Journal of Coastal Research	9	4	1136–1141	Fort Lauderdale, Florida	Fall 1993

DISCUSSION

Discussion of: Masselink, G., 1992. Longshore variation of grain size distributions along the coast of the Rhone Delta, Southern France: A test of the "McLaren Model". *Journal of Coastal Research,* 8(2), 286–291.

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INTRODUCTION

The paper by MASSELINK (1992) undertook a sediment trend analysis on 29 beach face samples according to a theory presented by MCLAREN and BOWLES (1985). The theory demonstrates how grain-size distributions must change in the direction of transport and describes a simple statistical technique to infer transport direction from these changes. The results achieved by Masselink were contrary to the expected longshore transport direction and he concluded that the use of the model is limited when applied to the nearshore zone.

Since the inception of the model (MCLAREN, 1981), many authors have supported the theory (see for example: HANER, 1984; DE MAEYER and WARTEL, 1988; LIVINGSTONE, 1989; PRAKASH and PRITHVIRAJ, 1988; MILES, 1988; CARTER, 1988; NORDSTROM, 1989; COLLINS, 1989). The statistical technique to determine a significant transport trend has been questioned and discussed by GAO and COLLINS (1991), and at least one paper vehemently denied assumptions that are supposedly underlying the theory (FLEMMING, 1988).

Yet other authors appear unable to make up their minds. In a paper by AMOS and NADEAU (1988), the technique was discounted altogether after a sediment trend analysis failed to agree with their interpretation of sediment transport on the Scotia Shelf. Paradoxically, AMOS and JUDGE (1991) use the results of a sediment trend analysis to support their findings of the transport regime on the Grand Banks.

As is frequently the case, there can be major difficulties encountered between the presentation of a theory and its correct application. Because this approach is now used widely for consulting purposes, there has been little effort to publish the precise techniques required to exploit the theory successfully. Furthermore, effective application requires, as in all models, a qualitative judgement that seldom finds a place for adequate description in the scientific literature.

The purpose of this discussion, therefore, is not to elaborate on the theory, nor to defend it, but simply to reassess the data and provide an alternative interpretation. In this, the author is grateful for the cooperation of Dr. Masselink in providing him with the original grain-size distributions for a re-analysis of the transport trends. It is recognized that Dr. Masselink was unaware of much unpublished information regarding the application of the theory, and an attempt has been made to fill this gap in the paper by MCLAREN *et al.* (1993) which is contained in this issue of the Journal of Coastal Research.

SEDIMENT TRENDS

Data Base

Only 28 of the 29 samples were available for the new analysis (the grain-size data for sample 1 has been lost). As described in MASSELINK (1992), the sediments were collected at 1 km intervals from the mouth of the Grand Rhone to Beauduc (Figure 1). The top few centimetres from the mid-beachface were taken, both organic matter and calcium carbonate were removed, and the distributions were obtained by sieving at ¼ phi intervals.

Based on empirical experimentation, it has been found that differences in grain-size distributions are best determined using ½ phi class intervals. In general, smaller class intervals result in an in-

