

Quantifying sediment dynamics and intermittency of gravel bed rivers across the Corinth Rift, central Greece

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1) Motivation and Aims

Grain-size and sediment supply is a fundamental control on the sedimentary record. Currently we lack field-derived constraints on sediment release in rifts at a regional scale.

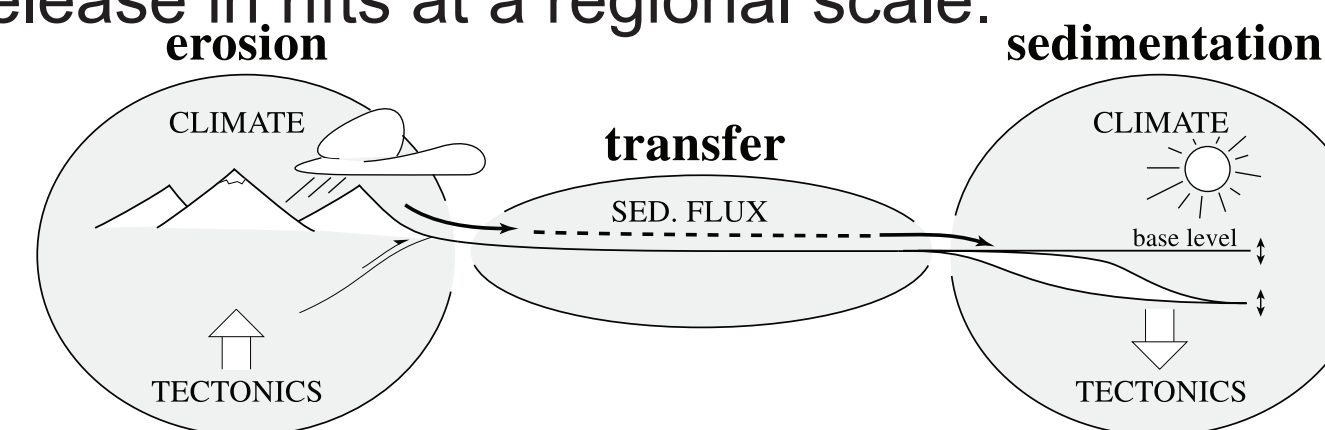


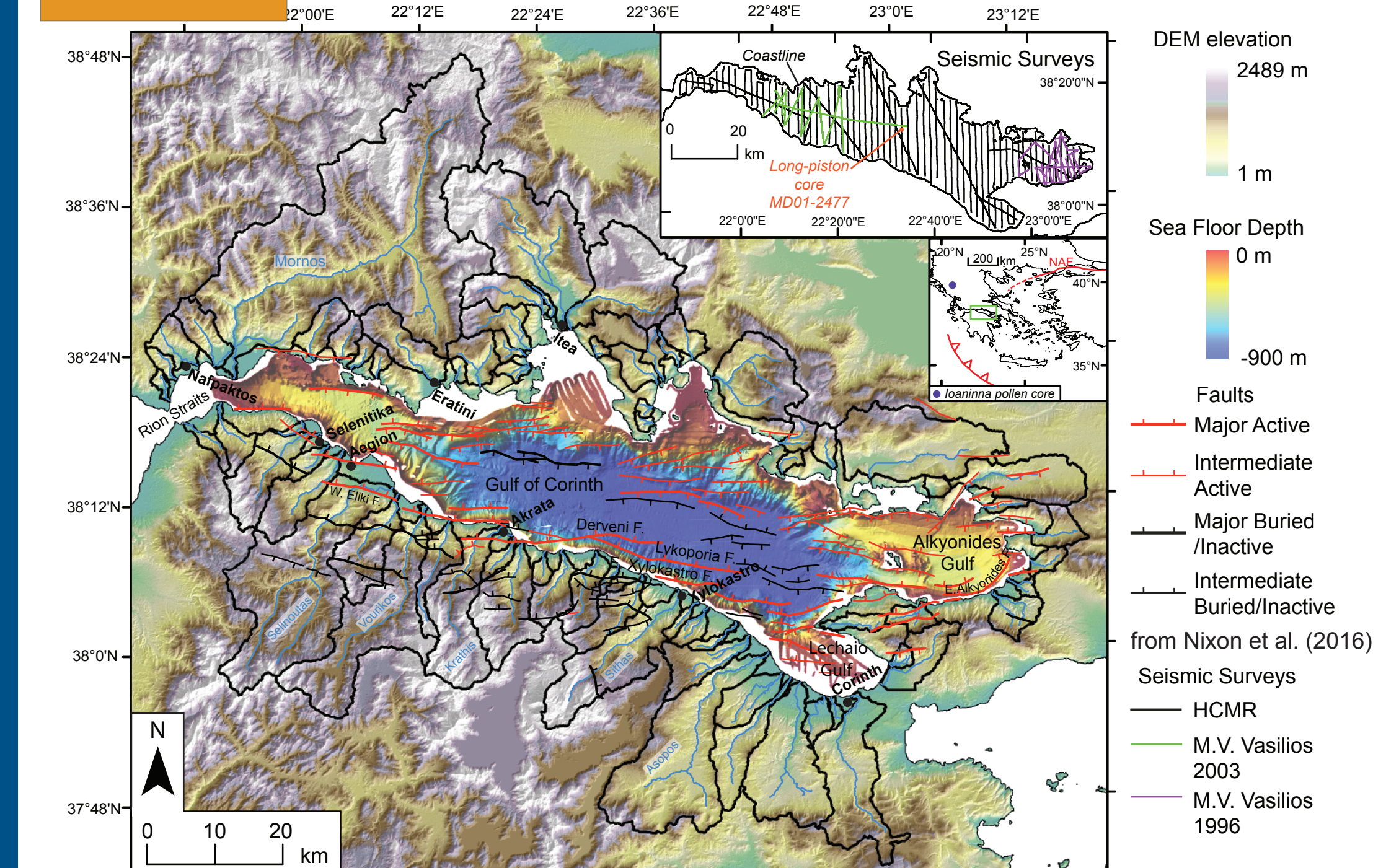
Fig. 1 - Simplified source-to-sink system from Castelltort and Van Den Driessche (2003)

