



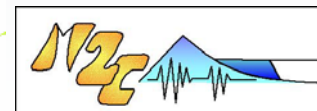
Conférence finale de la Phase 3 du Projet INTERREG IIIA Plages A Risques (PAR)
Dunkerque 27 juin 2008

Final Conference of Phase 3 INTERREG IIIA Project Beaches At Risks (BAR)
Dunkirk 27 June 2008

Principaux résultats scientifiques du Projet “Plages A Risque”
Main scientific results of the “Beaches At Risk” Project

ZEITSCHRIFT FÜR GEOMORPHOLOGIE
Supplement Volume

Edited by Arnaud Héquette (Université du Littoral Côte d'Opale)
& Cherith A. Moses (University of Sussex)



Zeitschrift für Geomorphologie

Annals of Geomorphology
Annales de Géomorphologie

A journal recognized by the International Association of Geomorphologists (IAG)

Neue Folge
Supplement Volume

INTERREG III A Project

Beaches At Risk

edited by A. Héquette and C. A. Moses



Gebrüder Borntraeger · Berlin · Stuttgart

Volume rassemblant 14 articles qui constituent une synthèse des principaux résultats scientifiques obtenus dans le projet



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1. Shoreline evolution and beach morphodynamics on the eastern Channel coasts

- Chaverot, S., Héquette, A. & Cohen, O. "*Changes in storminess and shoreline evolution along the northern coast of France during the second half of the 20th century*"
- Laignel, B., Costa, S., Lequien, A., Massei, N., Durand, A., Dupont, J.P. & Le Bot, S. "*Current inputs of continental sediment to the English Channel and its beaches: A case study of the cliffs and littoral rivers of the Western Paris Basin*"
- Costa, S., Levoy, F., Monfort, O., Curoy, J., De Saint Léger, E. & Delahaye, D. "*Impact of sand content and cross-shore transport on the morphodynamics of macrotidal gravel beaches (Haute-Normandie, English Channel)*"
- Watt, T. Robinson, D.A., Moses, C.A. & Dornbusch, U. "*Patterns of surface sediment grain size distribution under the influence of varying wave conditions on a mixed sediment beach at Pevensey Bay, southeast England*"
- Reichmüth, B. & Anthony, E.J. "*Seasonal-scale morphological and dynamic characteristics of multiple intertidal bars*"
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2. Influence of management practices on beach and coastal dune evolution

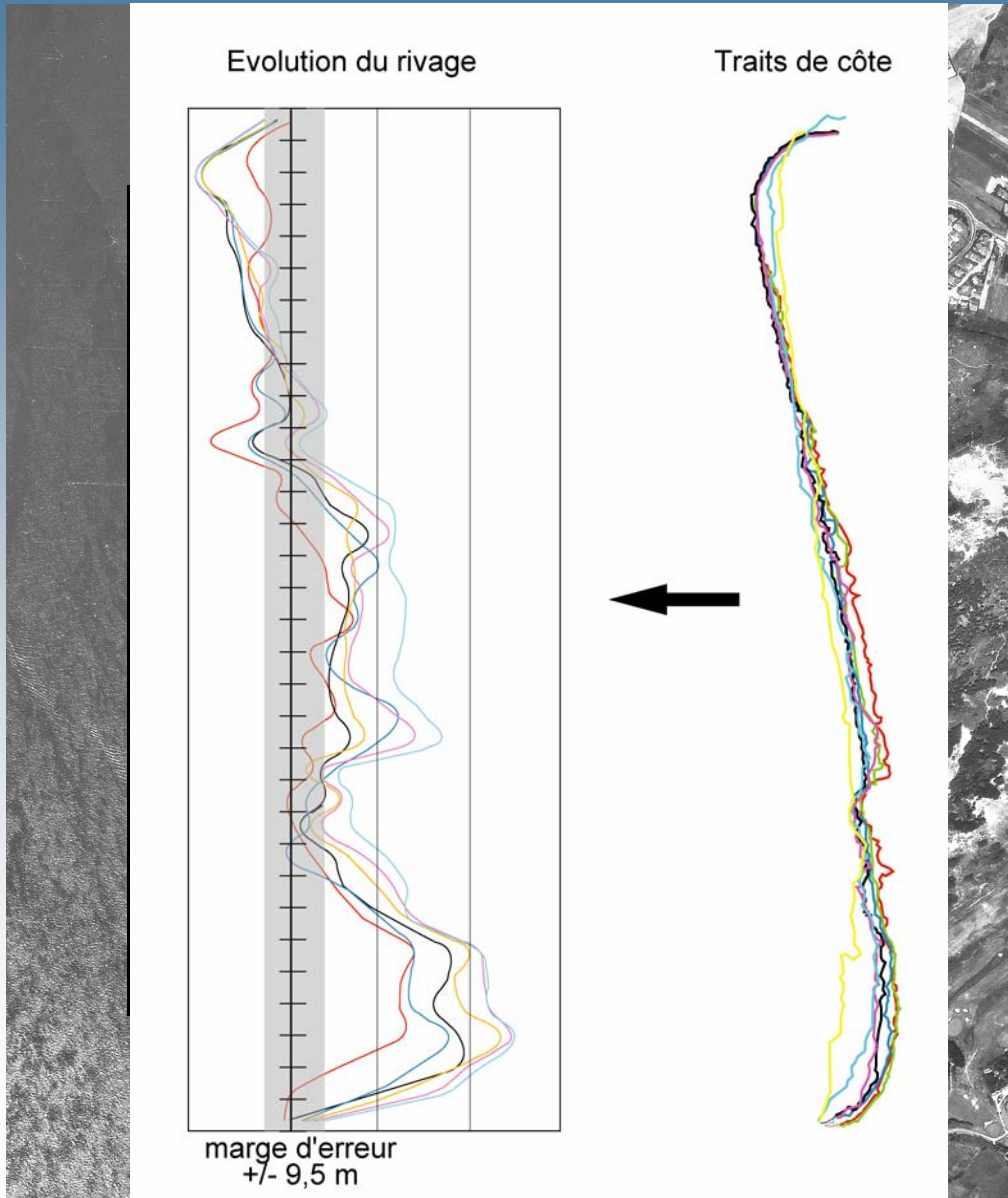
- Moses, C.A. & Williams, R.B.G. "*Artificial beach recharge: the South East England experience*"
- Dornbusch, U., Robinson, D.A., Moses C.A. & Williams R.B.G. "*Variation in beach behaviour in relation to groyne spacing and groyne type for mixed sand and gravel beaches, Saltdean, UK*"
- Aubry, A. & Ruz, M.H. "*Influences des épis sur la morphodynamique d'une plage à barres et à bâches, nord de la France*"
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3. Storm surge, sea level rise and marine flooding hazards

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- Swift, R.H. "*Secular trends in tidal parameters along the eastern Channel and southern North Sea Basin coastlines*"
- Pirazzoli, P.A. & Tomasin, A. "*Tentative estimation of extreme sea levels in the English Channel by the year 2050*"

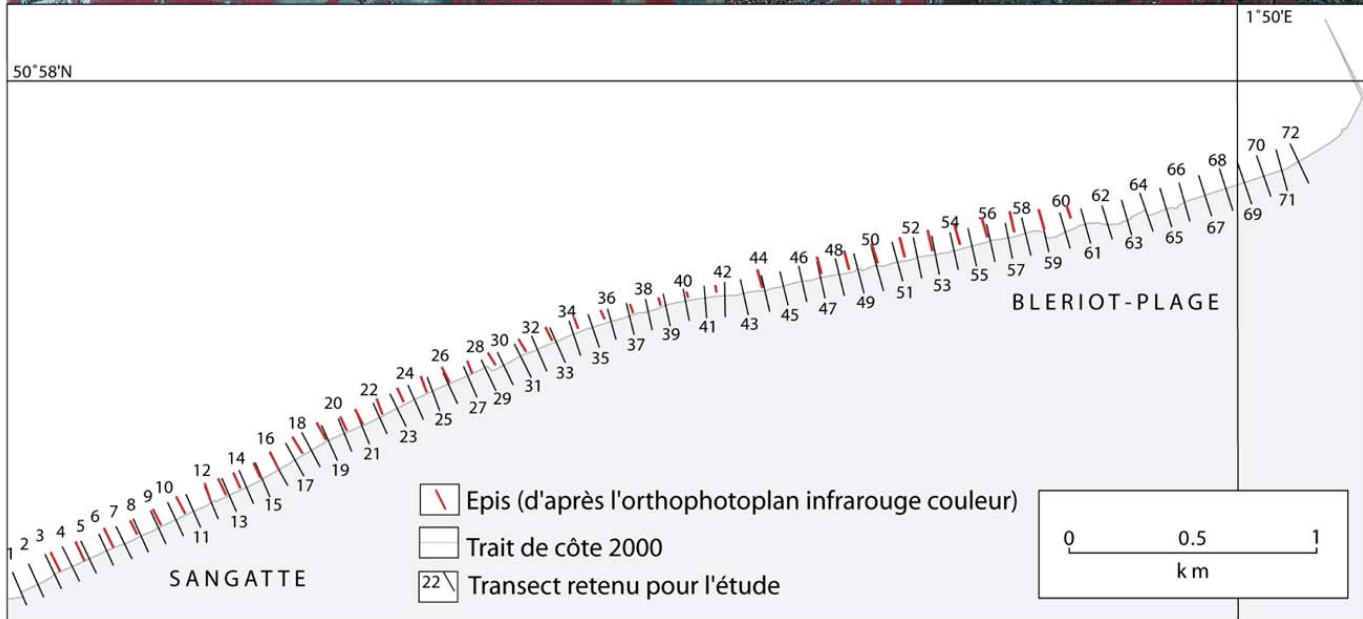
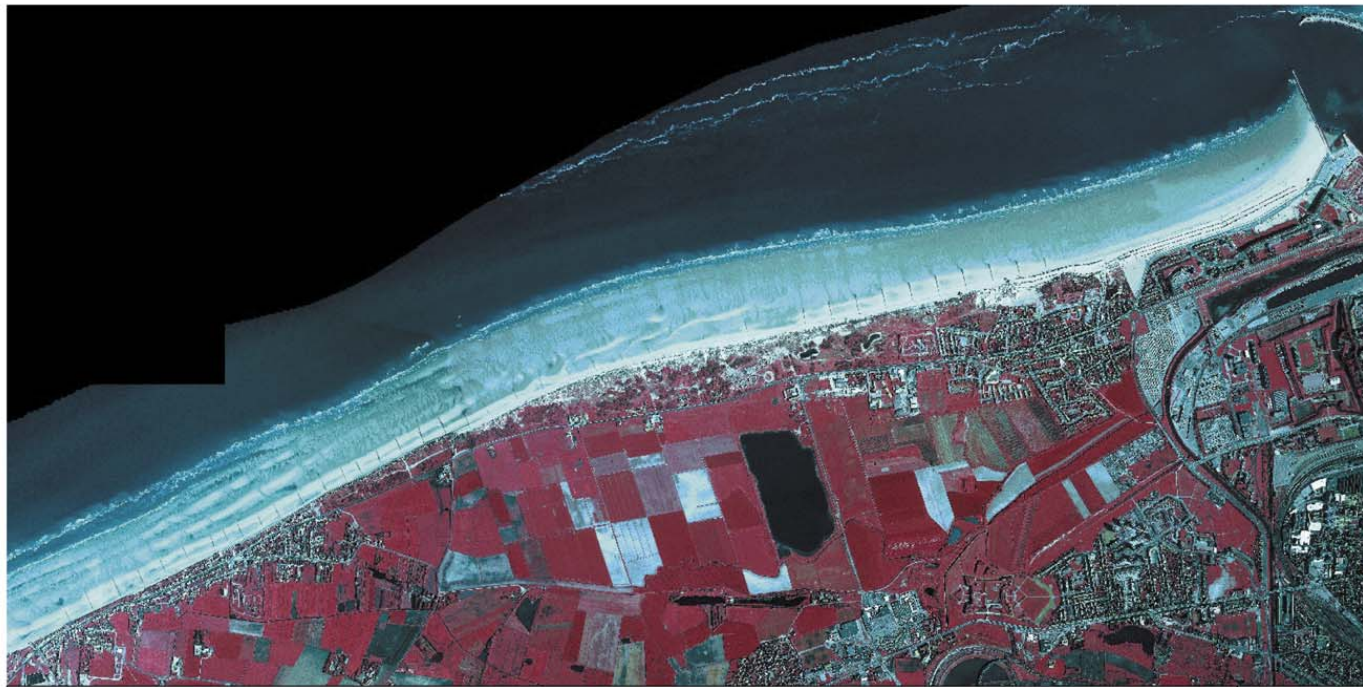
***Changes in storminess and shoreline evolution
along the northern coast of France during the
second half of the 20th century***

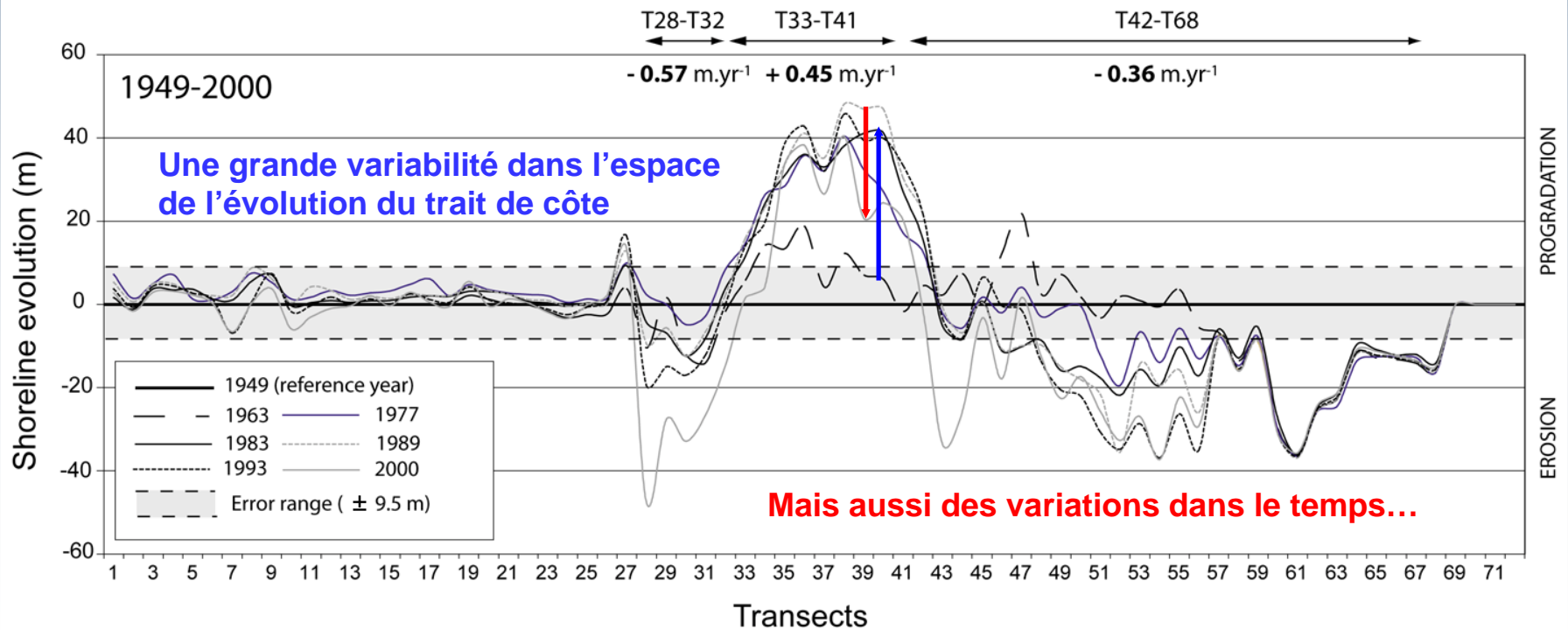
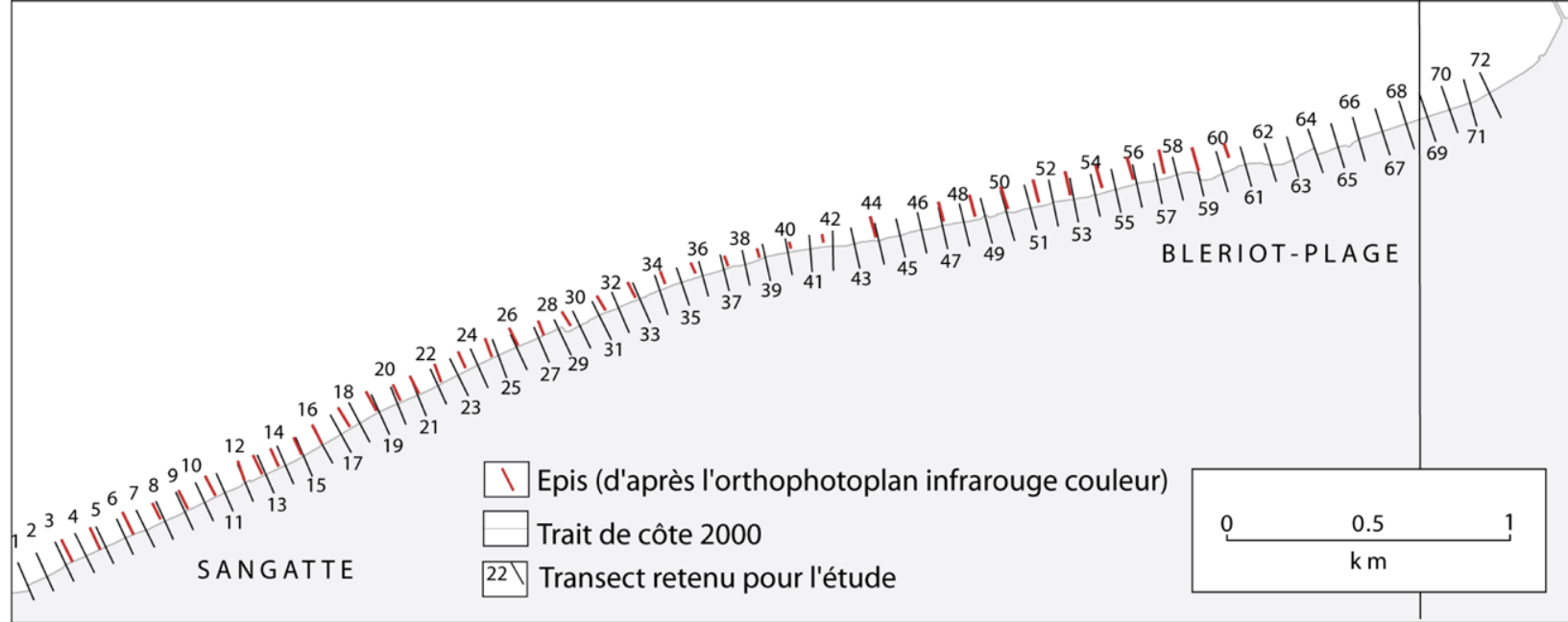
Chaverot, S., Héquette, A. & Cohen, O.

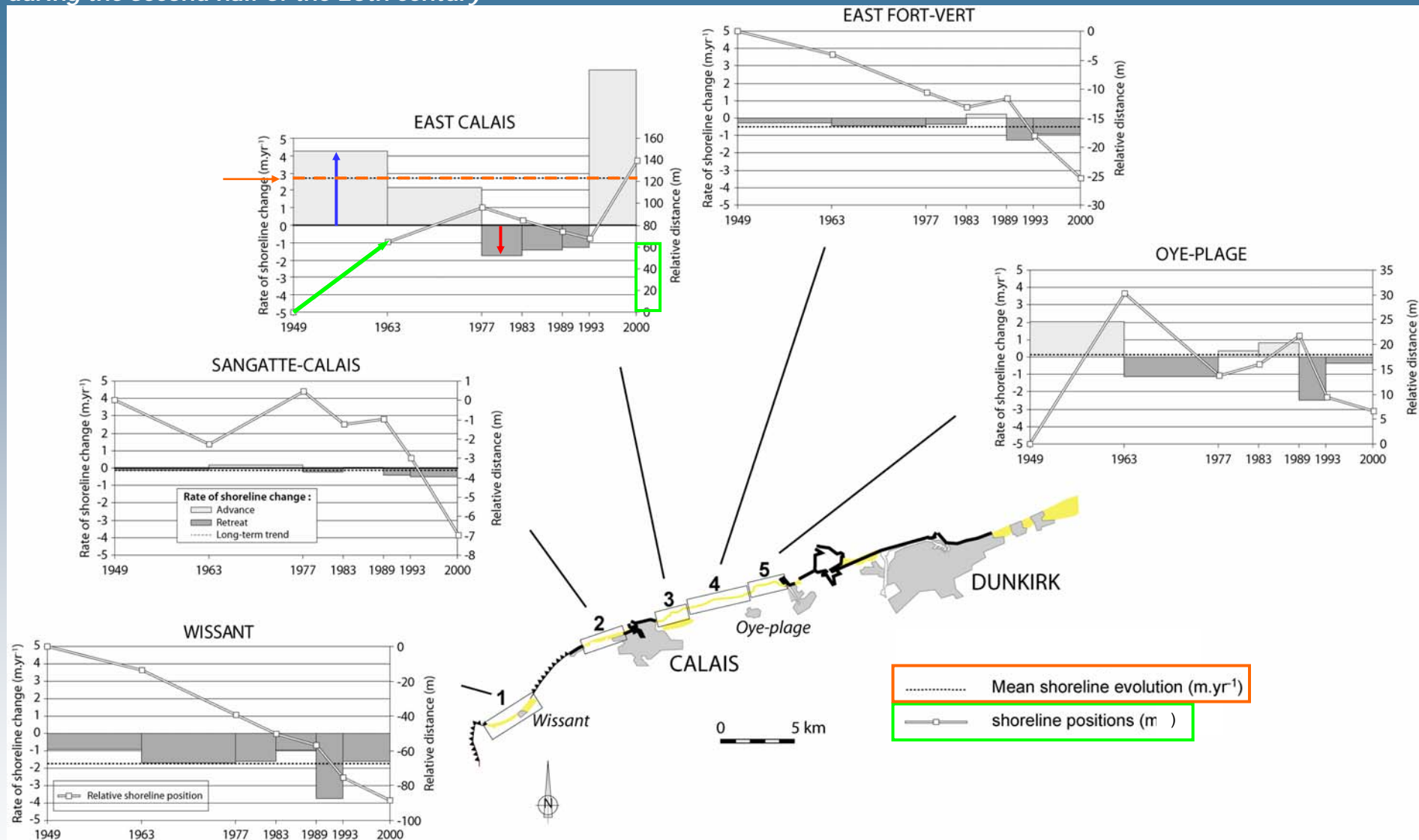


Cartographie de l'évolution du trait de côte :

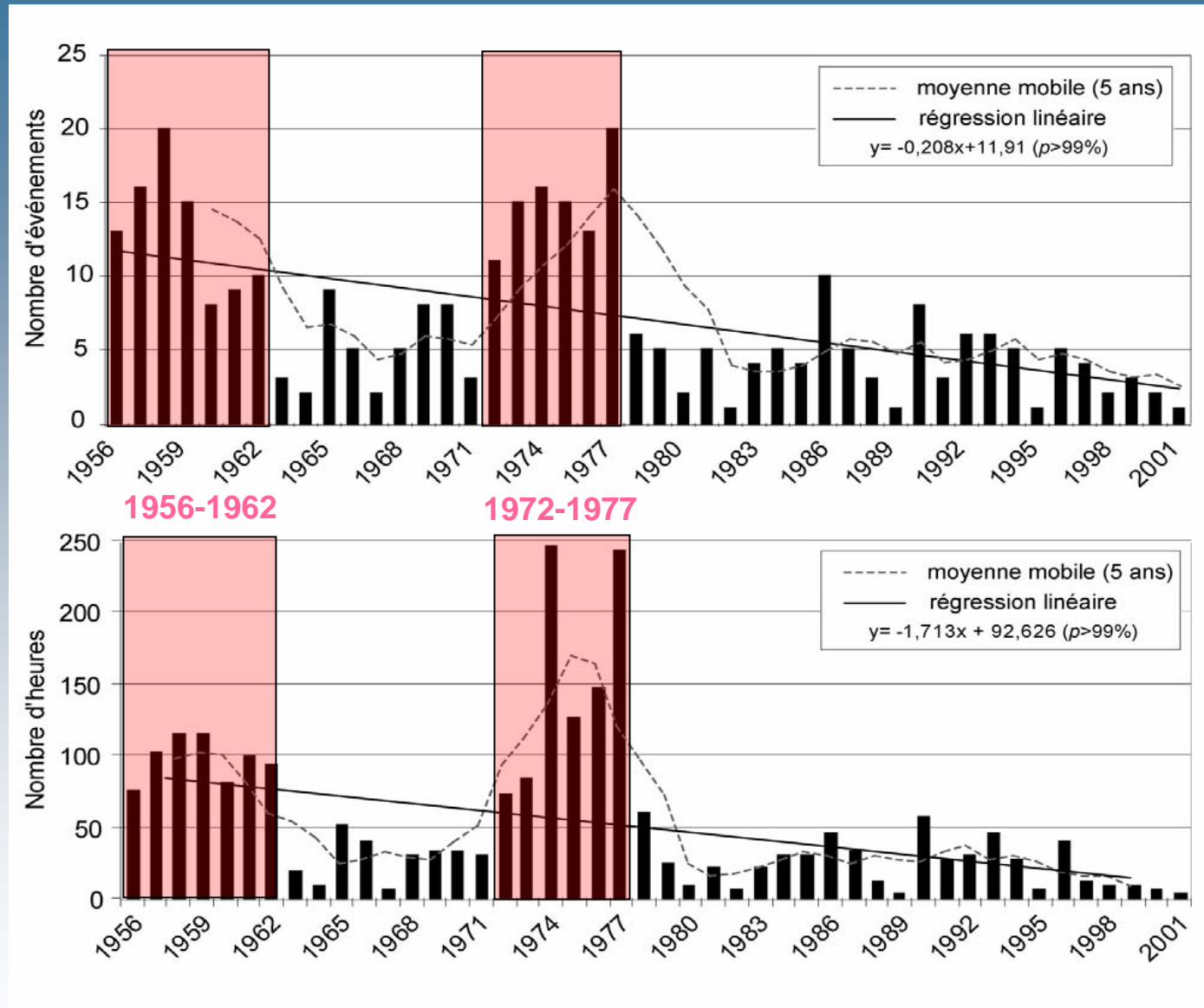
- Rectification géométrique de photographies aériennes (1949-2000)
- Digitalisation du trait de côte (logiciel ARCVIEW 3.1)
- Superposition des différents traits de côte et mesure des évolutions



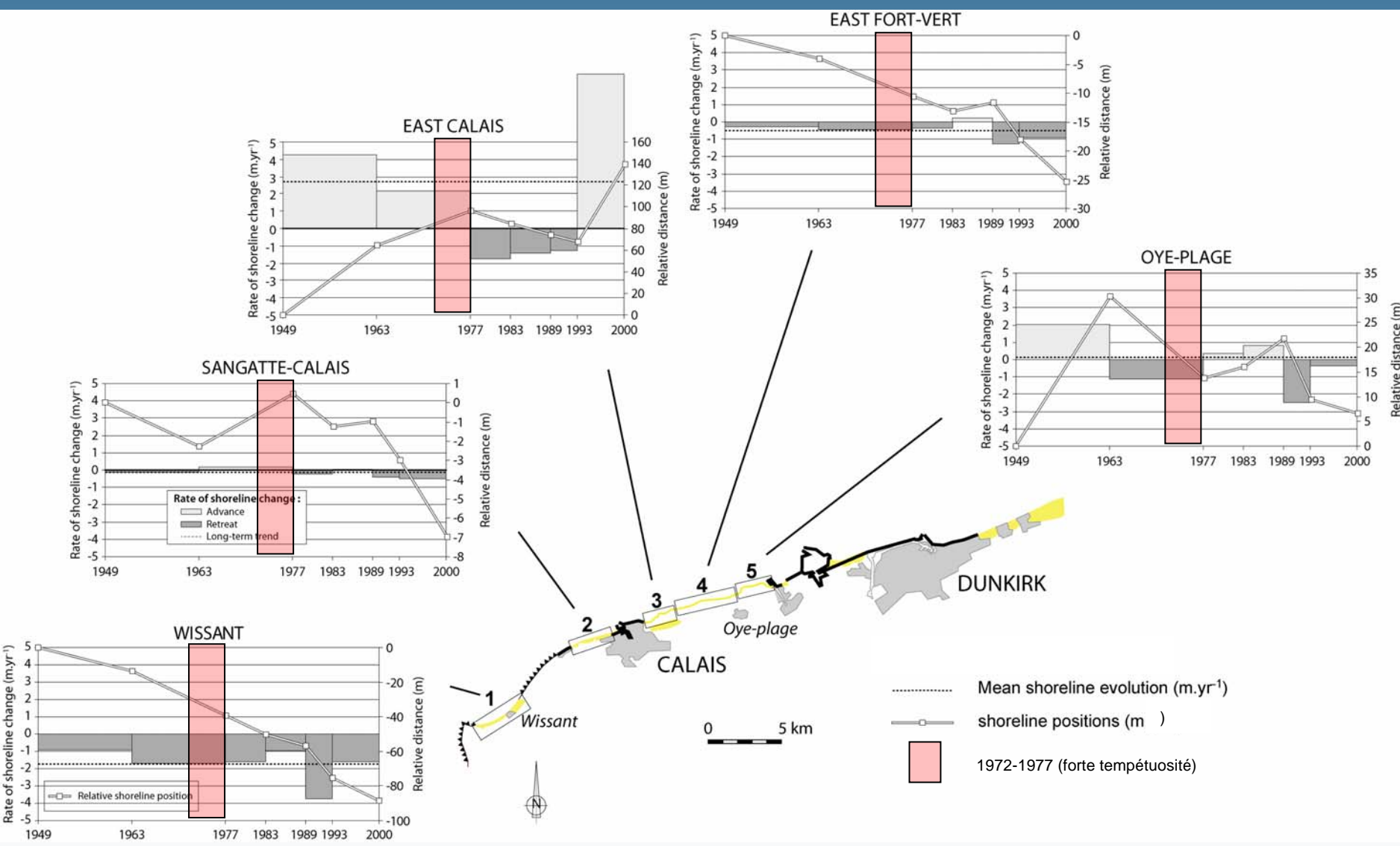




Une telle variabilité dans le temps, peut-elle être expliquée par des variations dans la fréquence ou l'intensité des tempêtes?



