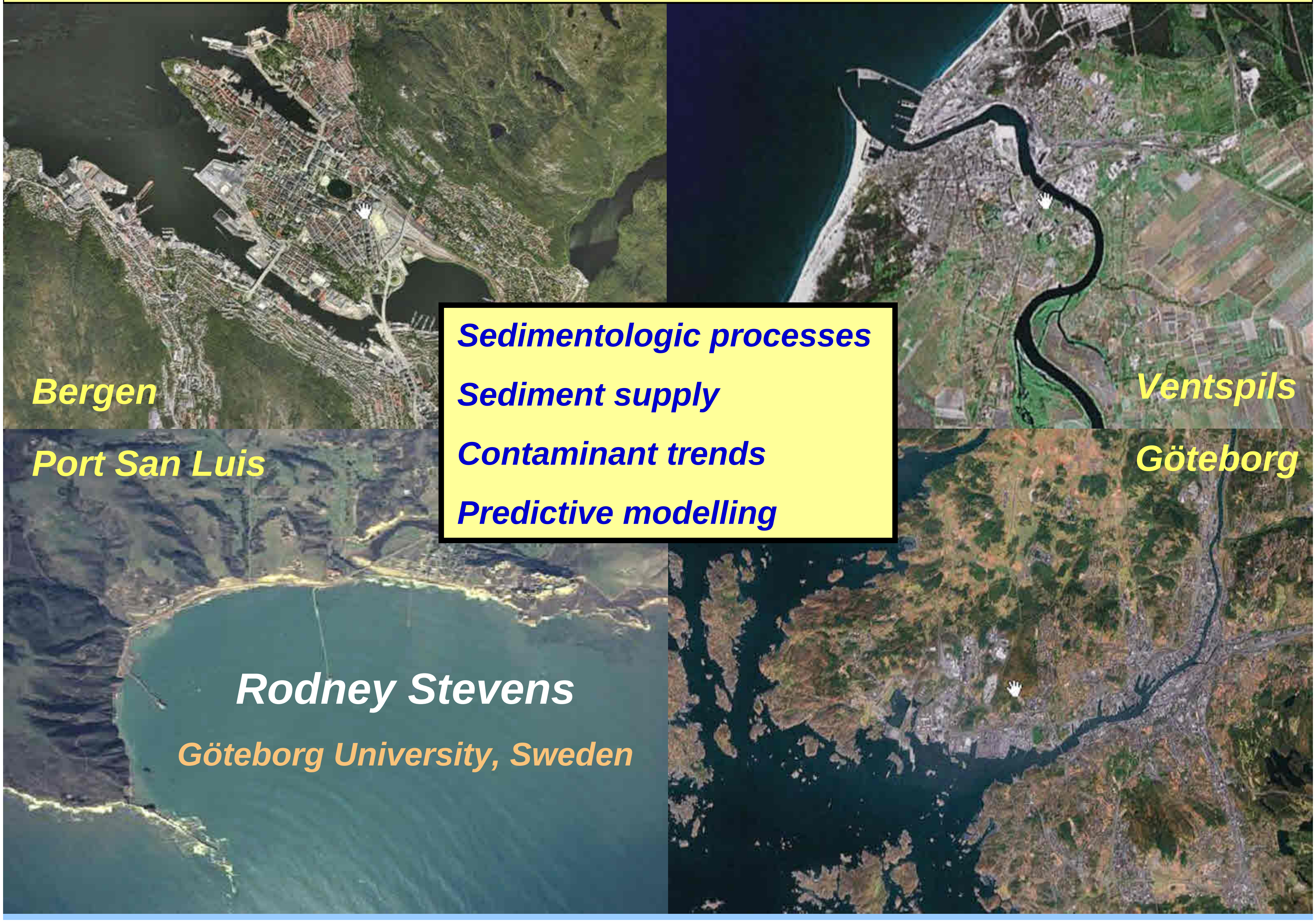
A comparison of environmental sedimentology in four harbours