Using the Gulf of Corinth as a natural laboratory, we:

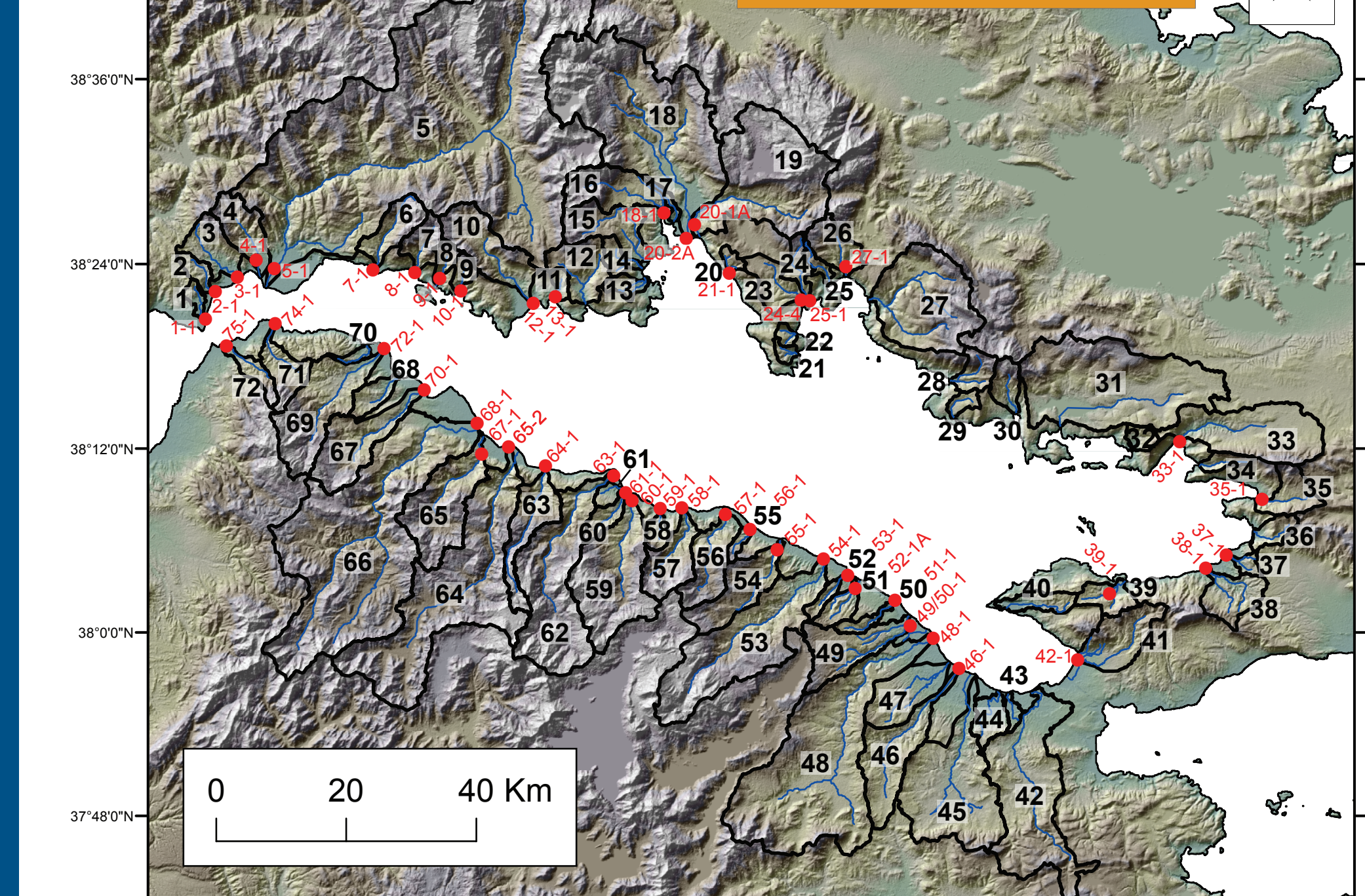
- Constrain the full-weighted grain-size distribution export into the Gulf
- Derive the total sediment budget for the Gulf of Corinth
- Calculate the millennial-scale intermittency of sediment transport of these rivers i.e., how often is sediment transported within these rivers

2) Study area

Datasets



Field Locations



3) Field Work

Collected:

Full weighted grain-size distribution by in-situ sieving

Grain-size distributions of clasts >1 mm (Wolman point count method)

Hydraulic Geometries:

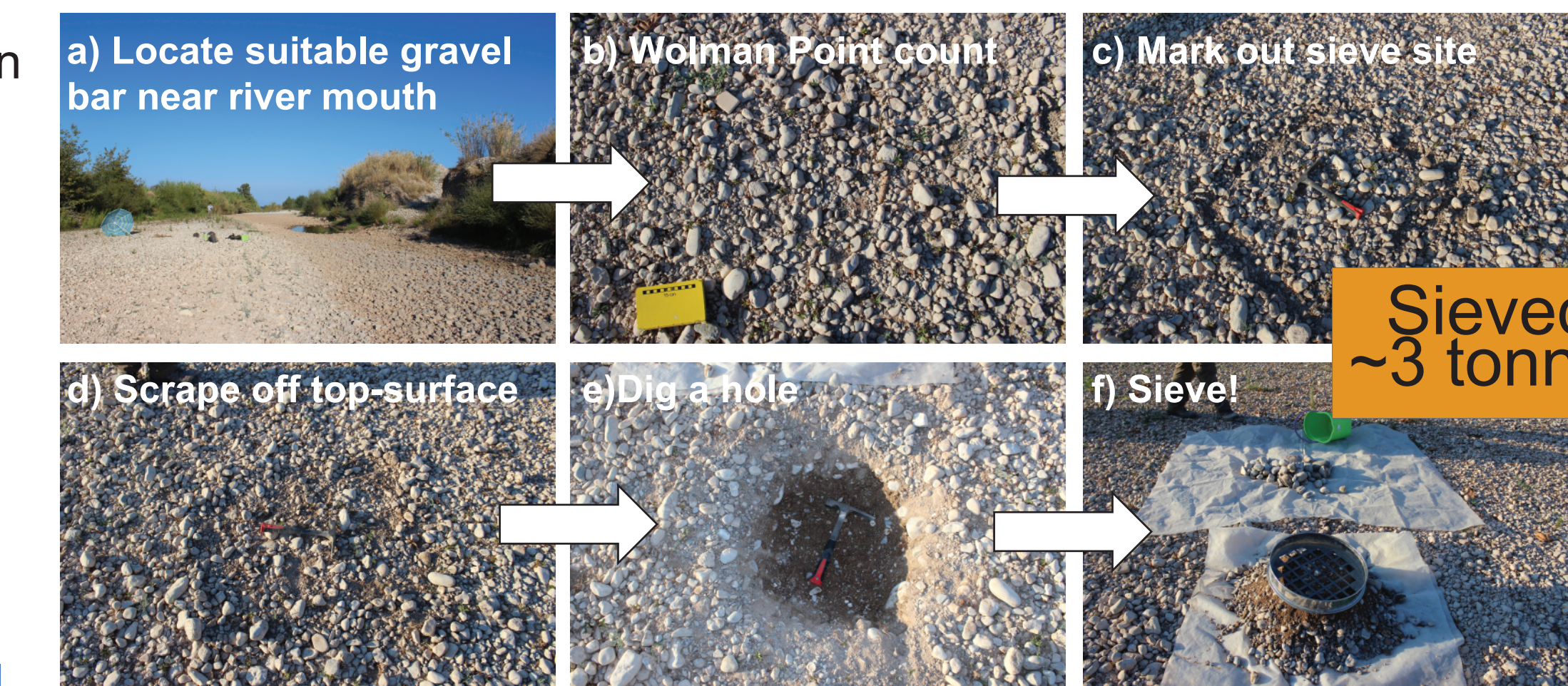
Bankfull Width (m)

Bankfull Height (m)

Slope (degrees)



Sieving:



Sieved
~3 tonnes

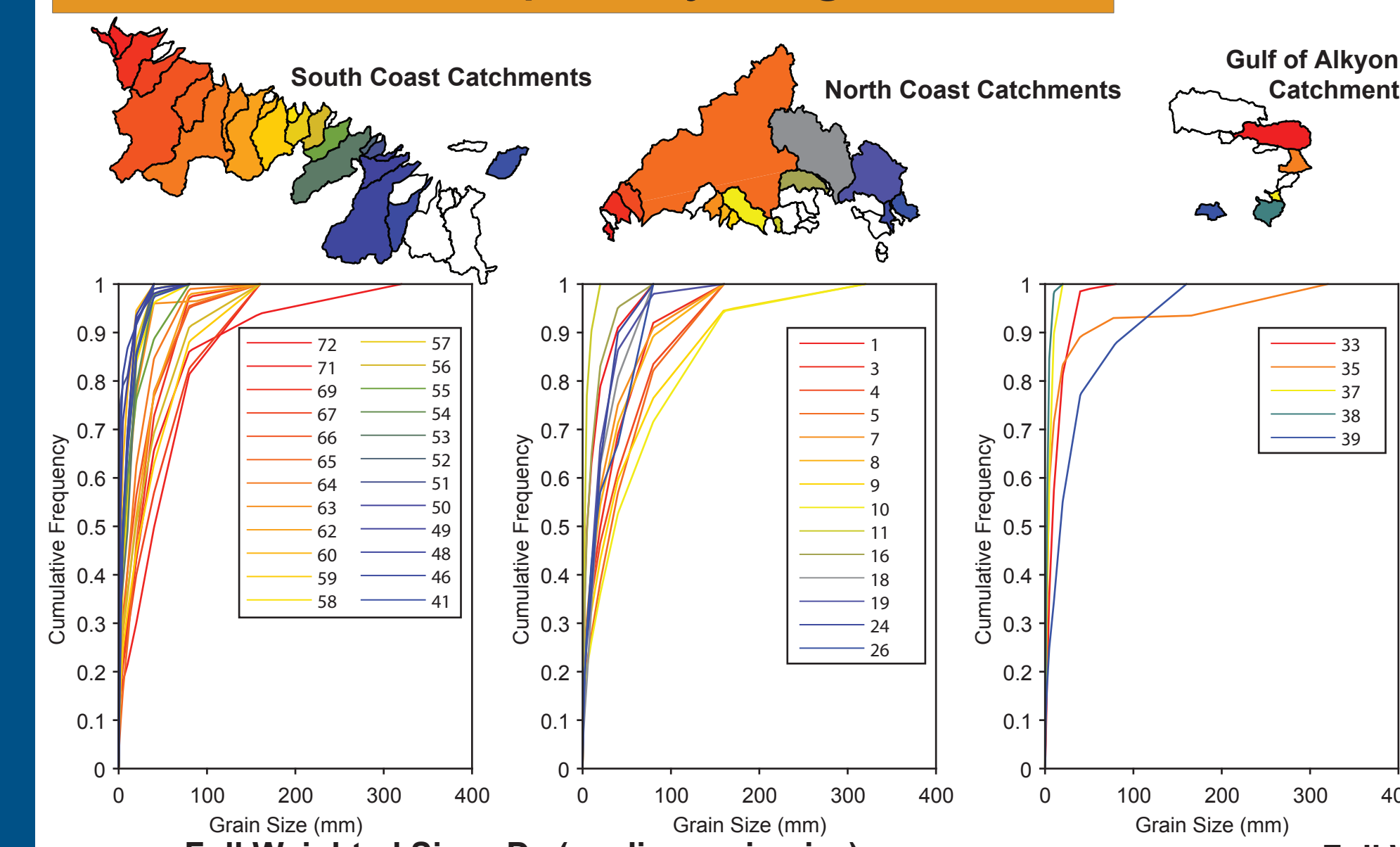
Full-weighted grain-size distribution was obtained by in-situ sieving of gravel bars, mobilised at bankfull discharge, near the mouth for 44 catchments into the Gulf of Corinth



