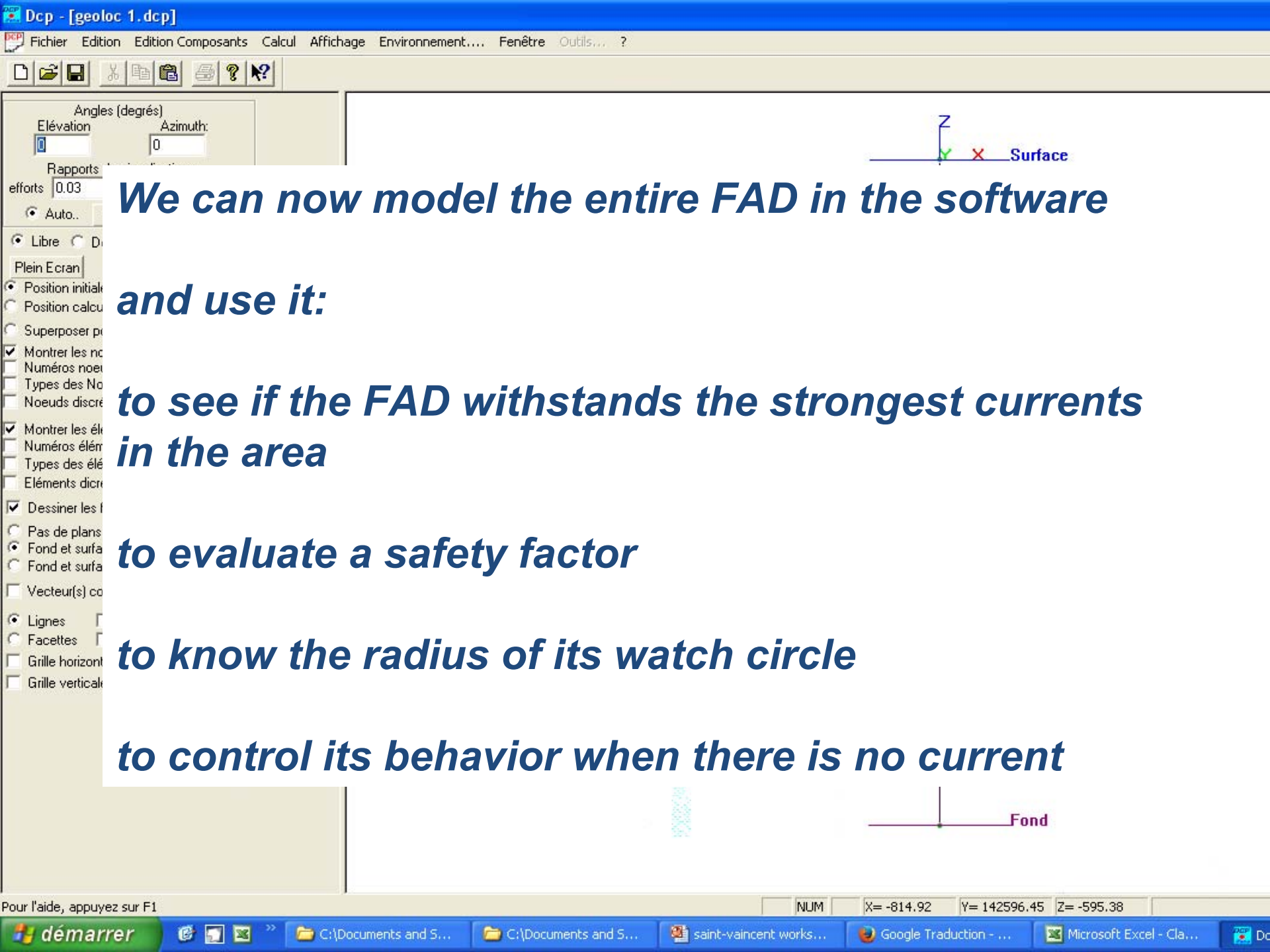
Dessin Formes automatiques

Prêt

démarrer | 3 Microsoft Office ... | 4 Explorateur Wind... | Microsoft Excel - calc... | Microsoft Excel - Cla... | rapport pose géoloc ... | Dcp - [Dcpge

Anchoring line design





We can now model the entire FAD in the software

and use it:

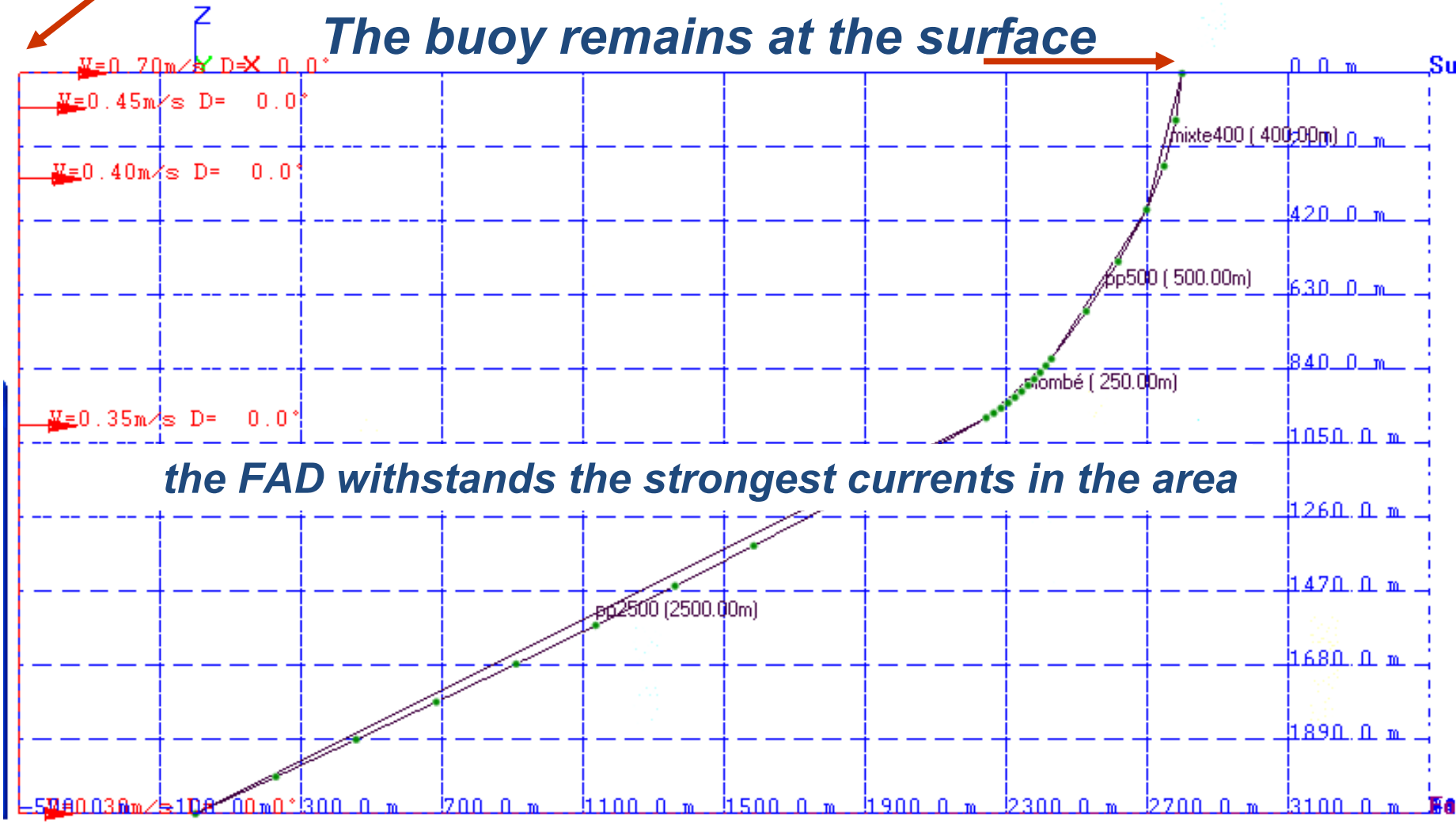
to see if the FAD withstands the strongest currents in the area