Sedimentologic processes

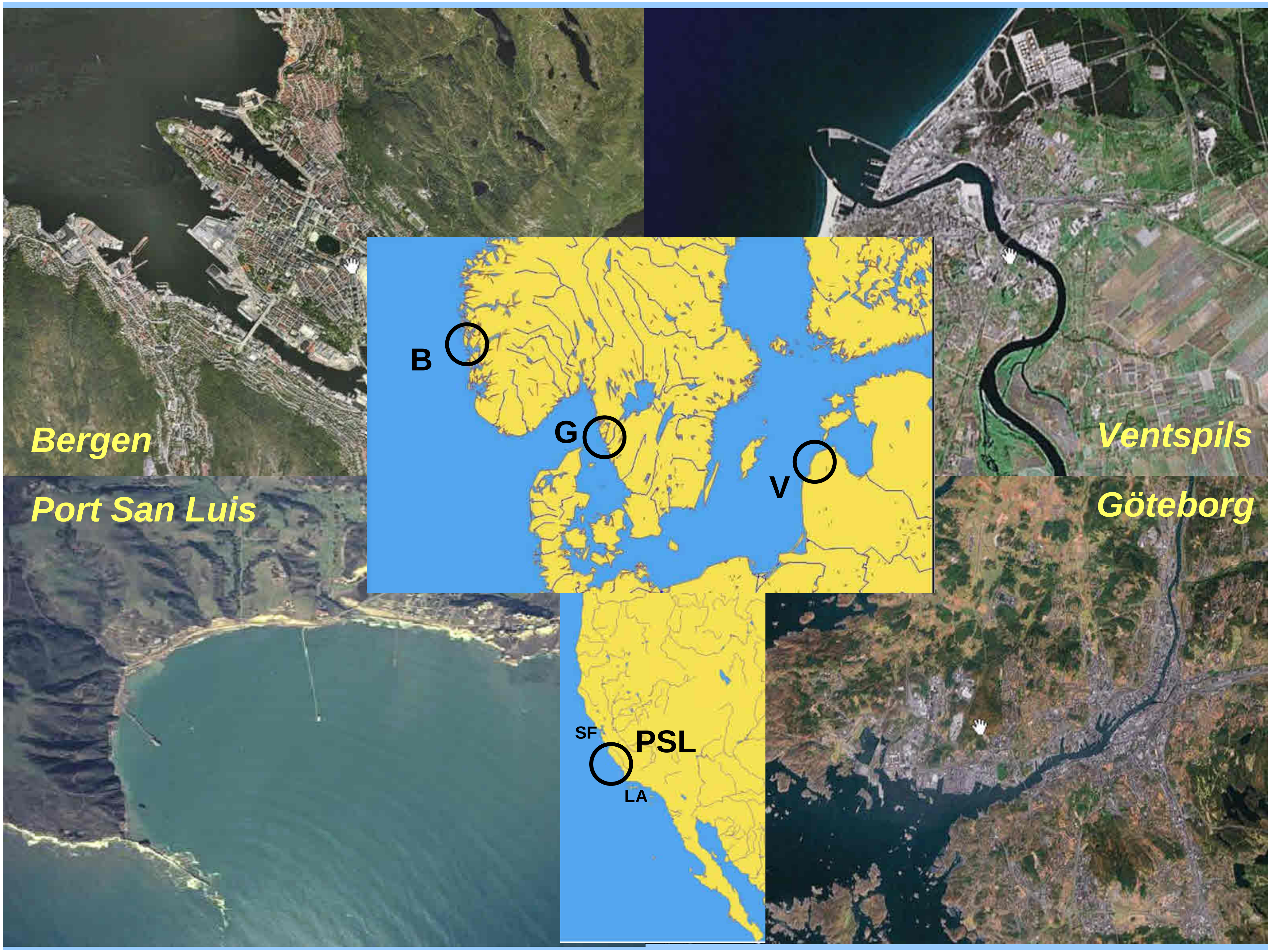
Sediment supply

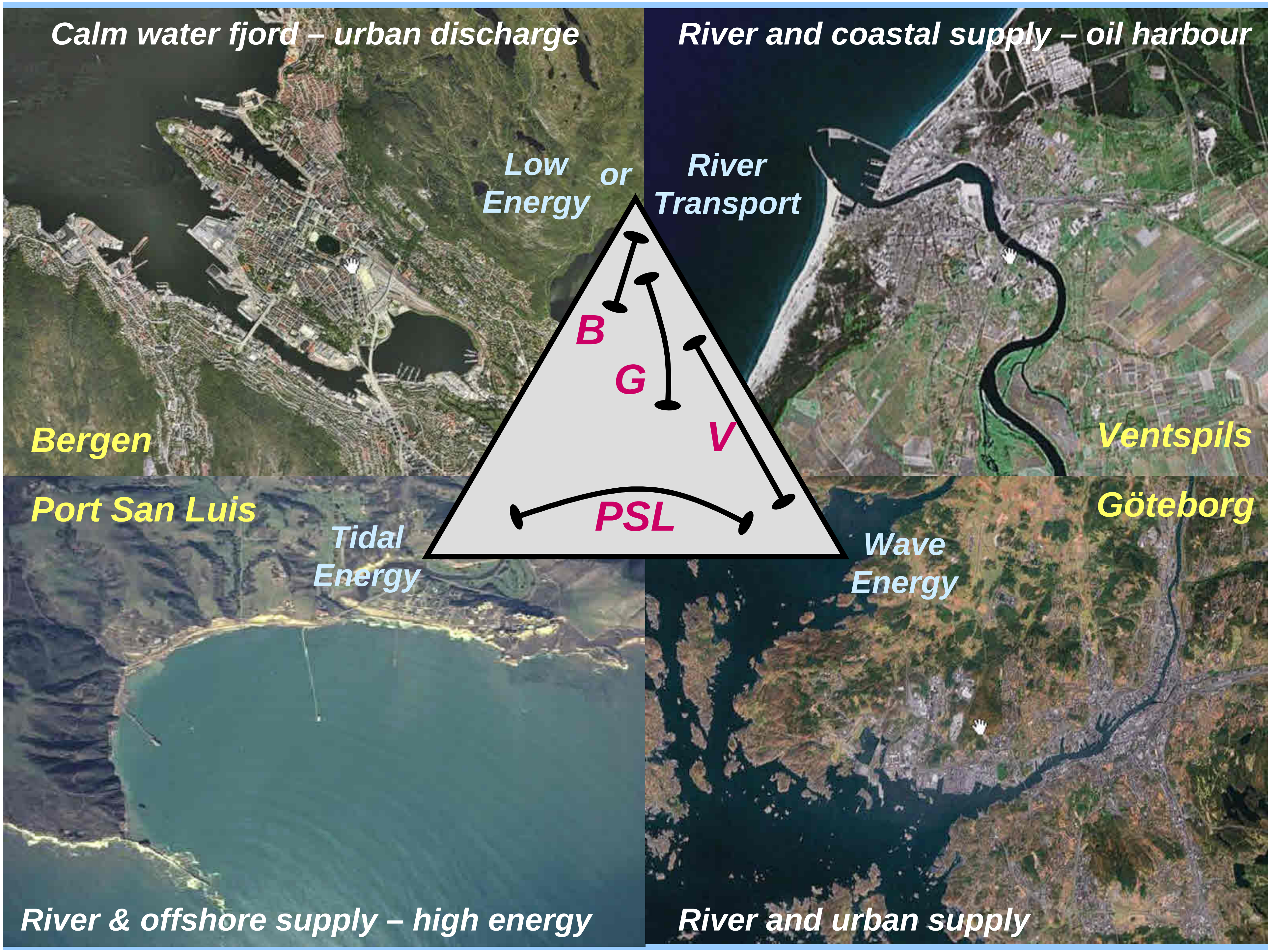
Contaminant trends

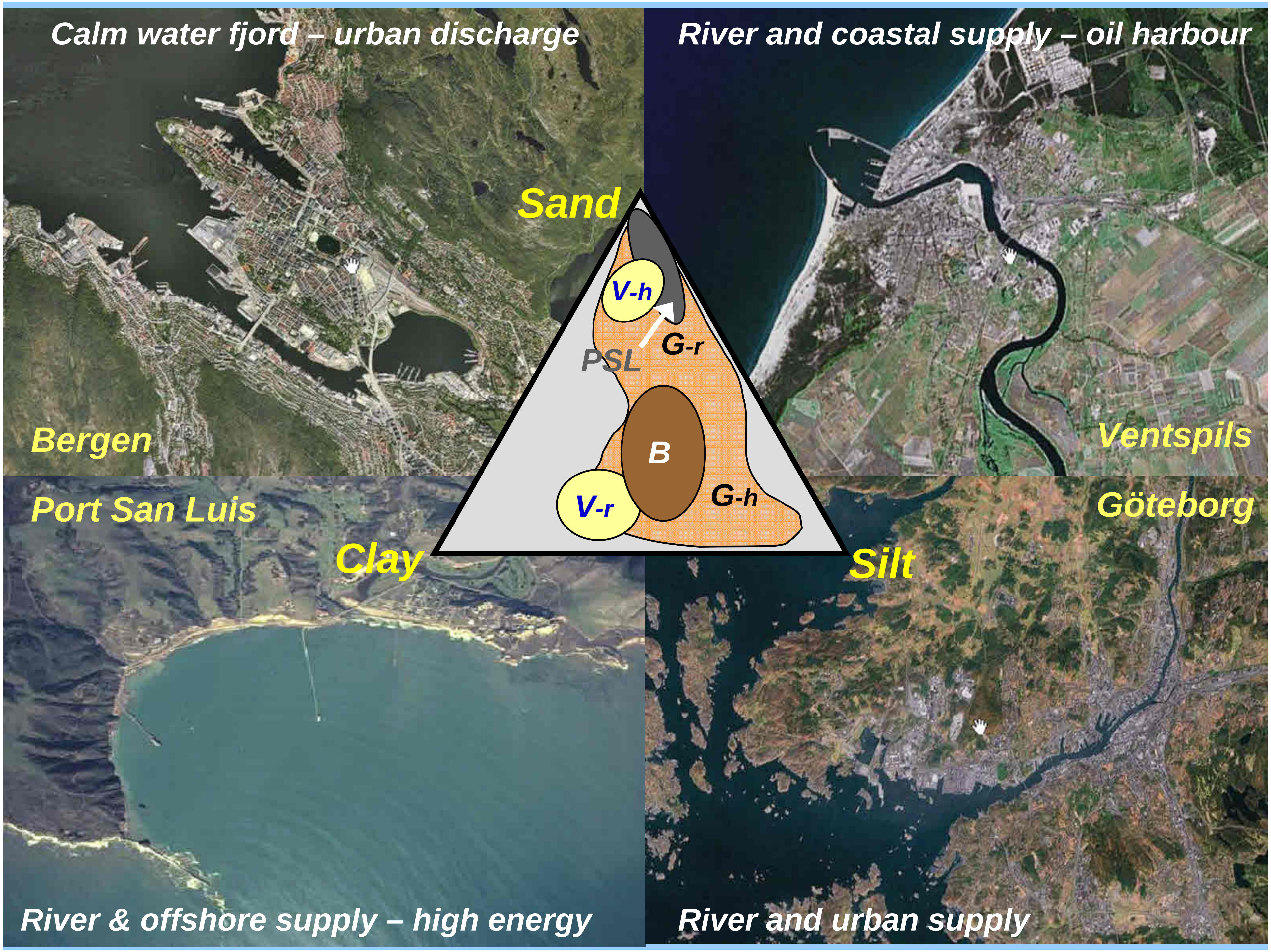
Predictive modelling

Rodney Stevens