Evolution des vents $> 16 \text{ m.s}^{-1}$ et des événements de tempête à Dunkerque (1956-2001)

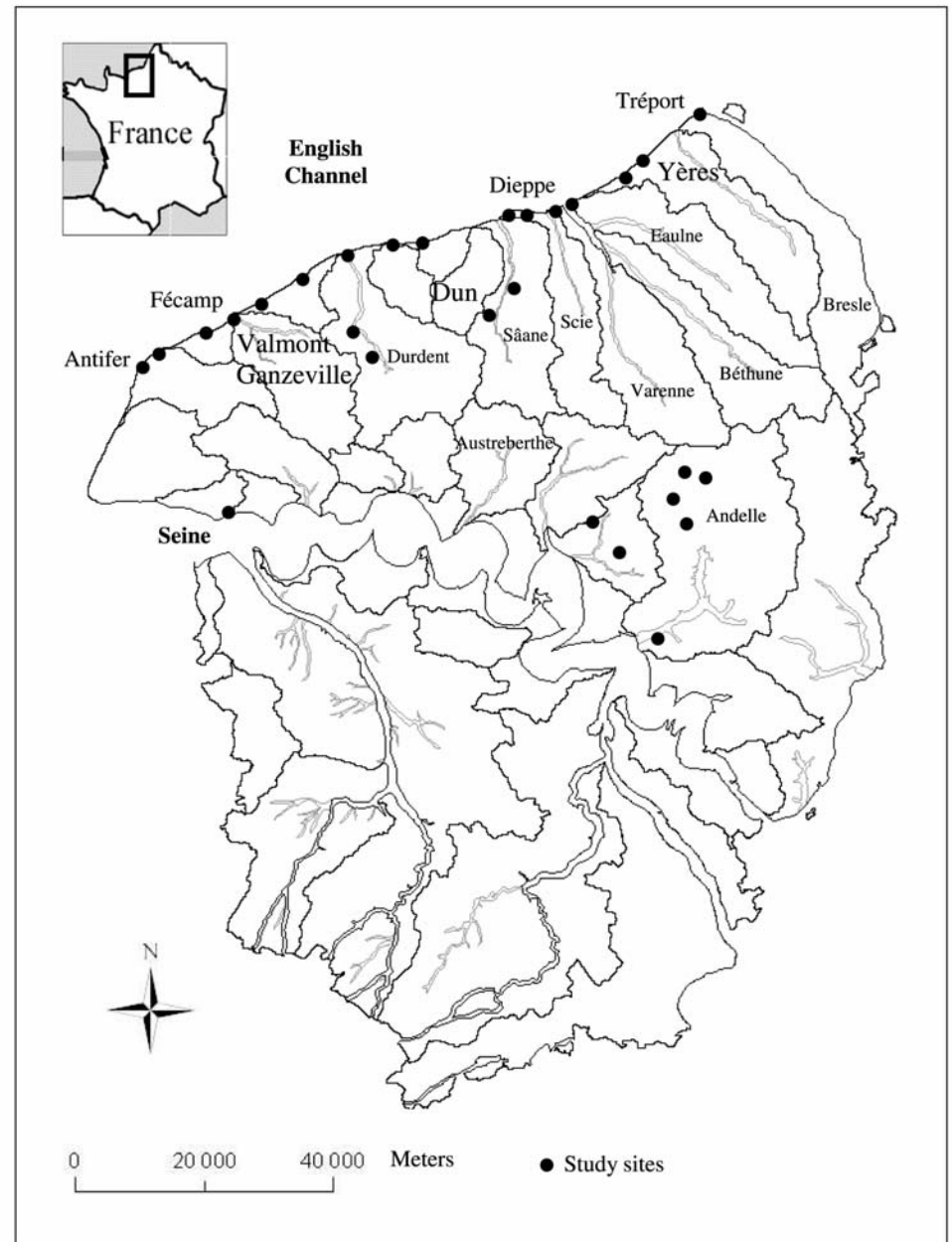


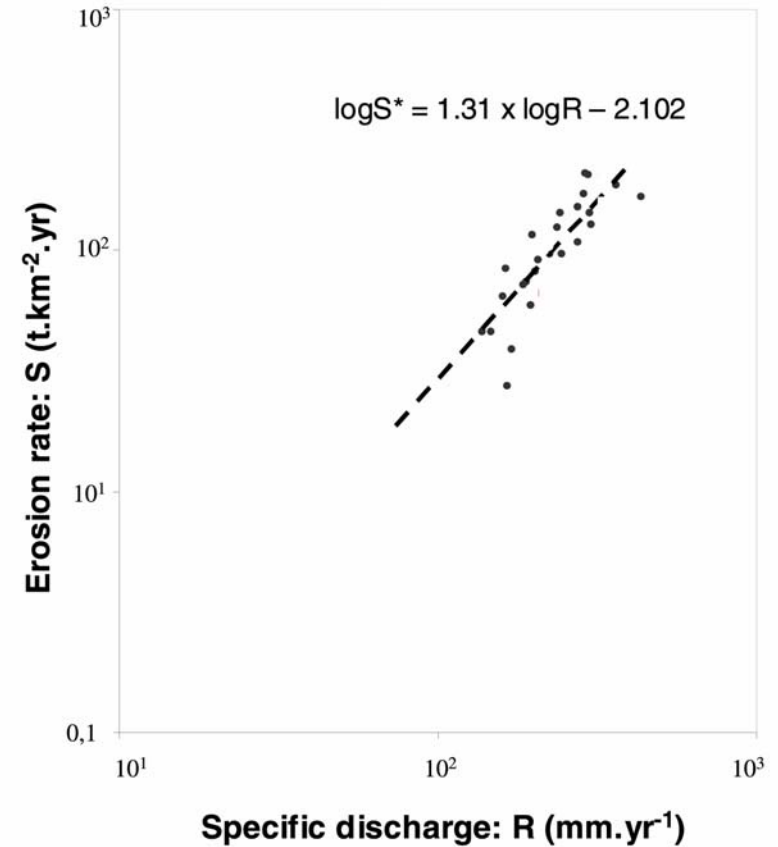
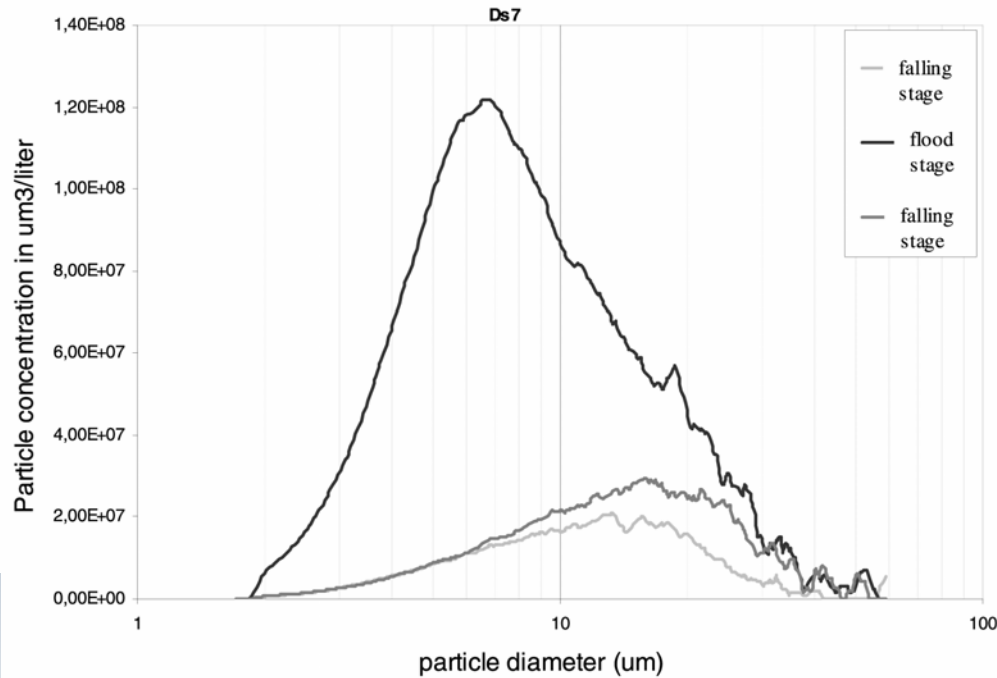
Une variabilité dans l'évolution du trait de côte fortement déterminée par le bilan sédimentaire local

Current inputs of continental sediment to the English Channel and its beaches: A case study of the cliffs and littoral rivers of the Western Paris Basin

Laignel, B., Costa, S., Lequien, A., Massei, N., Durand, A., Dupont, J.P. & Le Bot, S.

- Caractérisation et quantification des transferts sédimentaires du Nord-Ouest du Bassin de Paris vers la Manche en prenant en compte le recul des falaises marines et l'érosion des bassins versants littoraux





• Méthodologie qui repose sur l'analyse photogrammétrique du recul des falaises et la mesure haute fréquence du débit et de la charge solide en suspension dans l'eau...

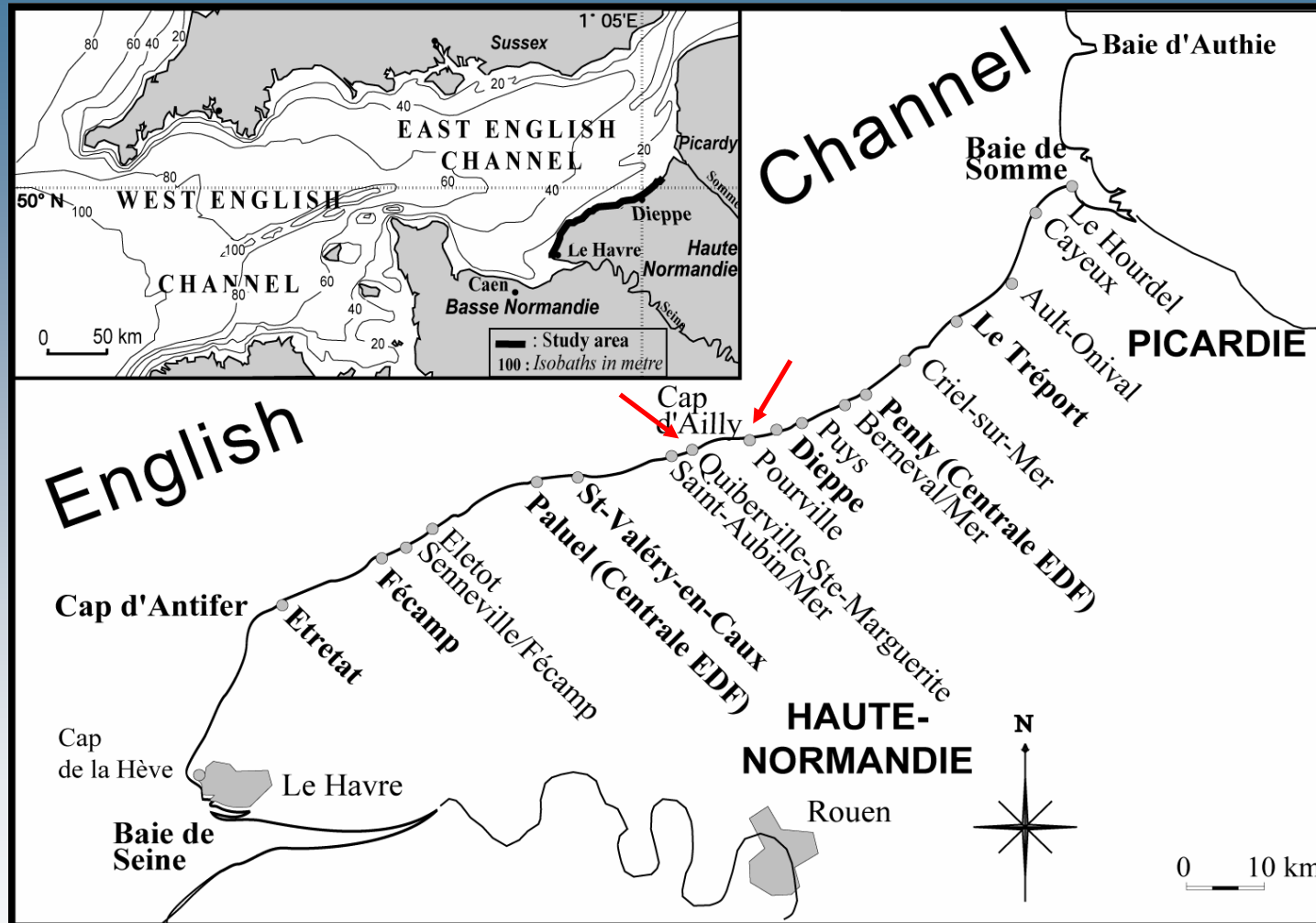
... complétée par une caractérisation granulométrique des sources

- Les résultats ont montré que l'apport annuel des rivières littorales est nettement plus faible que celui des falaises:
 - 43 000 t/an pour les rivières
 - 2 millions t/an (1 million de m³/an) pour les falaises

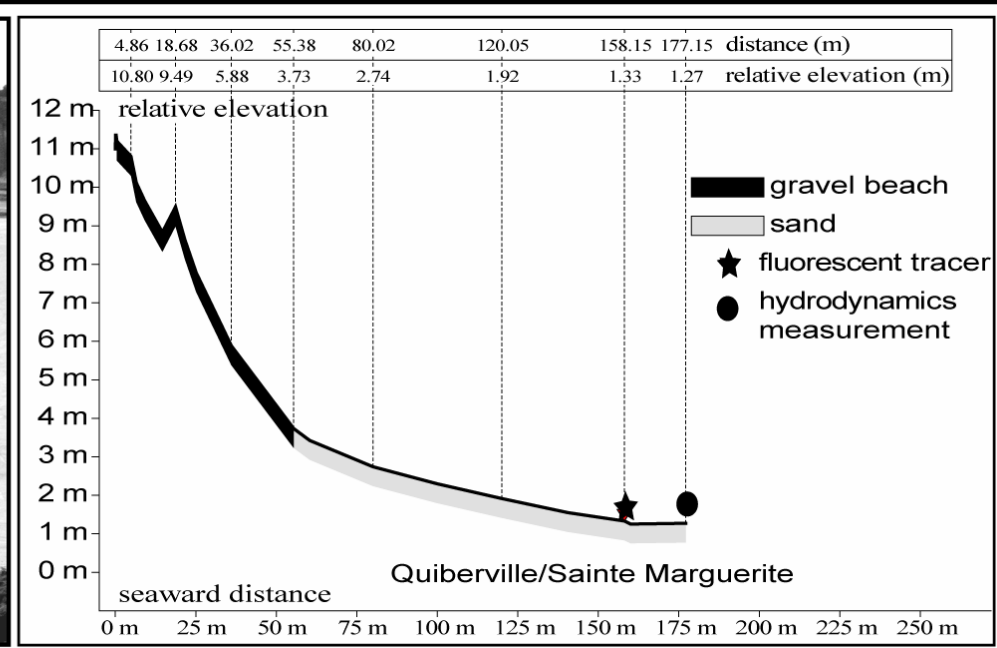
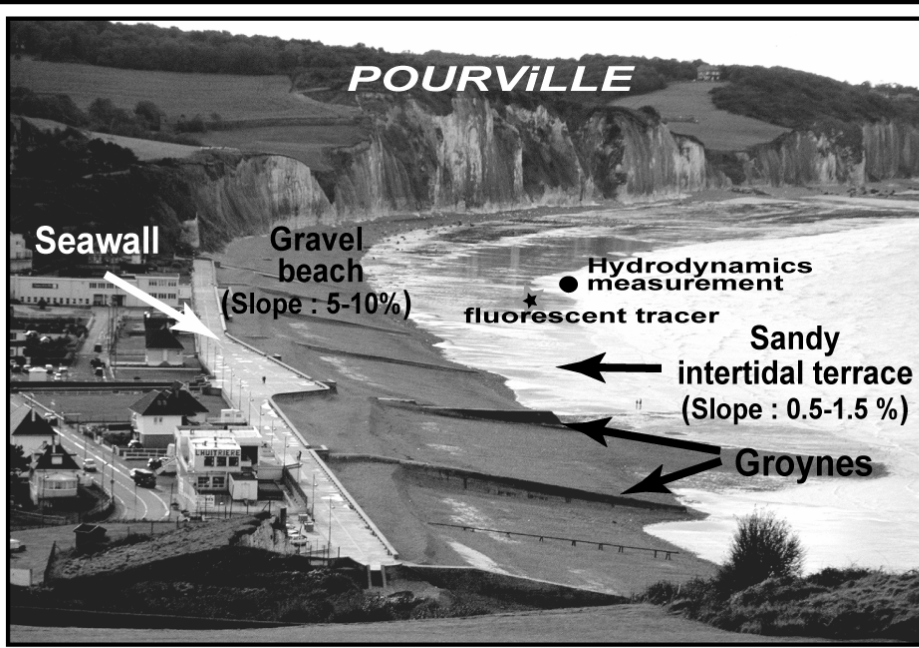
- A l'échelle d'un événement, l'apport par les rivières est également plus faible que celui des falaises:
 - 4 à 6 t/jour pour une crue fluviale
 - 100 à 1000 m³, soit 200 à 2 000 t, pour les éboulements les plus fréquents au niveau des falaises

***Impact of sand content and cross-shore transport on
the morphodynamics of macrotidal gravel beaches
(Haute-Normandie, English Channel)***

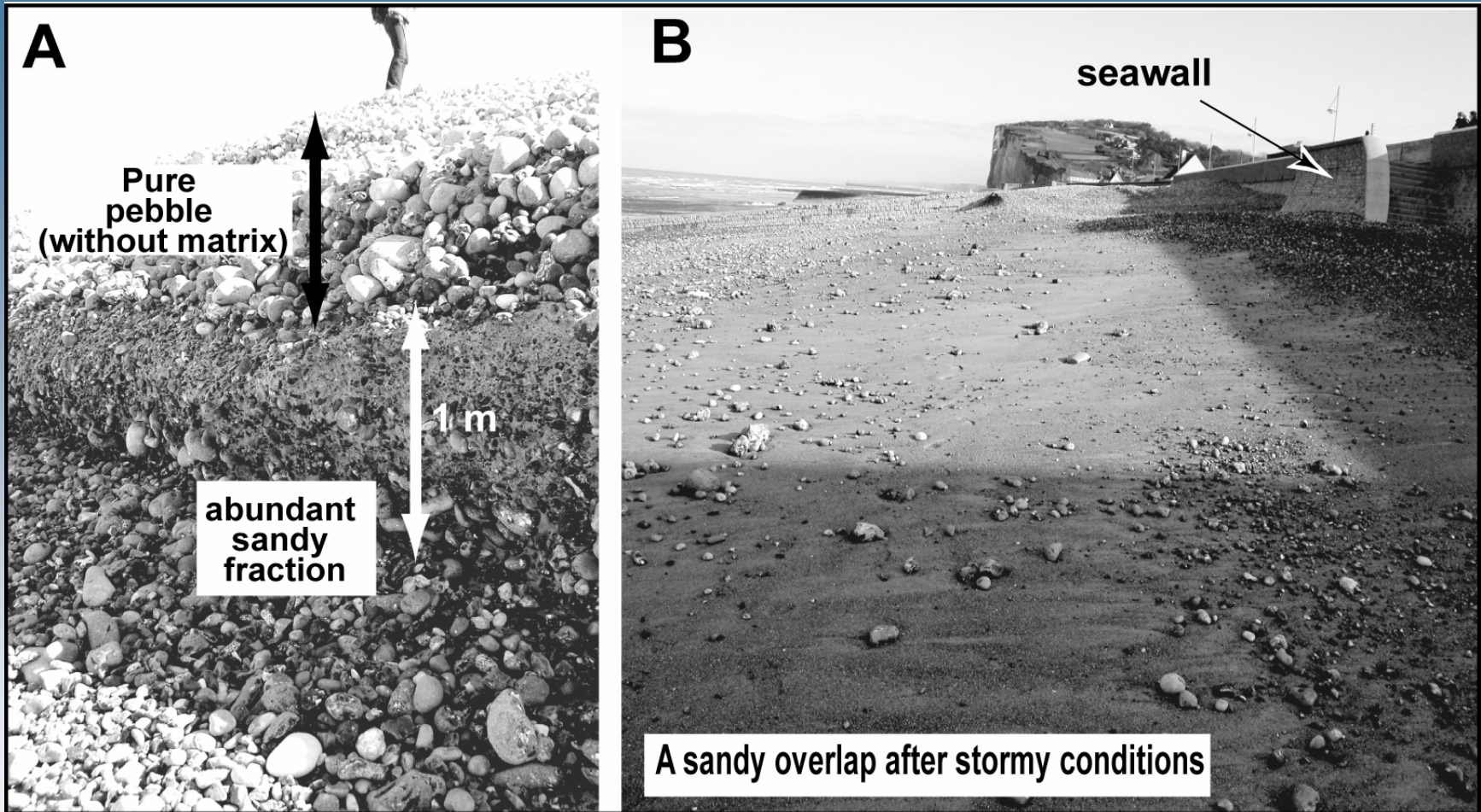
Costa, S., Levoy, F., Monfort, O., Curoy, J., De Saint Léger, E.
& Delahaye, D.



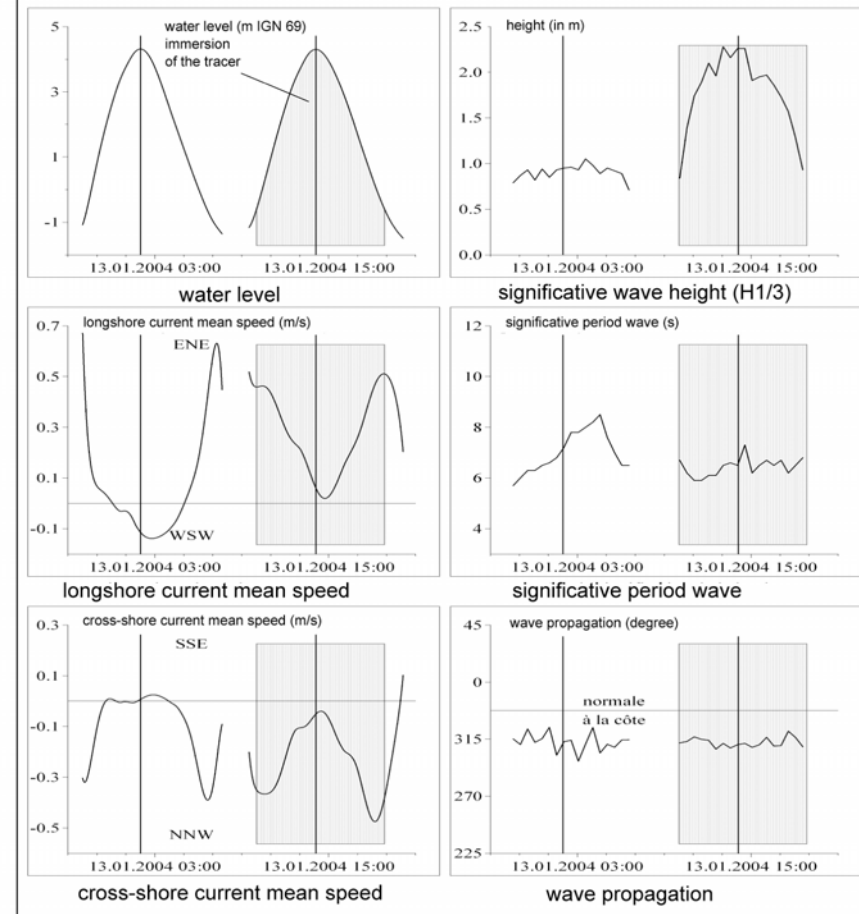
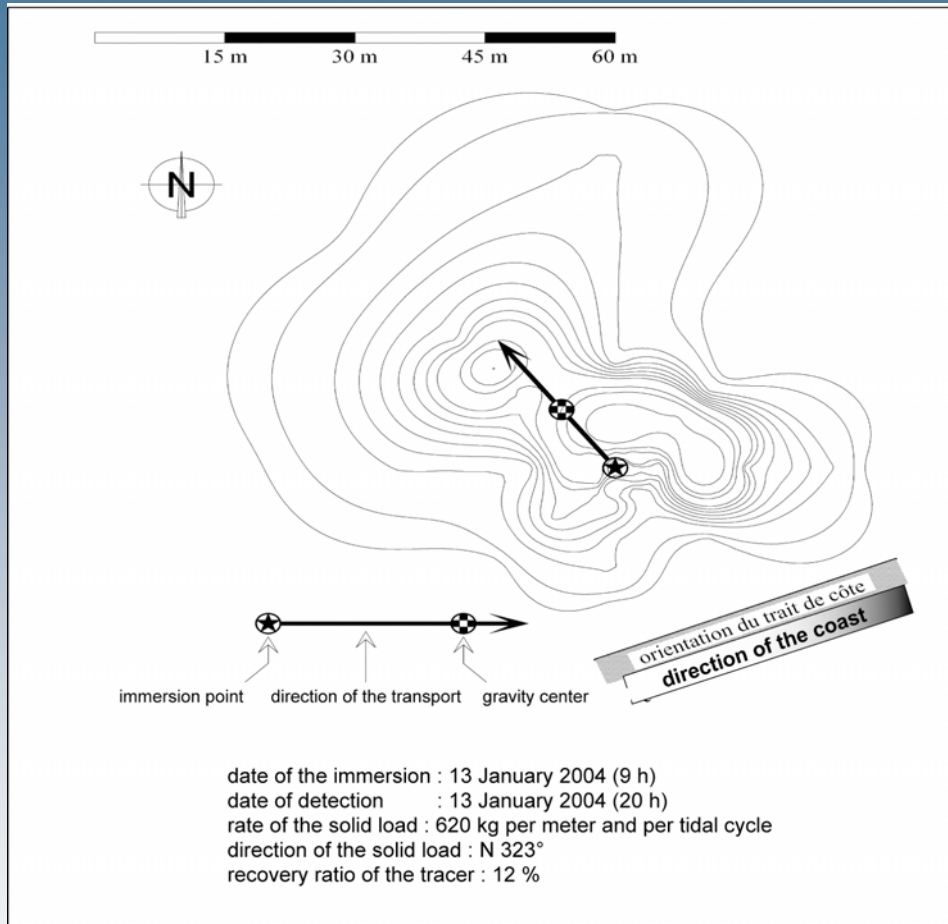
- Etude menée sur les plages de sédiments grossiers de Quiberville et de Pourville (Haute-Normandie)



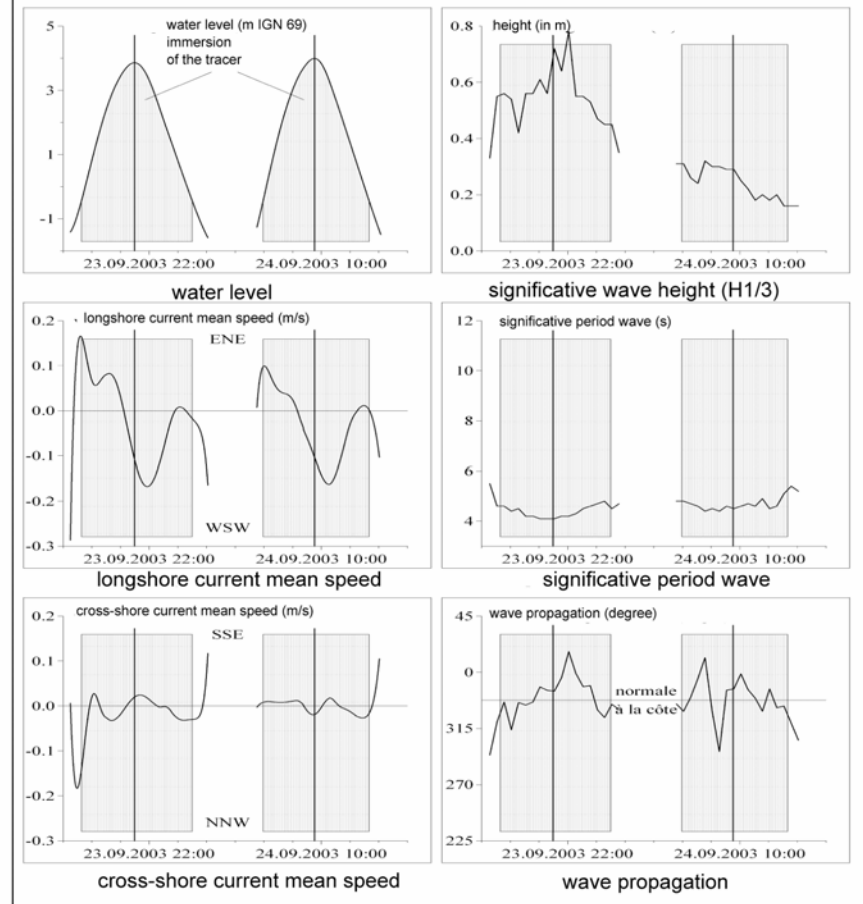
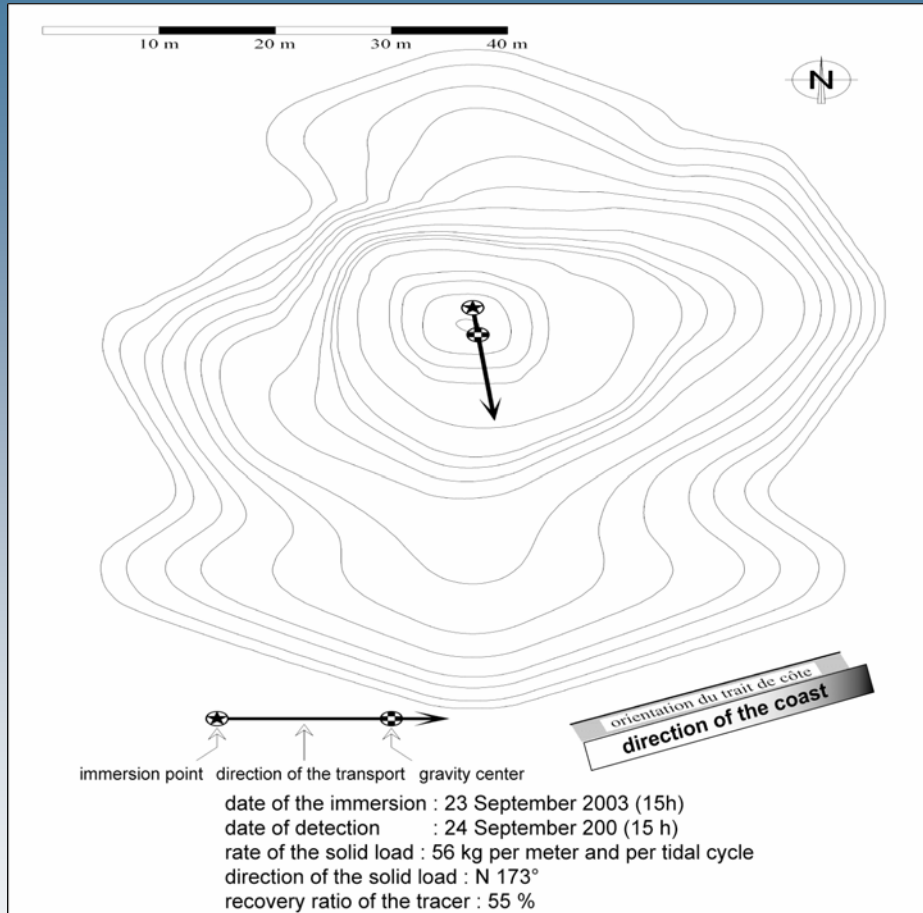
Caractérisées par une accumulation de sédiments grossiers de haut estran à forte pente, un estran sableux à pente douce, un environnement macrotidal, et perrés qui bloquent tout mouvement vers l'intérieur des terres