to evaluate a safety factor

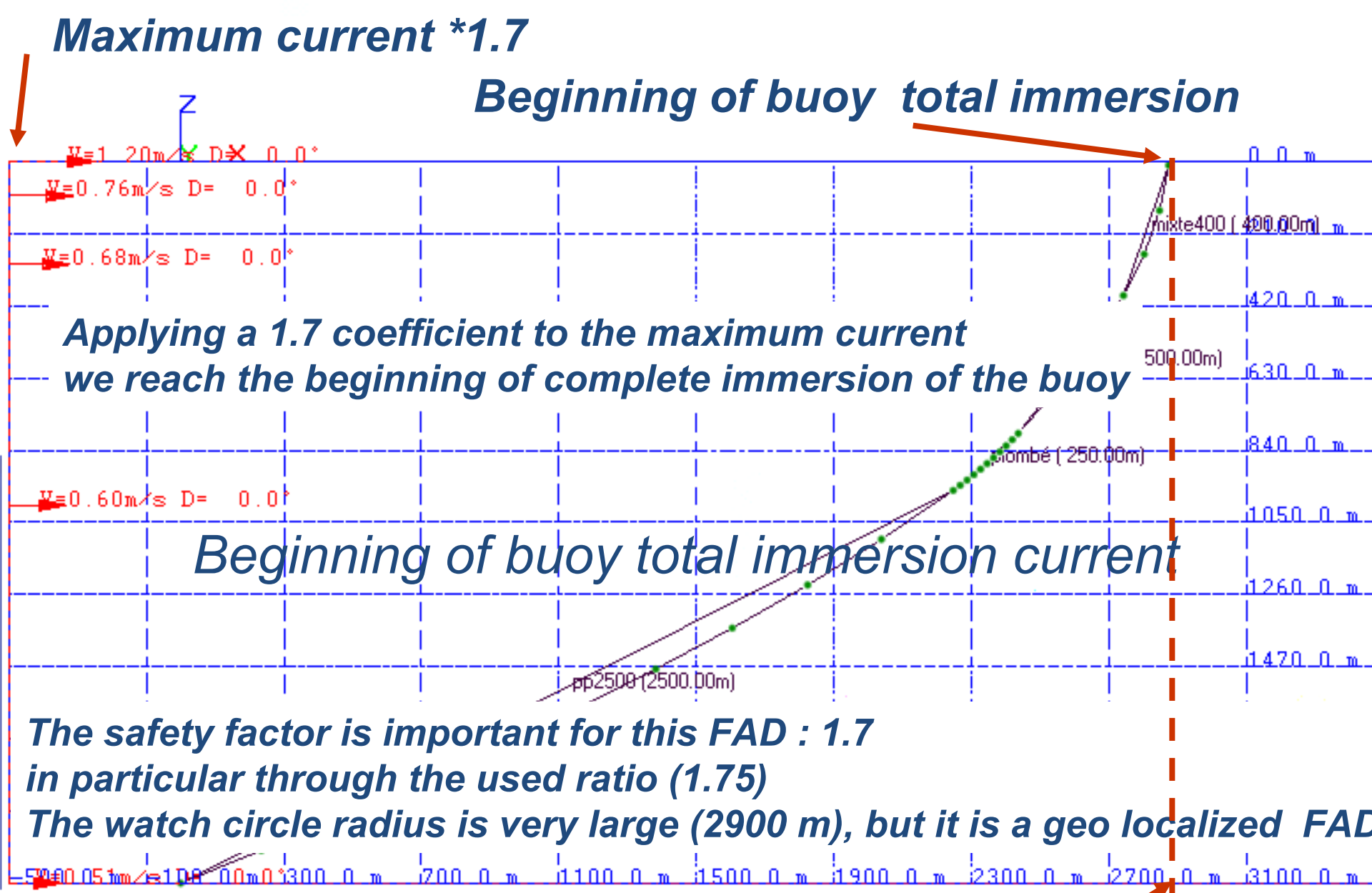
to know the radius of its watch circle

to control its behavior when there is no current

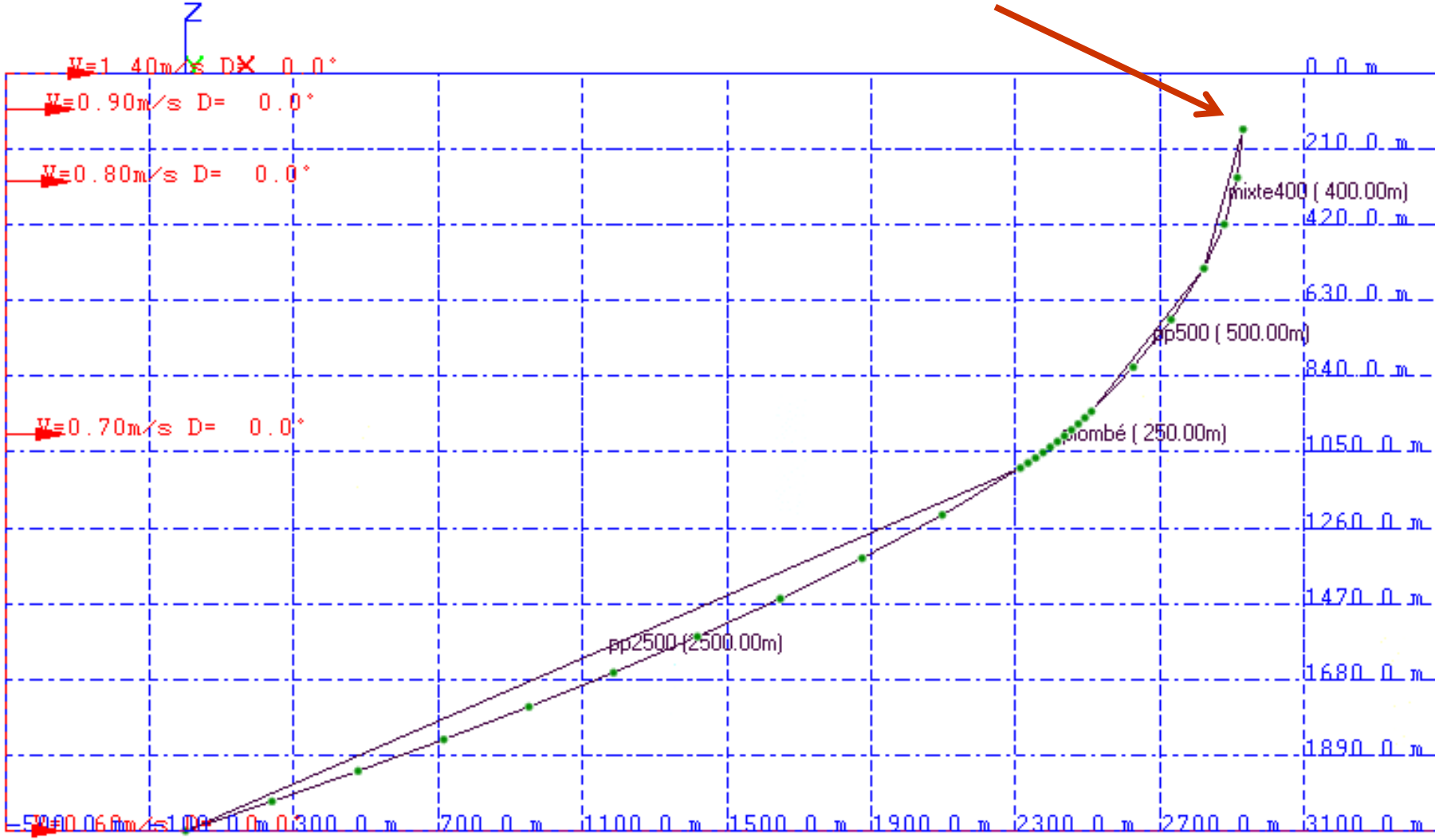
Maximum current profile in the area



Behavior in the maximum current speed in the area


Maximum current *1.7
Beginning of buoy total immersion
V=1.20m/s D= 0.0°
V=0.76m/s D= 0.0°
V=0.68m/s D= 0.0°
V=0.60m/s D= 0.0°
mixte400 (400.00m)
500.00m)
plombé (250.00m)
pp2500 (2500.00m)
0.0 m
420.0 m
630.0 m
840.0 m
1050.0 m
1260.0 m
1470.0 m
300.0 m
700.0 m
1100.0 m
1500.0 m
1900.0 m
2300.0 m
2700.0 m
3100.0 m
Applying a 1.7 coefficient to the maximum current
we reach the beginning of complete immersion of the buoy
Beginning of buoy total immersion current
The safety factor is important for this FAD : 1.7
in particular through the used ratio (1.75)
The watch circle radius is very large (2900 m), but it is a geo localized FAD
Radius of watch circle: 2900 m