Göteborg University, Sweden

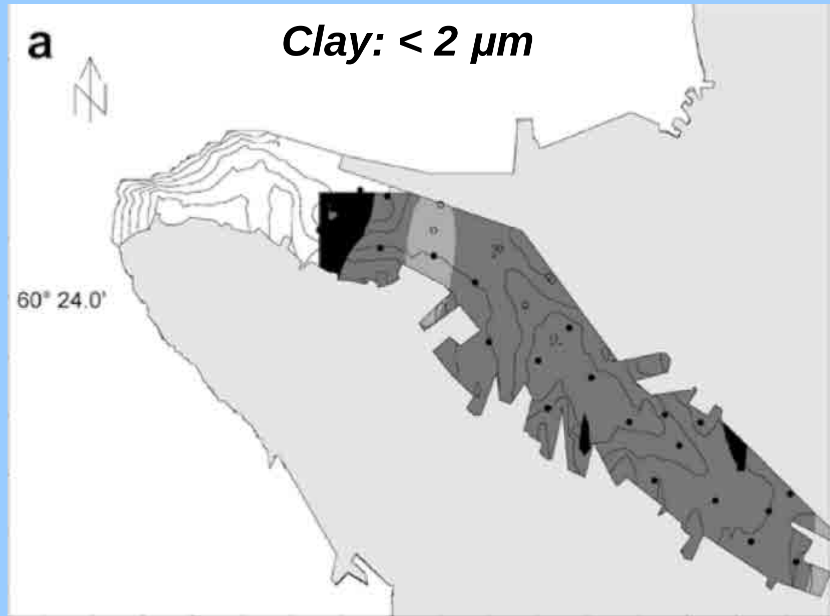

Bergen
Ventspils
Port San Luis
Göteborg
B
G
V
SF
PSL
LA

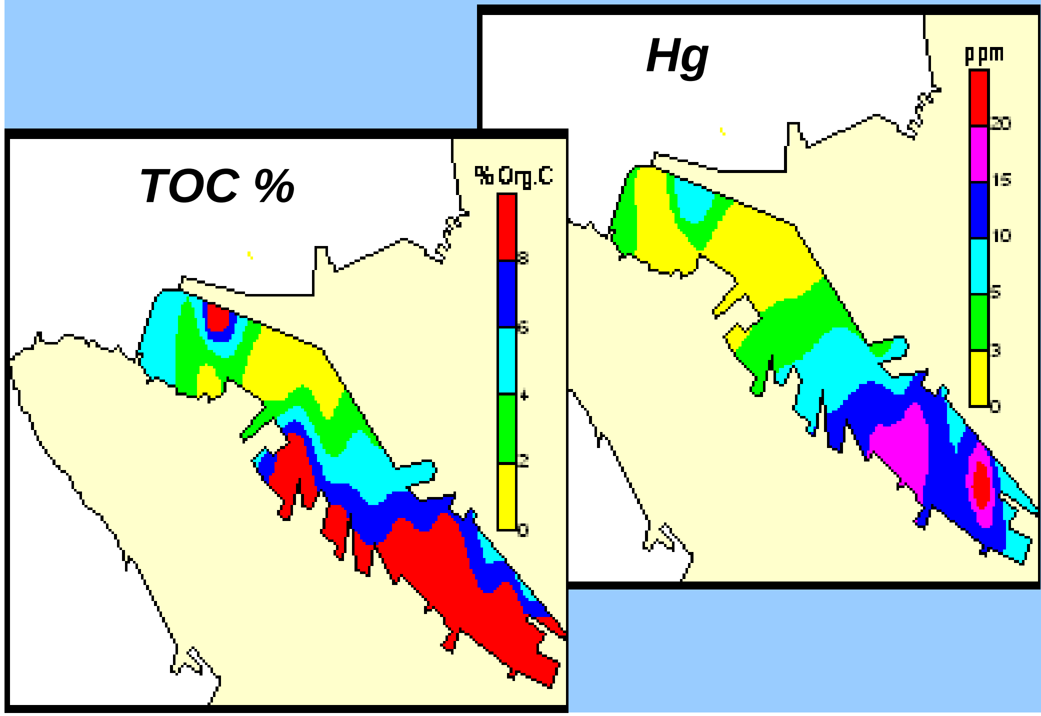

Calm water fjord – urban discharge