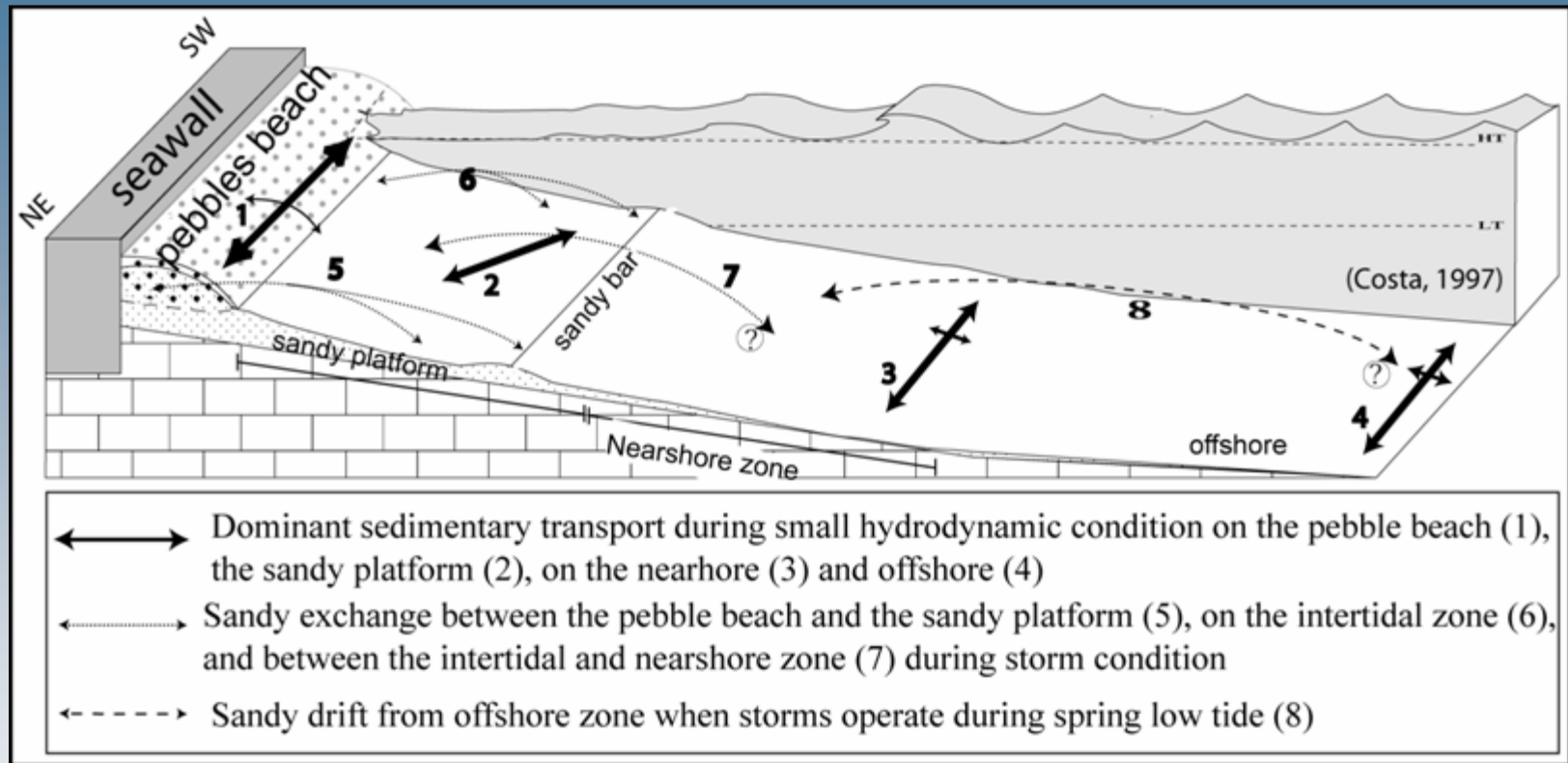
Structure interne constituée en grande partie par une fraction sableuse interstitielle. Contrairement aux sables de bas estran, ceux de la structure interne des cordons sont mal classés, hétérogènes, et surtout, contiennent 20 % d'éclats siliceux provenant de l'attrition des galets



A l'issue de périodes de forte agitation, des éclats de silex sont retrouvés sur le bas estran. Ces transferts de sédiments transversaux depuis le cordon vers la basse plage ont également été confirmés par des mesures hydrodynamiques et un suivi de traceurs fluorescents.



Lors de conditions de houles modérées, ces mesures ont montré des déplacements dans le sens contraire, soit de la basse plage vers le cordon de galets.



- Ces transferts sableux font partie du système d'adaptation des plages de galets aux conditions hydrodynamiques: déterminent le potentiel d'infiltration du cordon, voire l'aspect réflectif et dissipatif de l'ensemble de la plage.
- Ces résultats suggèrent que la compréhension du fonctionnement morpho-sédimentaire des accumulations de galets composites nécessite d'intégrer les flux de sédiments sableux de la basse plage, voire de la zone infratidale.

Patterns of surface sediment grain size distribution under the influence of varying wave conditions on a mixed sediment beach at Pevensey Bay, southeast England

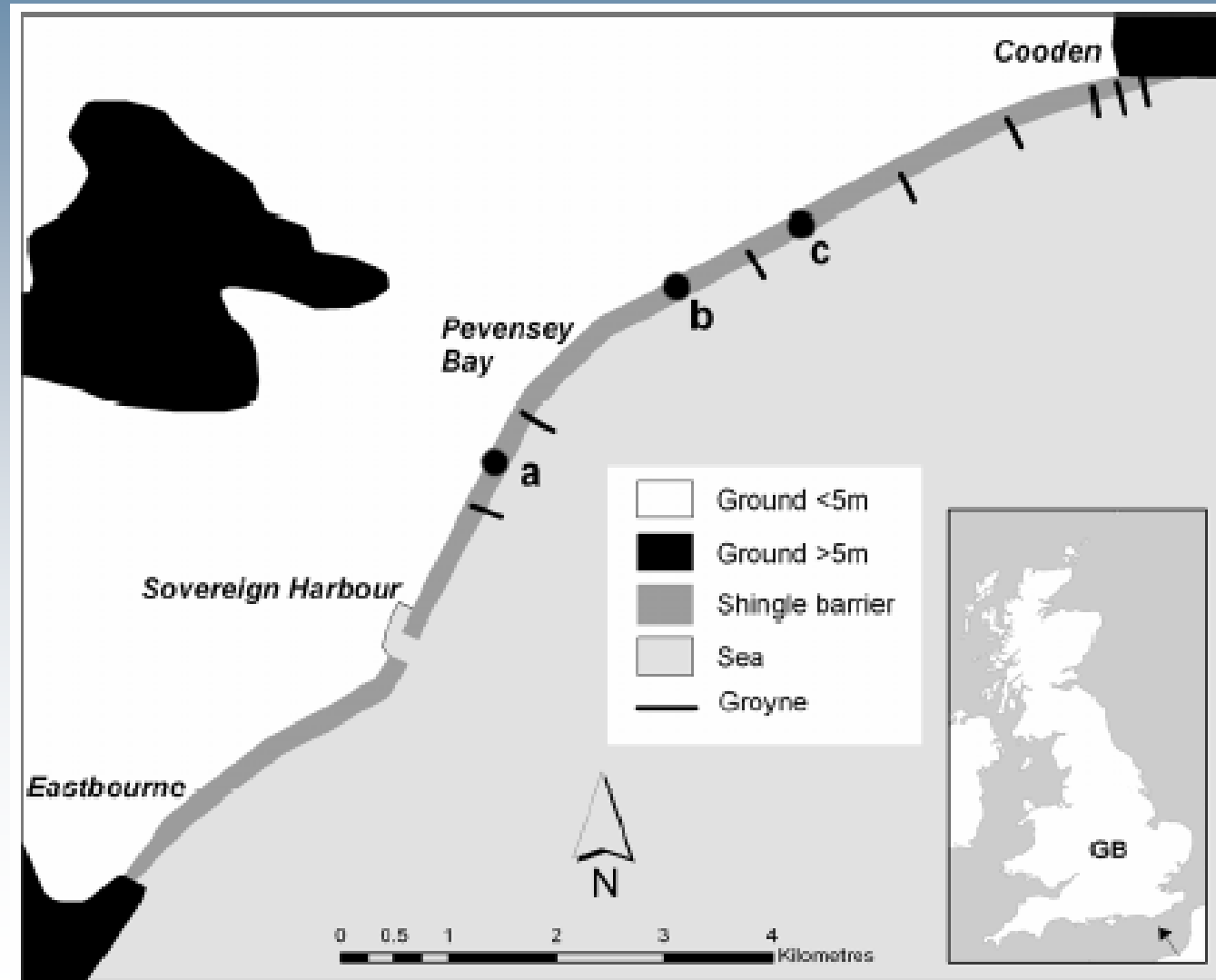
Watt, T. Robinson, D.A., Moses, C.A. & Dornbusch, U.

Watt, T. Robinson, D.A., Moses, C.A. & Dornbusch, U. "Patterns of surface sediment grain size distribution under the influence of varying wave conditions on a mixed sediment beach at Pevensy Bay, southeast England"

Pevensy Bay mixed sediment beach:

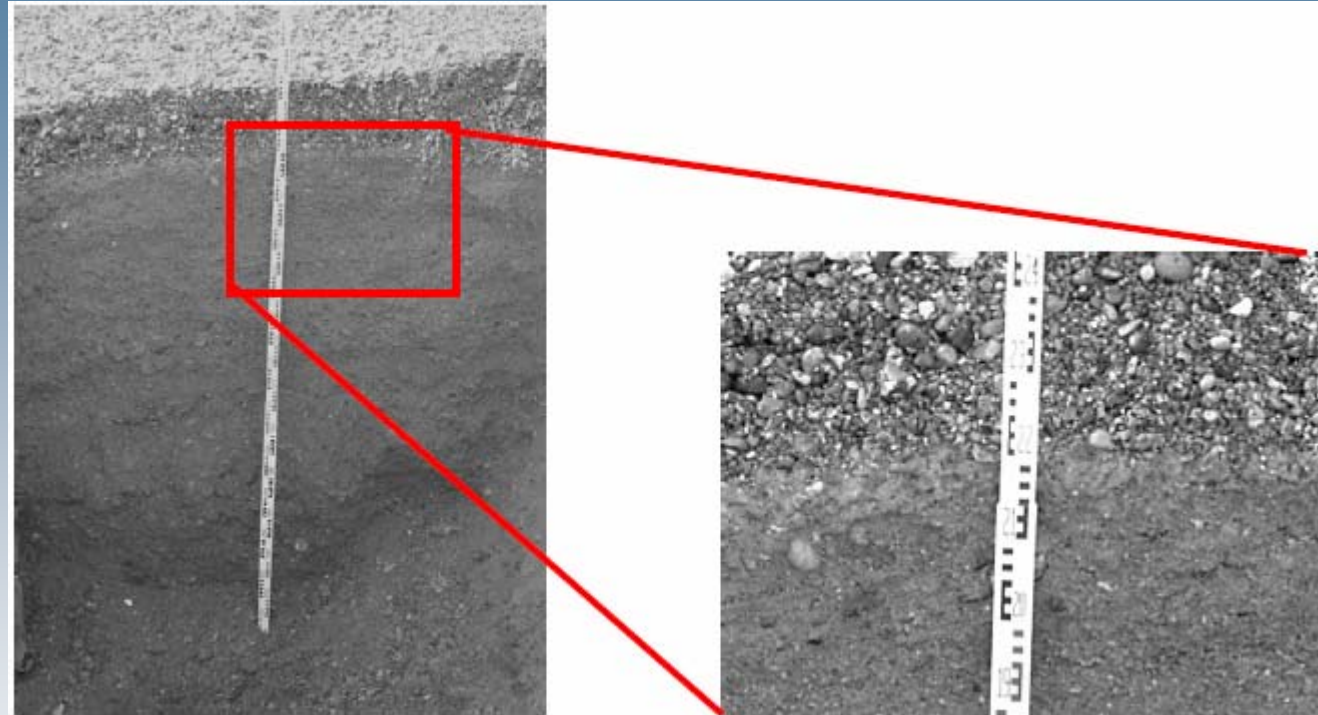
remaining groynes and location of the three sites studied under different management regimes.

- a. unmanaged
- b. renourished
- c. Recycled & reprofiled.



Watt, T. Robinson, D.A., Moses, C.A. & Dornbusch, U. "Patterns of surface sediment grain size distribution under the influence of varying wave conditions on a mixed sediment beach at Pevensy Bay, southeast England"

Coarse surface sediment overlying sand rich core (scale bar 10 cm & 1 cm intervals)

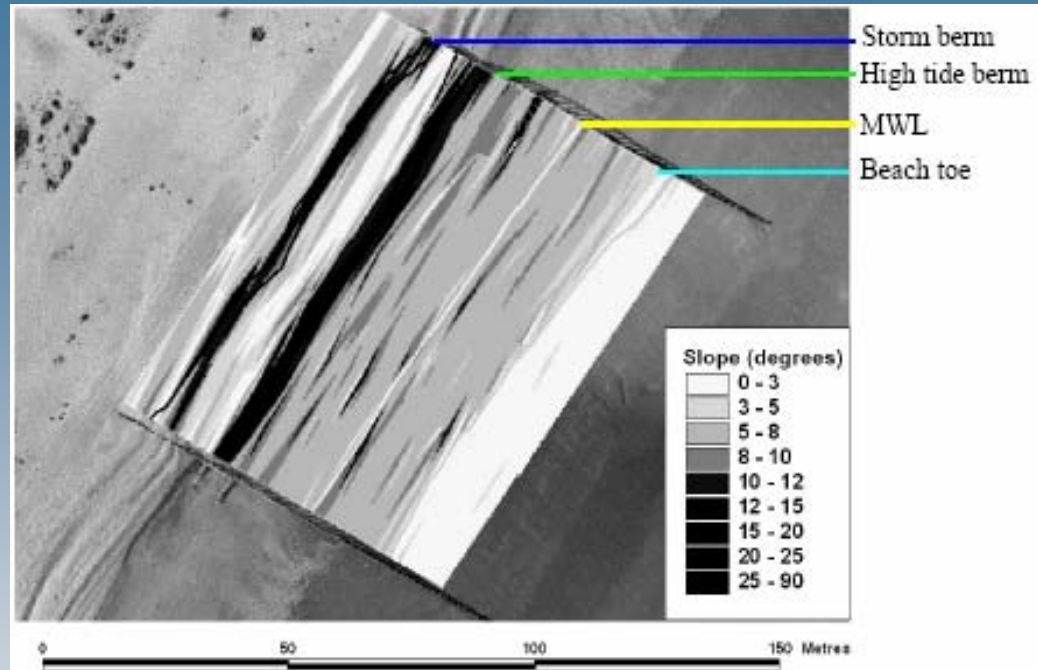


Standard grain size classes of beach surface sediments used in the mapping surveys (grid spacing 5 cm)

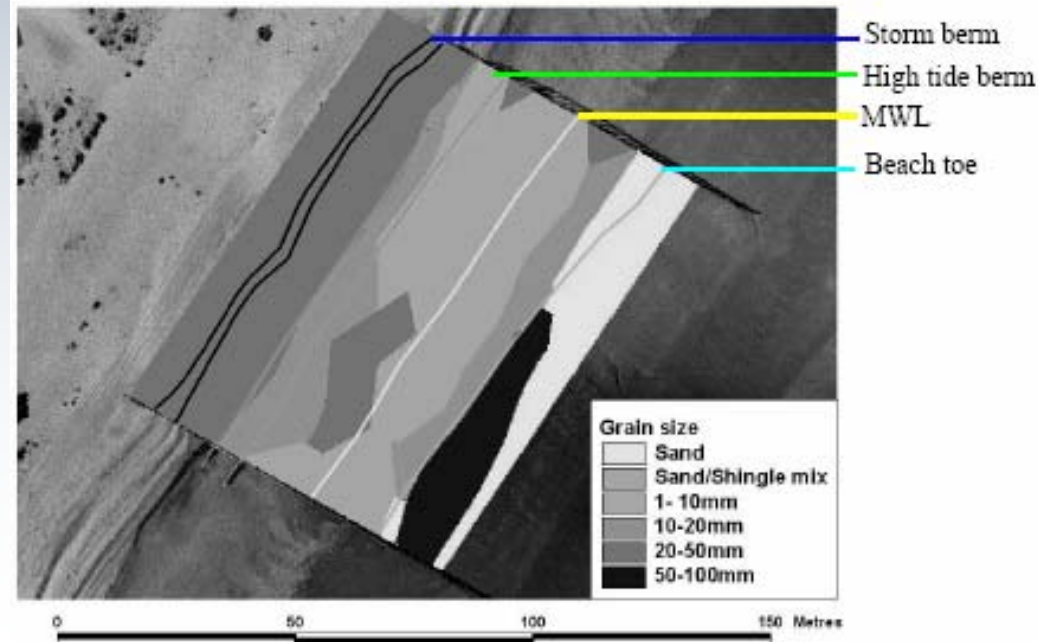


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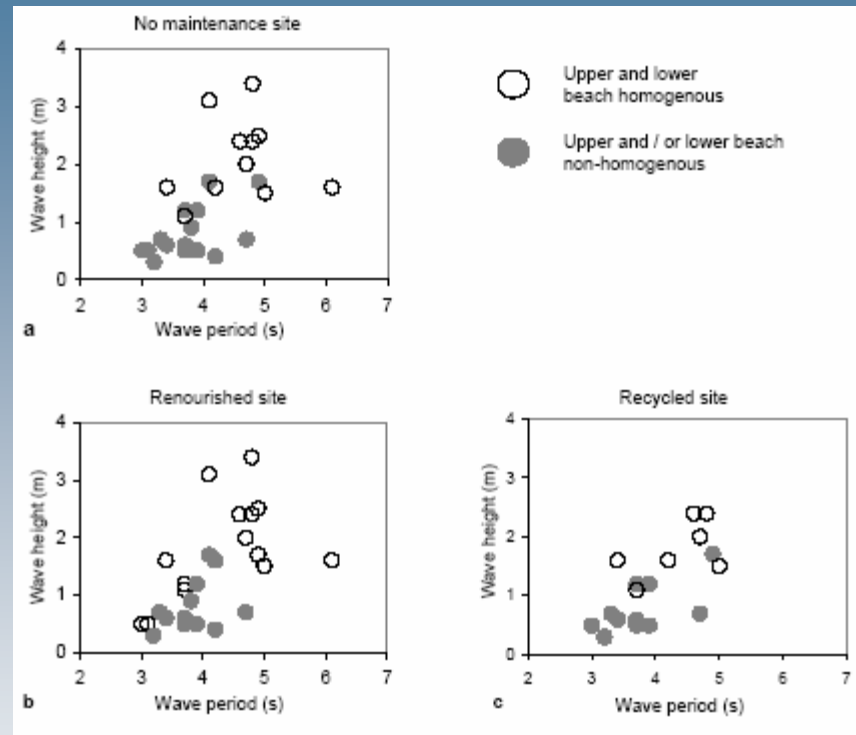
Beach surface slope map



Beach surface sediment map



Watt, T. Robinson, D.A., Moses, C.A. & Dornbusch, U. "Patterns of surface sediment grain size distribution under the influence of varying wave conditions on a mixed sediment beach at Pevensy Bay, southeast England"



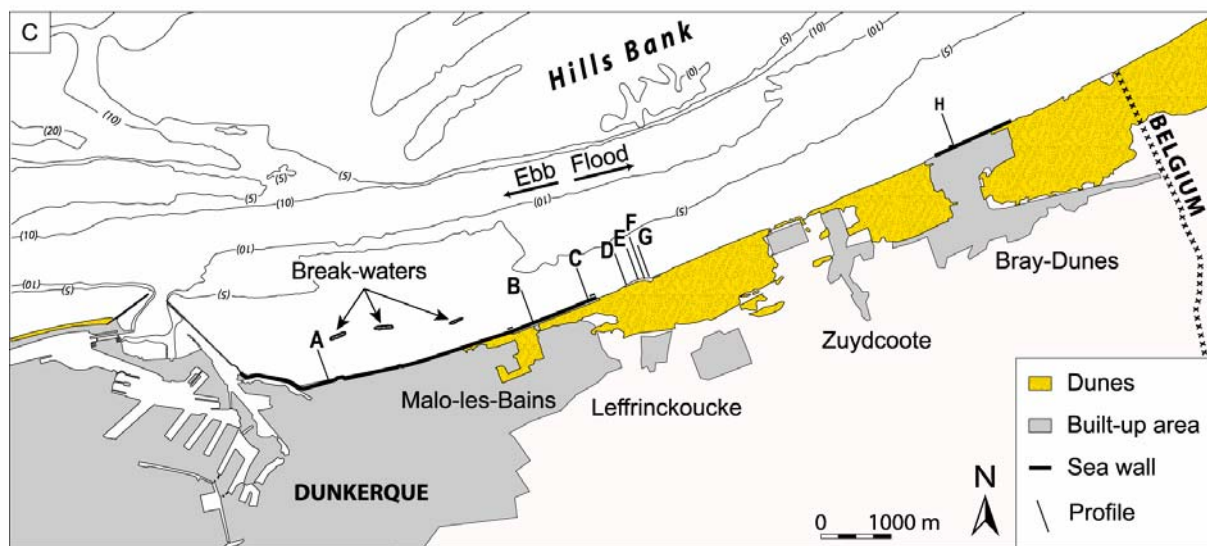
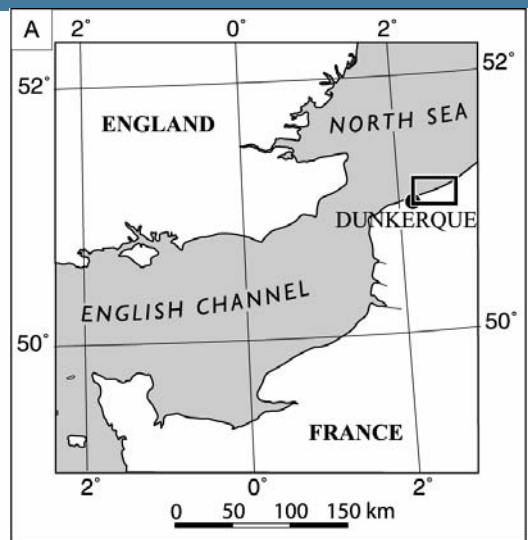
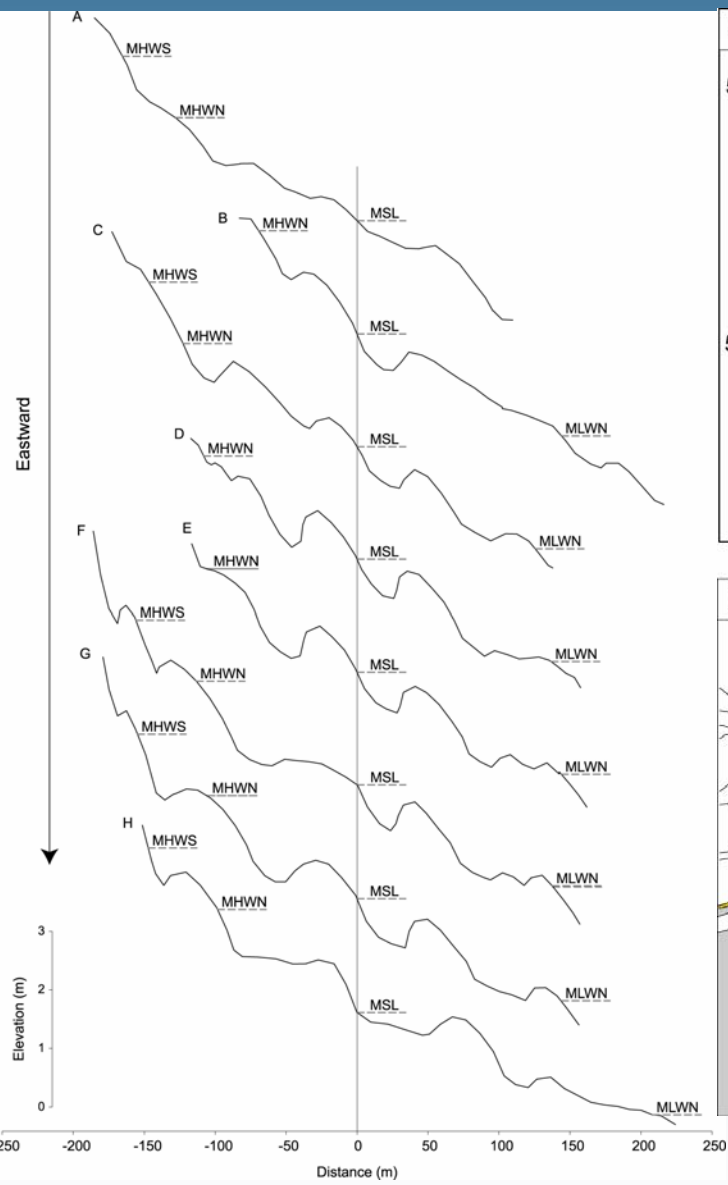
Storm conditions: pattern of surface sediment response most clear on least managed stretches of the beach and least discernable in the renourished section.

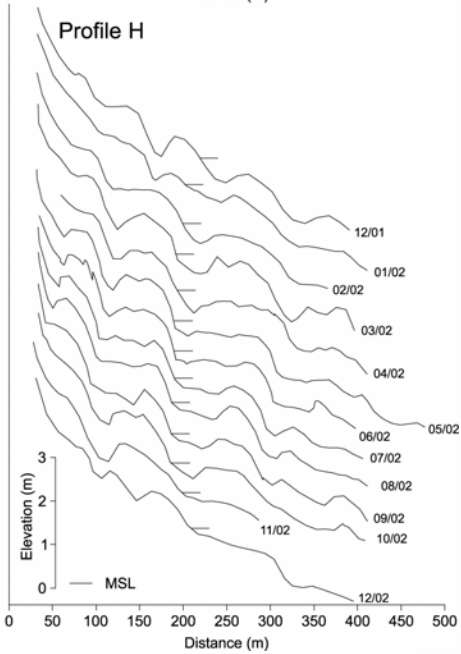
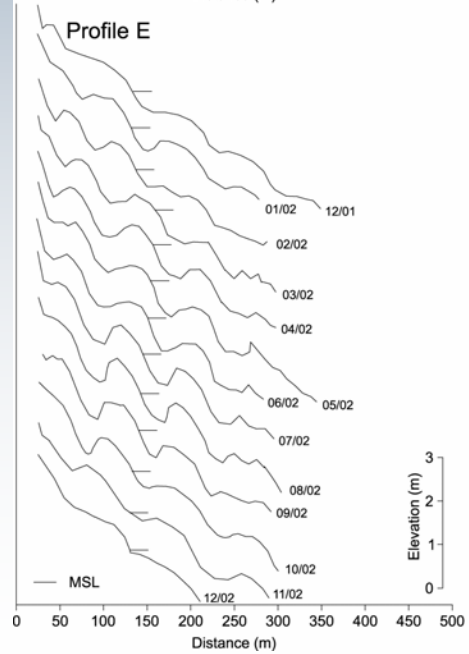
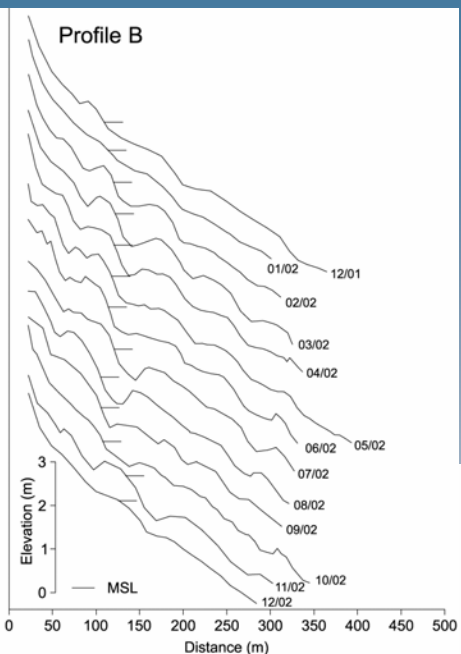
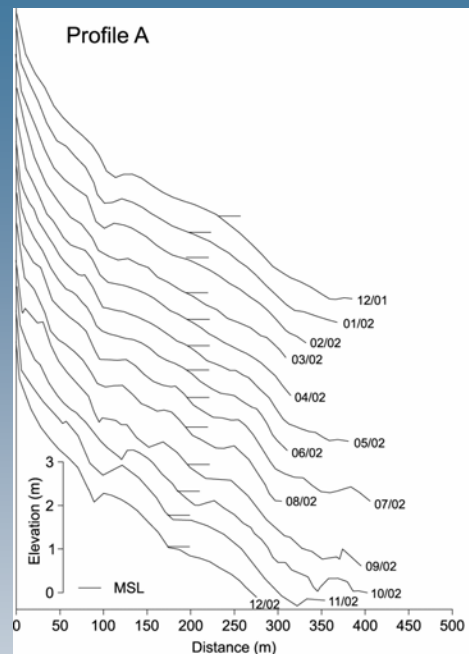
Higher energy waves produced a beach surface with a relatively homogenous grain size distribution.

Lower energy waves produce surfaces with a more mixed size distribution.