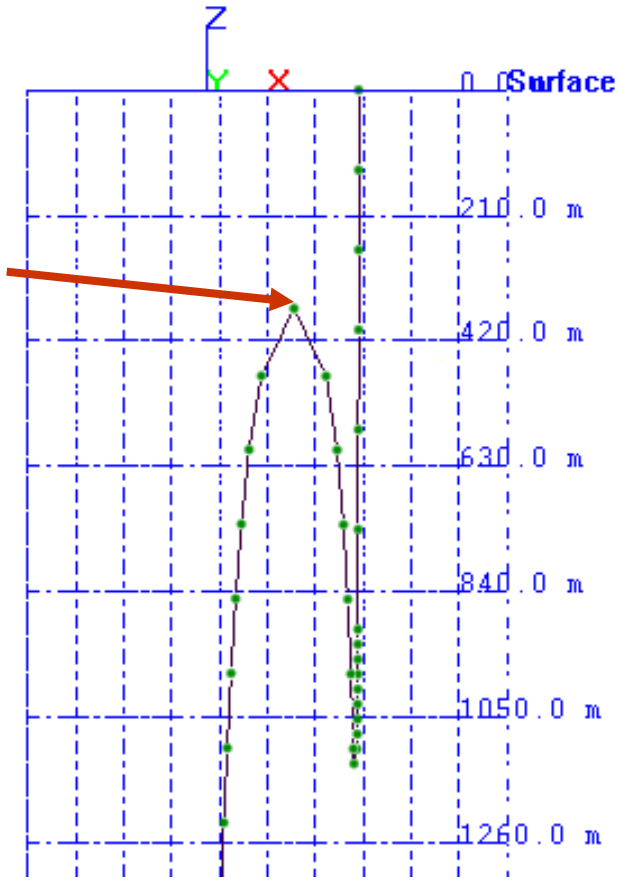
By further increasing the current , The FAD immerses deeper !



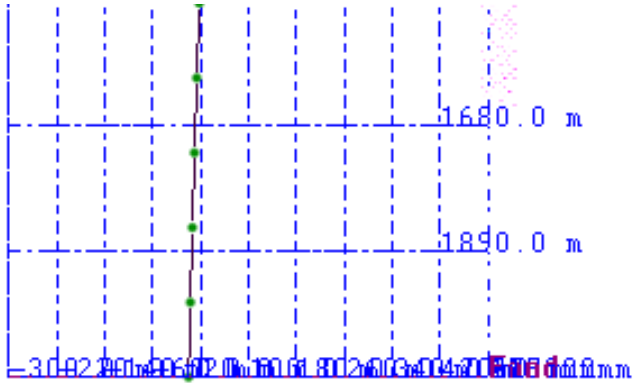
not normally possible!

Zero current

Depth of the loop: 350 m



with zero current we control the depth of the loop



du DCP

ngueur totale des éléments :	3650.000 m
ids total des éléments :	760.831 kg
lume total des éléments :	0.593 m3
ids total des noeuds libres :	200.000 kg
lume total des noeuds :	0.802 m3
ottabilité totale :	14014.940 N
ids total :	960.831 kg
ids apparent total :	

:
en m

Y	Z	
0.000	-2100.000	1
0.000	-0.638	2
0.000	-822.412	2
0.000	-678.637	3
0.000	-336.206	4

:

noeuds extrêmités N° du typ
6
1
3
2

The software provides all the calculation results as a text file including the efforts and tensions in the ropes, which is used to evaluate the safety factors in relation to the breaking loads of ropes

cul d'équilibre statique
Coordonnées exprimées en

X	Y	Z	FX	FY	FZ
.000	0.000	-2100.000	5.44	0.00	215.92
.573	0.000	-0.426	-0.18	0.00	-1540.75
.713	0.000	-1101.520	-0.16	0.00	28.35
.467	0.000	-901.863	-0.18	0.00	25.88
.398	0.000	-401.203	-0.24	0.00	183.77

workshop for training in using the DCP software this afternoon at 16:45

Thank you

RFM

JICA

FAO FIAT PANIS

COPACO
Western Central Atlantic Fishery Commission

l'Europe s'engage avec les Antilles-Guyane dans la Grande Caraïbe

Ifremer

PROGRAMME INTERREG CARAÏBES