Wolman Point Counts were also carried out to obtain the grain-size distribution of clasts >1 mm.

4) Grain-size export

Cumulative frequency of grain-size



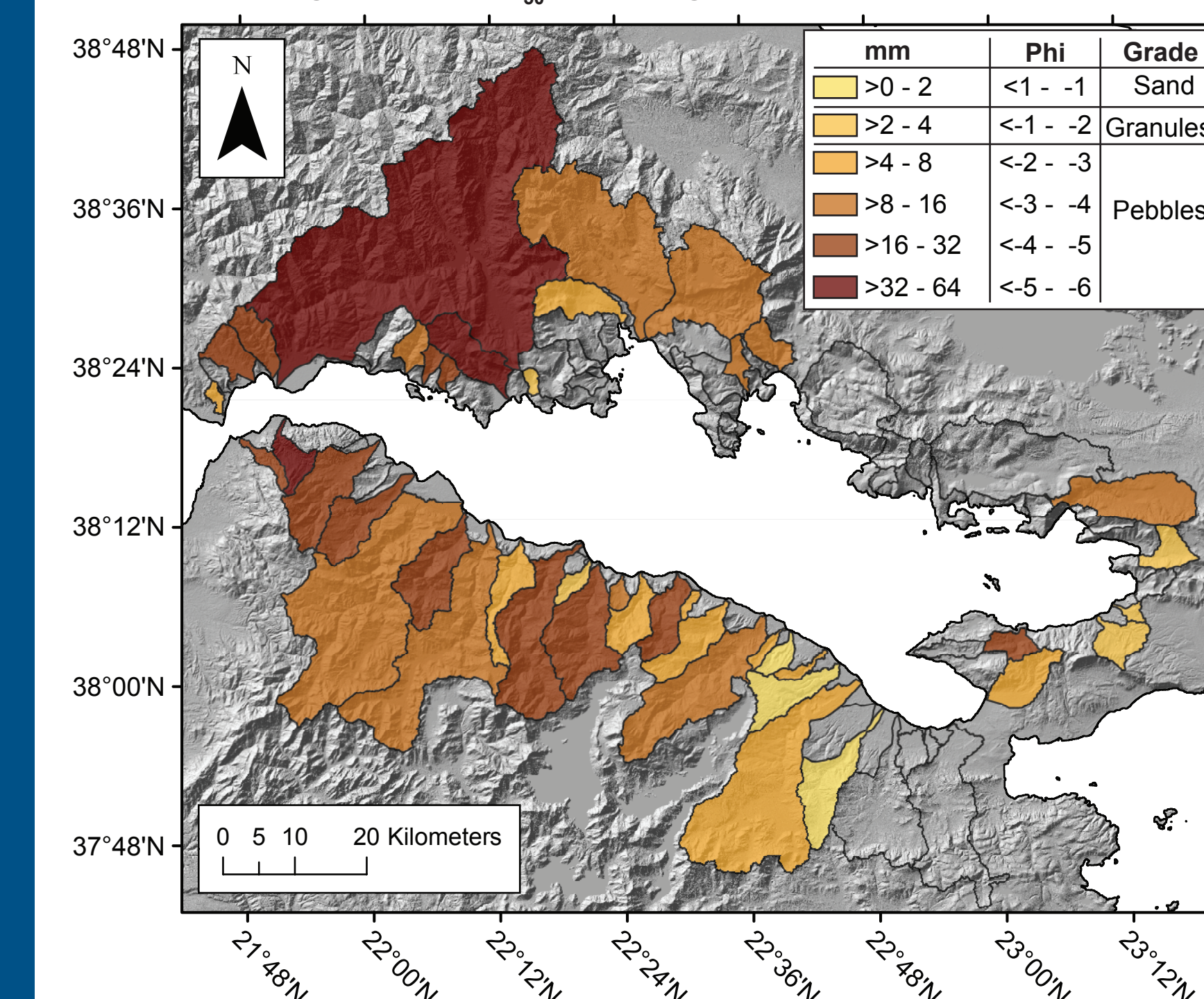
Grain-size sediment export increases in grain-size from east to west on the South coast