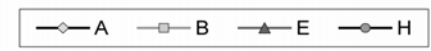
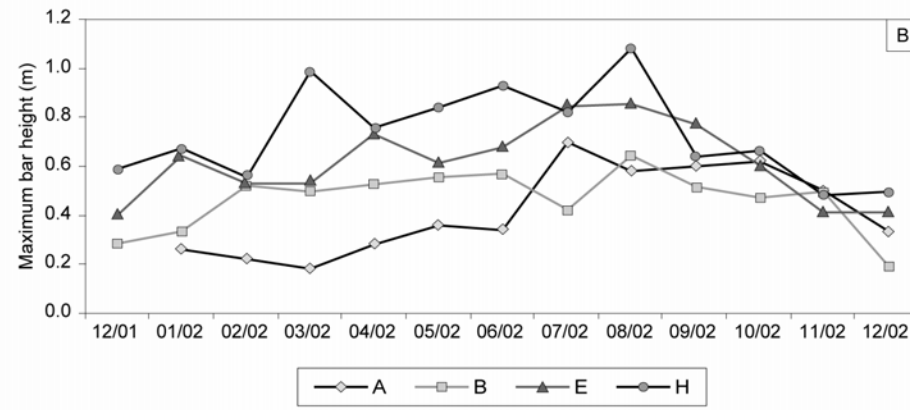
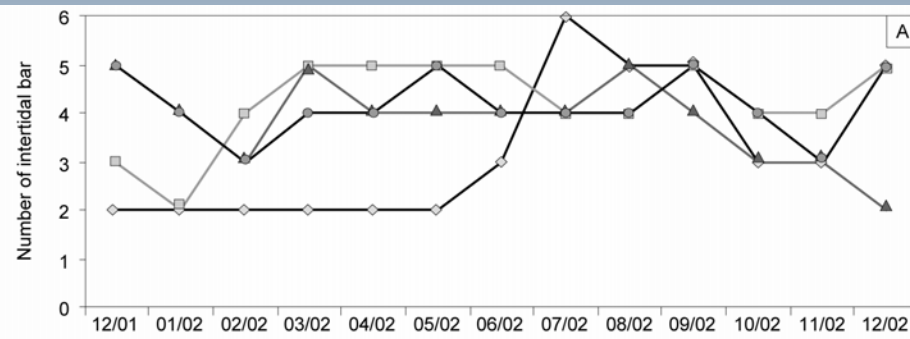
Seasonal-scale morphological and dynamic characteristics of multiple intertidal bars

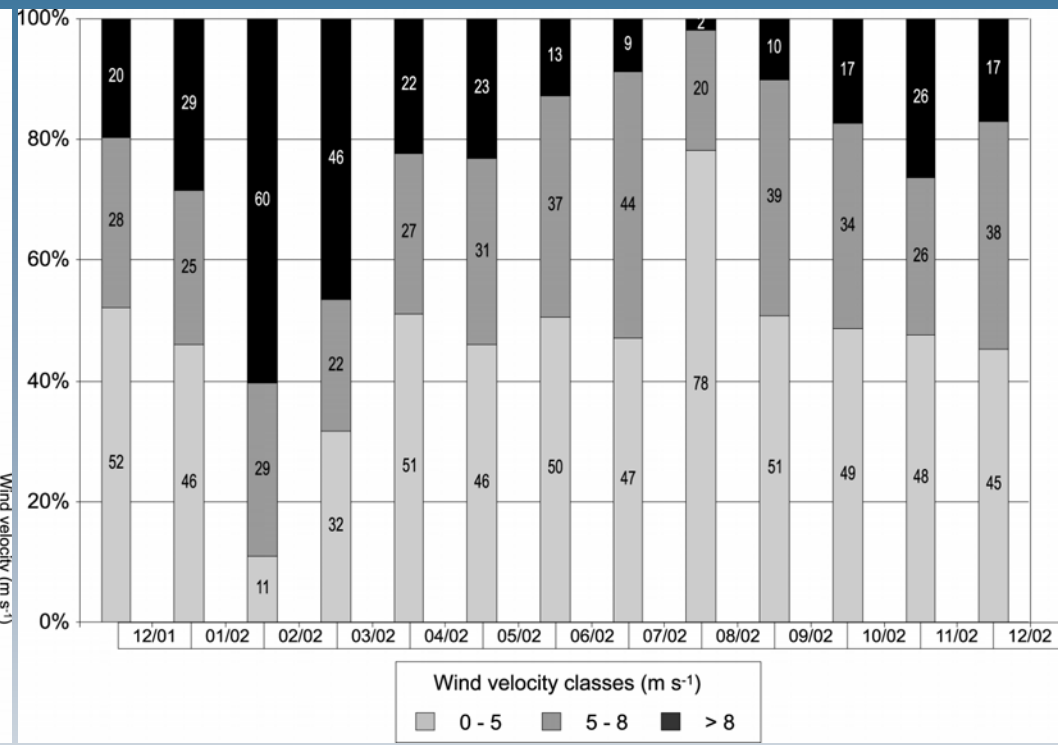
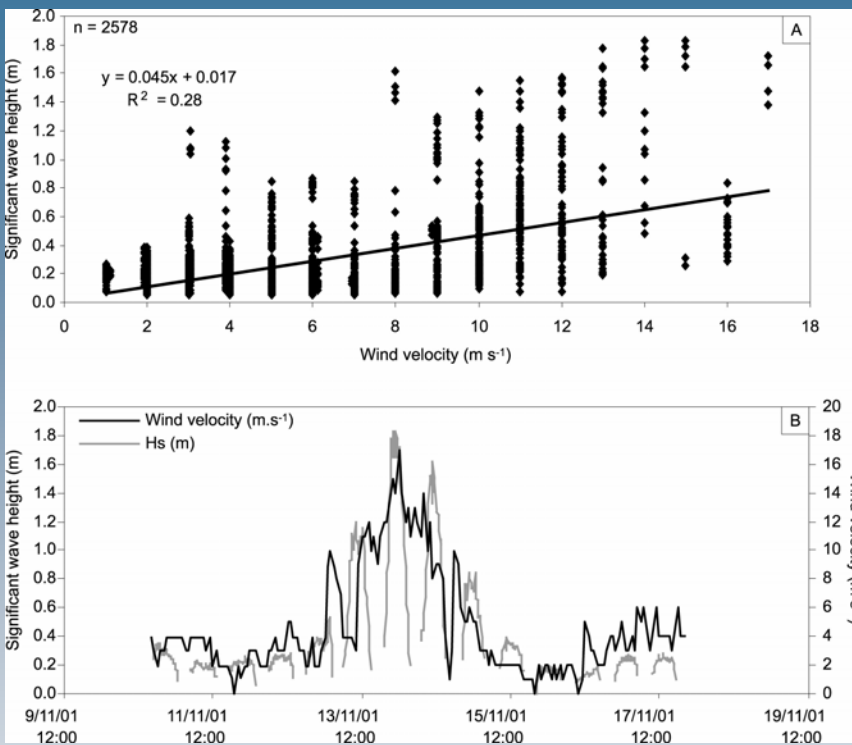
Reichmüth, B. & Anthony, E.J.





- Suivis topographiques réguliers pendant 13 mois, ce qui a permis de caractériser la morphologie et l'évolution des barres intertidales

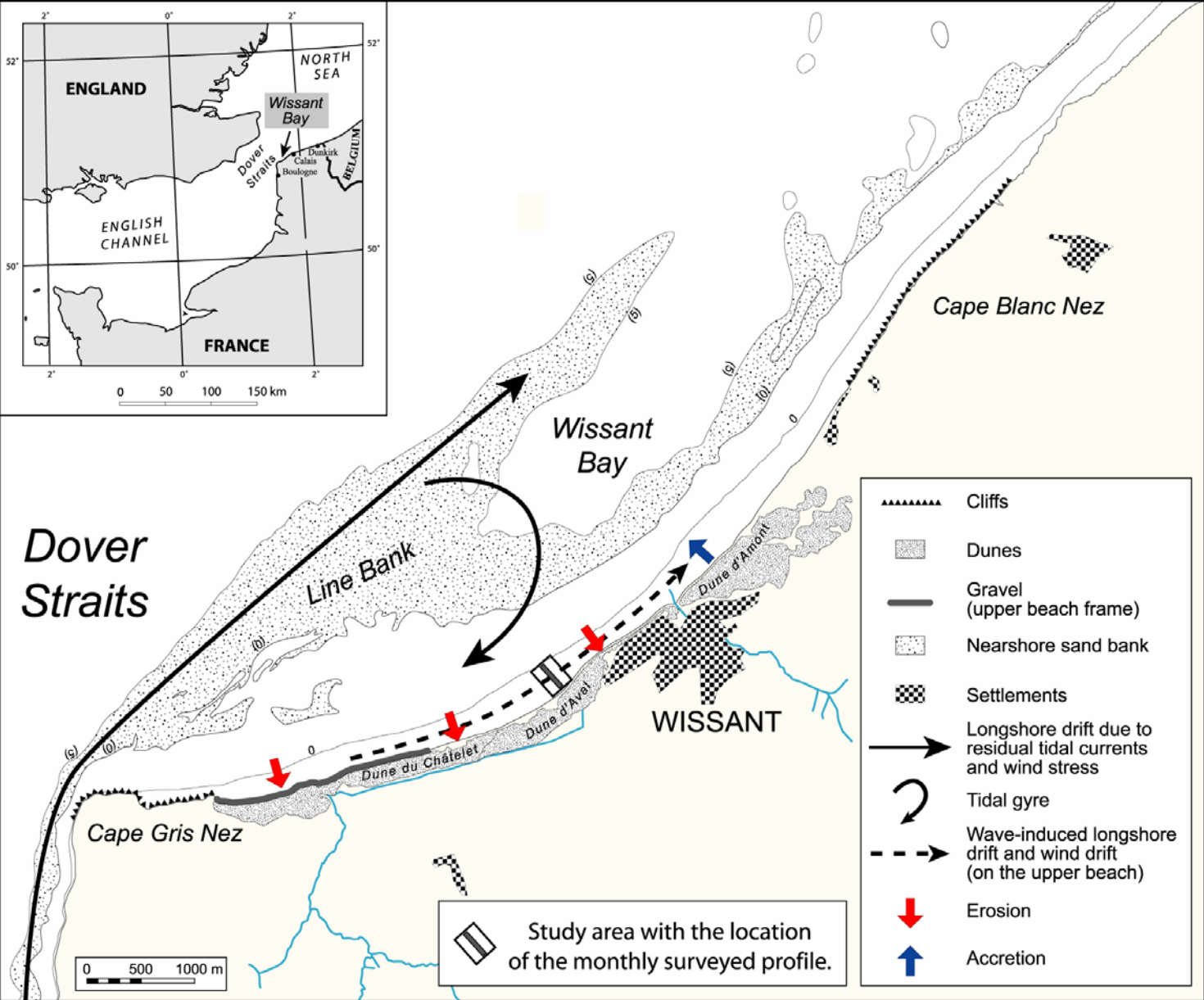


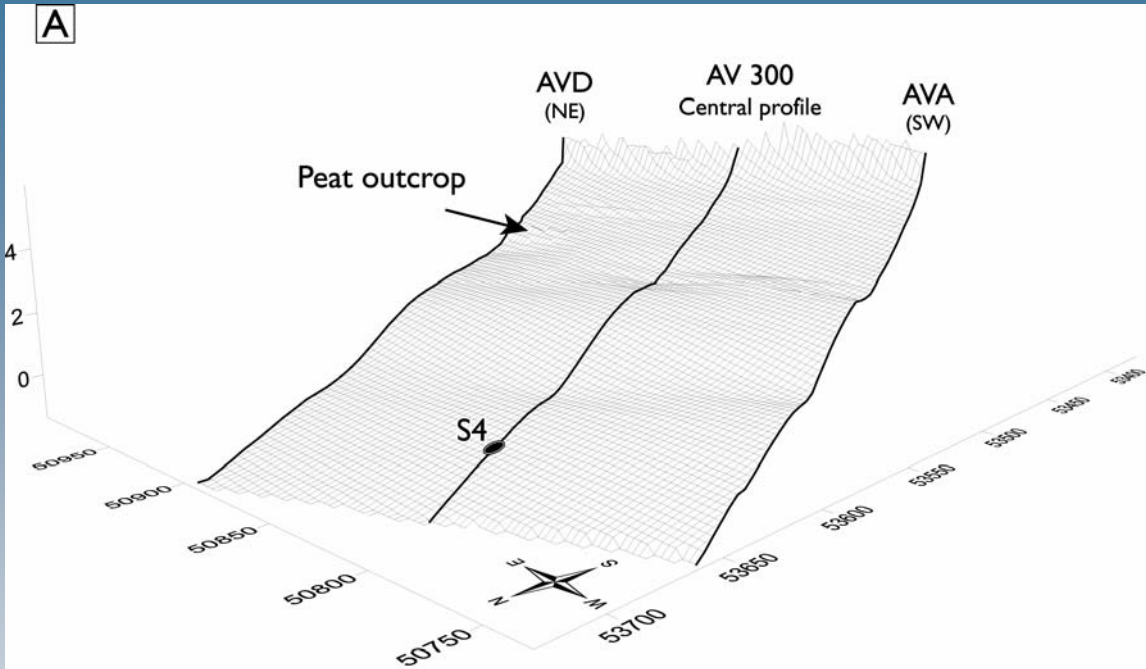


- Analyse des types de temps et des vagues à la côte a montré que ces barres sableuses ont tendance à se développer lors de conditions d'énergie modérée.
- Les variations morphologiques des profils sont dues en grande partie à des différences dans les conditions locales de vagues qui elles mêmes dépendent de la présence de bancs sableux à l'avant-côte ou de brise-lames.
- Les barres sont relativement stables dans l'ensemble, ce qui s'explique par un temps de réaction important de ces formes dans un environnement macrotidal et à énergie des vagues modérée.

Sediment dynamics and morphological change on the upper beach of a multi-barred macrotidal foreshore, and implications for mesoscale shoreline retreat: Wissant Bay, northern France

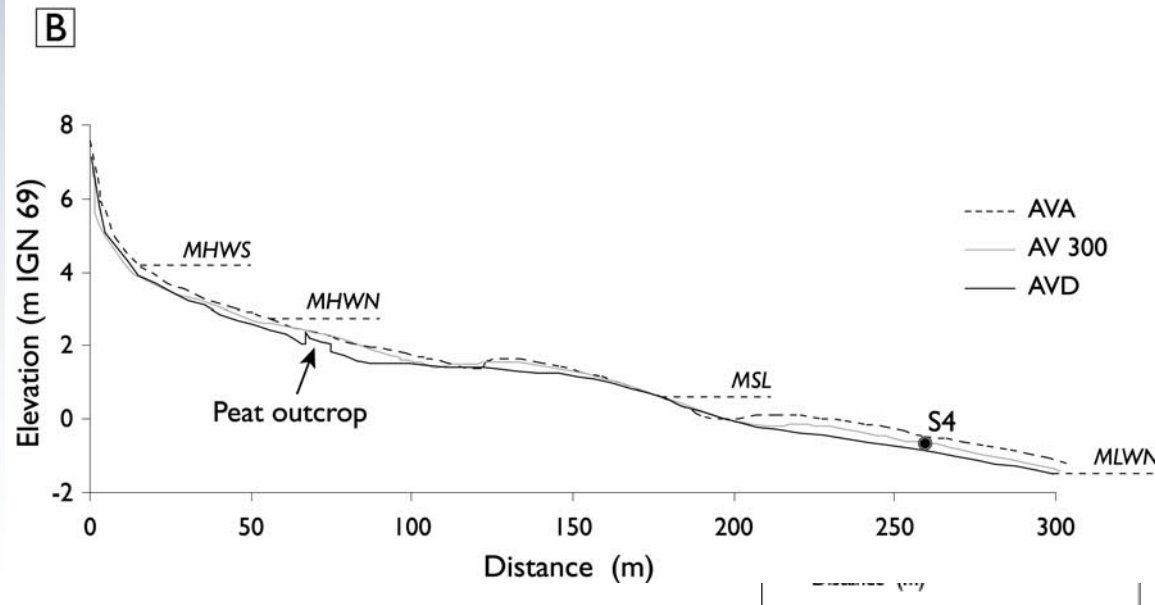
Sedrati, M. & Anthony, E.J.

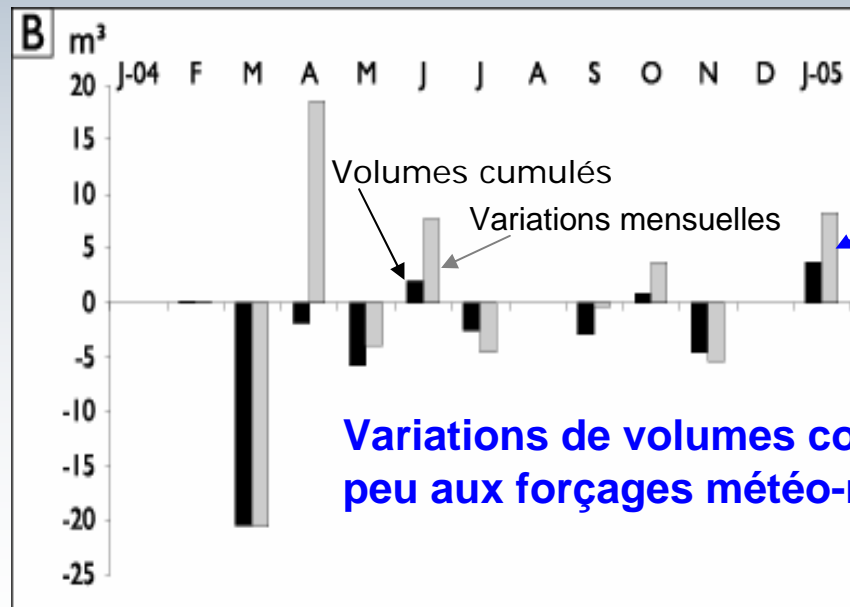
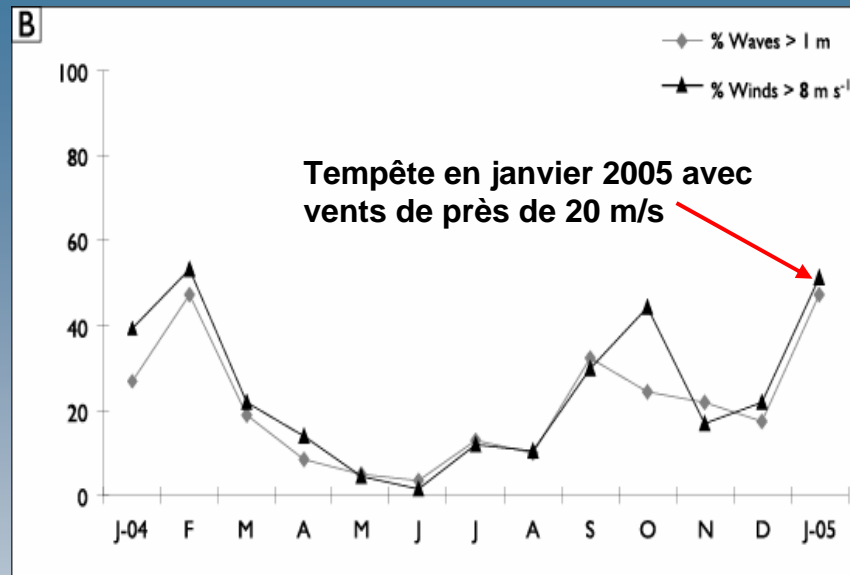
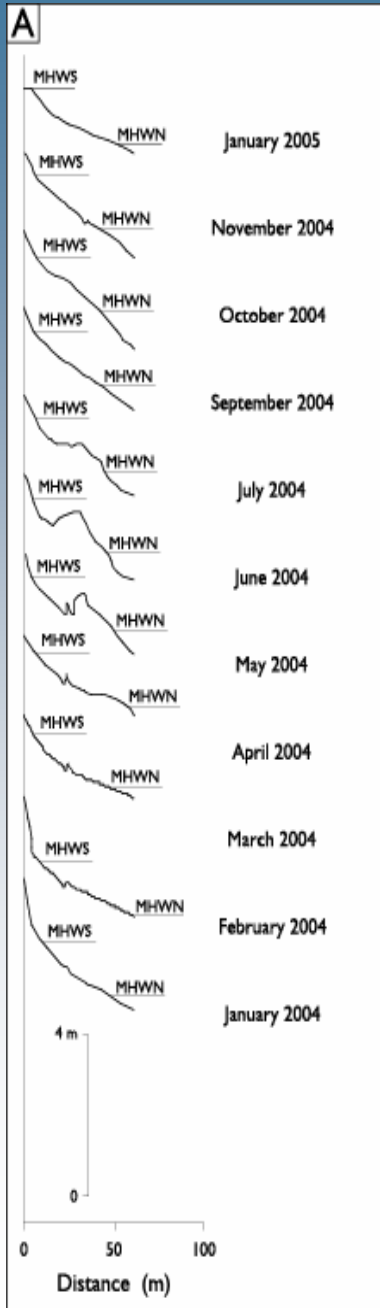




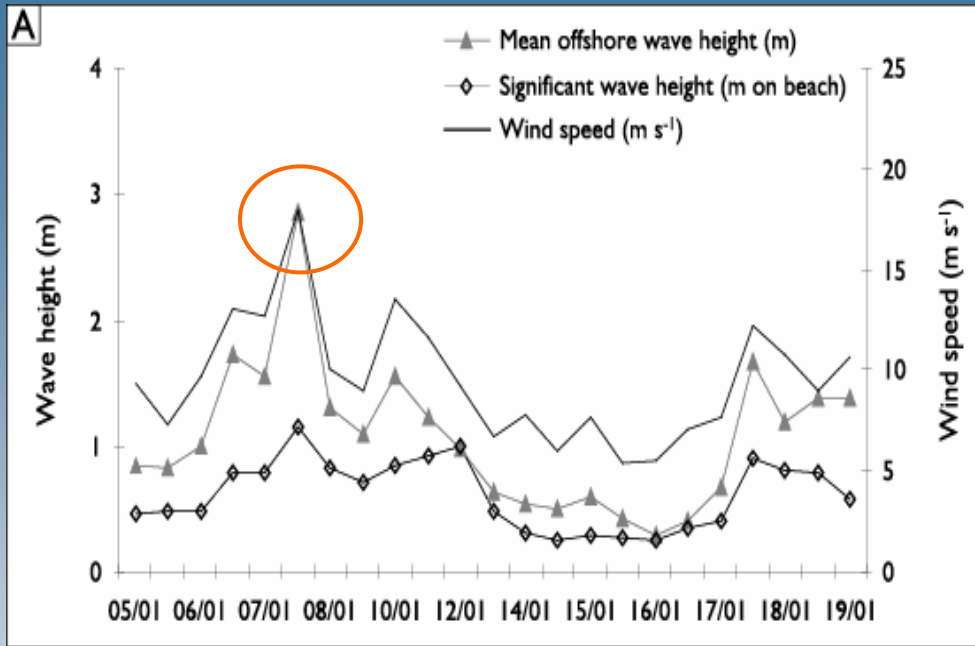
Levés topographiques mensuels pendant 1 an: Janvier 2004 à janvier 2005

Campagne courantométrique de 2 semaines en janvier 2005 avec suivi quotidien de profils

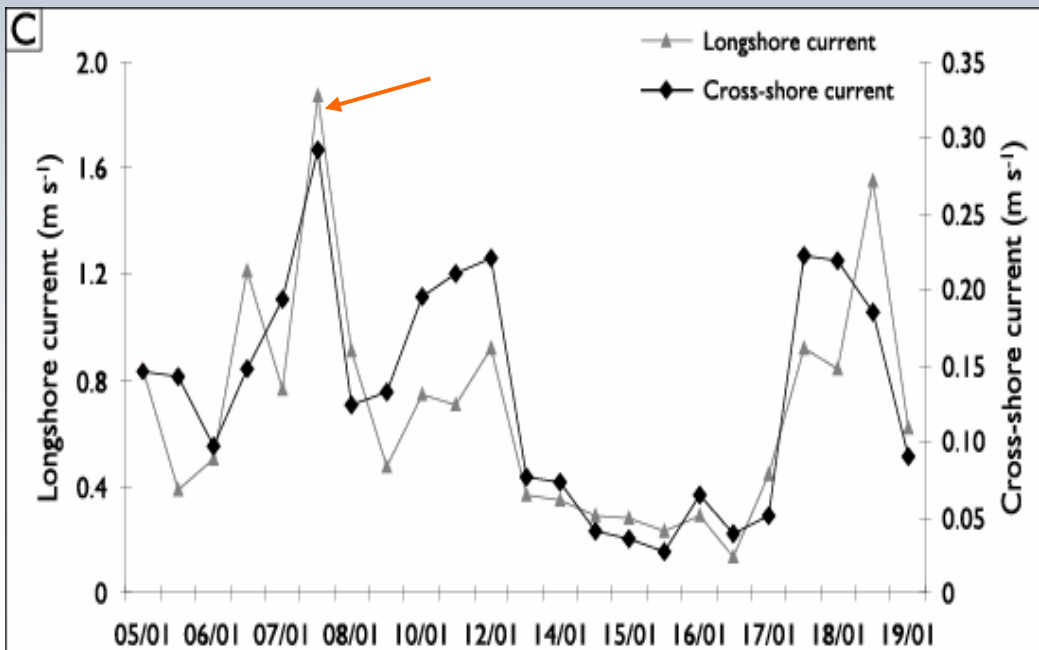




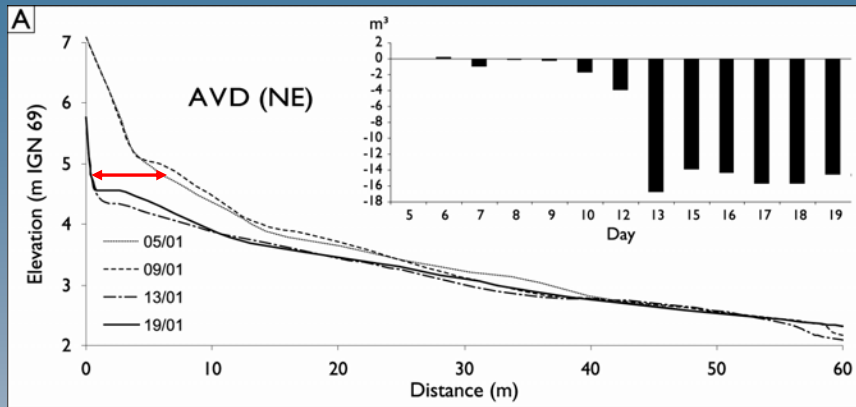
Variations de volumes sur le haut de plage



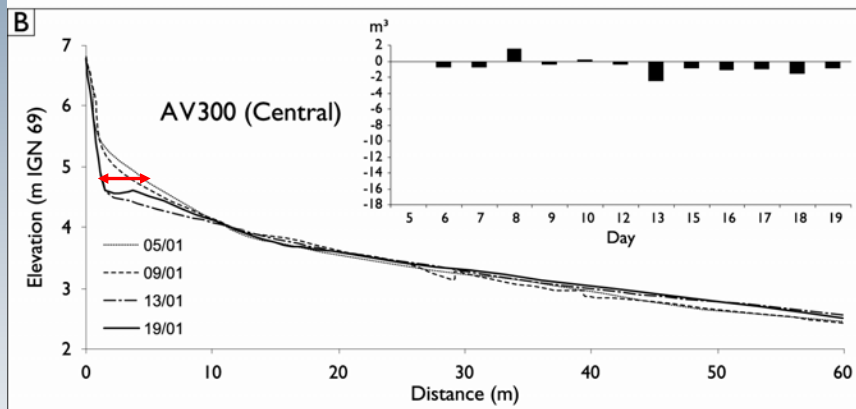
Tempête de janvier 2005



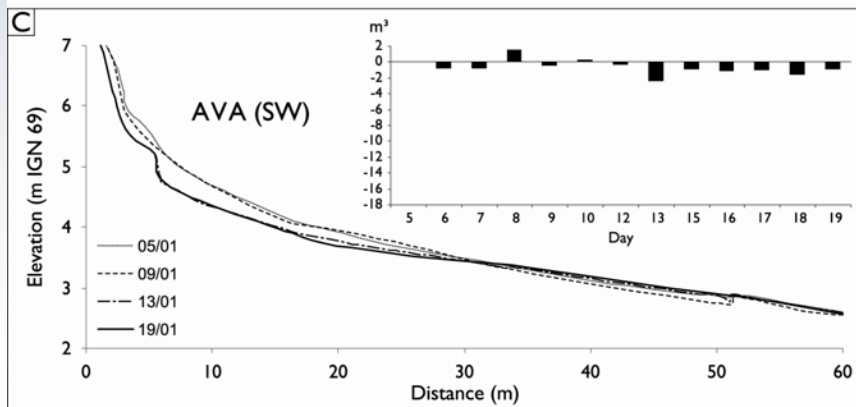
Augmentation des vitesses de courants, particulièrement courants longitudinaux = fort transport sédimentaire vers le nord-est



- Recul de plusieurs mètres du front dunaire en une seule tempête avec abaissement du haut de plage et perte de volume au niveau du profil AVD



- Faibles variations de volume du haut de plage sur autres profils, malgré un recul sensible du front dunaire



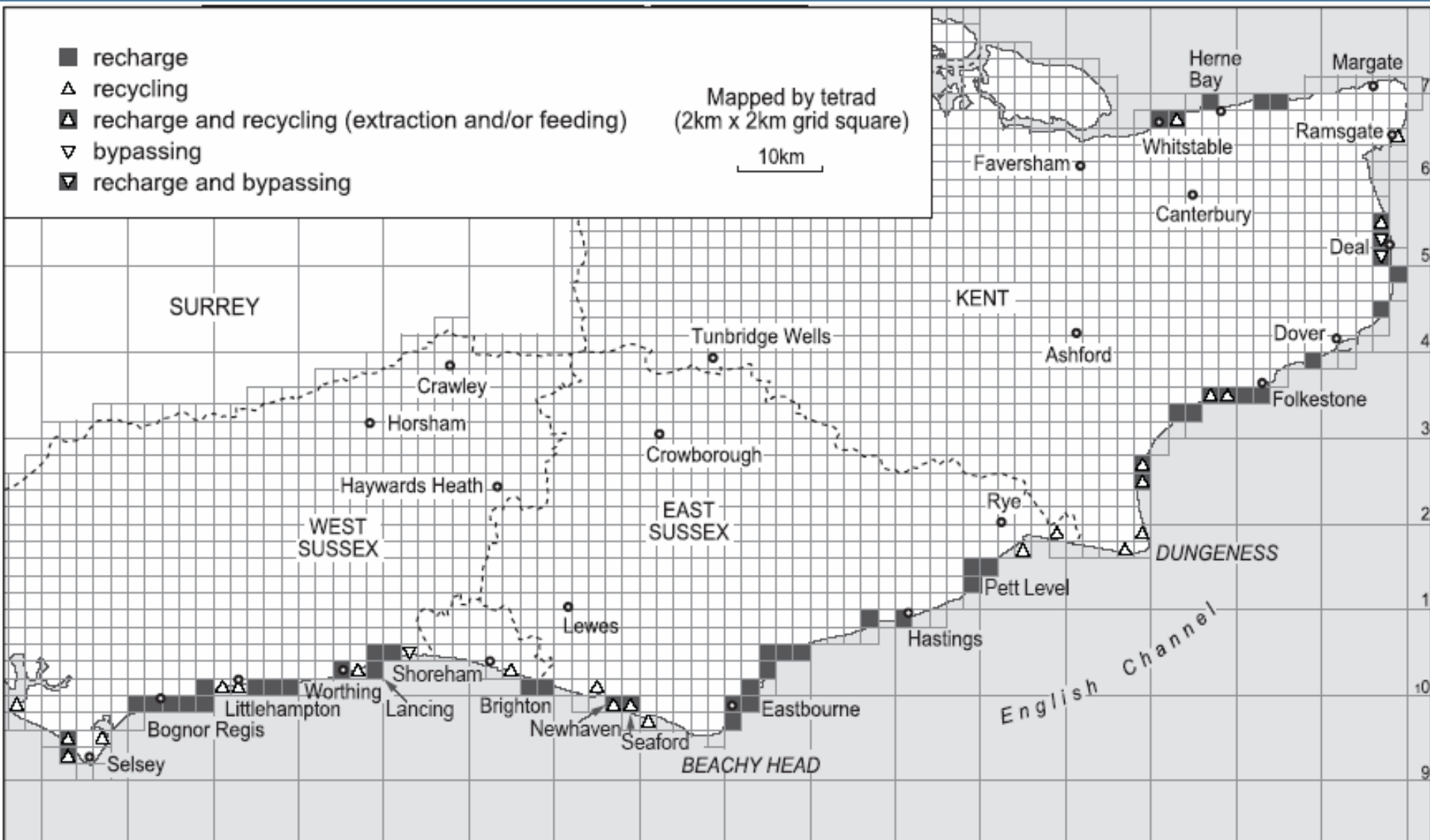
- S'explique par la migration longitudinale de mégarides sur le haut de plage sous l'effet des courants longshore

- Stockage temporaire sur le haut de plage de sables venant de l'érosion de la dune, ensuite évacués par courants longitudinaux

Artificial beach recharge: the South East England experience

Moses, C.A. & Williams, R.B.G.