River and coastal supply – oil harbour
Low Energy
or
River Transport
B
G
V
PSL
Bergen
Ventspils
Port San Luis
Göteborg
Tidal Energy
Wave Energy
River & offshore supply – high energy
River and urban supply

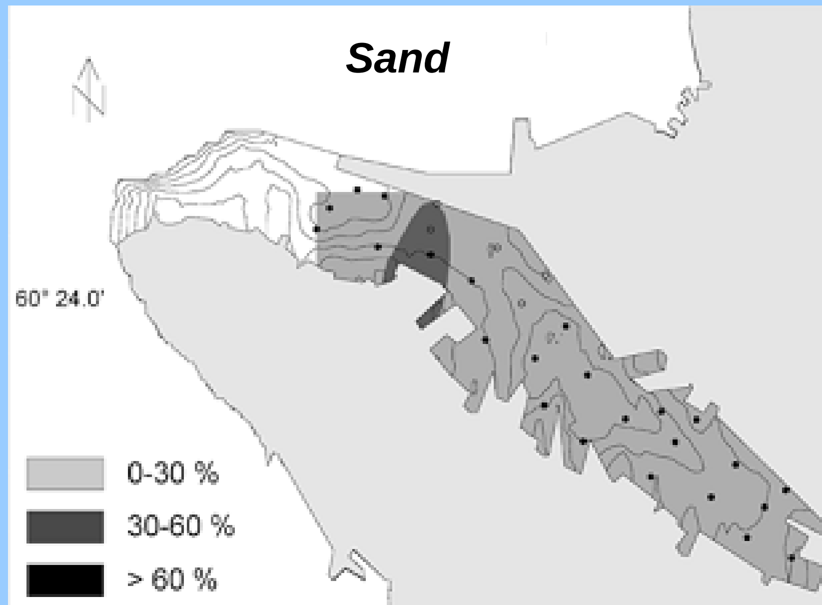

Calm water fjord – urban discharge
River and coastal supply – oil harbour
Sand
V-h
G-r
PSL
B
Bergen
Ventspils
Port San Luis
V-r
G-h
Göteborg
Clay
Silt
River & offshore supply – high energy
River and urban supply