The west Gulf of Corinth is exporting the largest grain-sizes

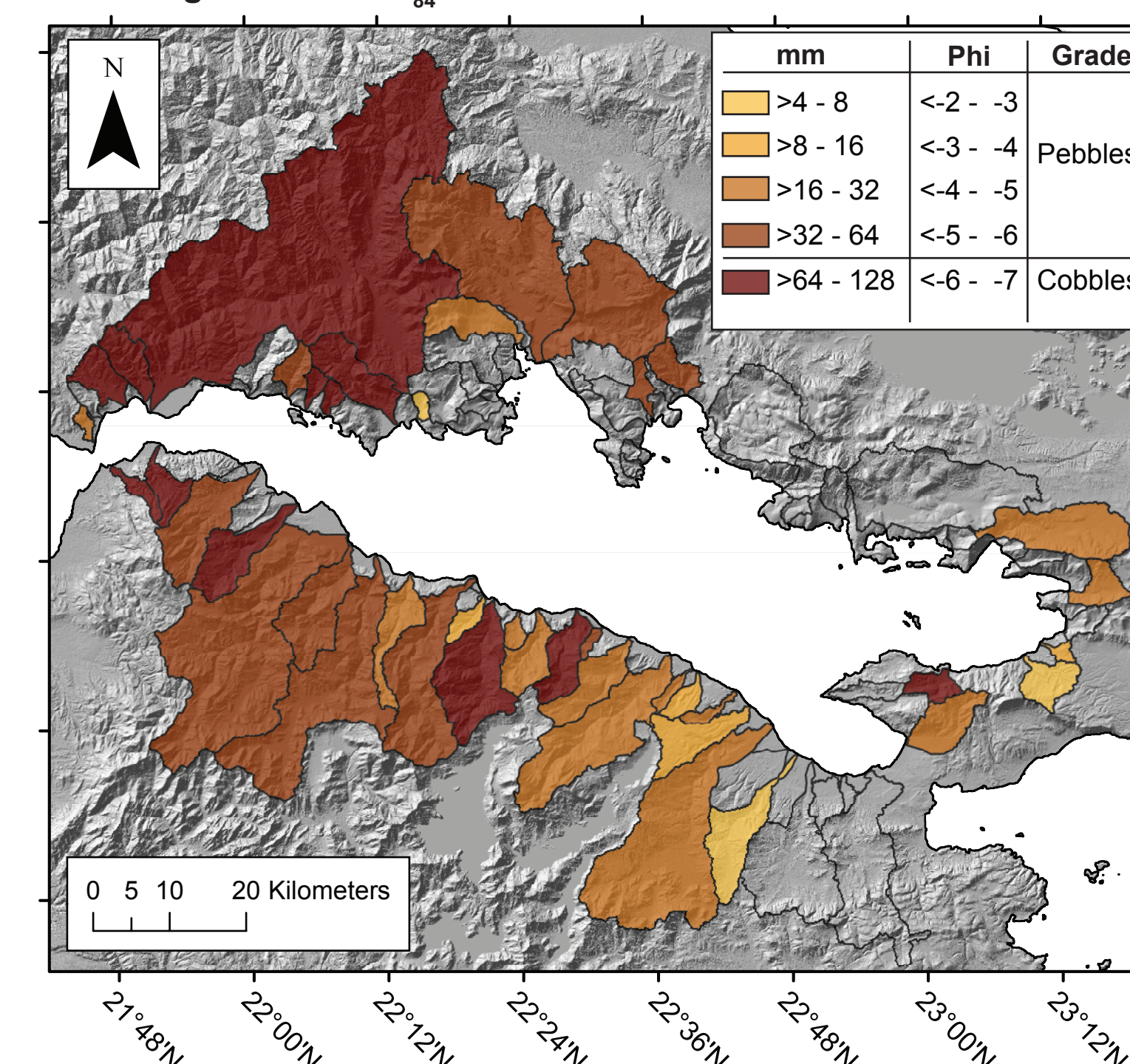
Median grain-size (D_{50}) increases along the south coast from east to west

D_{84} shows the same trend as D_{50} but more clearly

Full Weighted Sieve D_{50} (median grain-size)



Full Weighted Sieve D_{84}



5) Estimating Intermittency

1. Calculate shields stress outside the back water reach:

$$\tau^* = \frac{\tau_b}{(\rho_s - \rho_w)gD_{50}} = \frac{RS}{1.65 D_{50}}$$

2. Meyer-Peter-Muller Transport (MPM) Capacity ($\text{kgm}^{-1}\text{s}^{-1}$):

$$q_t = p_s \left(\frac{\rho_s - \rho_w}{\rho_w} g D_{50}^3 \right)^{1/2} C(\tau^* - \tau_c^*)^{3/2}$$