Distribution of beach volume maintenance schemes in Sussex and east Kent

Summary of beach volume maintenance schemes in Sussex and east Kent.

Time Period	Nourishment volume (million cubic metres)				Nourishment cost (million £)				Volume recycled (million cubic metres)			
	West Sussex	East Sussex	Kent	Total	West Sussex	East Sussex	Kent	Total	West Sussex	East Sussex	Kent	Total
Pre-1950	0	0	N/A	N/A	0	0	N/A	N/A	0	0.07	0.01	0.08
1950-54	0	0	N/A	N/A	0	0	N/A	N/A	0	0.17	0	0.17
1955-59	0	0	N/A	N/A	0	0	N/A	N/A	0	0.17	0.09	0.26
1960-64	0	0	N/A	N/A	0	0	N/A	N/A	0	0.17	0.19	0.36
1965-69	0	0	N/A	N/A	0	0	N/A	N/A	0	0.17	0.29	0.46
1970-74	0	0	0.01	0.01	0	0	N/A	N/A	N/A	0.17	0.33	0.50
1975-79	0.19	0	0.02	0.21	N/A	N/A	0.01	0.01	N/A	0.37	0.32	0.69
1980-84	0.05	0.01	0.02	0.08	N/A	N/A	0.01	0.01	N/A	0.69	0.32	1.01
1985-89	0.03	1.70	0.19	1.8	N/A	9.00	4.50	13.50	N/A	0.67	0.32	0.99
1990-94	0.26	0.05	0.08	0.39	6.00	N/A	5.02	11.02	0.15	0.67	0.32	1.14
1995-99	0.46	0.94	1.41	2.81	6.64	11.98	16.20	34.82	0.39	0.13	0.43	0.95
2000- 04	0.44	0.26	0.45	1.15	12.30	N/A	15.20	27.50	0.24	N/A	0.49	0.73
2005	0.11	0.04	0	0.15	N/A	N/A	N/A	N/A	0.09	N/A	0.18	0.27
TOTAL	1.54	3.00	2.18	6.72	24.94	20.98	40.94	86.86	0.87	3.45	3.29	7.61

Total investment in beach nourishment has a present day replacement value of about £134 million.

Recycling that has been undertaken can be valued at a further £10-11 million at present prices.

Potential future costs to raise the beach crest to keep pace with estimated sea level rise along the 130 km of beaches that protect low-lying land:

To raise the beach crest over this length of coastline would cost about £75.6 million in recharge alone.

To create a crest with a 20 m wide berm to provide a buffer against storm erosion would require adding a further 12,000 m³ per kilometre at a cost of £31.2 million.

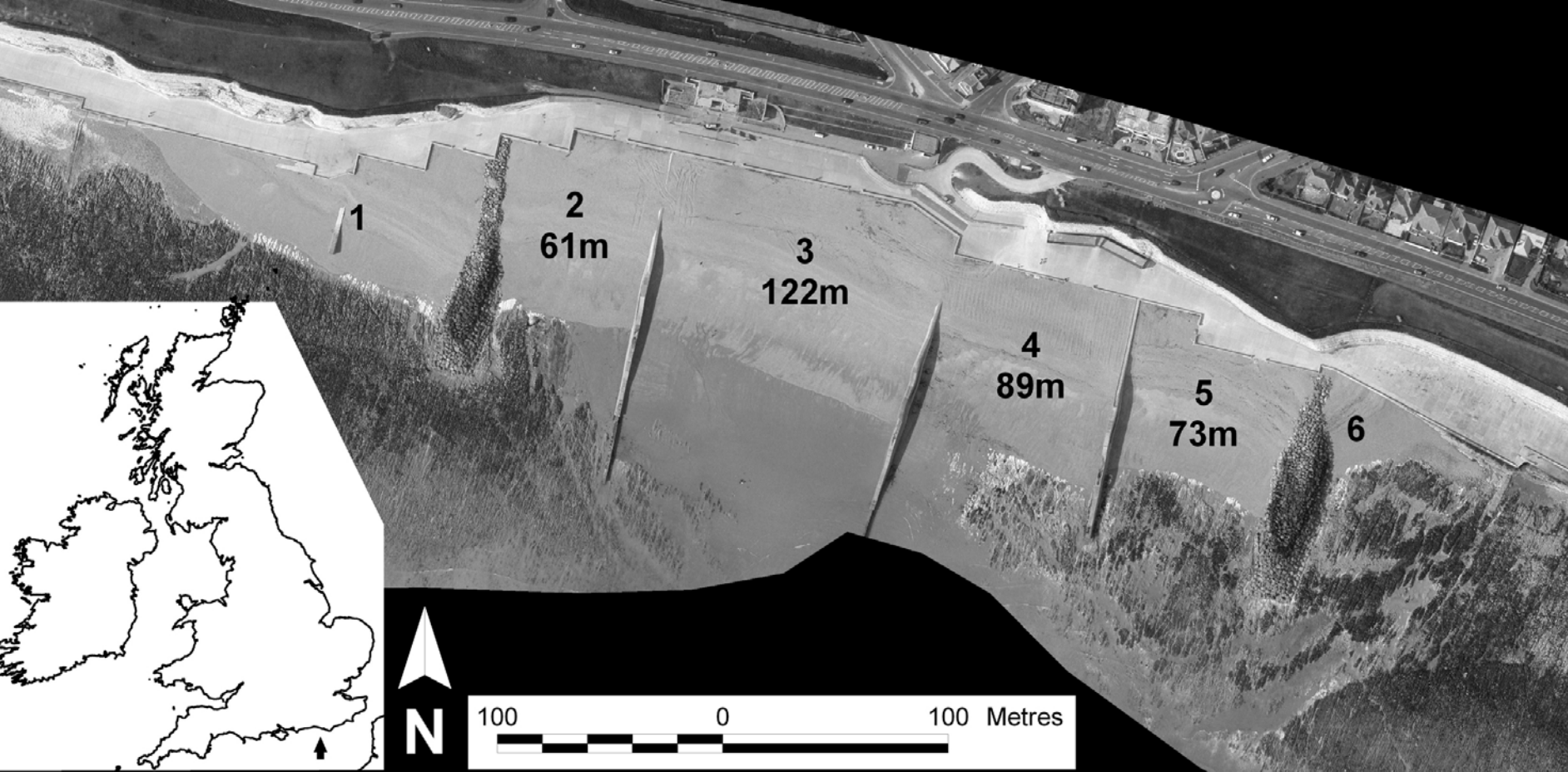
Additional costs:

- reconstructing existing sea-walls and other coastal defence structures
- raising and widening embankments along tidal stretches of rivers
- escalating cost of maintaining existing beach volumes though beach nourishment

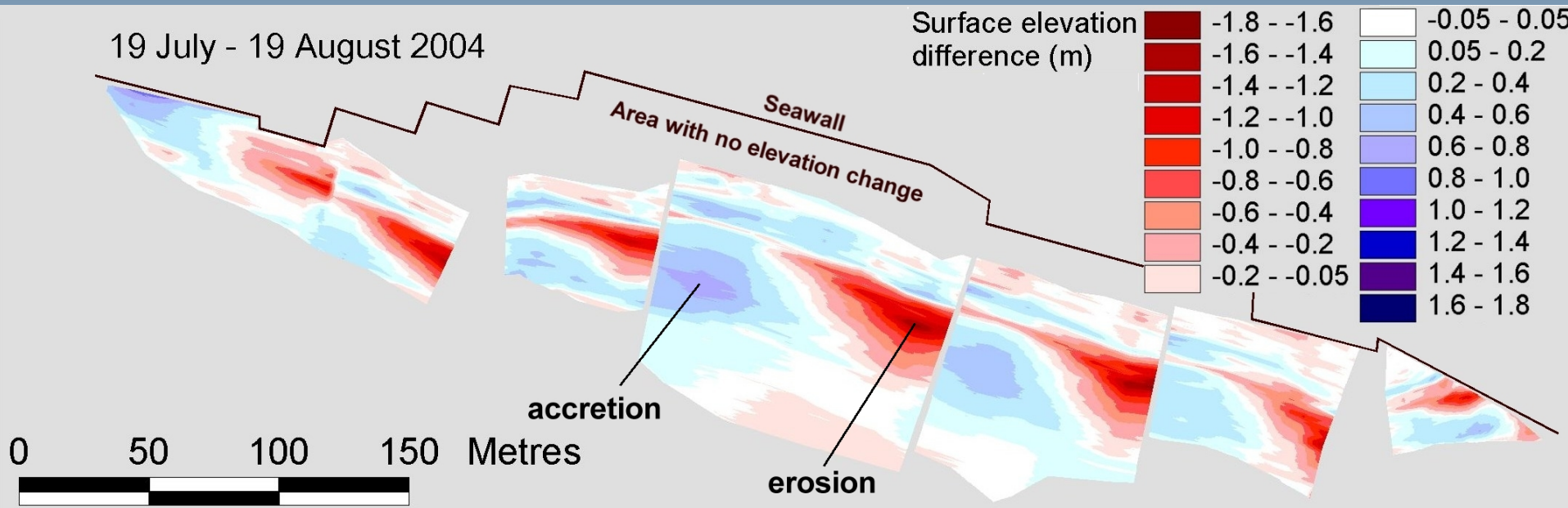
***Variation in beach behaviour in relation to groyne spacing
and groyne type for mixed sand and gravel beaches,
Saltdean, UK***

Dornbusch, U., Robinson, D.A., Moses C.A. & Williams R.B.G.

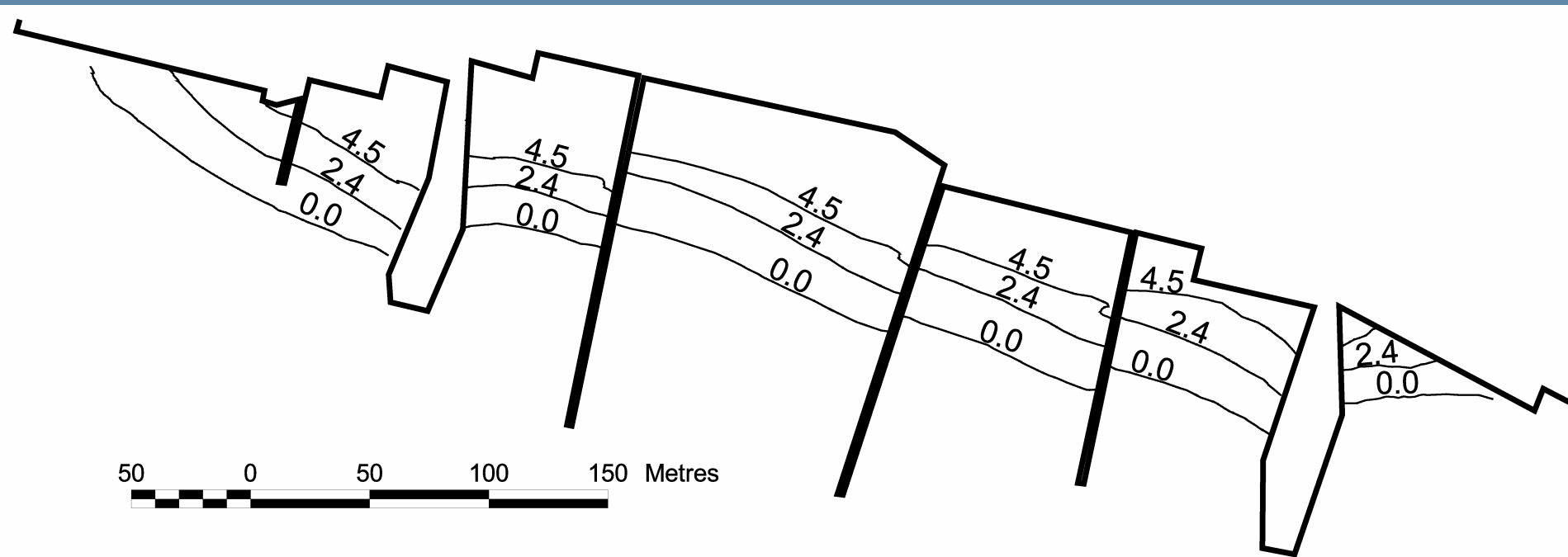
Dornbusch, U., Robinson, D.A., Moses C.A. & Williams R.B.G. "Variation in beach behaviour in relation to groyne spacing and groyne type for mixed sand and gravel beaches, Saltdean, UK"



Distribution of beach volumes



Beach geometry near groynes and beach planform rotation



The maximum rotation of the mean high water line: 9° .

Predicted maximum planform rotation:

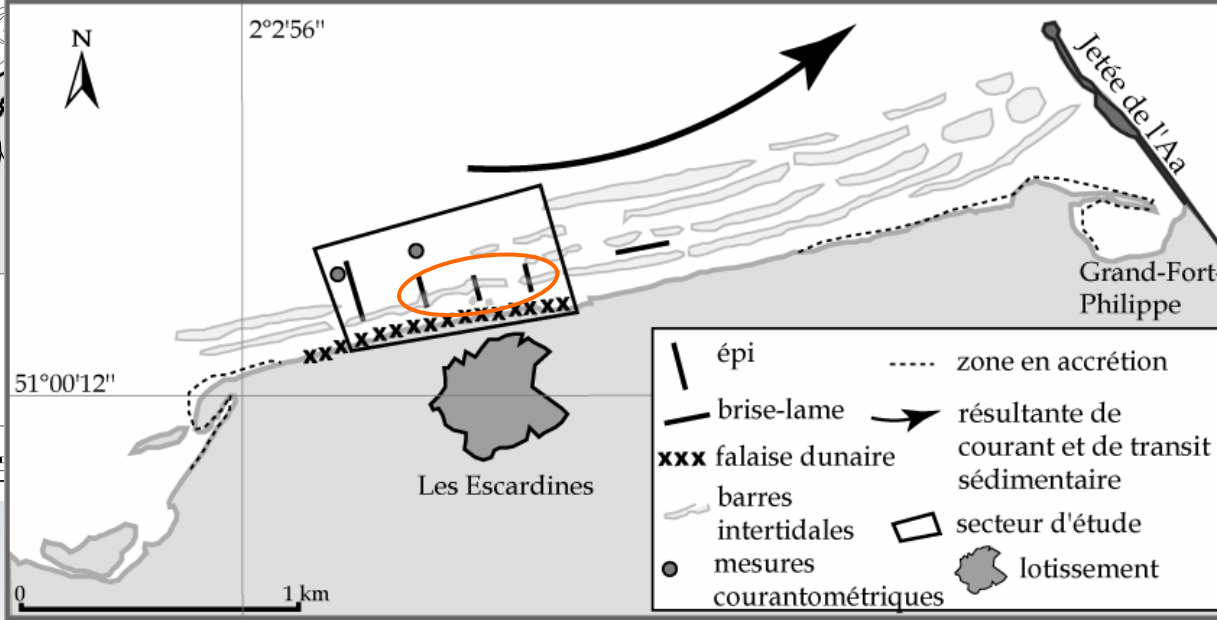
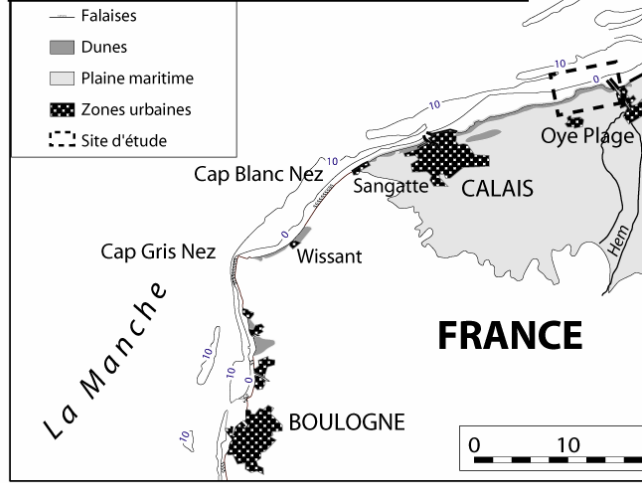
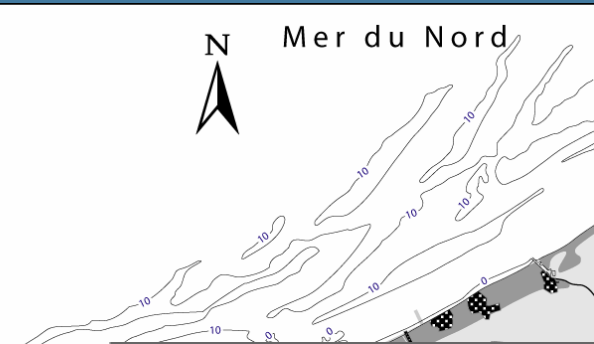
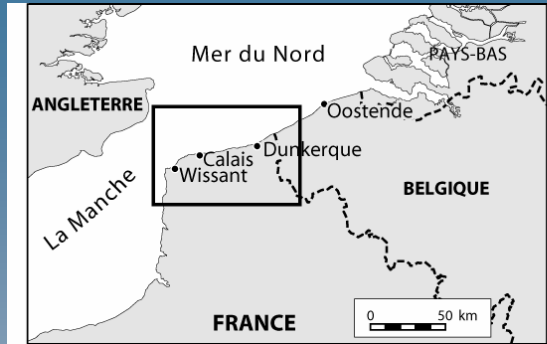
- up to 74°
- average of 25° for wave conditions similar to those experienced during the survey period

Key findings:

- (i) there is no natural cross shore exchange between the mixed beach and the subtidal zone
- (ii) the pattern of sediment movement within the groyne bays is very similar, independent of groyne spacing and type
- (iii) the magnitude of change is dependent on groyne spacing
- (iv) longshore transport occurs through boulder groynes at an average rate of between 0.5m^3 and 1.1m^3 per day (includes coarse and fine material)
- (v) at this particular site, almost 50% of the recharge material is in excess of that needed to provide satisfactory protection when the beach planform rotation during the study period is compared to that predicted by numerical modelling in the design study for the scheme.

*Influences des épis sur la morphodynamique d'une
plage à barres et à bâches, nord de la France*

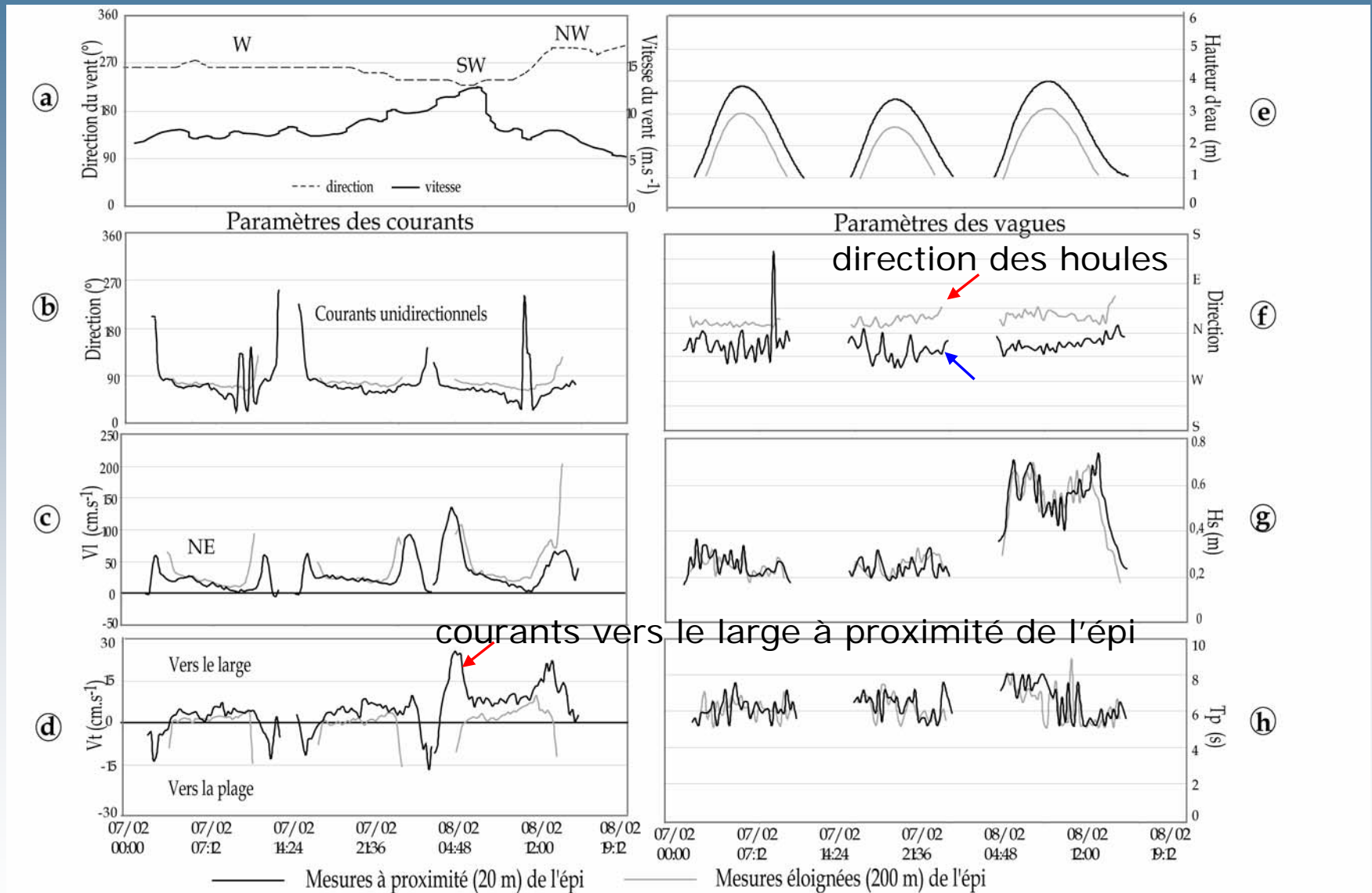
Aubry, A. & Ruz, M.H.

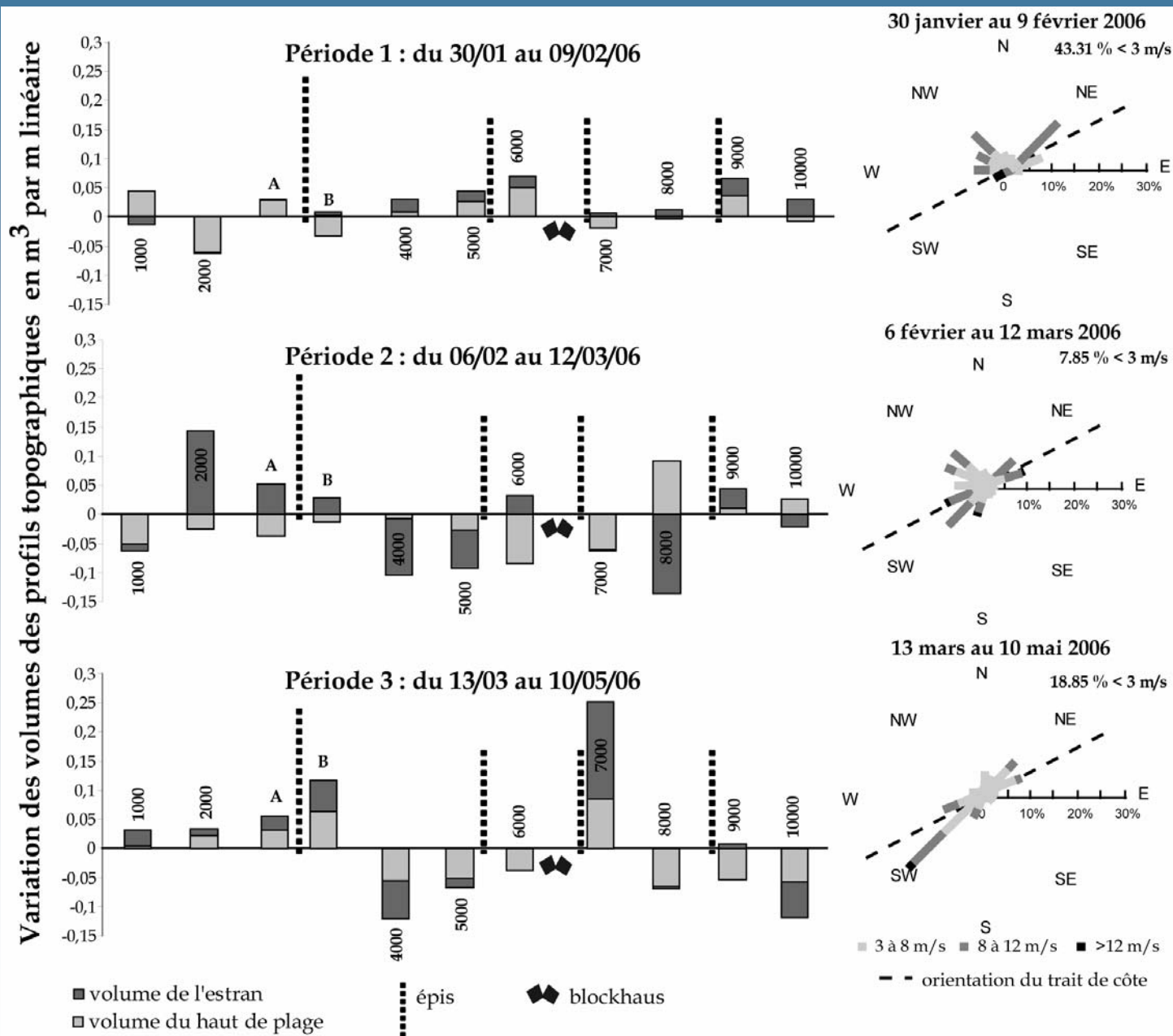


- Erosion dans la partie centrale (plusieurs dizaines de mètres entre 1949 et 2000)
- Installation de 3 épis en 1988
- 1 épi supplémentaire en 2000

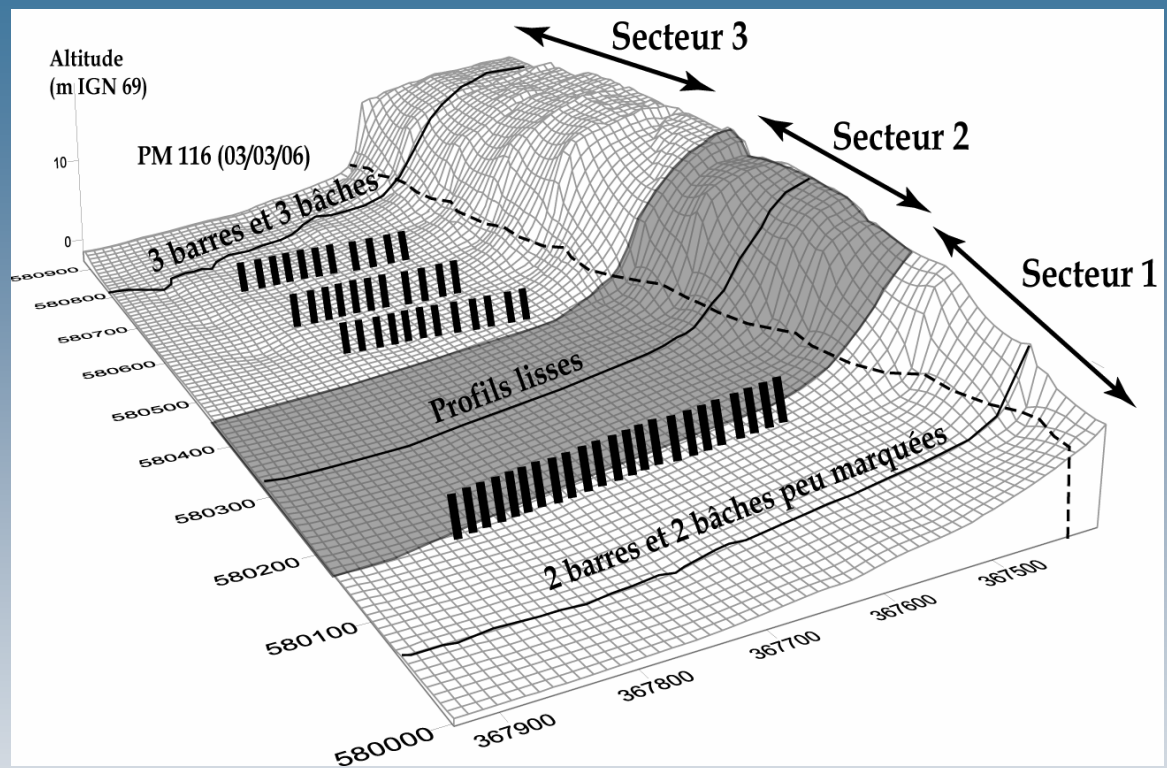
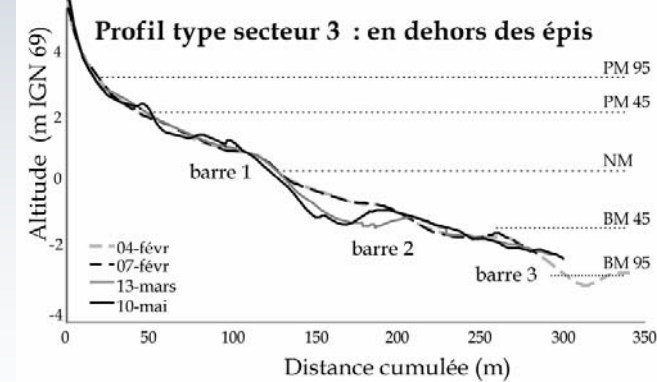
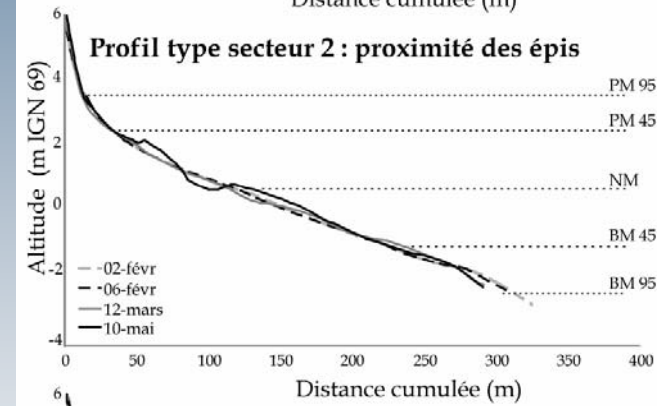
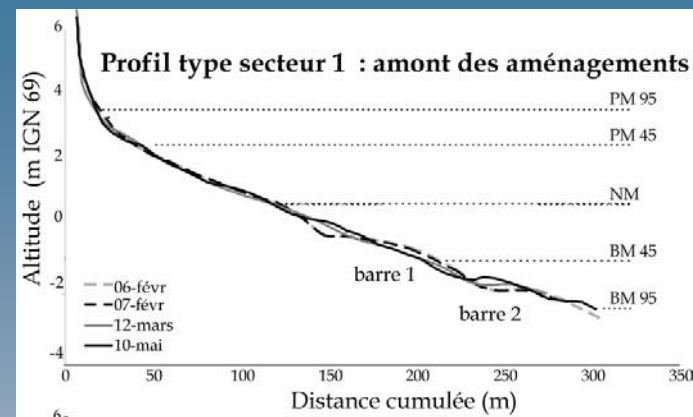


