Application of a semiempirical longshore transport formulation

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1. Introduction

The present paper deals with the determination of longshore sediment transport rate. Specifically, case study of Saline Joniche (Reggio Calabria, Italy, see fig. 1) is discussed. This case is of interest because, in this location, an artificial basin was built in the 70's. After few years, port entrance experienced total obstruction by sand (fig. 2). Actually, the area is abandoned and several projects have been proposed for revitalising port activities.

- *Objective*: this paper discusses a method for estimating the longshore sediment transport rate at Saline Joniche and complements previous methodology.

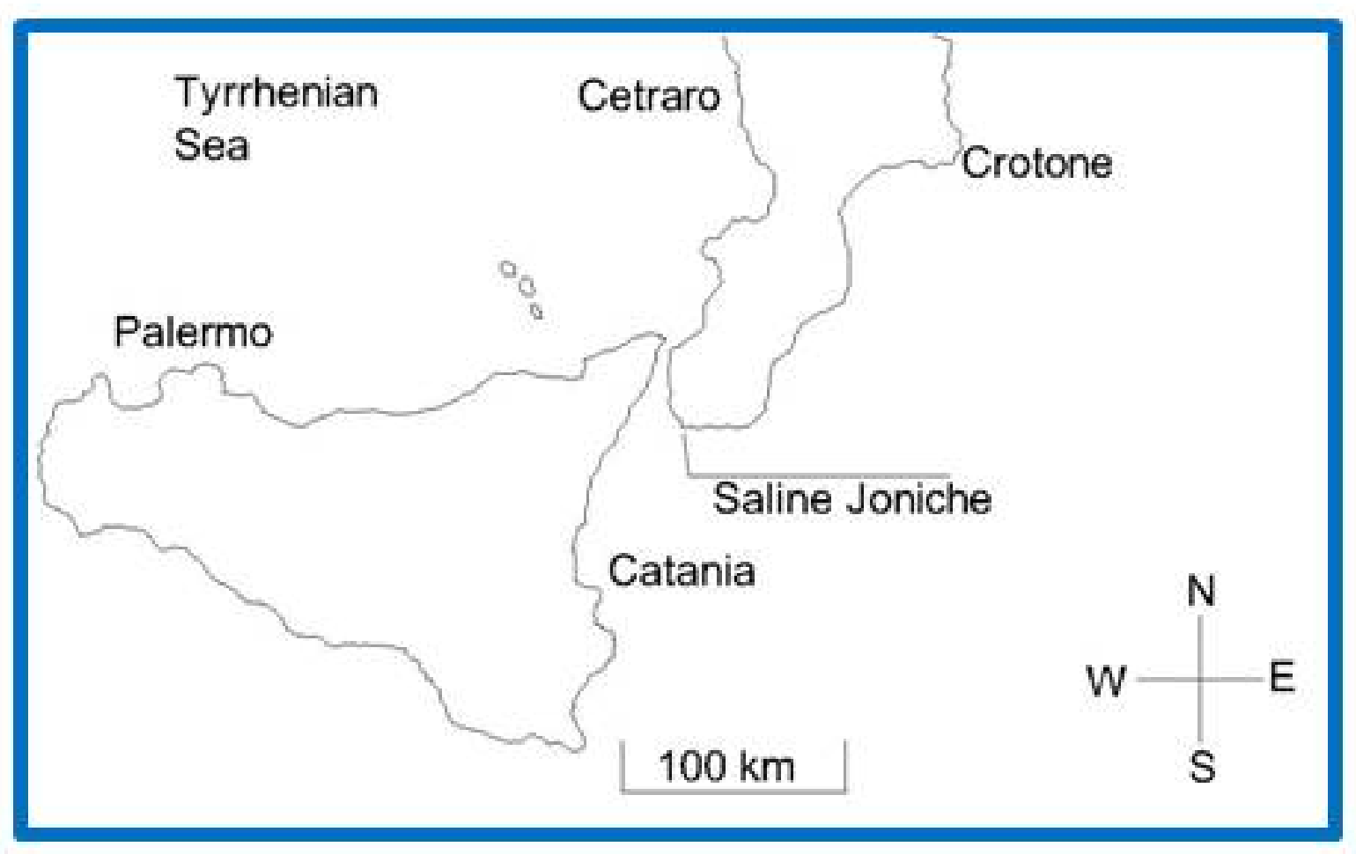

Figure 1. Location of Saline Joniche.

Figure 2. View of the port. Obstruction is highlighted.

3. Results

The method is applied in conjunction with wave data available in the location. Data gives the number of sea states having significant wave height and dominant direction within a certain interval. Data are utilized by the following procedure:

1. Wave data are partitioned in sectors of 10°. Then, only waves propagating to the shoreline are processes;
2. Frequency f_{ji} of a certain significant wave height interval is calculated in each sector;
3. Longshore transport rate Q_{ji} is calculated for each sector j and for each significant wave height interval i, by method discussed in section 2;
4. Longshore transporte Q_j associated to a certain direction of wave propagation is obtained as

$$Q_j = \sum_{i=1}^{n} Q_{ji} f_{ji} \qquad (5)$$

being n the number of significant wave height intervals.

Results are shown in fig. 3. Each bar denotes the mean longshore transport rate per year due to waves moving from a certain sector.