Surface sediment metal contents

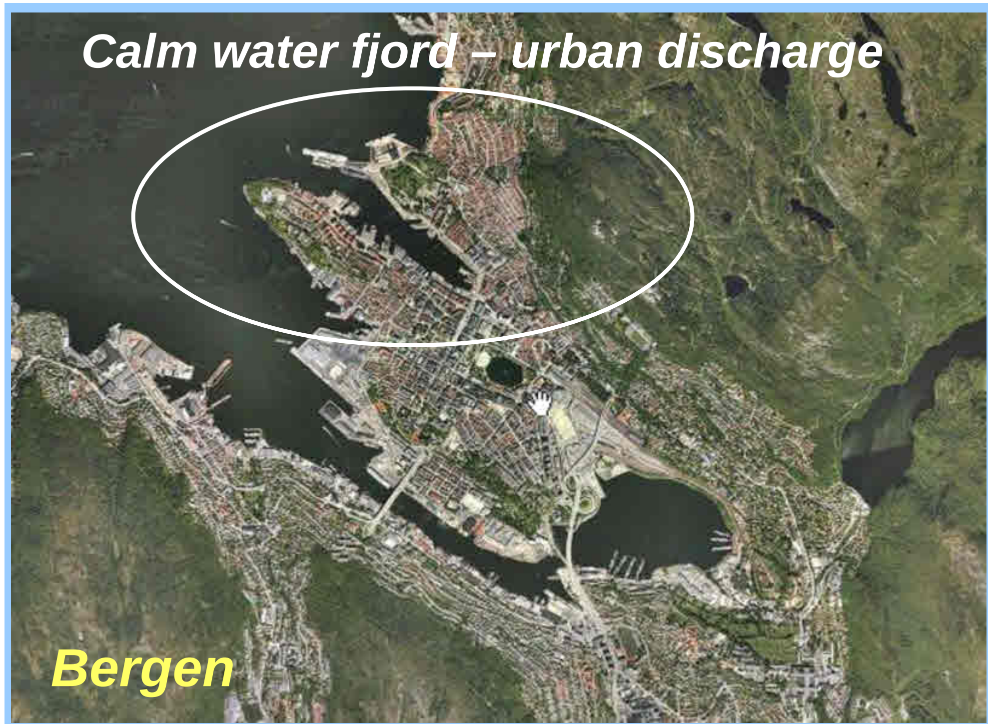
Element mg/kg	Bergen harbour Maximum	Göteborg harbour Mean	Göteborg harbour Maximum	Ventspils harbour Mean	Ventspils harbour Maximum
Cd	8	<1	1	< 1	< 2
Cr	187	162	983	41	71
Cu	1090	60	895	16.2	28.9
Hg (μg/kg)	38000	793	15800	47	65
Ni	109	28	51	19.7	35
Pb	1920	72	4610	12.7	44
Zn	2900	185	1060	80.1	254