Plusieurs perturbations des vagues et des courants par l'épi

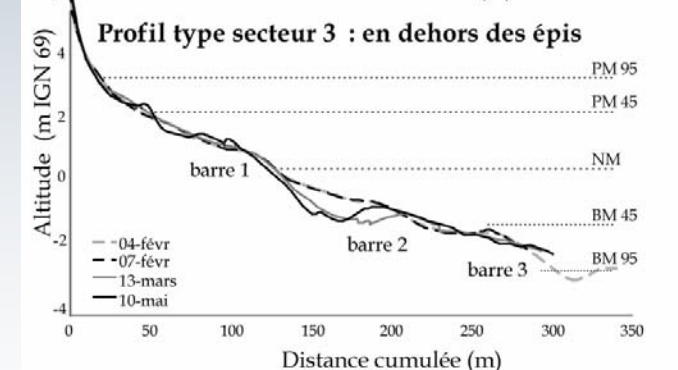
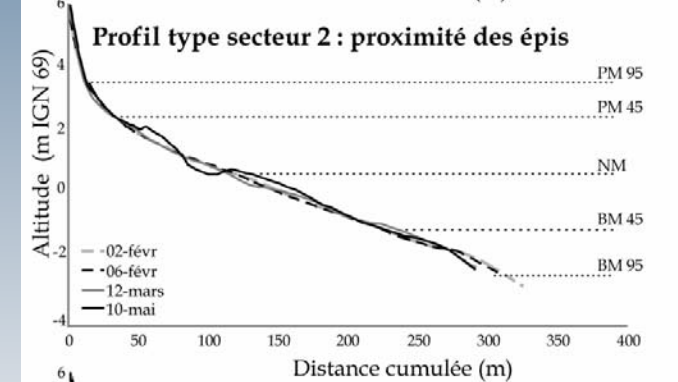
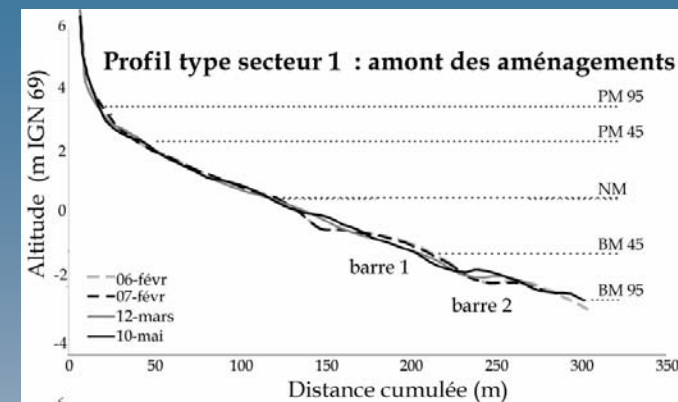
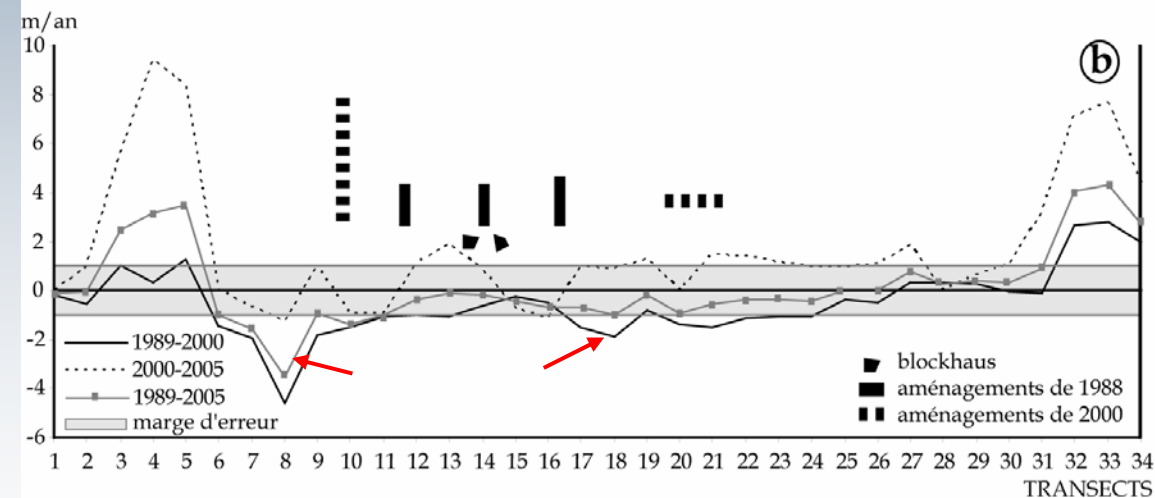
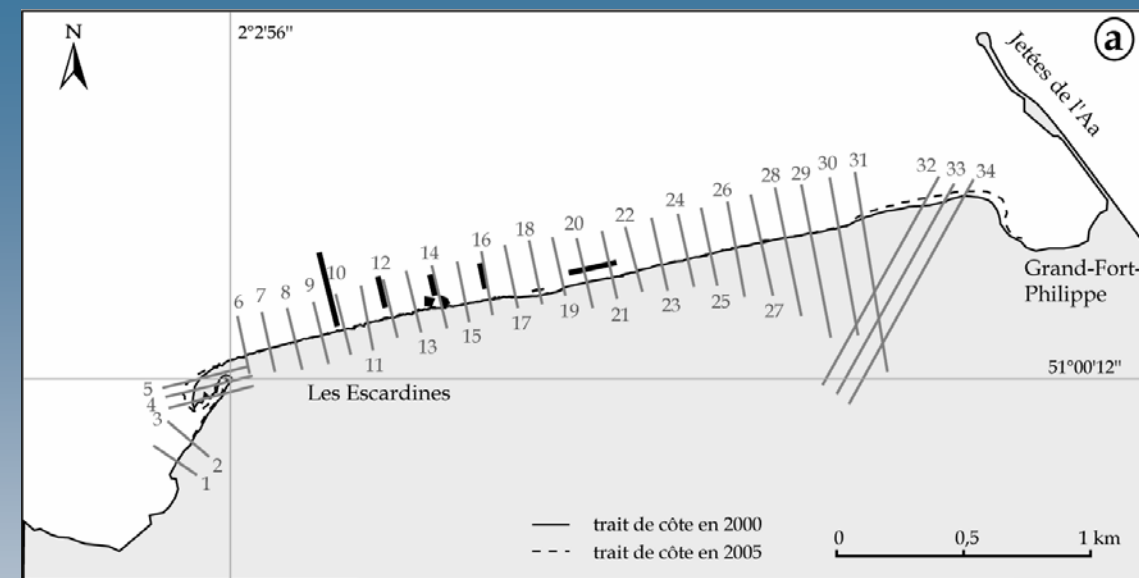




Evolution des volumes pendant la période d'expérimentation



Variabilité de la morphologie des profils de plages le long de la côte: barres intertidales nettement moins développées à proximité des épis

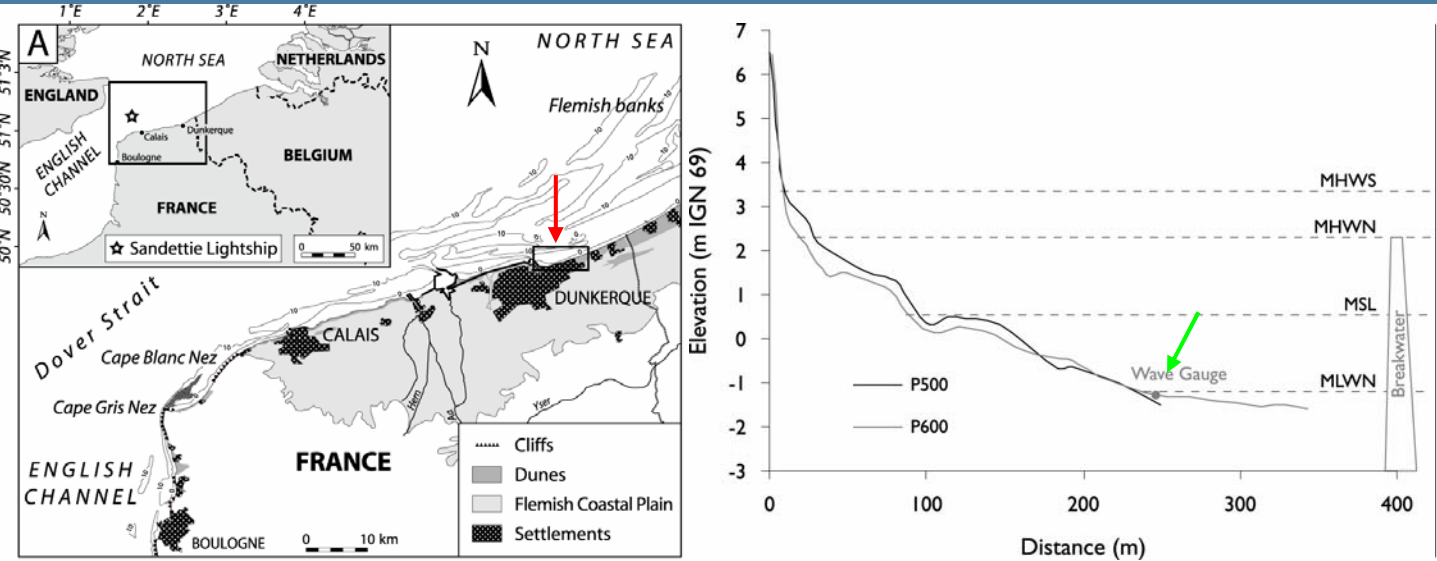


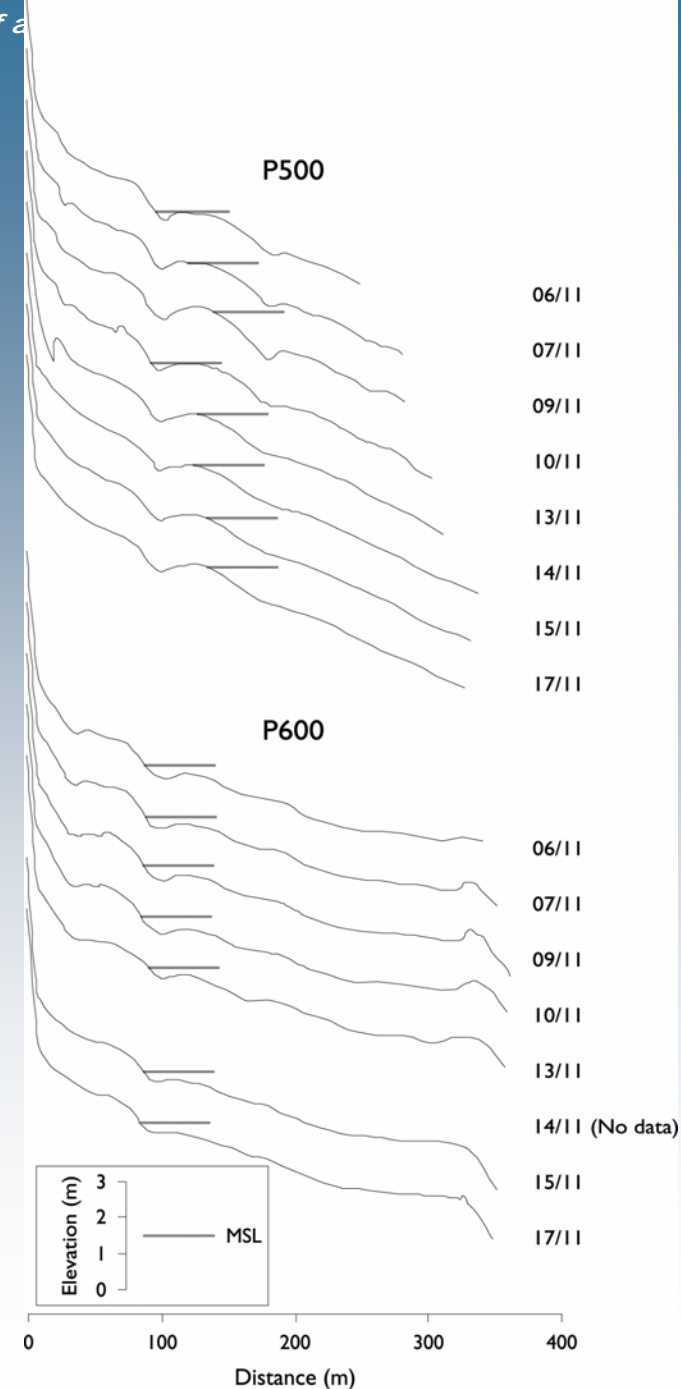
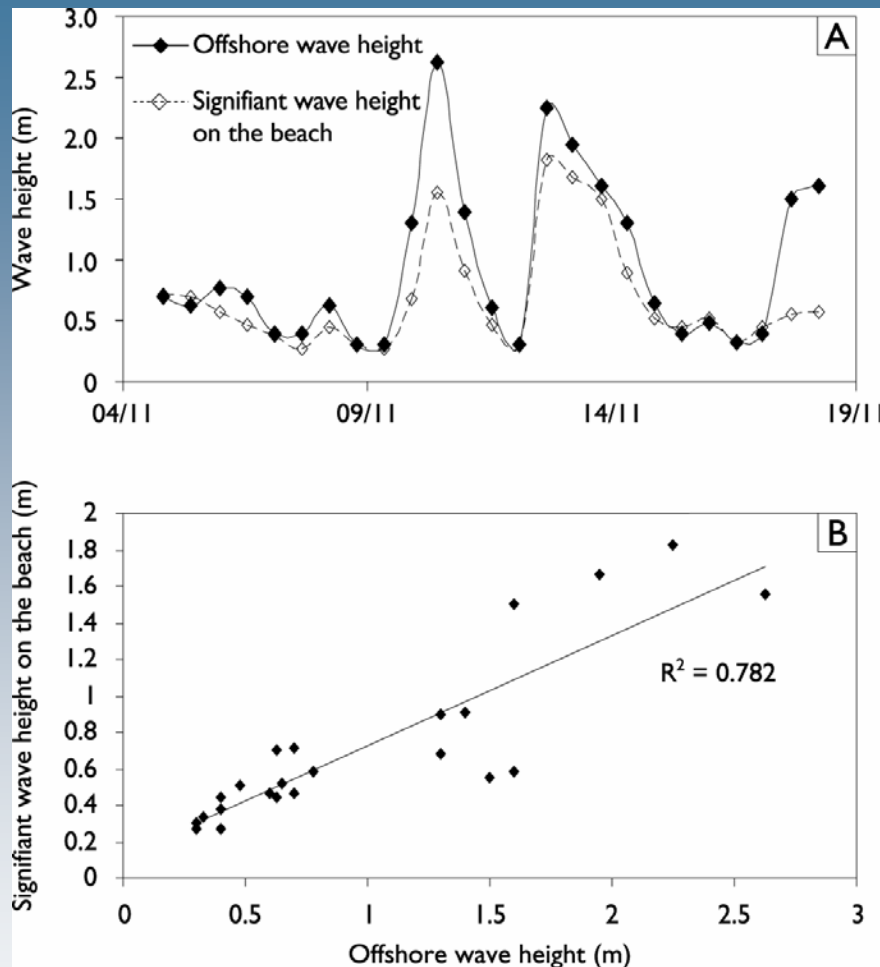
Analyse de l'évolution du trait de côte après l'implantation des épis montre une efficacité limitée des ouvrages

Epis pourraient être à l'origine d'une déstabilisation du système barres-bâches qui contribue à dissiper l'énergie des vagues (rôle de l'espacement entre épis ?)

Wave attenuation and intertidal morphology of a multi-barred macrotidal beach behind a breakwater

Oblinger, A. & Anthony, E.J.

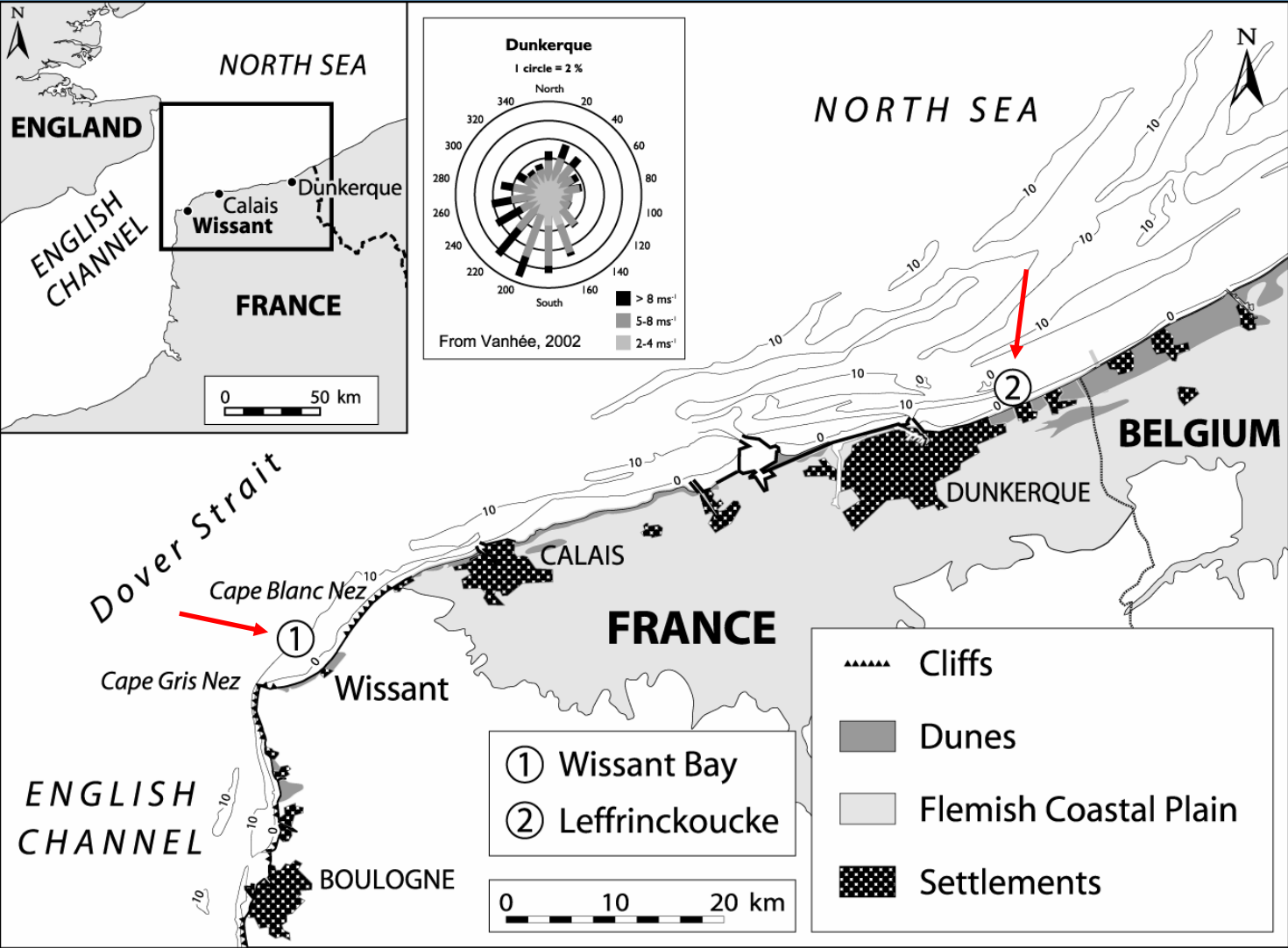


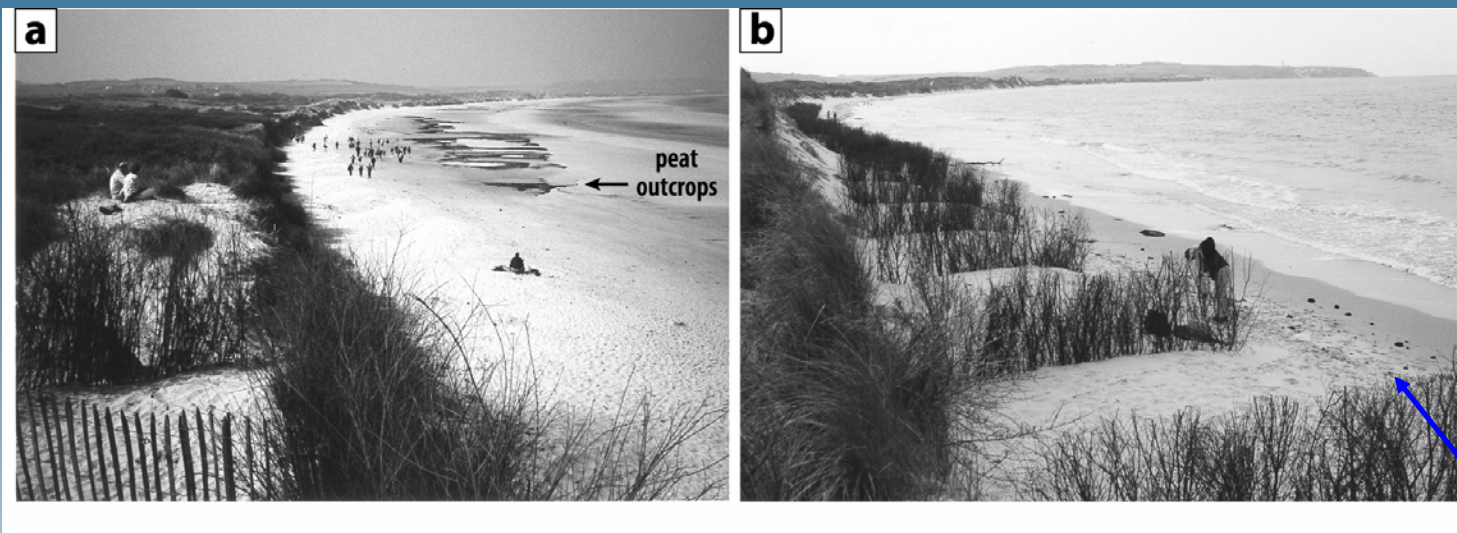


- Difficulté d'apprécier l'effet du brise-lame sur les hauteurs de vagues, car les houles sont atténuées par les bancs au large
- Accumulation sédimentaire à l'arrière du brise-lames mais avec barres intertidales moins développées que sur plages avoisinantes

Sand trapping by brushwood fences on a beach-foredune contact: the primacy of the local sediment budget

Ruz, M.H & Anthony, E.J.





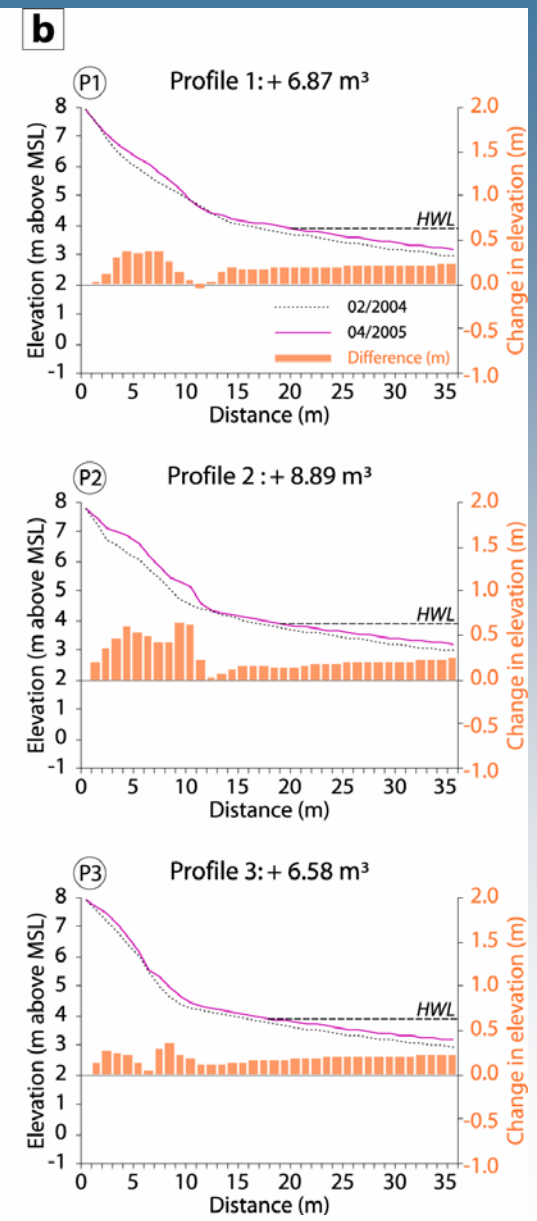
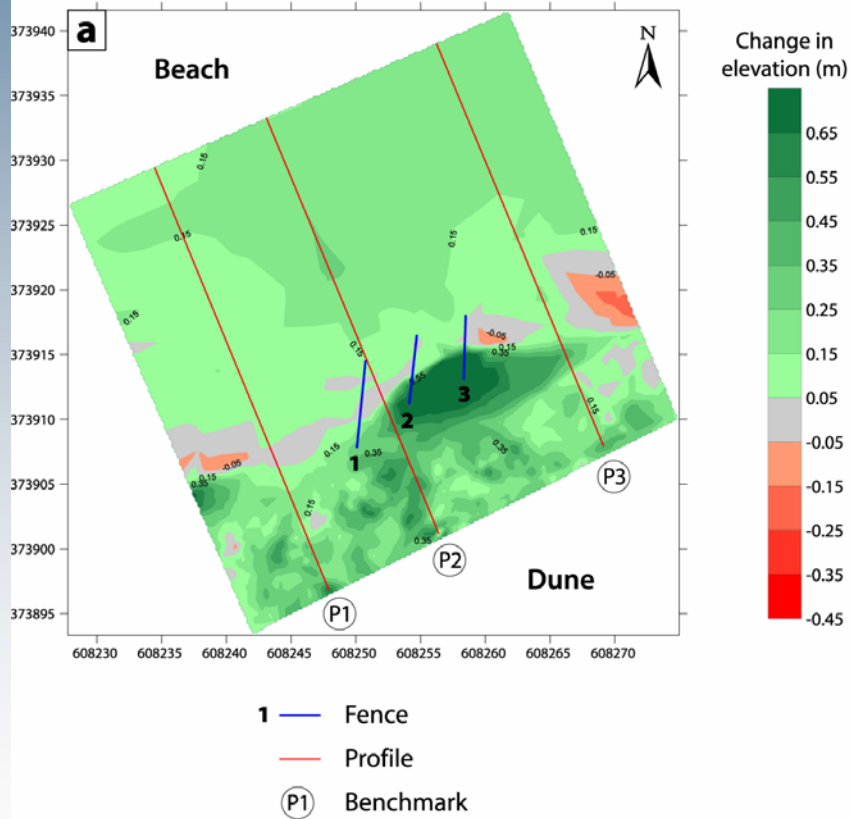
Site de Wissant, Pas-de-Calais

Fascines mises en place en haut de plage (et non pas dans les dunes)

