Habitat hydraulic modeling for assessing changes of mesohabitat types in a Greek mountain river

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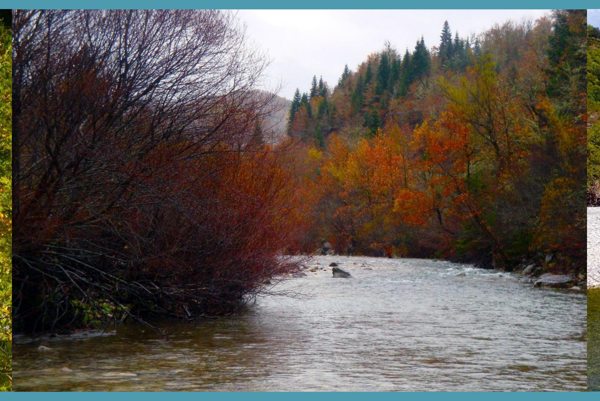
ABSTRACT

The aim of this study is to describe and assess changes in physical attributes of mesohabitat types in response to different flows in a Greek mountain river. Hydraulic simulations were applied using two one-dimensional hydraulic models, MIKE 11 and HEC-RAS. A representative 200 m reach length was chosen as a study site, in relatively undisturbed conditions in the upper part of Acheloos river. Transects were typically placed in areas representative of the various habitat types, proportionally determined by a habitat mapping process at a larger stream segment. The channel and floodplain were surveyed to create a digital elevation model (DEM) of the river. A detailed topographic survey with a GPS/GNSS Geomax - Zenith 20 was made using reference stations at geodetic control points for highest accuracy. Also, a gauging station was installed downstream of the reach in order to provide water level data in an hourly step. Hydraulic models were applied over a range of flows and river stages, based on past measurements. For selecting the control transects a thorough analysis of various parameters, such as habitat representativity, streambed slope and substrate types, was applied. The results from the hydraulic models were combined with fish habitat simulation curves (HSCs) focusing on the integration of mesohabitat and microhabitat types in the environmental flow assessment scheme.

Keywords: hydraulic models, habitat types, Greek rivers

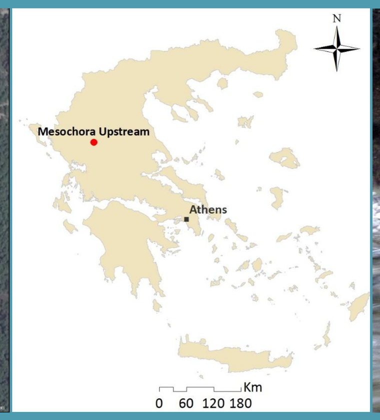



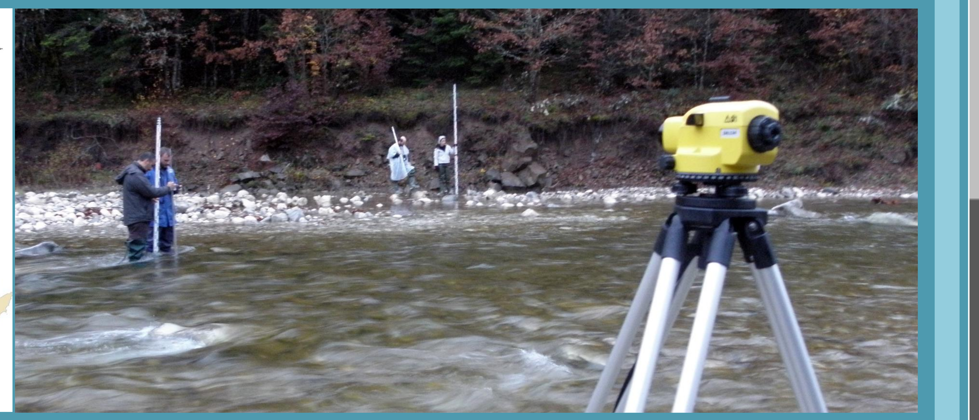

STUDY AREA

Mesochora Upstream site is located in the mountainous part of the Acheloos River catchment. The mean elevation of the study reach is equal to 670 m a.s.l. with average slope 2.5%. Summer flows are ranging from 2 to 5 m^3/sec based on past measurements of Public Power Corporation of Greece.

Acheloos River (220 km long and drainage area of 4860 km^2) is characterized by a typical montane Mediterranean climate (i.e. low flows, high evapotranspiration in summer and high flows in late autumn, winter and spring). The average annual rainfall is 1100 mm.