3. Convert unit sediment discharge ($\text{kgm}^{-1}\text{s}^{-1}$) into sediment flux (m^3s^{-1}):

$$\frac{\text{MPM} * \text{Bankfull width}}{\rho_s}$$

5. Use BQART sediment fluxes for each river and scale to known volume in the basin (see Watkins et al. in revision).

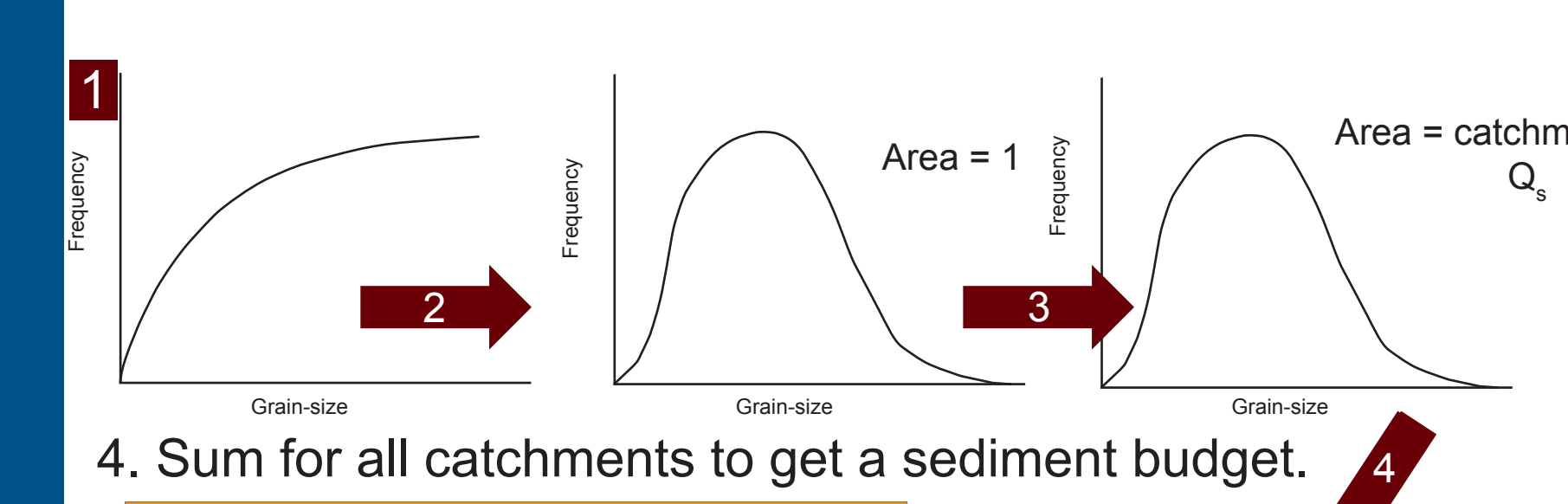
4. Bedload transport formulations allow us to estimate the transport capacity of rivers at their mouths. We calculate annual bedload flux from this, assuming sediment transport is continuous through time and space. The intermittency factor is estimated by calculating the ratio of sediment flux between the scaled BQART method and the MPM method:

$$q_{s_BQART} = \text{Intermittency factor} * q_{s_MPM}$$

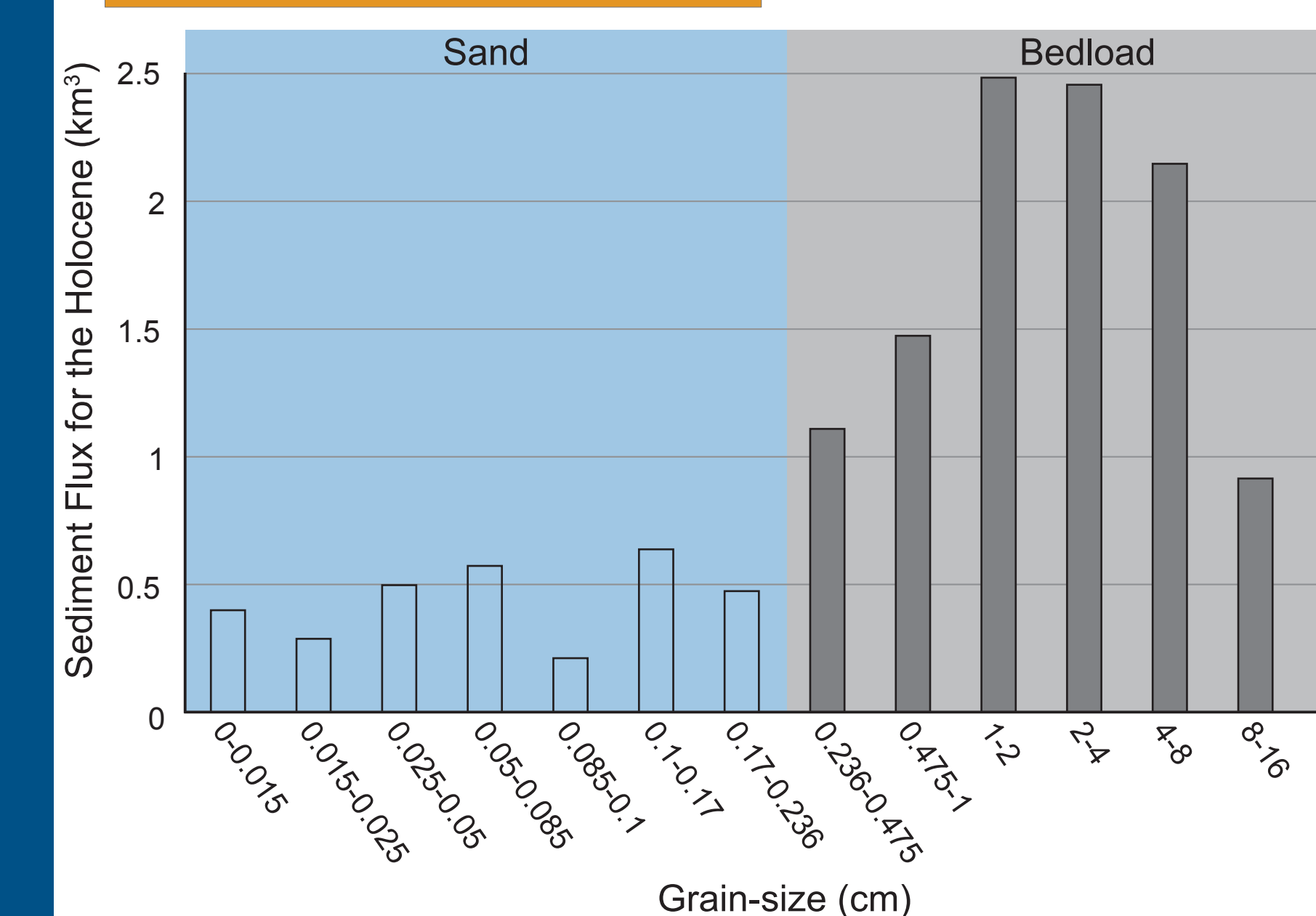
6) Complete bedload sediment budget for the Gulf