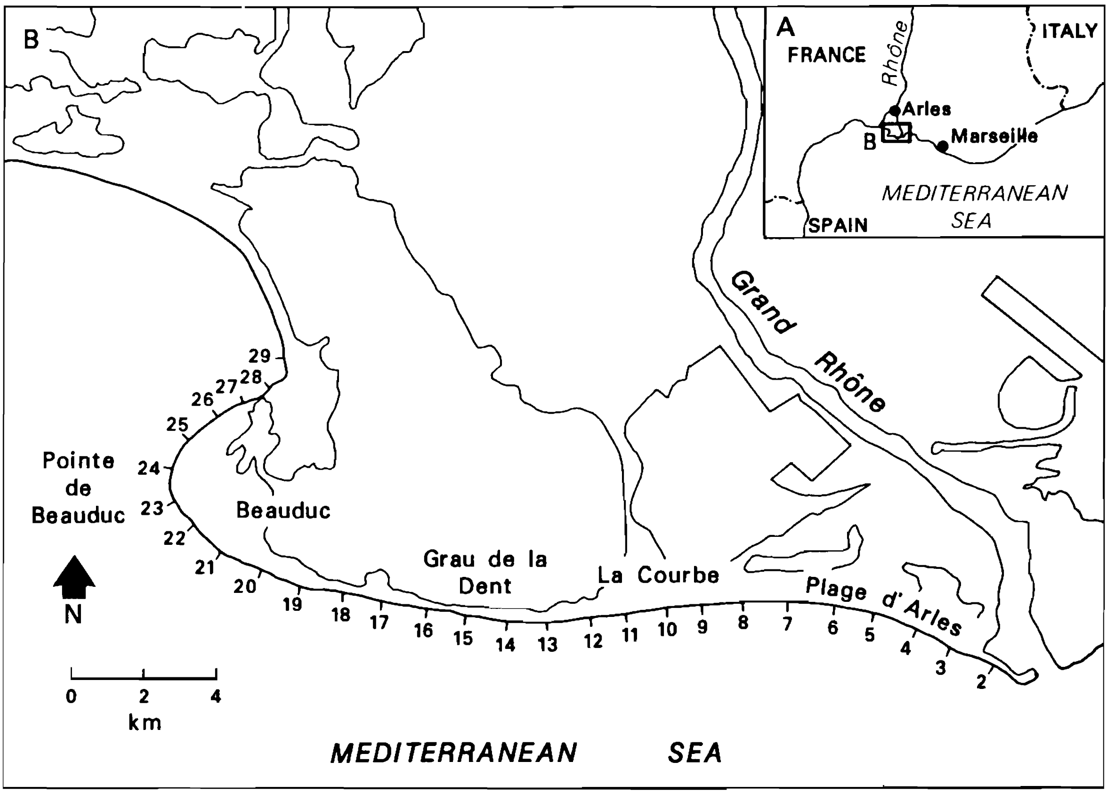

Figure 1. Sample location map.

crease in "distribution noise", whereas information is lost when larger class intervals are used (BOWLES and MCLAREN, 1985). Because these sediments fall into an unusually narrow size range (0.75 phi to 3.0 phi), no attempt was made to reduce the number of class intervals.

Interpretation

In order to repeat Masselink's findings, all 28 samples were examined for a trend. Despite the trend statistics (Table 1) which indicate a Case C (sediment coarsening) transport regime in the eastward direction, this trend as determined by Masselink must be considered unreliable for two reasons. First, the R^2 value is extremely low (0.13; Table 1) indicating that there is a poor "transport-relationship" among the 28 samples. In this case, it is likely that more than one transport system has been sampled. Second, the derived X-distribution for the trend produces a shape that cannot be accepted (Figure 2). The meaning of both R^2 and the X-distribution is discussed more fully in MCLAREN *et al.* (1993).

In order for a trend to be determined on a strictly statistical basis, a minimum of 9 samples in a sequence is required. On rejecting the trend comprised of all 28 samples, further trends were looked for using 9 samples at a time (*i.e.* samples 2 to 10, 3 to 11, 4 to 12, *etc.*). This approach identified three distinct regimes referred to as East Beach, Centre Beach and West Beach, respectively (Table 1; Figure 3). For East Beach, no trends could be determined. Samples from Centre Beach produced a trend showing net westward transport and an X-distribution indicative of net accretion (Figure 4). The R^2 value, however, is very low (0.40; Table 1). The remaining seven samples from West Beach indicate an eastward, high energy sediment transport regime with an X-distribution suggesting dynamic equilibrium (Figure 5). Although much higher than that for Centre Beach, the R^2 value is still fairly low (0.73; Table 1).

Table 1. *Sediment trend statistics for beach face samples on the Rhone delta.*

Sample Line	Case	R^2	Direction	N	x	Z	Status
All samples 2-28	B	0.13	E	378	18	−4.55	Unacceptable X-distribution
			W		51	0.58	
	C		E		154	16.60*	
			W		25	−3.46	
East Beach 2-11	B	N/A	E	45	1	−2.09	No trend
			W		5	−0.28	
	C		E		9	1.52	
			W		2	−1.63	
Centre Beach 11–22	B	0.40	E	66	3	−1.95	Net accretion
			W		22	5.12*	
	C		E		11	1.02	
			W		9	0.28	
West Beach 23-29	B	0.73	E	21	4	0.91	Dynamic equilibrium
			W		2	−0.41	
	C		E		8	3.55*	
			W		1	−1.07	

Case B = Sediments become finer, better sorted and more negatively skewed in the direction of transport
Case C = Sediments become coarser, better sorted and more positively skewed in the direction of transport
R^2 = multiple correlation coefficient derived from the mean, sorting and skewness of each sample distribution along the line. This is a relative indication of how well the samples are related by transport
N = number of possible pairs in the line of samples
x = number of pairs making a particular trend in a specific direction
Z = Z-score statistic. (*) are those trends significant at the 99% level
Status = interpretation of the X-distribution (*i.e.* net erosion, accretion, dynamic equilibrium *etc.*). For a complete explanation see McLaren *et al.* (1993) (this journal)