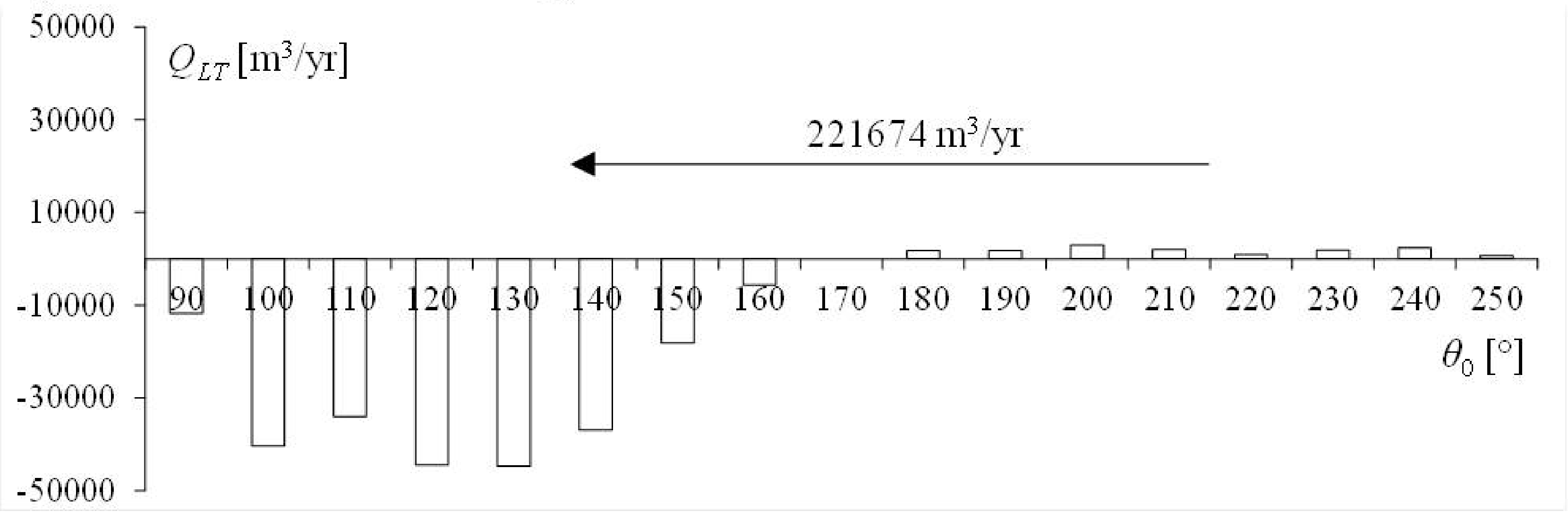

Figure 3. Longshore sediment transport rate.

2. Method

The method for calculating the longshore transport was proposed by Lamberti and Tomasicchio (1997) for rouble-mound breakwaters and extended by Tomasicchio et al. (2013) for application to sandy beaches. It is based on semiempirical formulation of the problem. It involves calculation of a modified stability index, which accounts for sea wave and sediment characteristics. The formulation is semiempirical, because specific empirical correlations between factors defining the longshore transport and the modified stability index must be utilized. Specifically, the longshore transport is determined by the equation

$$\frac{S_N}{\sin \beta_{kb}} = \frac{l_d}{D_{n50}} \frac{N_{od}}{1000} \qquad (1)$$

where: S_N is the transport measured as number of transported stones per wave, β_{kb} is the wave obliquity at the breaking point (it is assumed that the element moves with obliquity equal to the wave obliquity), l_d is the displacement length of the unit, D_{n50} is the mean nominal diameter of stones (side length of an equivalent volume cube), N_{od} is the "damage index" representing the number of stones removed from a 1 D_{n50} wide strip. Quantities l_d/D_{n50} and N_{od} depend on the *modified stability number,* N_s^{**}:

$$N_S^{**} \equiv \frac{H_k}{C_k \Delta D_{n50}} \left(\frac{s_{m0}}{s_{mk}} \right)^{-1/5} (\cos \beta_0)^{2/5} \cong \frac{0.89 H_{kb}}{C_k \Delta D_{n50}} \qquad (2)$$

where: H_k is a characteristic wave height, Δ is the relative density, C_k is the ratio between H_k and the significant wave height H_s, s_{m0} the wave steepness at offshore conditions and s_{mk} the reference steepness (assumed equal to 0.03). N_s^{**} is a modification of the traditional stability number accounting for the effects of a non-Rayleighian wave height distribution (in shallow waters), of wave steepness, of wave obliquity, while it maintains the numerical value of the traditional stability number for average values of these last two factors. N_s^{**} can be given as a function of the characteristic breaker height, H_{kb}, by considering that $s_{mo} = s_{mk} = 0.03$.

Specific formulae are calibrated for determining l_d/D_{n50} and N_{od}. By processing longshore field and laboratory data, the following relations were proposed:

$$\frac{l_d}{D_{n50}} = \frac{1.4 N_s^{**} - 1.3}{\tanh^2 (kd)} \qquad (3)$$

$$N_{od} = \begin{cases} 20 N_s^{**} (N_s^{**} - 2)^2; & for \;\; N_s^{**} \le 23 \\ \exp[2.724 \ln(N_s^{**}) + 1.123]; & for \;\; N_s^{**} > 23 \end{cases} \qquad (4)$$

The calibration utilizes the following data: Van Hijum and Pilarczyk, 1982; DUCK85, Kraus, 1989; Burcharth and Frigaard, 1987, 1988; Van der Meer and Veldman, 1992; Schoonees and Theron, 1993; Wang et al., 1998; SANDYDUCK - Miller, 1999; LSTF - Smith et al., 2003.

4. Conclusions

The calculation shows that there is a prominent direction of propagation. Most sediments are transported to the North-West direction. Further, the total mean longshore transport rate is calculated. The result implicitly shows that obstruction problem could be predicted by longshore transport analysis. However, result is expected to be beneficial also for implementing solutions to the obstruction problem.

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