Cross-section geometry data comprised 29 transects (covering the channel and floodplain) within the 200 m reach length. All transects were placed perpendicular to the main direction of flow. The elevation data were recorded with the GGRS '87 Greek Geodetic Reference System designated in 1987.





METHODS

Habitat mapping was carried out in a segment of 1.5 km length in the beginning of October 2013 in low flow conditions to identify the Hydromorphological Units according to published methods (Dolloff et al. 1993). Habitat mapping was fundamental for the selection of the representative study reach. In this way a river stretch was comprised with all the relevant habitat features present in the broader river segment under study.

The channel and floodplain were surveyed to create a digital elevation model (DEM) of the river. A **detailed topographic survey** with a GPS/GNSS Geomax - Zenith 20 was made using reference stations at geodetic control points for highest accuracy. At each point the spatial coordinates and the dominant substrate type were recorded in the river channel and floodplain.

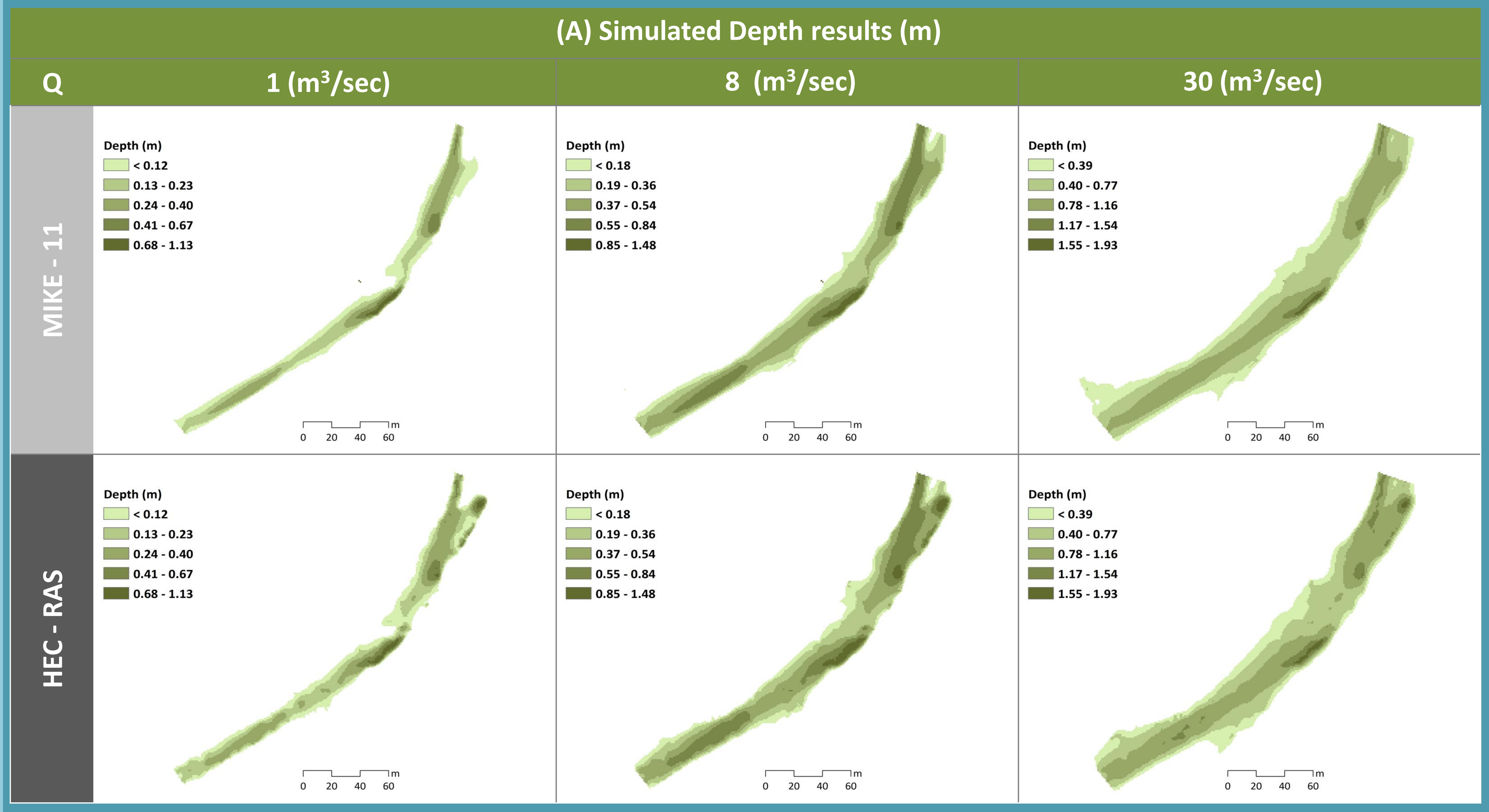
	Recorded Substrate type	Size (mm)
1	Vegetation	-
2	Silt (Mud)	<0.06
3	Sand	0.06-2
4	Gravel	8 - 64
5	Cobble	64-264
6	Boulder	>264