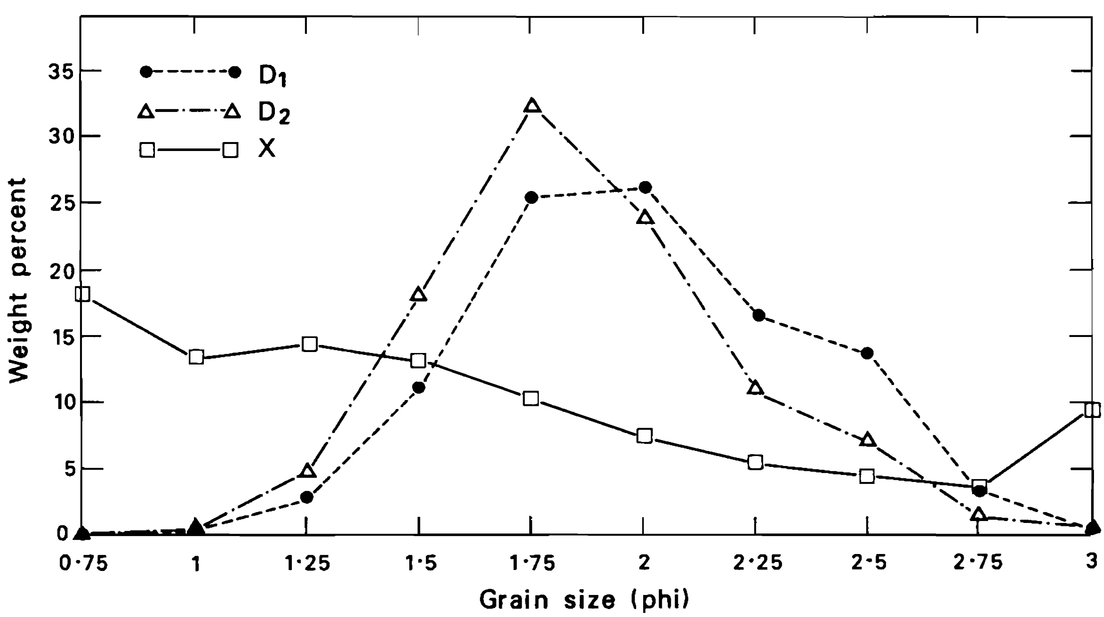

Figure 2. D_1, D_2 and X-distributions derived for all 28 samples. D_1 represents the average "up-current" sample and D_2 the average "down-current" sample. The shape of the X-distribution is anomalous and the trend cannot be accepted. (Compare with Figure 3 in McLaren *et al.*, 1993.)

