SHORT TERM MOBILITY 2015
FINAL REPORT

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1. OBJECTIVES

The overall objectives of the STM in subject were:
-to review observations and data (often only available as grey literature or institutional reports) about water and sediment discharge from Balkan rivers to the Adriatic Sea.
-to begin assessing main features and oceanographic implications of Balkan river discharge to oceanographic and sediment-transport regimes
-to pave the way to improve current understanding of basin-wide sediment pathways, with the identification of main sources, erosional hotspots and depositional sinks of pelagic and terrigenous sediment.

2. BACKGROUND

Albania and Montenegro have the largest free flowing and relatively untouched river stretches in the Balkan countries and probably in Europe (Milliman and Meade, 1983; Simeoni et al., 1997). Presently, the Drin is the only river that has undergone a major hydrodynamic and sediment transport control resulting from hydropower reservoir construction. Large rivers, such as the Vjosa, Shkumbin and the Seman system (Seman-Devoll-Osam) have not been interrupted by dams until recently, but the construction of a large number of plants is planned throughout the hydrographic network of Albania.

Simeoni et al. (1997) estimate that 50×10^6 tons/year is currently discharged by rivers along the Albanian coastline, and that 65×10^6 tons/year for the

period 1948-1990 (with an average water discharge of 41.27 $x10^6$ m^3/s. Drini and Semani, with water dischargea much smaller than that of the Po River, historically produced about three times the amount as did the Po (45 vs 15 x 10^6 t/yr). Pano (1992) estimates that dams along the Drini, Mati and Bistrica presently intercept 60-70% of the total sediment transported by the rivers. For some rivers, such as Drin and Buna, the frequent river diversion and possible confluence make impossible to consider such rivers independently. Shkumbini, Semani and Vjose , for instance, collective provide a total sediment load of 32 $x10^6$ tons/year, that is about half of the total sediment load discharged by all Albanian rivers. Simeoni et al. (1997) document the modifications of Shkumbini and Semani rivers during the XX century. Kocileri et al. (2011) provide some estimate of sediment transport in the Devolli river and some of its tributaries, but the sampling methods are not clear.

As of yet, however, we know relatively little about the flux or fate of these sediment, since the source the data still uncertain. To better characterise water and sediment regimes from Balkan rivers, the sparse information currently available should be organised into a database and integrated with estimates produced by conceptual models at the catchment-scale. Of particular importance is the availability of hourly discharge data, which are critical for an accurate estimate of sediment discharge. An accurate estimate of Albanian river contribution of freshwater and sediment to the Southern Adriatic is required, particularly in consideration of regional circulation and sediment transport patterns (e.g., coastal currents, dense shelf-water formation, and off-shelf downflow, along-slope contour currents.) and their impacts in terms of sediment, biogeochemical transport and seabed geomorphology.

3. FIRST RESULTS

The prime purpose of Prof. Milliman visit under the Short Term Mobility grant to CNR-ISMAR, Venice, was to discuss linkage between terrestrial and marine sedimentary processes, specifically, land erosion and the flux and fate fluvial sediments into the Adriatic Sea.

Most geologists have considered that the northern Italian rivers, specifically the Po and adjacent rivers, provide as the prime sedimentary sources for the Adriatic. While it is true that these rivers discharge the bulk of sediment deposited in the northern Adriatic, reported sediment discharge from Albanian rivers – notably the Vjose, Drin, Buna and Shkumbin rivers –

contribute as much as 60-70 percent of all sediments entering the Adriatic (Milliman and Farnsorth 2011).
Why Albanian rivers contribute so much sediment is still not fully understood, but presumably it is a function of basin geometry and topography as well as their small size and thus lack of adequate storage areas (Milliman and Syvitski, 1992), being the average slope of all territory more than 27%, high rainfall rate (1800-2300 mm/year) Cullaj et al., 2005, land use (Grazhdani & Shumka, 2007), and frequent earthquakes and high rainfall rate. To the international community, the fate of the sediments coming from the southwest Adriatic region is, therefore, very poorly understood (Carniel et al., 2015).

Geochemical data suggest that some of the sediment may be also flushed offshore into the Adriatic deep, presumably via density currents (e.g., Mulder et al., 1998). Recent works employing a high-resolution numerical model with bathymetry resulting from last-generation multibeam surveys confirm that this may be the case (Bonaldo et al., 2015). In any case, the flux of these sediments may have important societal relevance; indeed, such sediments appear to be highly polluted, possibly the result of poor environmental controls in Albania during the 50-year period between 1945 and 1995.