Hydraulic Modeling. The HEC-RAS (Version 4.1) and Mike 11 (DHI 2014) one dimensional hydraulic models were used to simulate ten river flows, producing results of mean velocity and water depth. The models use the step-backwater model to compute water surface elevation (WSE) profiles by solving either the energy equation (gradually varied flow) or the momentum equation (transition from supercritical to subcritical and vice versa), and the mass balance equation.
The same initial and boundary conditions were used in both models.

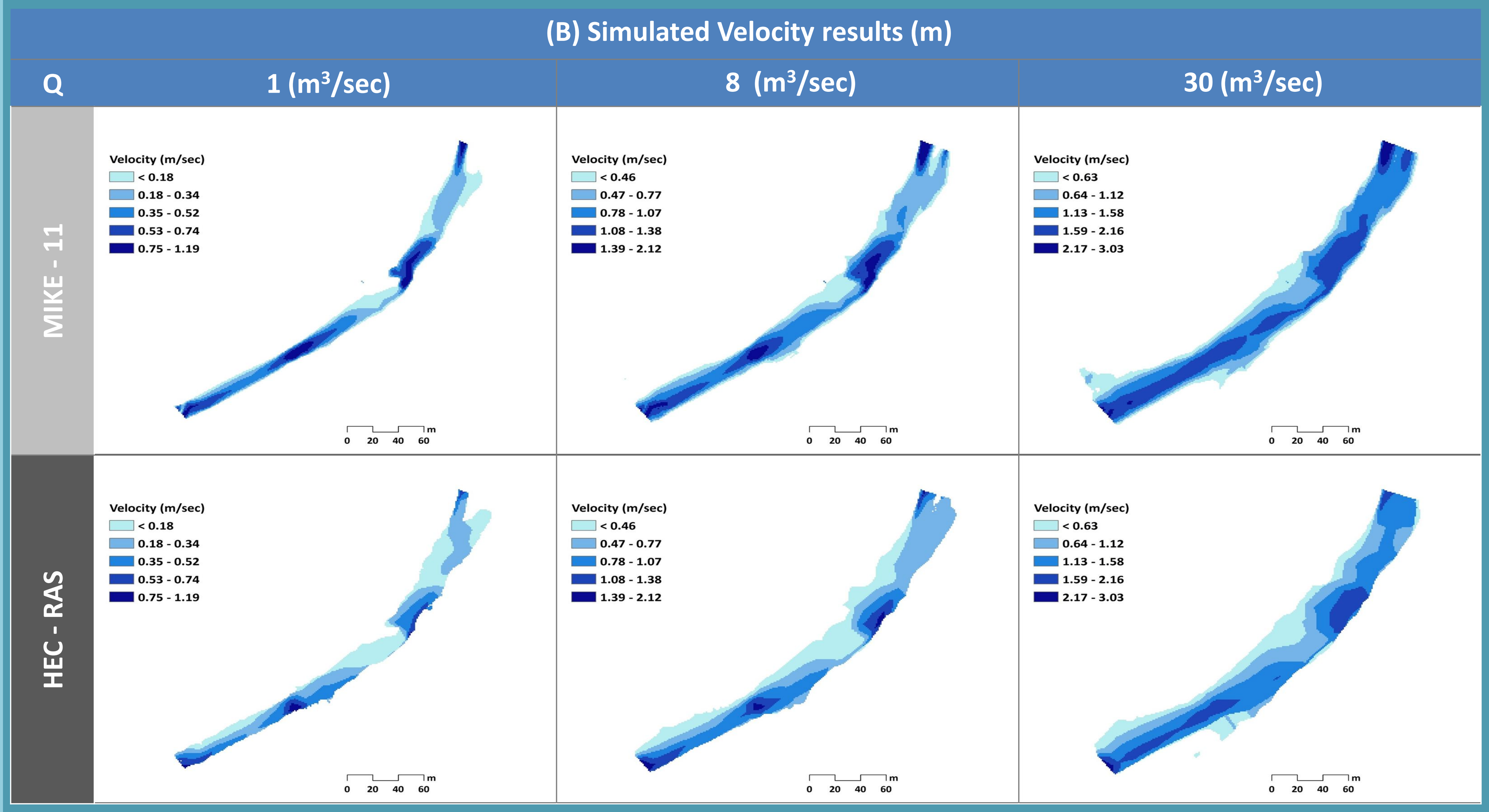
Cross section analysis. In HEC-RAS every cross-section was divided in sub-sections (cells) in order to calculate the mean velocity at each cell. The division was made according to streambed roughness in the form of Manning's coefficient, which was estimated from field data and aerial photographs. In Mike 11 one mean depth and mean velocity value was estimated for each cross section.