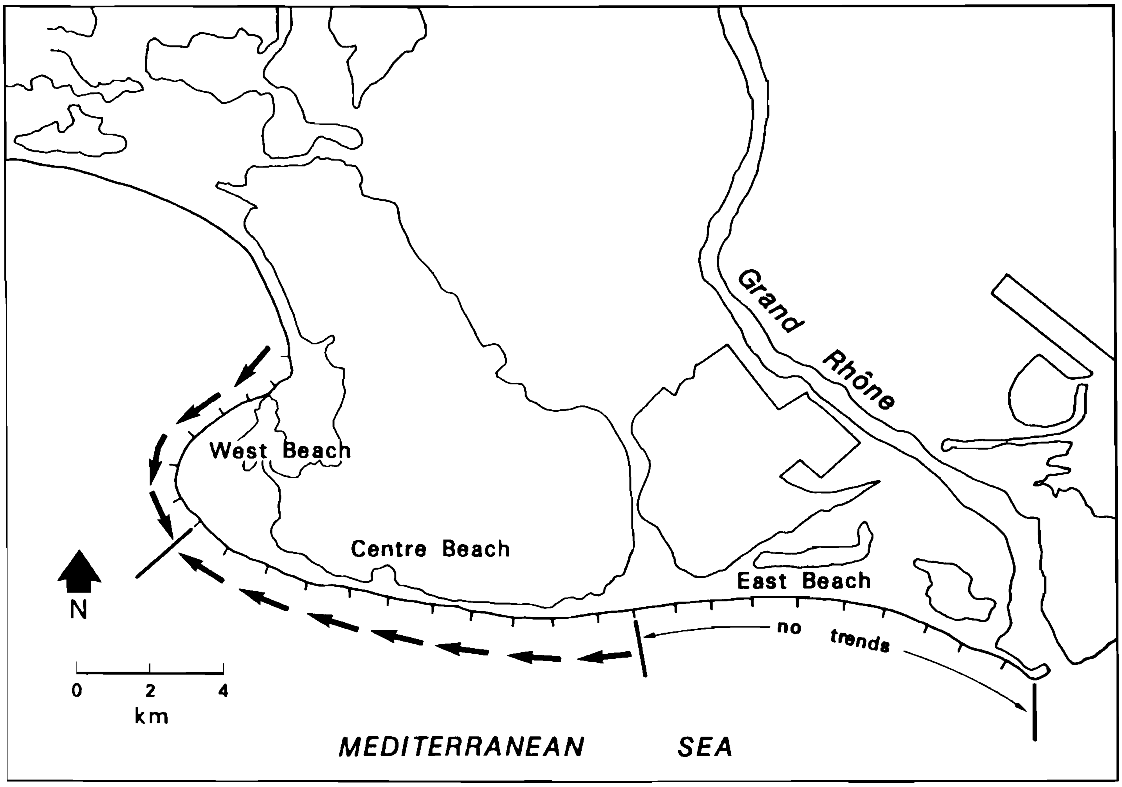

Figure 3. A re-interpretation of the sediment transport pathways on the beach face of the Rhone delta.

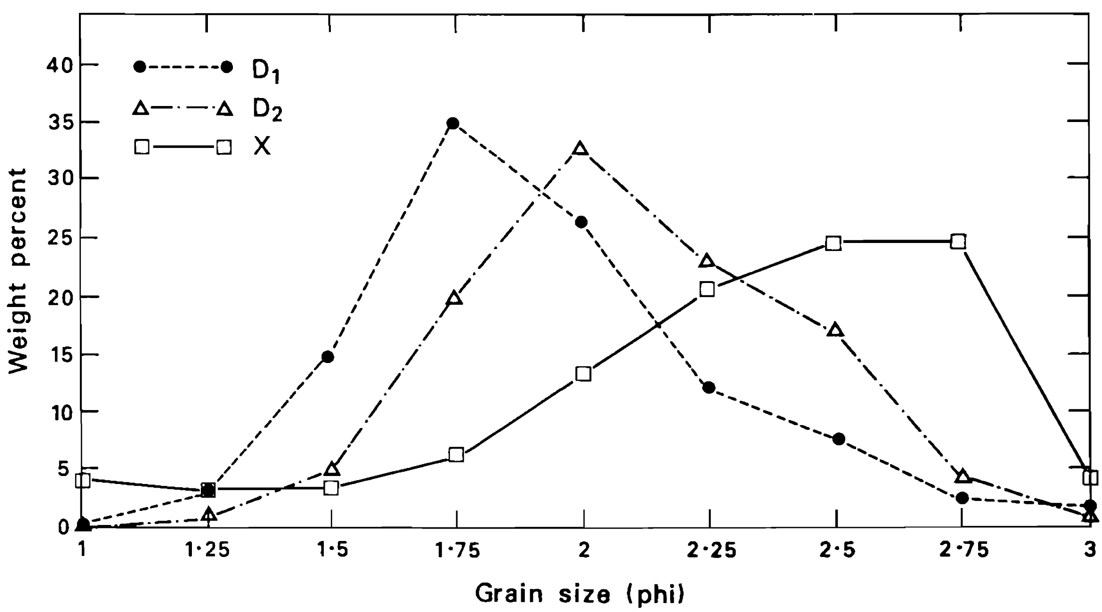

Figure 4. D_1, D_2 and X-distributions for Centre Beach indicating net accretion along the transport path.