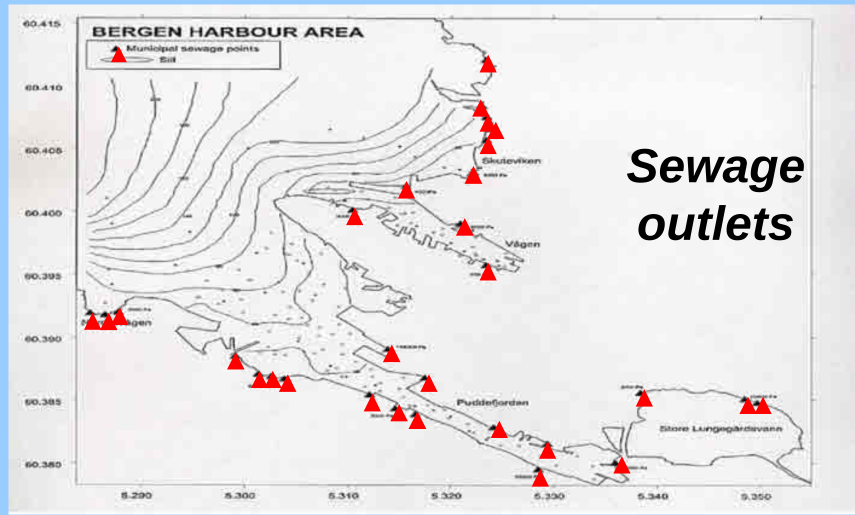




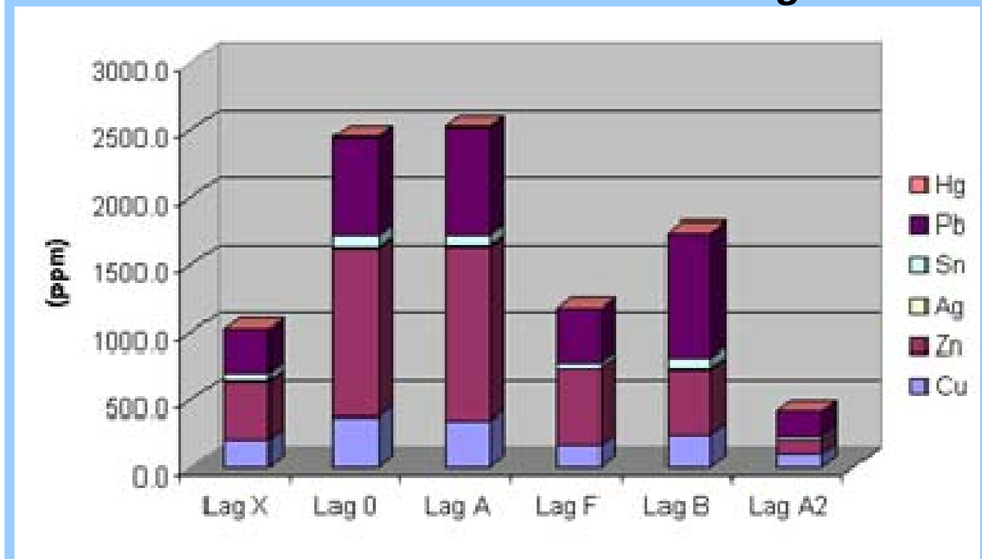
Paetzel et al. 2003



A. Mathisen & Prestmo (1999)

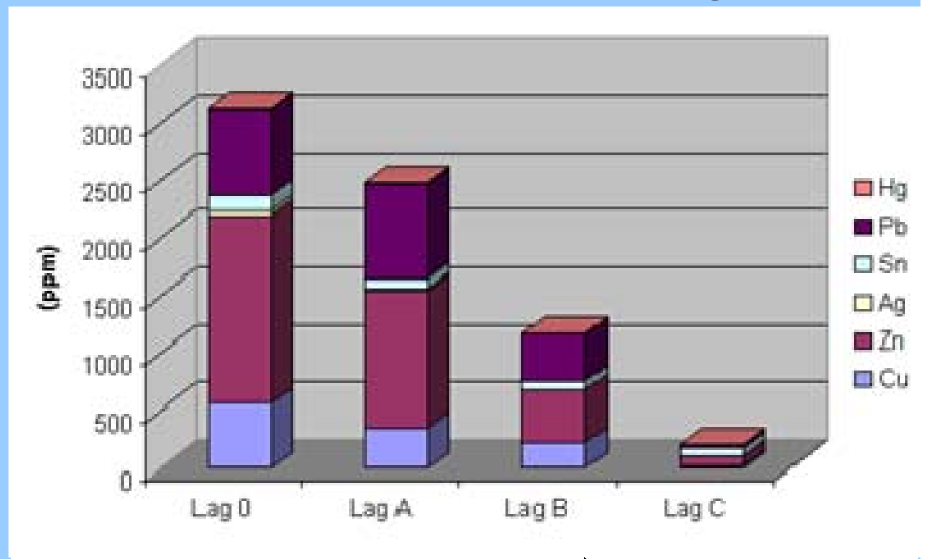