HYDRAULIC MODELING RESULTS

The models simulated results regarding **depth** indicated similar values for all simulated flows (A).



The **simulated velocities results (B)** indicated differences among the two models, highlighting the fact that the discretization of the cross sections can be an important factor influencing the velocity simulations.



HABITAT SUITABILITY INDEX

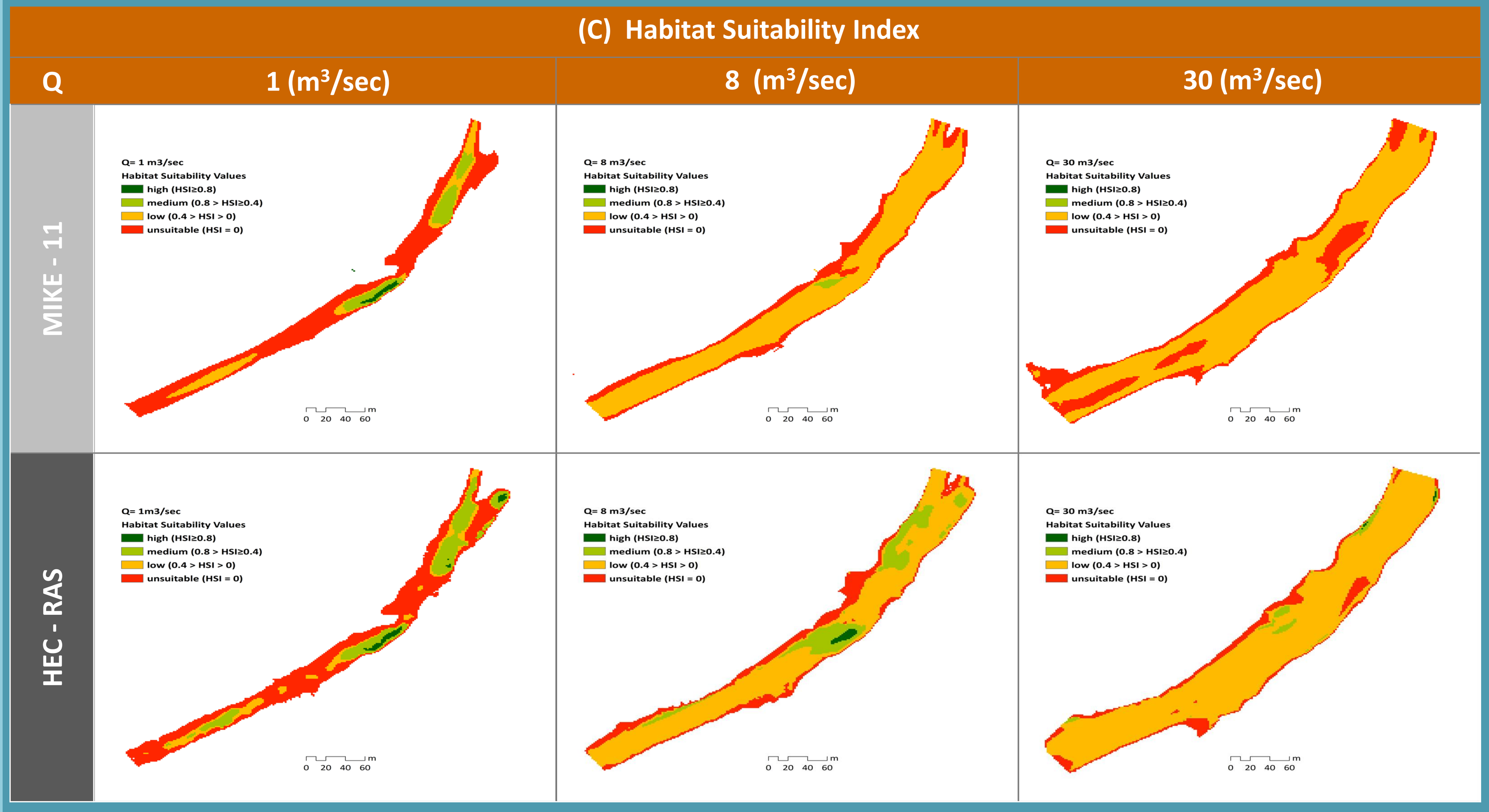
Habitat suitability curves for adult brown trout (*Salmo trutta* L. 1758), extracted from former studies of trout habitat in North American streams (Boove 1978) regarding depth and water velocity, were used to assess habitat suitability for the different river flows.