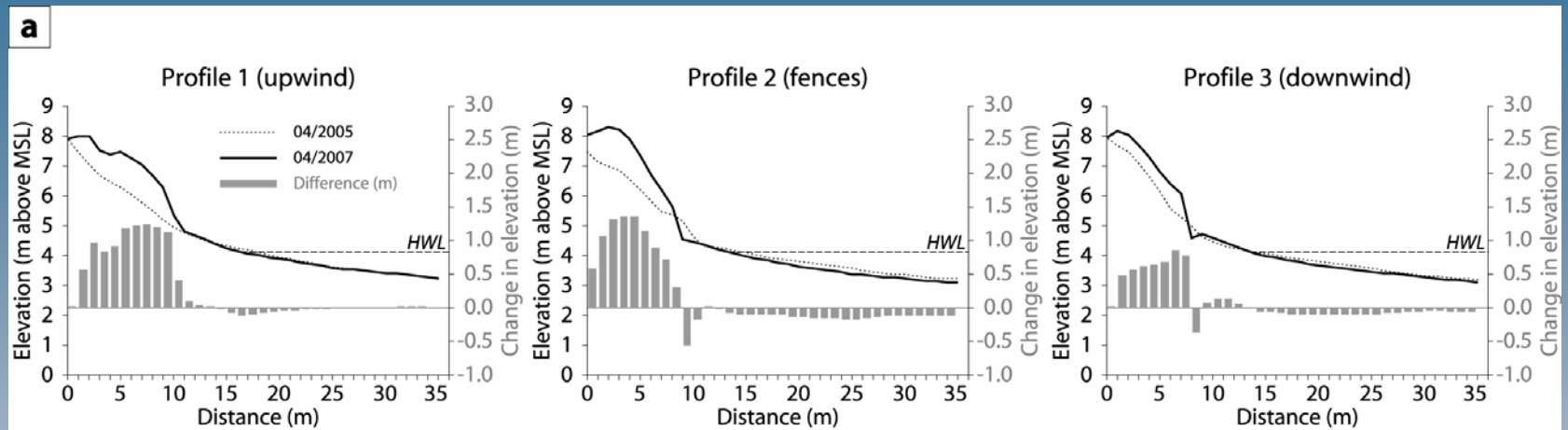


Site de Leffrinckoucke, mer du Nord

Leffrinckoucke

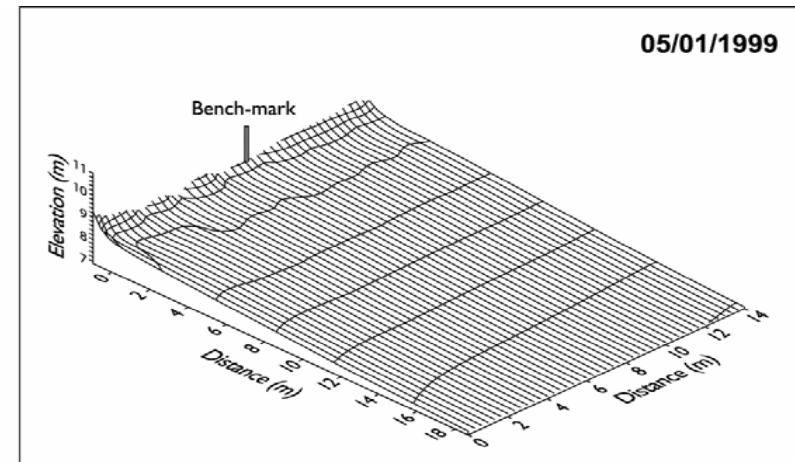
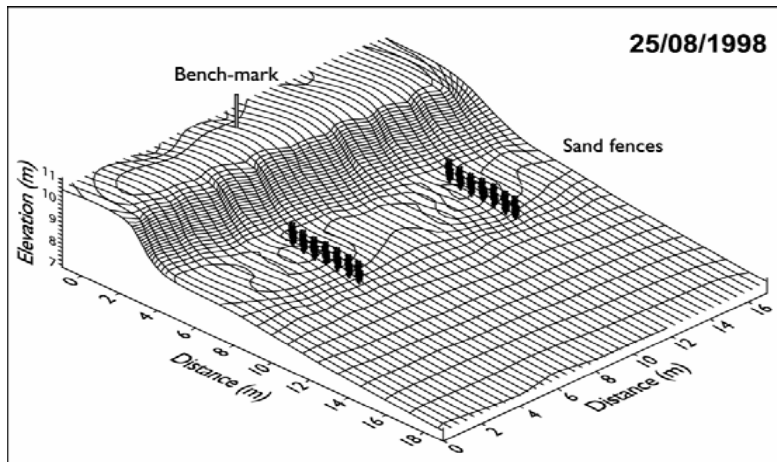


Accumulation en haut de plage entre février 2004 et avril 2005



- Accumulation toujours notable entre avril 2005 et avril 2007, non seulement au niveau des fascines mais plus haut sur la dune bordière qui s'exhausse
- Les fascines ont cependant favorisé l'accumulation éolienne sur la dune bordière et donc contribué à sa stabilisation

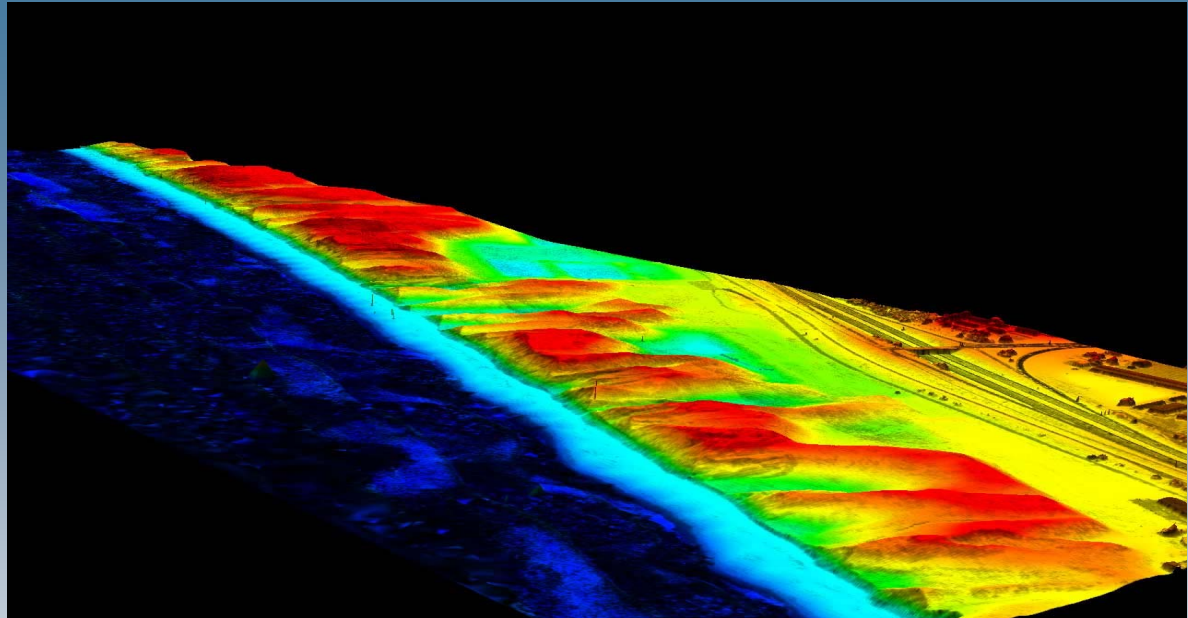
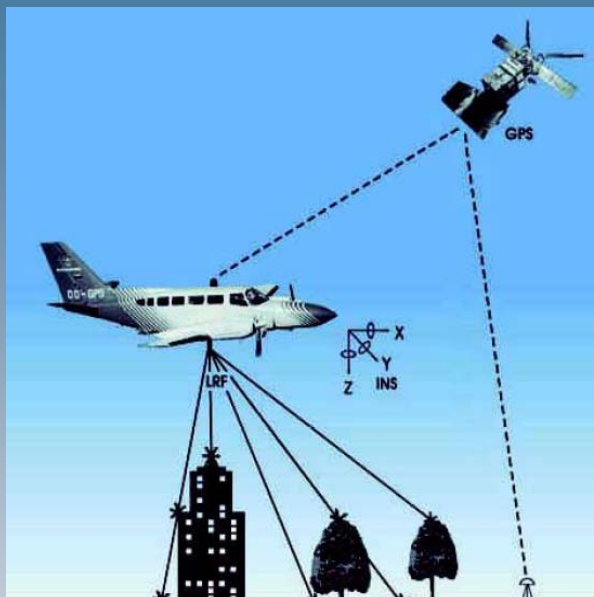
Baie de Wissant



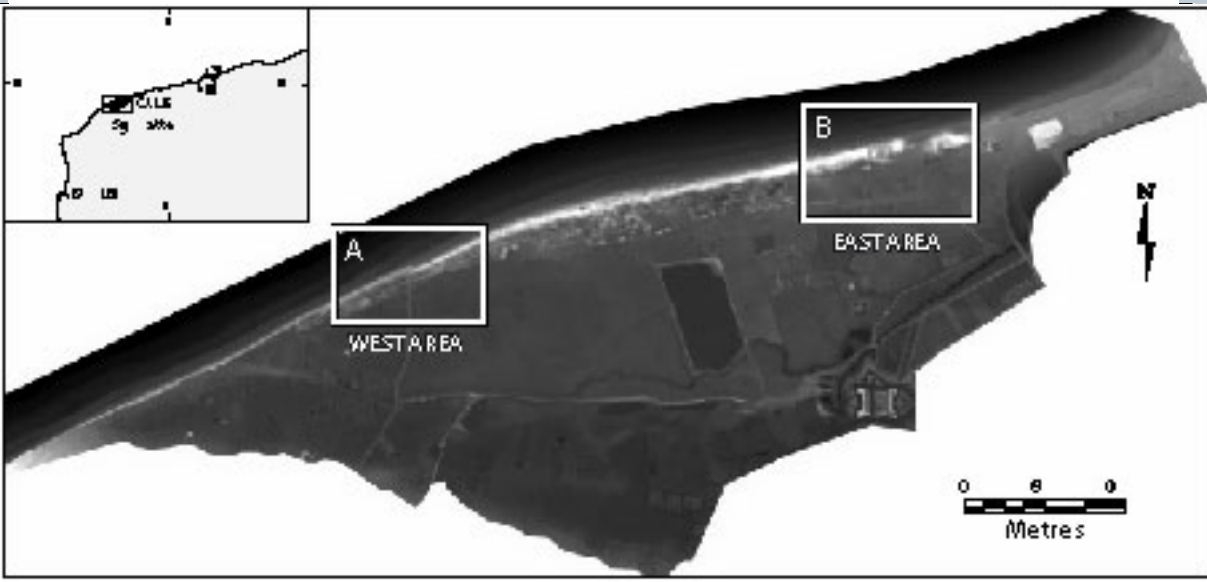
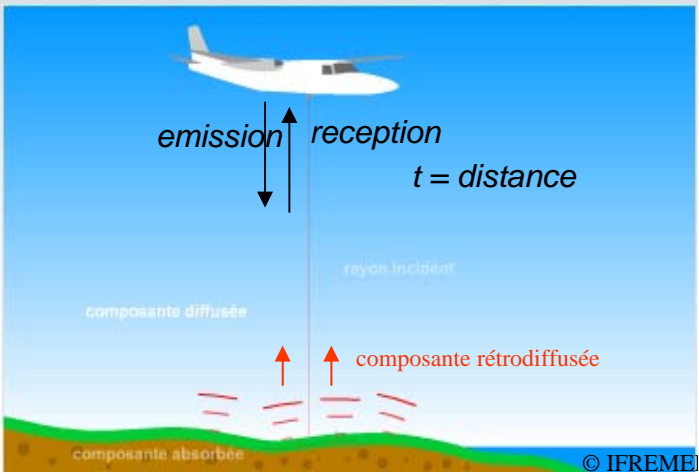
Par contre dans un contexte de déficit sédimentaire, comme en baie de Wissant, fascines en haut de plage sont peu efficaces car s'il y a accumulation pendant l'été, il y a érosion des fascines et de la dune bordière pendant l'hiver

Assessing the vulnerability of coastal lowlands to marine flooding using LiDAR data, Sangatte coastal dunes, northern France

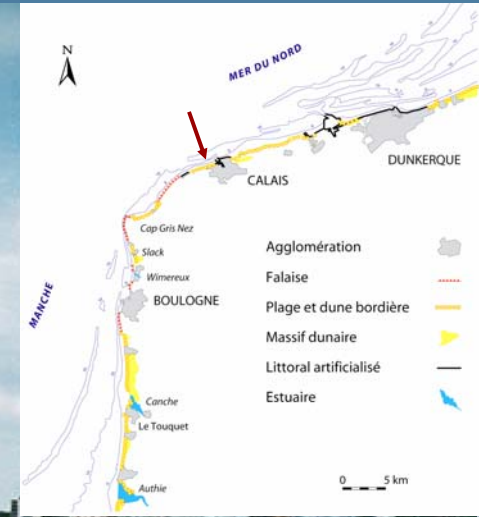
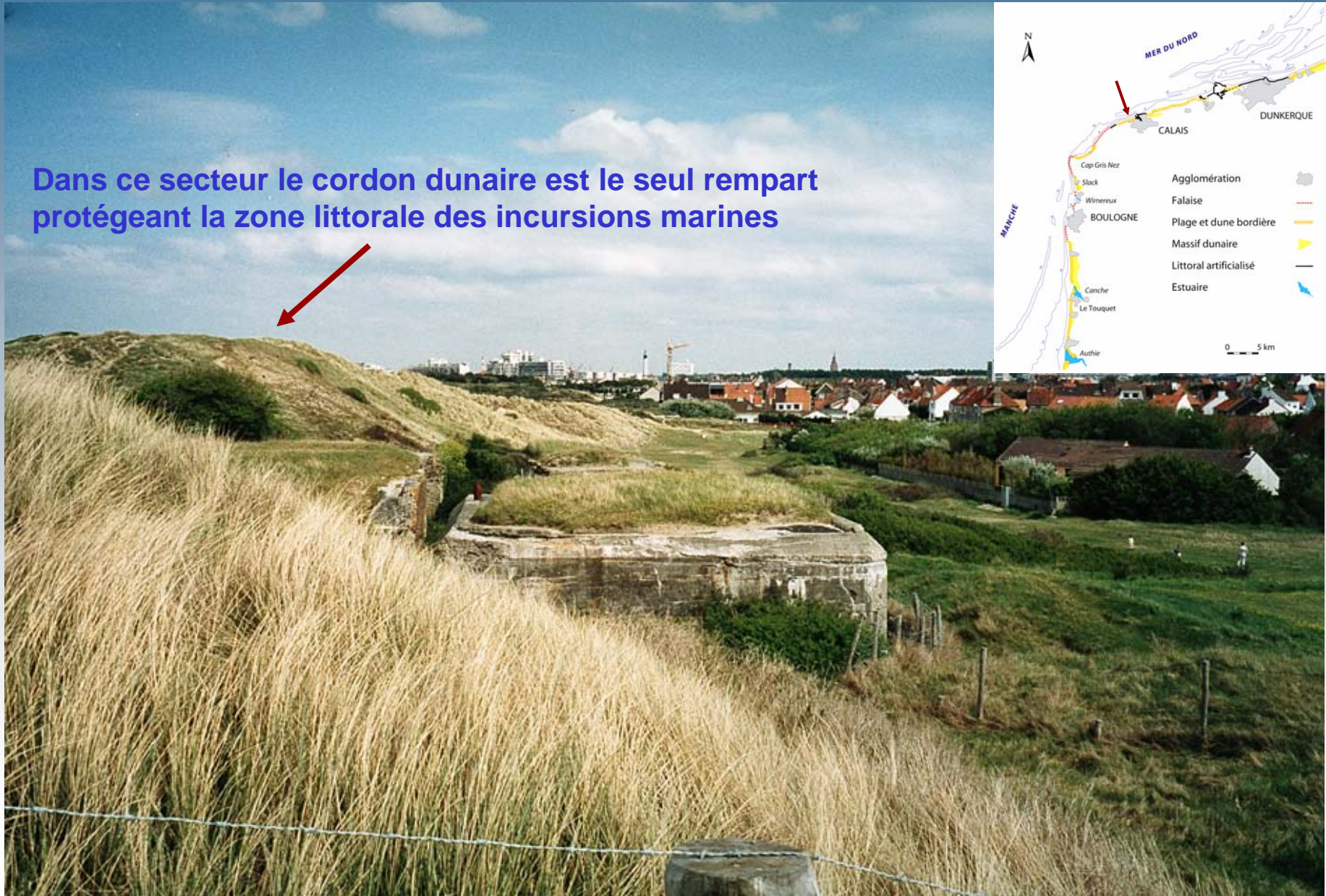
Rufin-Soler, C., Héquette, A. & Gardel, A.

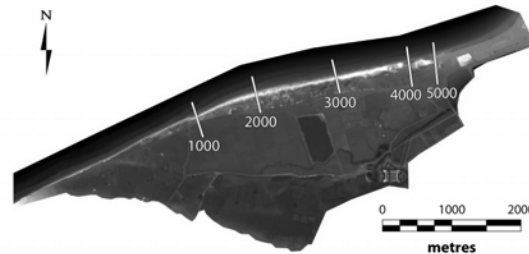
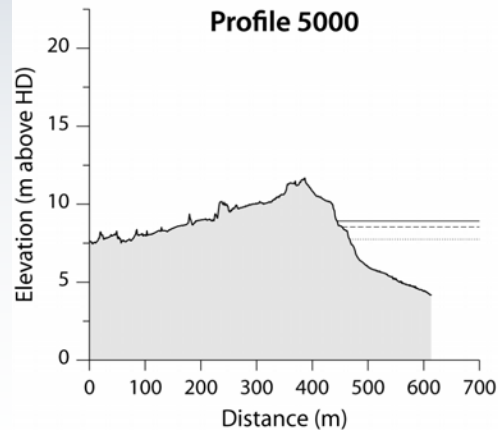
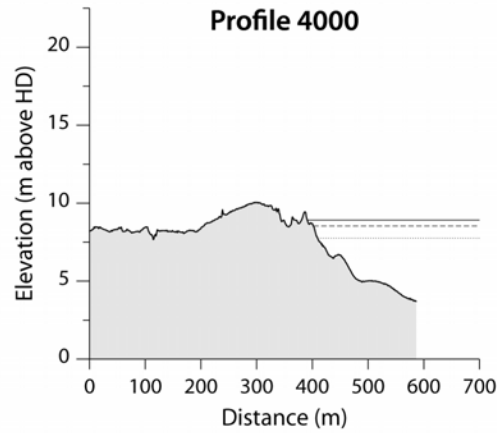
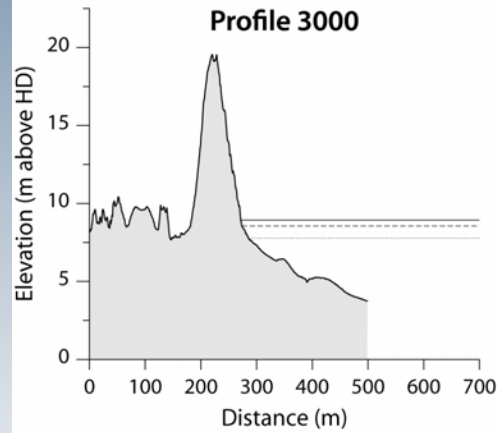
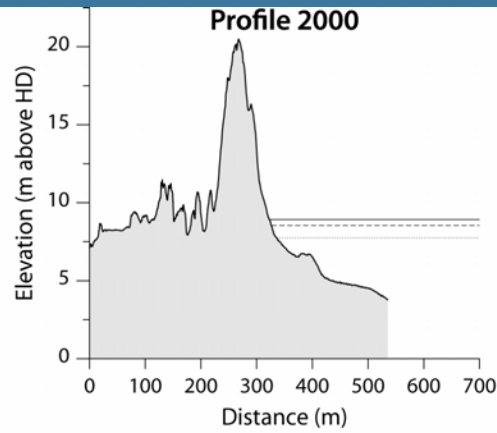
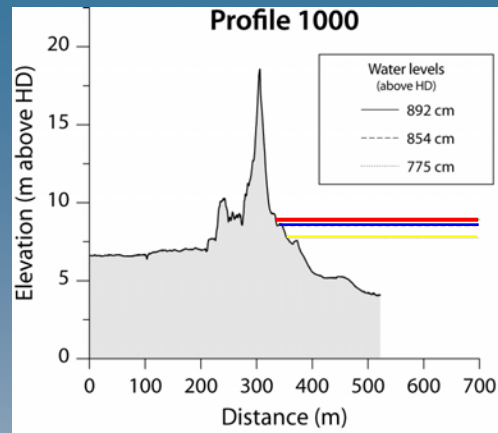


LIDAR (Light Detection and Ranging)
 précision altimétrique < 15 cm



Dans ce secteur le cordon dunaire est le seul rempart protégeant la zone littorale des incursions marines





Estimation de hauts niveaux d'eau avec différentes périodes de retour en 2050 (avec une hausse du niveau marin de + 17 cm, IPCC, 2001)

- **775 cm** = niveau actuel des plus hautes mers astronomiques
- **854 cm** = niveau de surcote avec période de retour de 10 ans en 2050
- **892 cm** = niveau de surcote avec période de retour de 100 ans en 2050

Rufin-Soler, C., Héquette, A. & Gardel, A.
"Assessing the vulnerability of coastal lowlands to marine flooding using LiDAR data, Sangatte coastal dunes, northern France"

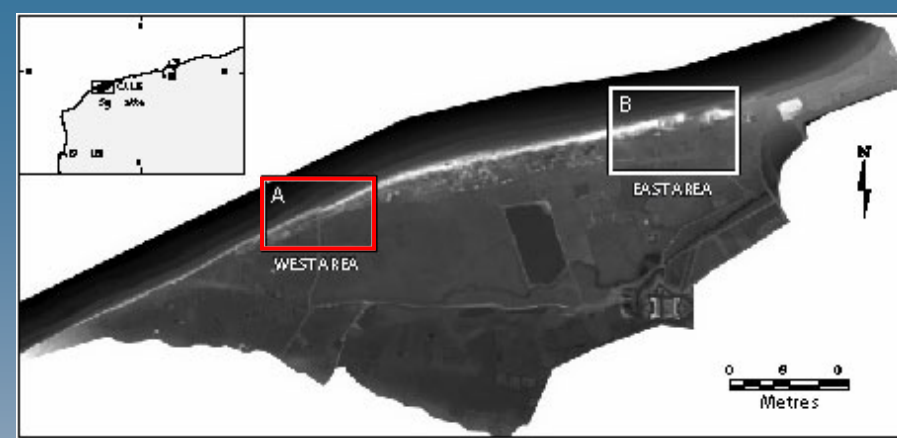
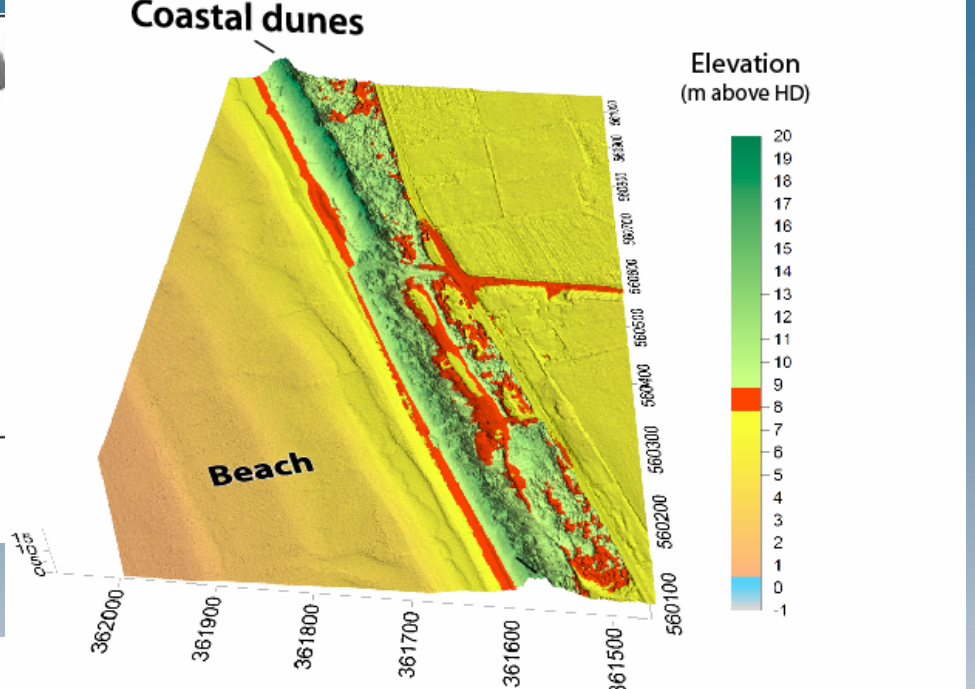
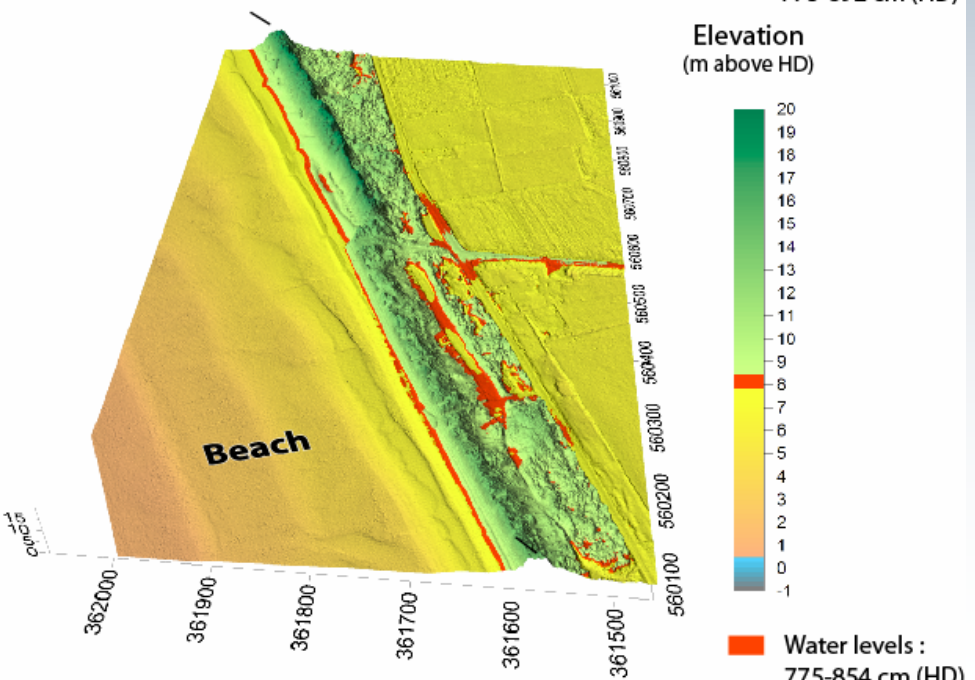
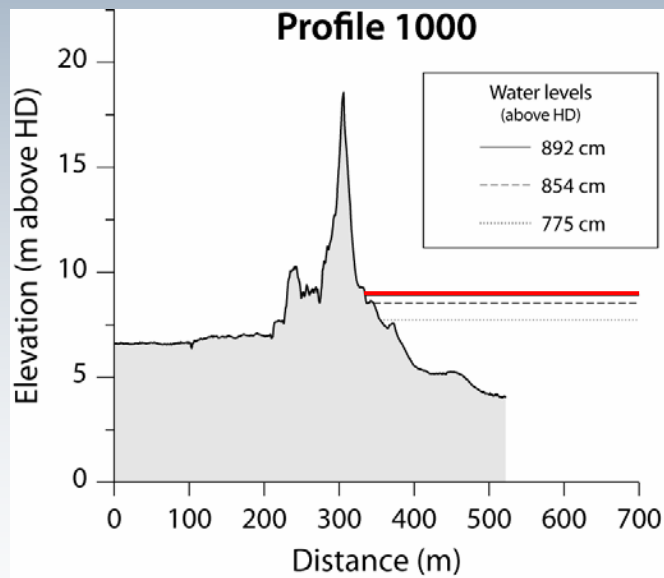


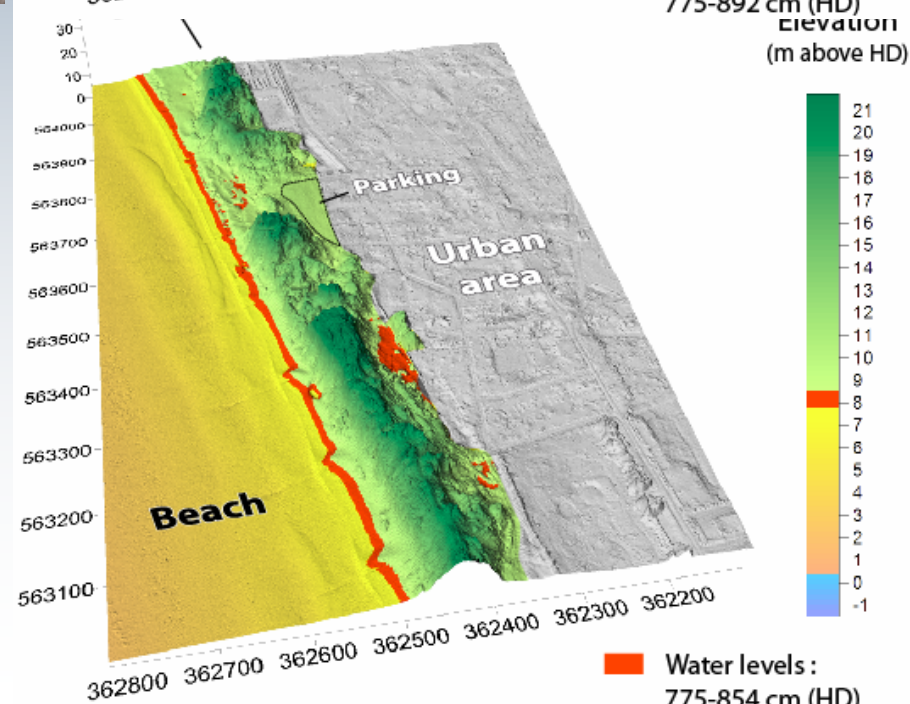
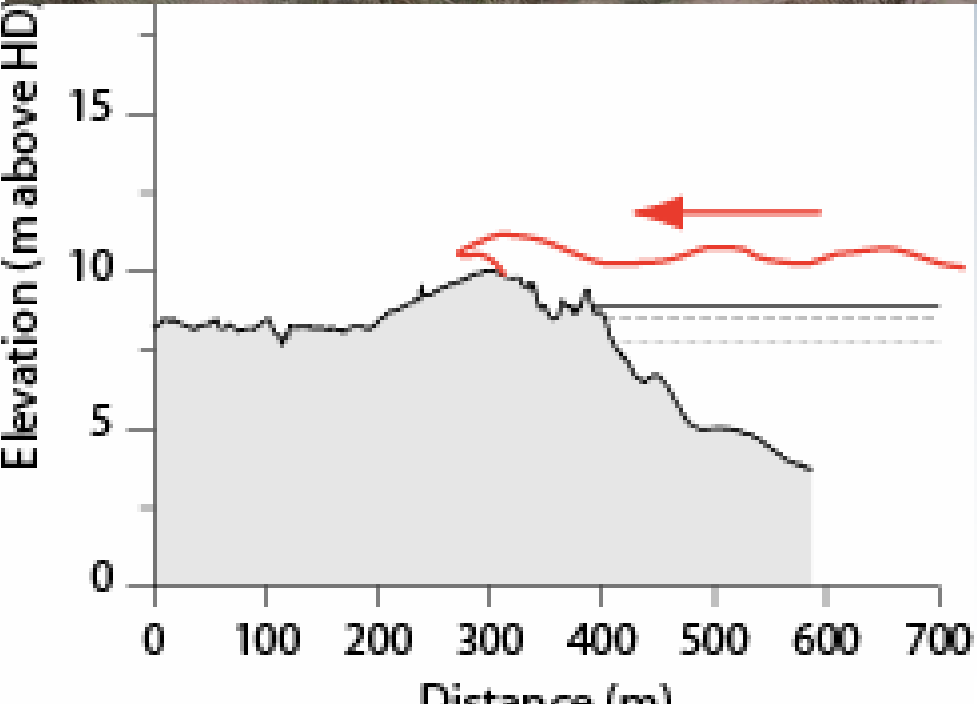
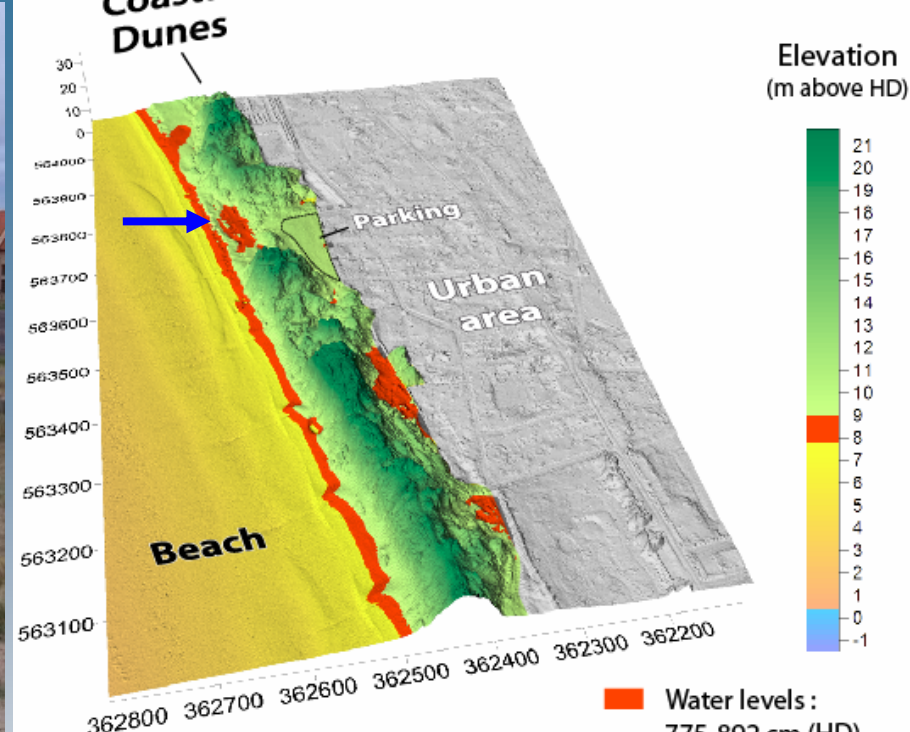
Fig 1