To understand more fully the importance of the flux and fate of these sediments first requires assurances that the reported sediment discharge values from Albanian rivers – as well as smaller Italian rivers draining into the western Adriatic – in fact are accurate. Small rivers characterised by small catchment tend to be highly episodic, floods often lasting only a few hours; consequently temporal changes in sediment concentrations – and hence sediment discharge are best documented from hourly discharge data. Hourly data from Taiwanese rivers, for example, often show an order of magnitude greater sediment discharge than would be calculated using daily discharge values (Milliman and Farnsworth, 2011).

During the staying a series of literature has been and reviewed, including:

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Hamzaraj, E., Lazo, P., Paparisto, A., Duka, S., Mavromati, J., Halimi, E., & Topoviti, D. (2014). AN OVERVIEW OF WATER QUALITY OF VJOSA RIVER IN ALBANIA BASED ON BIOLOGICAL AND CHEMICAL PARAMETERS. *International Journal of Advances in Engineering & Technology*, *7*(5), 1359–1374.

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Pano, N. (1992). Dinamica del litorale albanese (sintesi delle conoscenze). In *X Congresso della Associazione Italiana di Oceanografia e Limnologia (in Italian)* (pp. 3–10). Alassio.

Pano, N., & Avdyli, B. (2009). A Method to Estimate Buna River Discharge, Albania, (4), 66–72.

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Pano, N., Frasheri, A., & Avdyli, B. (2010). The climatic change impact in water potential processes on the Albanian hydrographic river network. *Modelling for Environment's Sake: Proceedings of the 5th Biennial Conference of the International Environmental Modelling and Software Society, iEMSs 2010*, *1*, 927–933.

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Tomadin, L. (2000). Sedimentary fluxes and different dispersion mechanisms of the clay sediments in the Adriatic Basin. *Rendiconti Fisica Accademia Dei Lincei*, *11*, 161–174.

4. OPEN ISSUES, NEEDS AND GAPS

After the preliminary assessment carried out during the STM grant, we can better address some needs and gaps. These aspects will need to be analyzed in the next future, benefiting from a continuation of the activity performed during the short visit, and will have to involve other ISMAR branches (e.g., marine geology).

Frequency of data acquisition

One key question, then, is whether reported Albanian and eastern Italian river sediment values are derived from hourly or daily discharge data? Stated another way, before an accurate investigation on the fate of the Albanian river sediment in the Adriatic Sea may be carried out, we need to

know more accurately the actual flux: are the reported values accurate or (perhaps) underestimated?

Climate Change effects

At the same time, we are interested in the possible effect that climate change may have on discharge – and thus fate – of Albanian river sediment. As the "snow-line" becomes ever higher due to climatic warming, what were once heavy snowstorms now become rainstorms, which could increase the number of rapid flooding events. This could increase the sediment discharge to the coastal ocean.

Overall sediments fate

Once the flux of sediments is better understood, we can then turn our attention to the fate of these sediments. Once again, the results of this study have not only sedimentological and oceanographic significance, but also societal relevance in terms of the distribution and transport of polluted sediments derived from Albanian rivers.

Sea-truth campaign

An oceanographic campaign based on physical and geological survey techniques would be crucial for investigating Eastern Adriatic continental margin morphology, stratigraphy and current regimes. In particular, high-resolution bathymetric and seismic surveys would allow to characterize the fate of terrigenous sediment off the Balkan coasts, while physical observations would allow to describe the mechanisms responsible for along- and off-shelf sediment transport and their relationship with regional ocean circulation.

Numerical Models

In particular, the relationship between ocean circulation and transport and dispersal of terrigenous sediments could be addressed by the use of high-resolution numerical modeling tools, following consolidated and more recent experiences collected in this field by the ISMAR group (e.g. Benetazzo et al., 2013; Falcieri et al., 2014; Benetazzo et al., 2014; Bonaldo et al, 2015; Carniel et al., 2015). Model results could support the explanation of geological evidences collected on the continental margin and the evaluation of the spatial distribution of possibly polluted sediments coming from the Balkan rivers (Dolonec et al., 1998).

5. ON-GOING AND FUTURE COLLABORATIONS

We underline that the STM activity deals with a subject that plays a potentially paramount role in continental margin dynamics and large-scale transport patterns, which at present is just partially accounted for in existing studies.

The subject appears to be particularly promising in the context of the EUSAIR initiatives (http://www.adriatic-ionian.eu/) and USA-Italy bilateral collaboration. Collaboration with VIMS (USA) have been established so that further visits and exchanges have been already planned, in order to allow post-doc and tenured scientists to foster the collaboration. A possible field-test dealing with large-scale sediment flux and transport in the Adriatic region would be extremely welcome, and could possibly be framed within the already funded initiatives (e.g. RITMARE National Flagship project).

Due acknowledgement of support received by CNR will be be made in any publication divulgating results deriving from such research activity. All data and technical – administrative or scientific information which the Contractor will gain possession of during the carrying out of the above-mentioned undertaking, will be and will remain confidential.

6. REFERENCES

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