Brown Trout is a European introduced species that is closely related to the native trout of Acheloos, Balkan Brook Trout *Salmo fariodes* (Delling B., 2003). The Brown Trout data are used provisionally to the complete absence of any local HSI development. For this preliminary application, first the results of the hydraulic model for each river flow (depth, mean velocity) were exported and converted into raster layers in the GIS software ARC Map (ESRI, Redlands, CA, USA, 2009). The whole process is an adaptation of the physical habitat simulation technique (PHABSIM) included in the IFIM methodology (Boove et. al 1998), which has been applied in other Mediterranean countries successfully, at a microhabitat and mesohabitat scale (Costa et. al 2012).

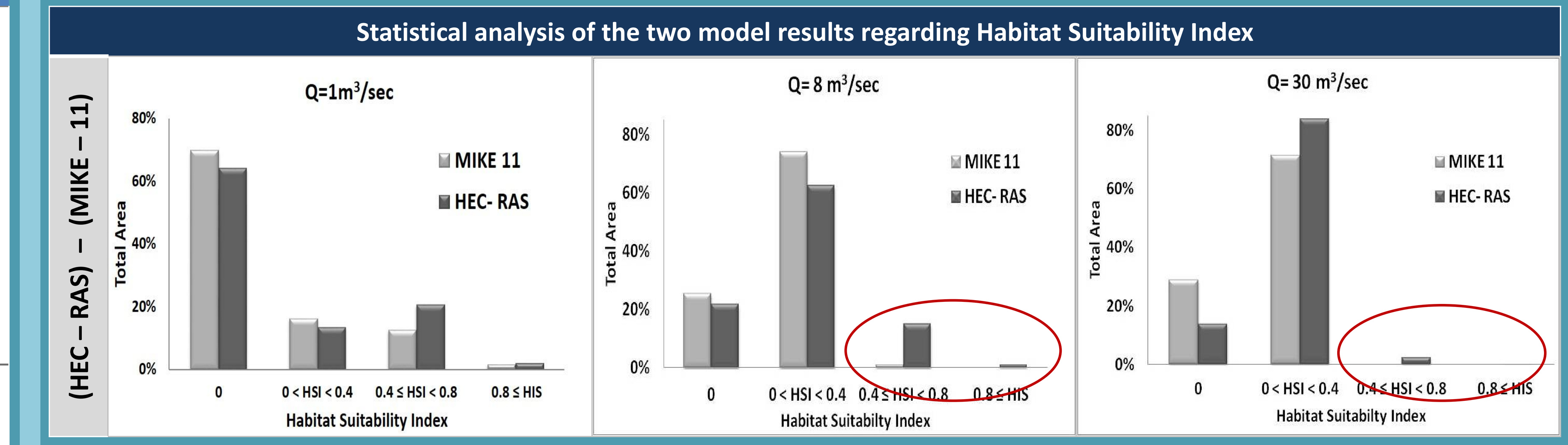



HABITAT SUITABILITY RESULTS

Depth and mean velocity simulated results were converted into their corresponding values of habitat suitability index (C). Based on these two values, the aggregated Habitat Suitability Index (HSI) was calculated for each cell. This study uses a multiplicative aggregation technique, i.e. the product of the velocity suitability index times the depth suitability index. For an easier interpretation, the HSI values were reclassified into four classes (Brown et. al 2000) representing high (HSI≥0.8), medium (0.8 > HSI≥0.4), and low (0.4 > HSI > 0) suitability, and unsuitable habitat (HSI = 0).



As the flow rate increases the model which uses the discriminated cross sections depicts higher discrimination of habitat suitability.



CONCLUSIONS

In the HSI maps, it was observed that as the flow rate increases, the wetted area increases, while the habitat suitability values decrease significantly, indicating unsuitable conditions for adult trout.

The different adopted approach regarding the velocity distribution factors in the cross-sections in the two models lead to different HIS results. Especially in the higher simulated flows the HSI results that delivered from MIKE 11 showed no suitable areas for the adult trout. Even with such a change, it may still be the fact that the discrimination of the cross sections can lead to more accurate results than by only using one mean value of velocity for each cross section.

Though, this provisional simulations may have particular weaknesses in respect to the original North American HSCs and the lack of on site hydrological measurements. Further analysis and validation of the models will be done in the near future.

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