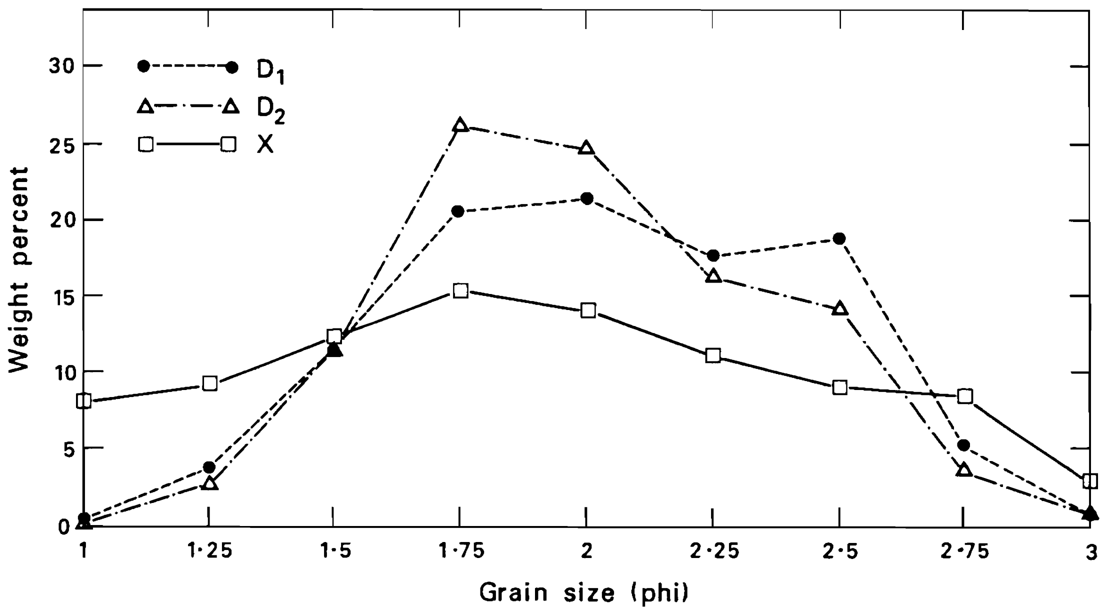

Figure 5. D_1, D_2 and X-distributions for West Beach indicating that these sediments are in dynamic equilibrium.

DISCUSSION

The delineation of three distinct transport environments along the length of beach under study fits almost exactly with the morphology of its plan view. East Beach which contains no trends is defined by a concave shape, and here the beach is possibly attempting to align with the dominant wave approach. The absence of any trend certainly suggests that onshore-offshore movement of sediment must dominate over a longshore transport regime. Centre Beach is essentially convex and westward transport accompanied with net accretion could be expected in the direction of Pointe de Beauduc, a cuspate foreland. Finally, on the northwest side of Pointe de Beauduc (West Beach) the transport direction is reversed suggesting that the foreland is being maintained by transport from both directions.

Neither of the trends for Centre and West Beaches is particularly strong (*i.e.* R^2 values are low). For this reason, there would, ordinarily, be little effort made to justify these results on the basis of a single line of samples. Nevertheless, the re-interpretation shows clearly that this stretch of beach does not belong to a simple, unidirectional transport system which was assumed by Masselink at the start of his analysis. The full behaviour of the beach can only be determined by extending the sediment trend analysis to discover the precise relationships between the beach and the offshore.

It should also be emphasized that the top few centimetres of beach face will not provide an indication of the long-term erosion events that characterize this coastline. According to MASSELINK (1992), the entire coast between Grand Rhone and Pointe de Beauduc is eroding. This does not preclude the finding that, over the time interval represented by the samples, the sediments are accreting towards Pointe de Beauduc and are in dynamic equilibrium on West Beach.

Masselink suggests that the technique of sediment trends requires three major assumptions which are violated in the nearshore zone. First, that uni-directional flow is assumed. This is incorrect. To prove the changes that must occur in grain-size distributions in the direction of transport, a uni-directional net sediment transport is assumed, not a uni-directional flow. Regardless of all the pathways that particles in a "transport-population" might be subjected to, the final deposits can only produce one net sediment transport direction.

Second, the sediment in transport must be derived from a single source. FLEMMING (1988) also incorrectly inferred this assumption from the McLaren and Bowles (1985) paper despite its assertion: "We now wish to determine the relative changes in sediment distributions among sequential deposits D_1, D_2, D_3, . . . , bearing in mind that r(s), t(s) and (frequently) g(s) are not observable". (r(s), t(s) and g(s) are the distributions of the sediment in transport, the probability of each size going into transport, and the distribution of a hypothetical "source sediment".) Although a hypothetical source distribution is required in the proof, it is irrelevant in the application of the sediment trend model. Sediment in transport might have a huge variety of sources which, when mixed, form deposits according to the principles of the theory. In fact, the correct application of the technique will clearly identify the introduction of new sources and has proven to be particularly useful in determining the fate and behaviour of dredged material at designated disposal sites.

Third, Masselink suggests that the model assumes net sediment transport is the primary factor in causing textural trends. This is *not* an assumption of the model, rather it is a conclusion that is self-evident by its successful application in environments that include lakes, rivers, deltas, beaches, estuaries, and open ocean.

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