Steps to produce the sediment budget for the gulf:

- Generate cumulative frequency distributions of grain-size for each sieved catchment.
- Produce the probability density function (pdf) of grain-size released from catchments.
- Multiply this pdf by each of the catchments' respective sediment flux derived from the BQART model.
- Sum for all catchments to get a sediment budget.

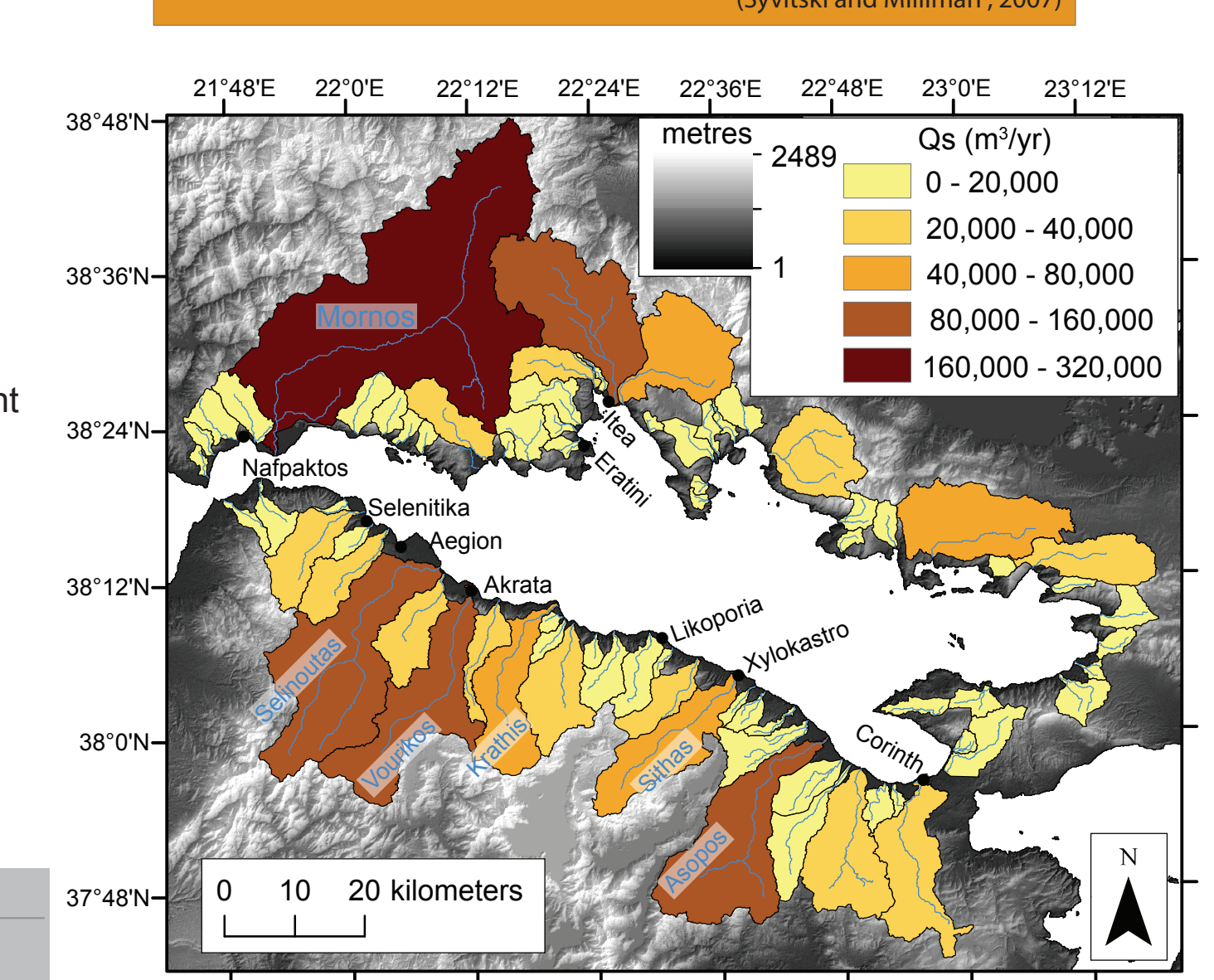


Bedload sediment budget:



Deriving sediment fluxes:

$$Q_s = \omega BQ^{0.31}A^{0.5}RT$$



see Watkins et al., in revision, GSA Bulletin

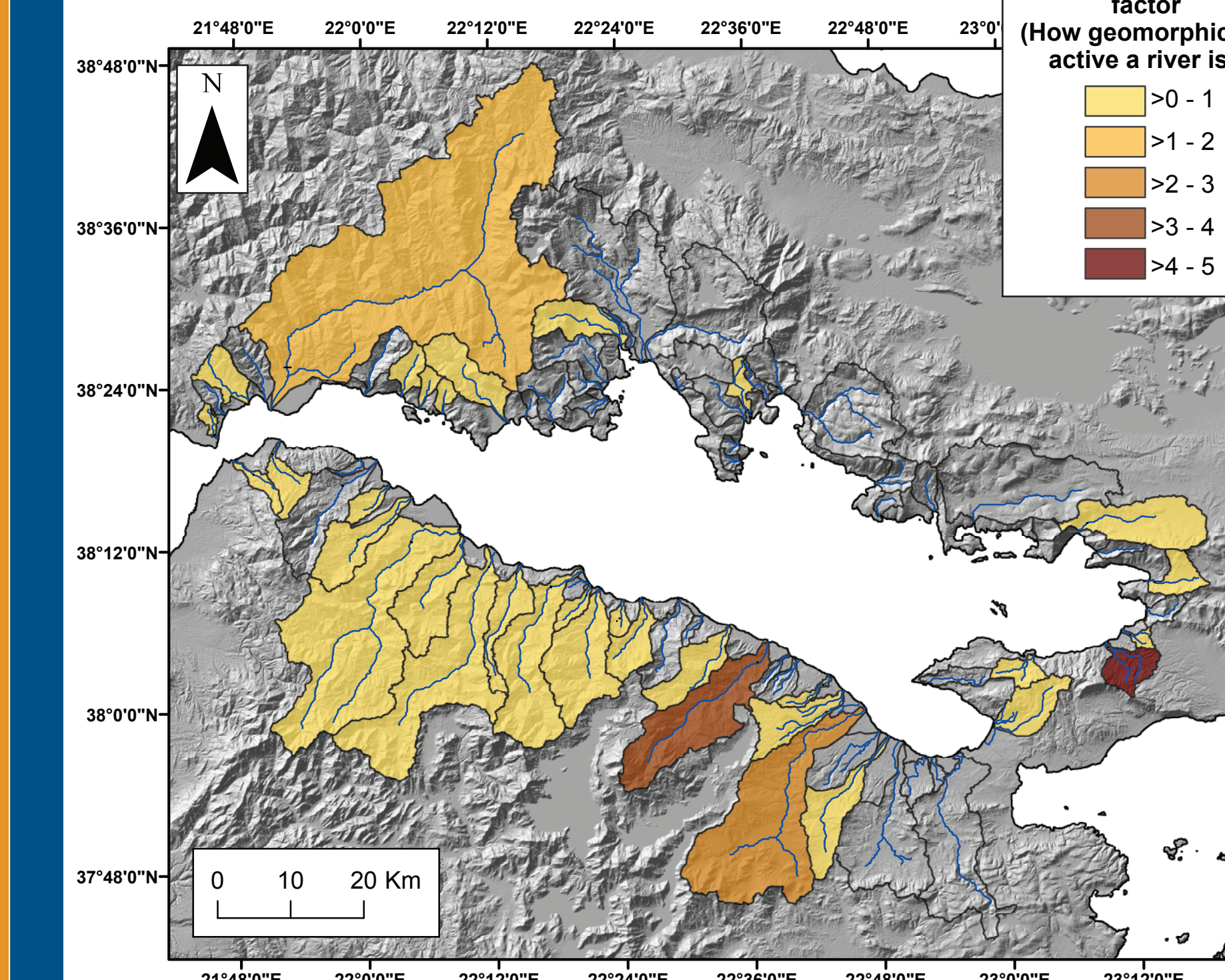
Assumed bedload to suspended ratio was 35:65 to get a bedload sediment flux

Sediment transport mechanics dictate that gravel in these rivers is dominantly in bedload thus allowing a comparison of the MPM and BQART methods

Sediment budget unimodal, with majority of bedload 1 - 4 cm in size. River mouths lack sand and muds - likely bypassed into the basin

7) Millennial intermittency results

Median intermittency for the Gulf of Corinth rivers is 0.0014 i.e., 0.14% of time for millennial timescales



Sediment is in transport only 12 hours a year using the median intermittency factor of 0.0014

Corinth rivers are therefore "flashy" compared to other rivers around the world

How does the Corinth rivers intermittency factor compare with others around the globe?

Rivers	Intermittency Factor	%	How active a year	hours	days
Sand dominated system					
Atchafalaya River, California	0.35	35	3066	127.75	
Mississippi	0.34	34	2978.4	124.1	
Red river, California	0.26	26	2277.6	94.9	
Trinity River, Texas	0.05	5	438	18.25	
Gravel dominated system					
Fly-Strickland River, Papua New Guinea	0.175	17.5	1533	63.875	
Corinth rivers	0.0014	0.14	12.264	0.511	

8) Conclusions

- D_{50} & D_{84} maps show a coarsening from east to west, with D_{84} grain-sizes ranging from sand grade to cobble grade.
- The distribution of the bedload sediment budget is extremely coarse.
- Sediment transport occurs very intermittently in these rivers over millennial timescales, and sand bed rivers like the Mississippi transport sediment 2 orders of magnitude more frequently than the Corinth rivers.
- Transport of bedload sediment in high discharge events, which occur less frequently.