Water levels :
775-892 cm (HD)



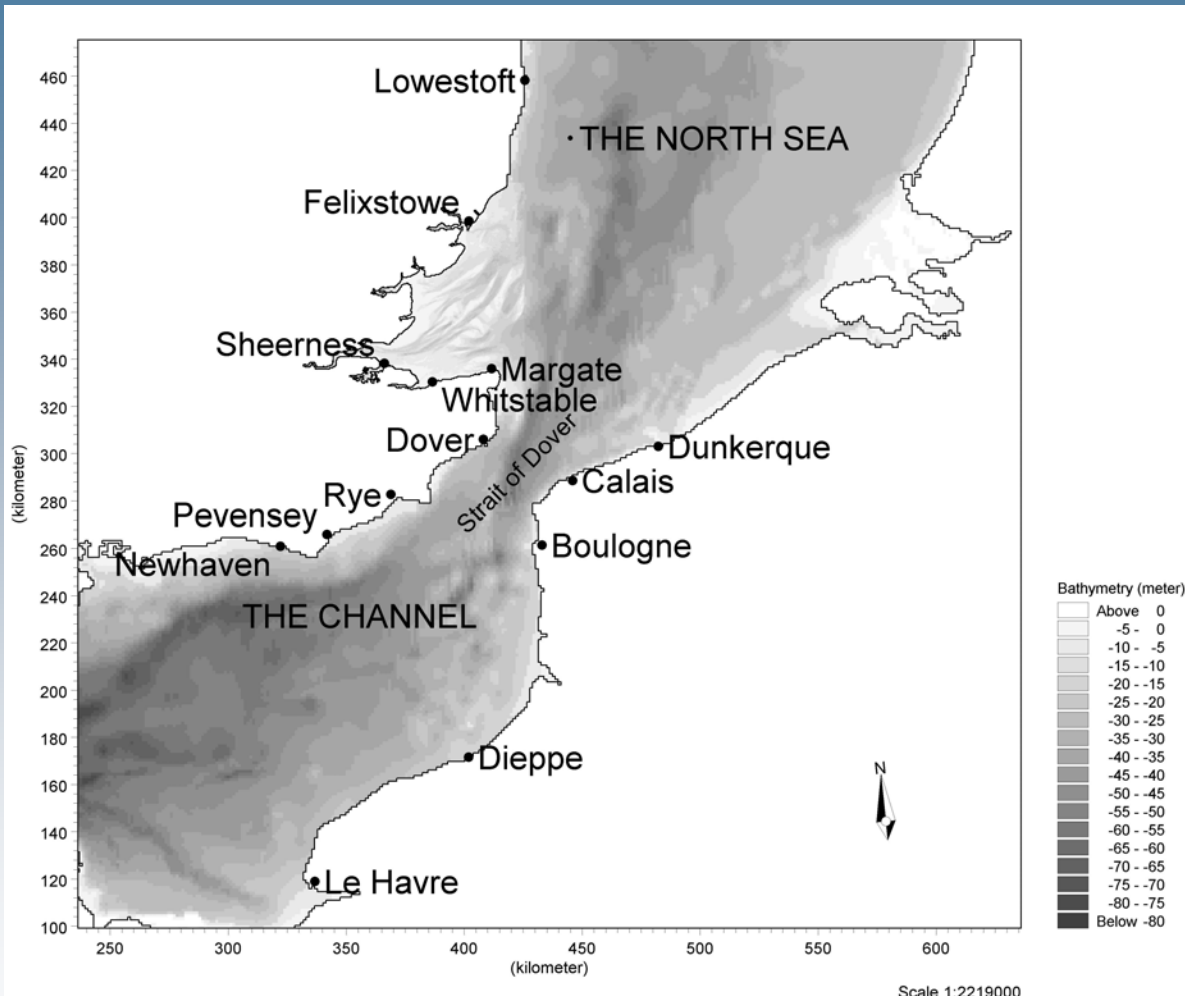
Water levels :
775-854 cm (HD)



***Secular trends in tidal parameters along the eastern
Channel and southern North Sea Basin coastlines***

Swift, R.H.

Swift, R.H. "Secular trends in tidal parameters along the eastern Channel and southern North Sea coastlines"



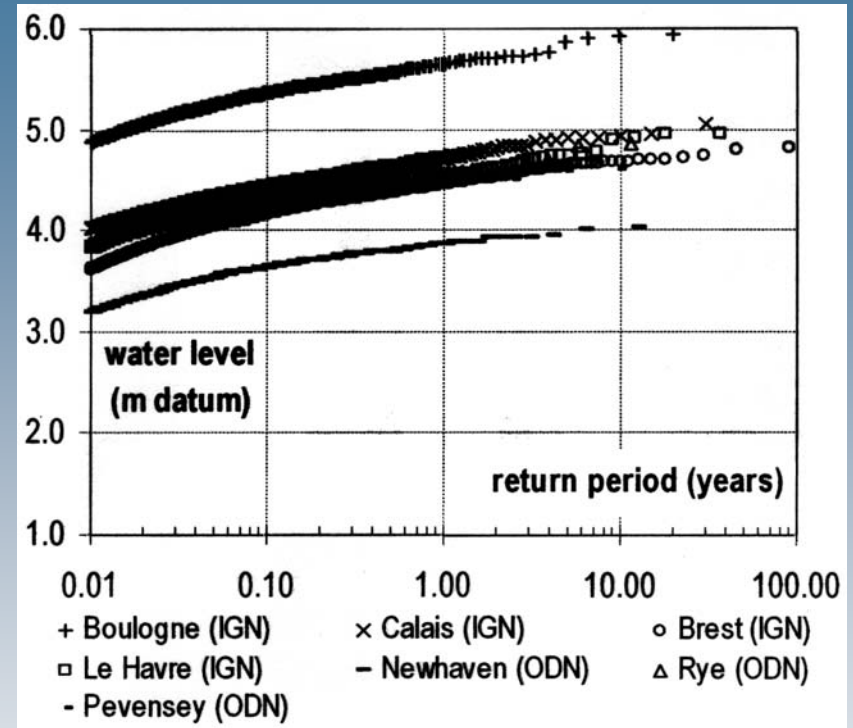
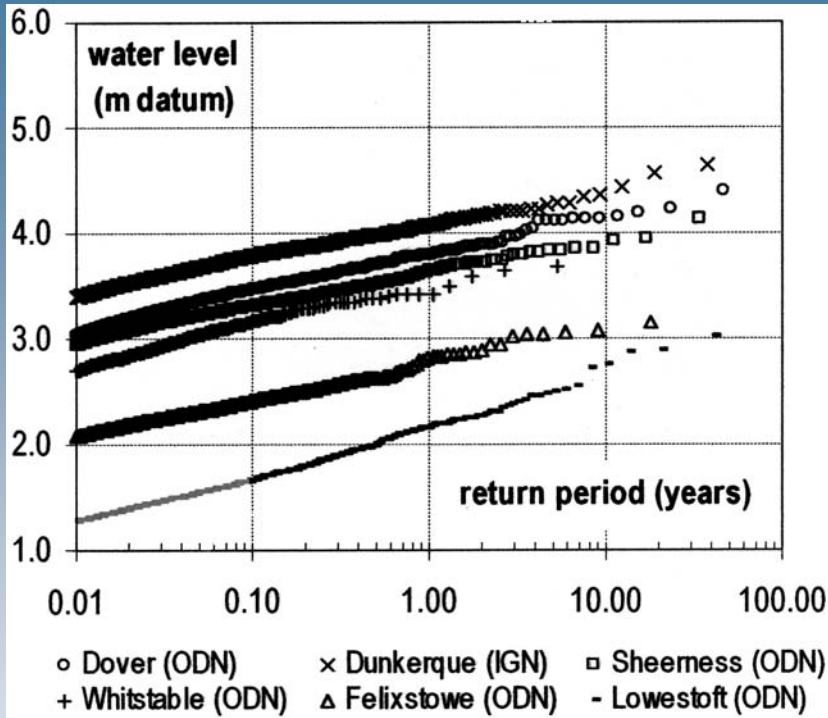
France: Le Havre to Dunkerque

England: Brighton to the Isle of Grain in the Thames Estuary

Tide gauge data from 16 long-term data sets analysed for:

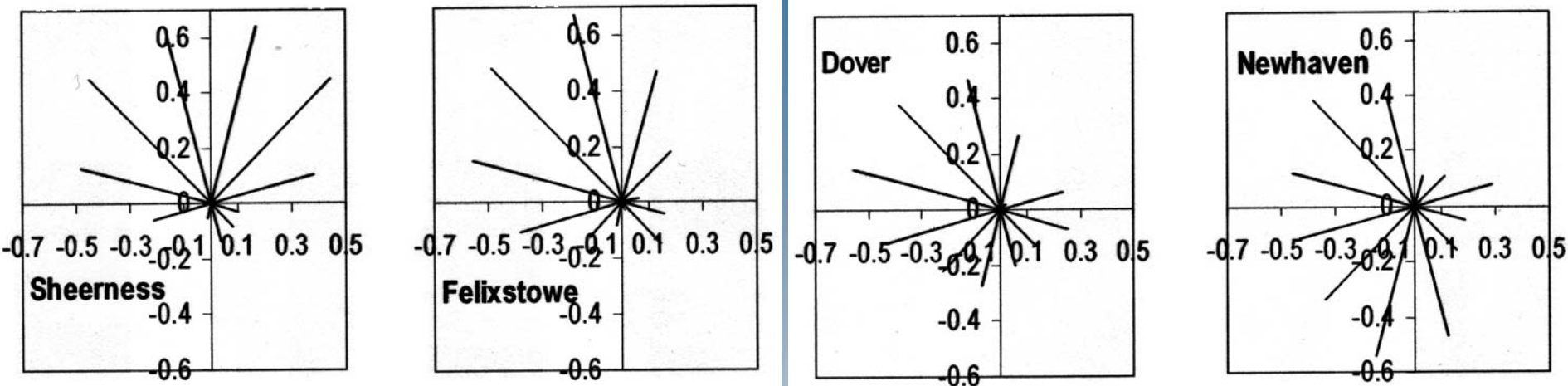
- extreme return period behaviour of water levels
- secular changes in mean sea levels, High Waters, tidal ranges, peak surges and surge values at High Water.

Swift, R.H. "Secular trends in tidal parameters along the eastern Channel and southern North Sea Basin coastlines"



Extreme return period behaviour

- locations in the area tidally defined by the southern North Sea basin are likely to be exposed to a greater level of risk
- east coast extreme events leak through the Strait of Dover, but dissipate as they expand moving southwards into the Channel, with the result that they do not register as major occurrences further to the west.



Polar plots of directional correlation between wind speed and predicted surge

Surge in the outer Thames area behaves in a regional manner in relation to directional wind speeds and is only moderately affected by local orientation of the coastline.

Dover presents not only a detectable correlation component arising from the southern North Sea, but also input from westerlies moving up the Channel from the Atlantic.

Newhaven shows strong correlation all around the sectors from the south to the north west.

Key findings:

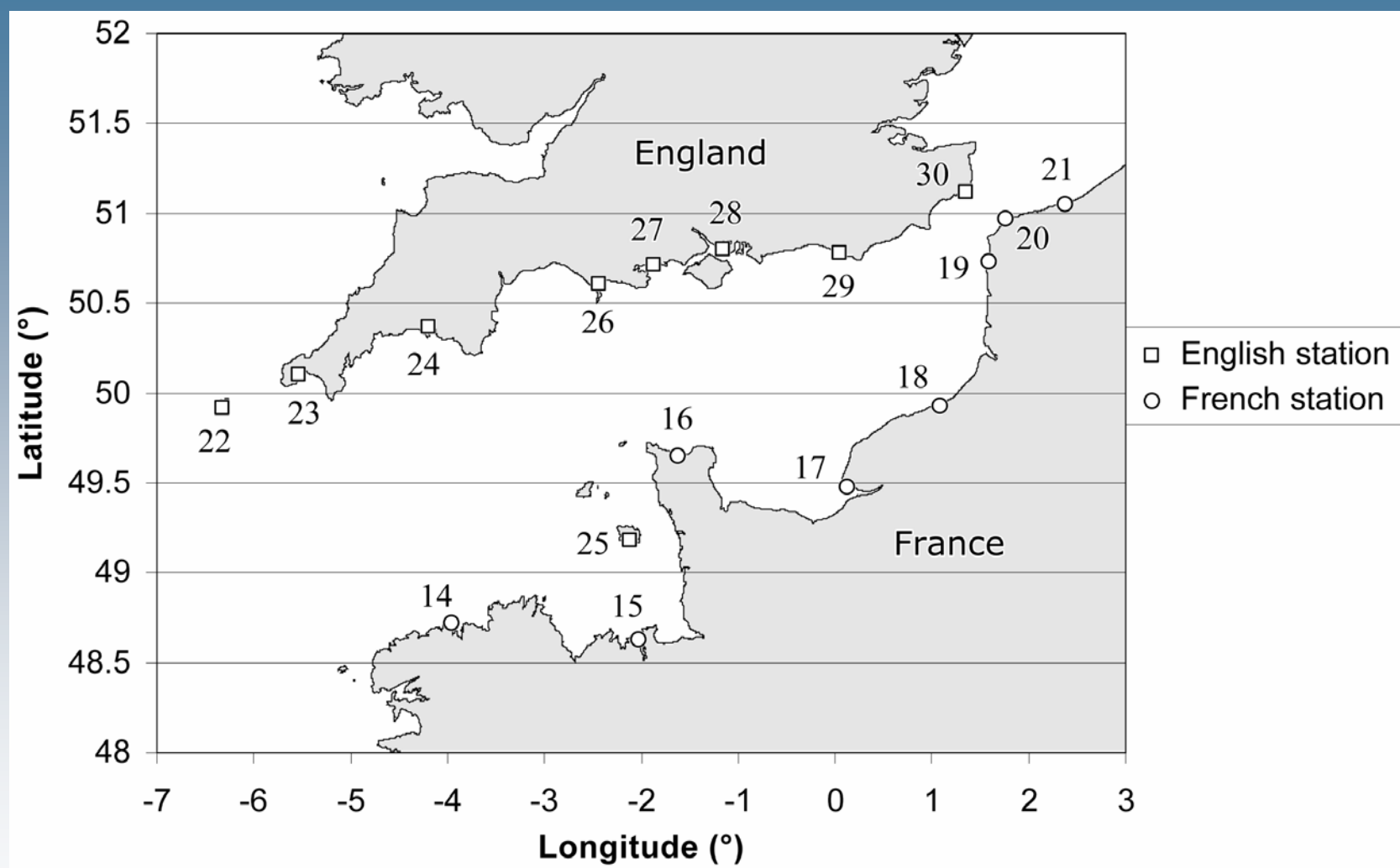
Secular trends in High Waters:

- in the southern North Sea coastline they are greater than those arising from mean sea level alone
- in the Channel they are less than or equal to those arising from mean sea level increases.

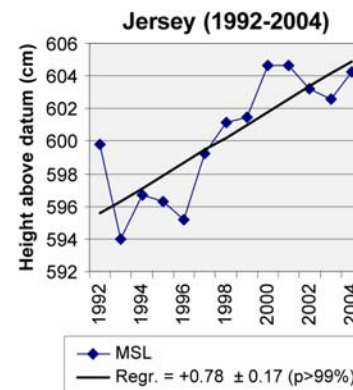
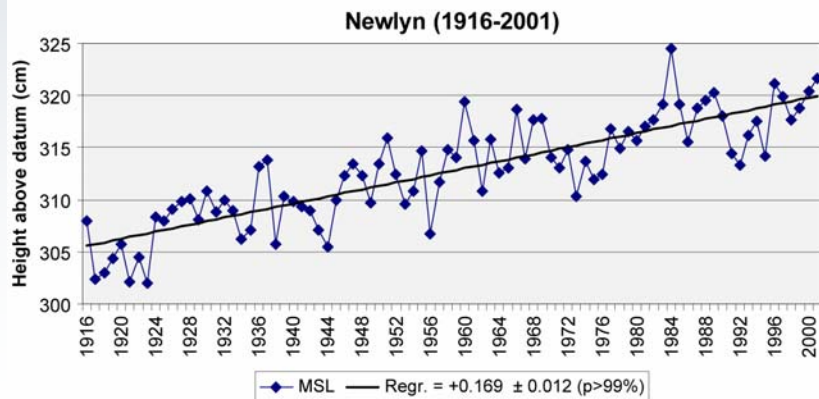
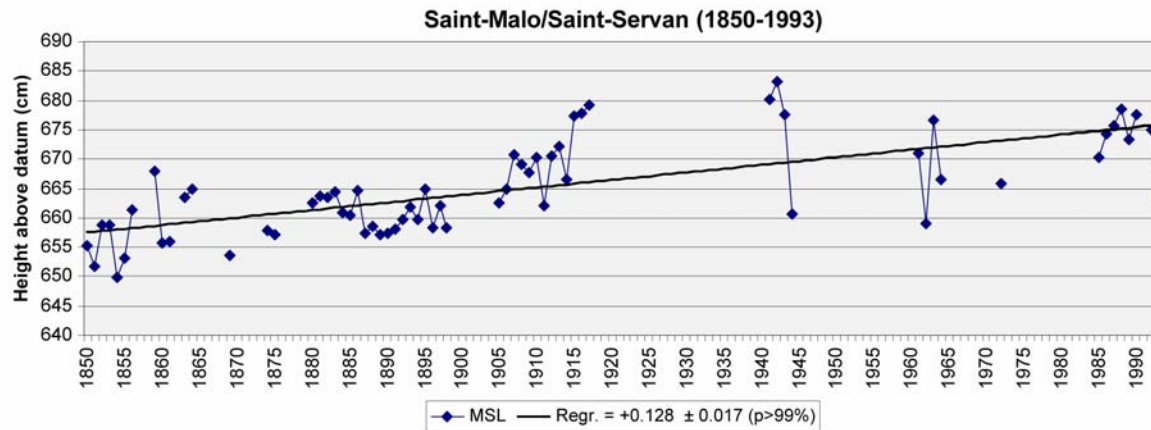
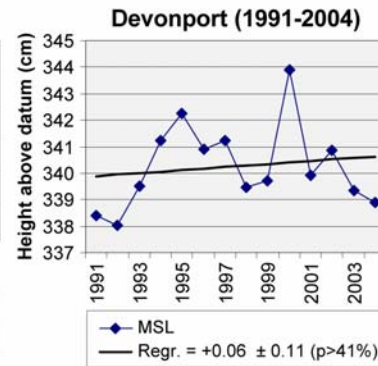
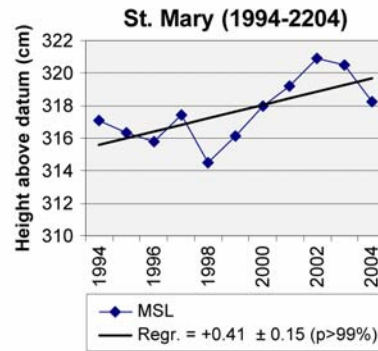
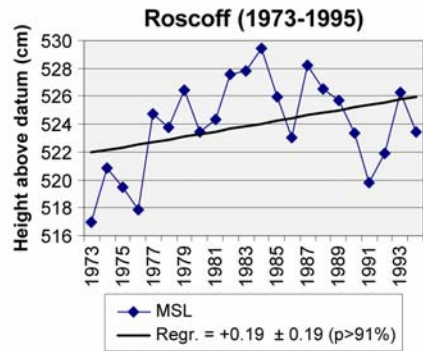
Tidal ranges are increasing along the southern North Sea coastline, with High Water levels increasing more rapidly than Low Waters.

*Tentative estimation of extreme sea levels in the
English Channel by the year 2050*

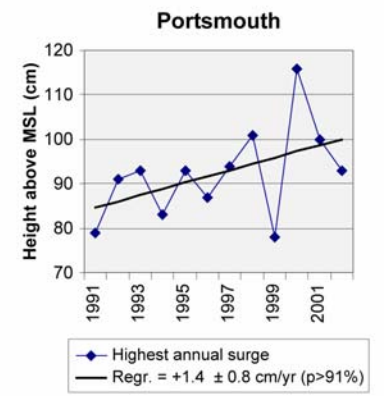
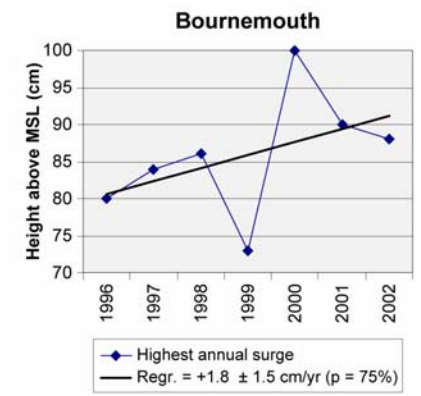
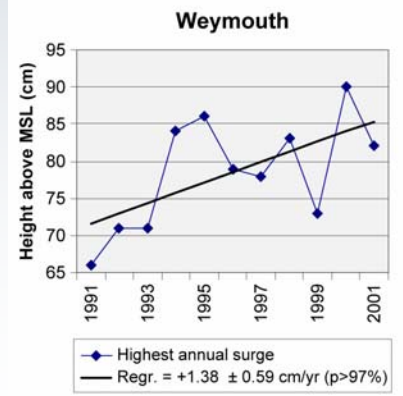
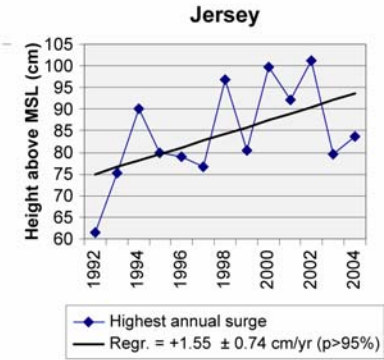
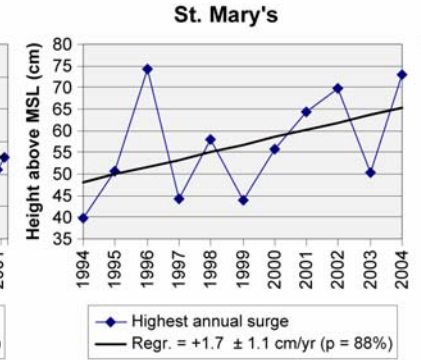
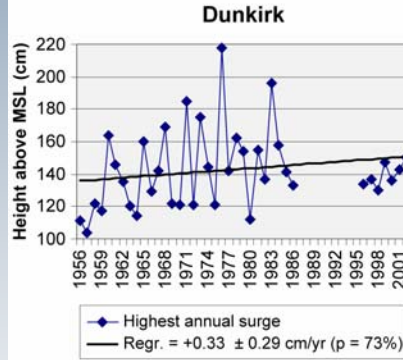
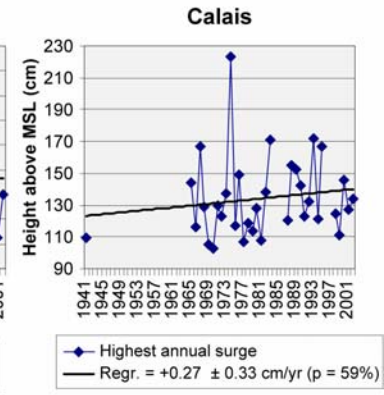
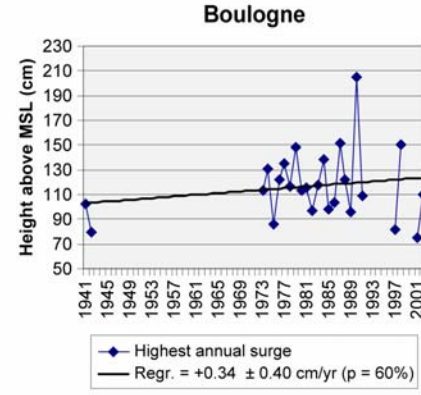
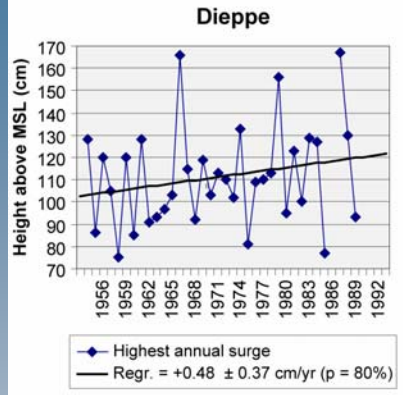
Pirazzoli, P.A. & Tomasin, A.



MSL



Maximum annual surges



Pirazzoli, P.A. and Tomasin, A. "Tentative estimation of extreme sea levels in the English Channel by the year 2050"								
Station	Lat.	Long.	Record length (equivalent full years)	Maximum recorded height (cm)	Maximum recorded surge (cm above MSL)	Height estimations (cm) in the year 2000 for return times of:		
						10 yr	50 yr	100 yr
14. Roscoff	48.72	-3.96	20.2	994	98	988	1,002	1,009
15. St.-Malo/ St.-Servan	48.63	-2.03	46.3	1,368 ^a	192	1,347	1,369	1,377
16. Cherbourg	49.65	-1.63	28.6	715	135	704	721	729
17. Le Havre	49.48	0.12	32.5	899 ^a	202	880	903	915
18. Dieppe	49.93	1.08	31.3	1,058 ^a	167	1,033	1,056	1,066
19. Boulogne	50.73	1.58	17.4	980	205	971	996	1,006
20. Calais	50.97	1.66	26.6	817	223	802	827	839
21. Dunkirk	51.05	2.37	33.9	735 ^a	218	707	736	749
22. St. Marys's	49.92	-6.32	10.3	644	74	645	658	662
23. Newlyn	50.06	-5.33	84.4	641 ^a	118	622	638	643
24. Devonport	50.37	-4.19	12.2	634	94	632	646	652
25. Jersey	49.18	-2.12	11.8	1,219	101	1,215	1,234	1,242
26. Weymouth	50.61	-2.44	10.5	289	90	288	303	310
27. Bournemouth	50.71	-1.87	6.5	280	100	283	299	305
28. Portsmouth	50.80	-1.16	10.9	549	116	547	563	571
29. Newhaven	50.78	0.05	14.7	769	132	764	781	788
30. Dover	51.12	1.35	39.9	805 ^a	175	783	809	820

Pirazzoli, P.A. and Tomasin, A. "Tentative estimation of extreme sea levels in the English Channel by the year 2050"								
Station	Overtaking of the tidal peak above the hourly value (cm)	Local relative MSL rise (from Fig. 2) (cm)	Global sea-level rise (IPCC, 2001) (cm)	Increase of maximum annual surges (from Fig. 3)(cm)	Maximum total height (cm) in the year 2050 for return times of :			Height of the present maximum astronomical tide (cm)
					10 years	50 years	100 years	
14. Roscoff	+10	+9.5±5.5	+17±12	±0?	1,025±13	1,039±13	1,046±13	973
15. St.-Malo / St.-Servan	+19	+6.4	+17±12	±0?	1,389±12	1,411±12	1,419±12	1,347
16. Cherbourg	+14	+7.5±2	+17±12	±0?	742±12	760±12	768±12	703
17. Le Havre	+20	+9±2	+17±12	±0?	926±12	949±12	961±12	843
18. Dieppe	+17	+26.5±3.5	+17±12	+24±18.5 ?	1,117±22?	1,141±22?	1,151±22?	1,000
19. Boulogne	+21	+22±3	+17±12	+17±20?	1,048±24?	1,073±24?	1,083±24?	942
20. Calais	+22	±0 ?	+17±12	+13.5±16.5	854±20?	880±20?	892±20?	773
21. Dunkirk	+22	+10.5±2.5	+17±12	+16.5±14.5 ?	773±19?	802±19?	815±19?	648
22. St. Mary's	+10	+20±7	+17±12	+85±54?	777±-56?	790±56?	794±56?	624
23. Newlyn	+12	+8.5±0.6	+17±12	±0?	659±12	675±12	680±12	605
24. Devonport	+10	+3±5	+17±12	±0?	662±13	676±13	672±13	606
25. Jersey	+10	+39±8.5?	+17±12	+78±37	1,359±40?	1,378±40?	1,386±40?	1,209
26. Weymouth	+10	+49±9.5	+17±12	+69±29.5	433±33	448±33	455±33	269
27. Bournemouth	+10	+46.5±6	+17±12	+90±75?	446±76?	462±76?	468±76?	244
28. Portsmouth	+12	+55.5±8	+17±12	+70±40	701±43	717±43	725±43	519
29. Newhaven	+13	+3±9	+17±12	±0?	797±15	814±15	821±15	739
30. Dover	+18	+8±2.5	+17±12	±0?	826±12	878±12	889±12	736

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