Outer harbour cores - Vågen

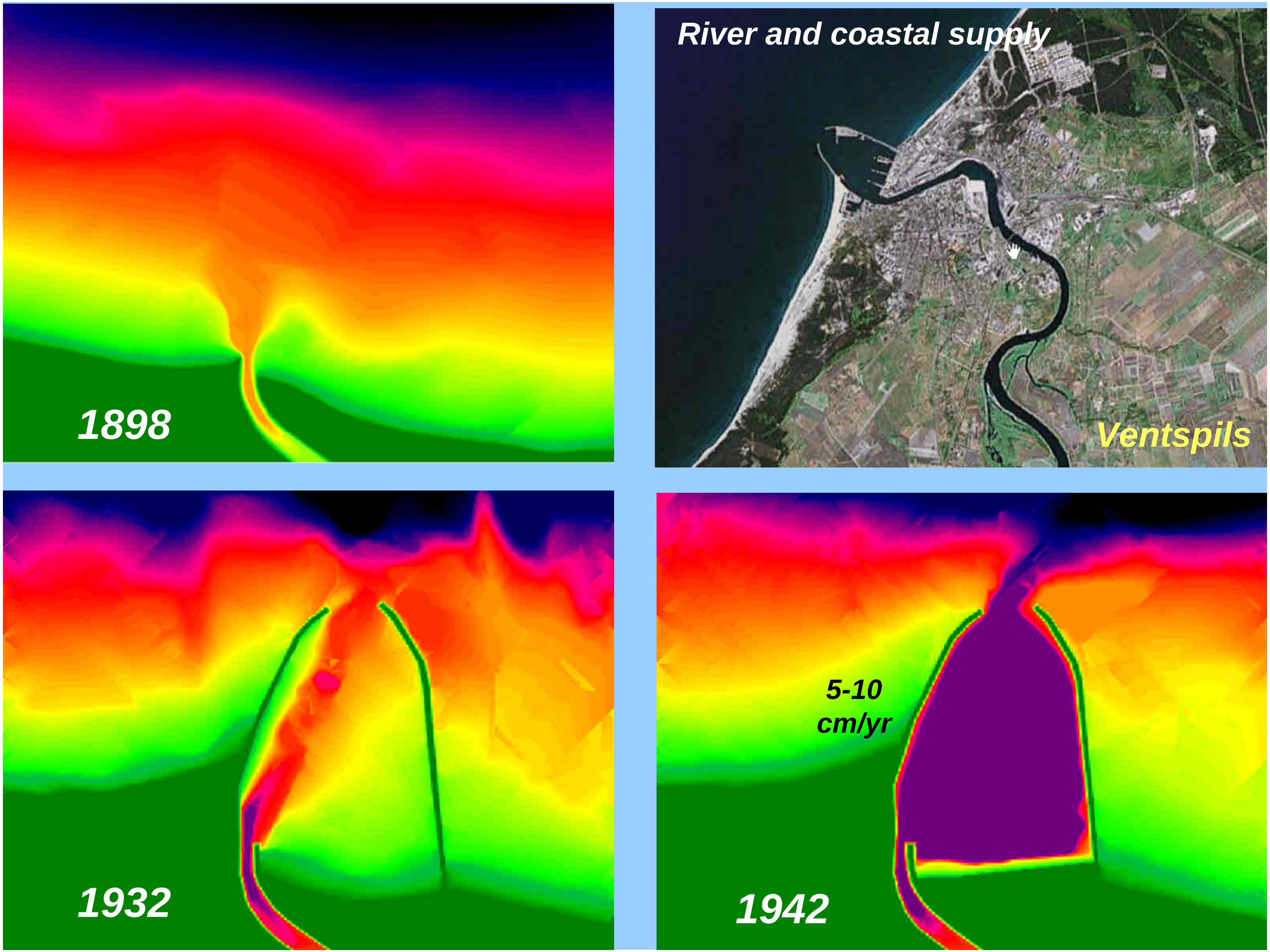


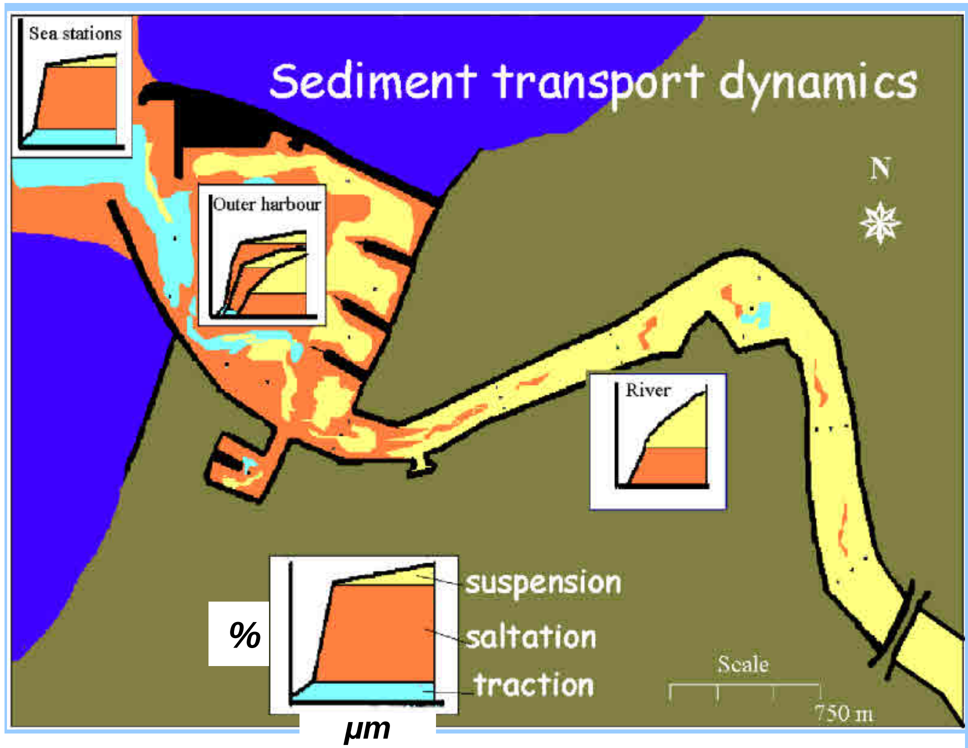
depth →

Inner harbour cores - Vågen

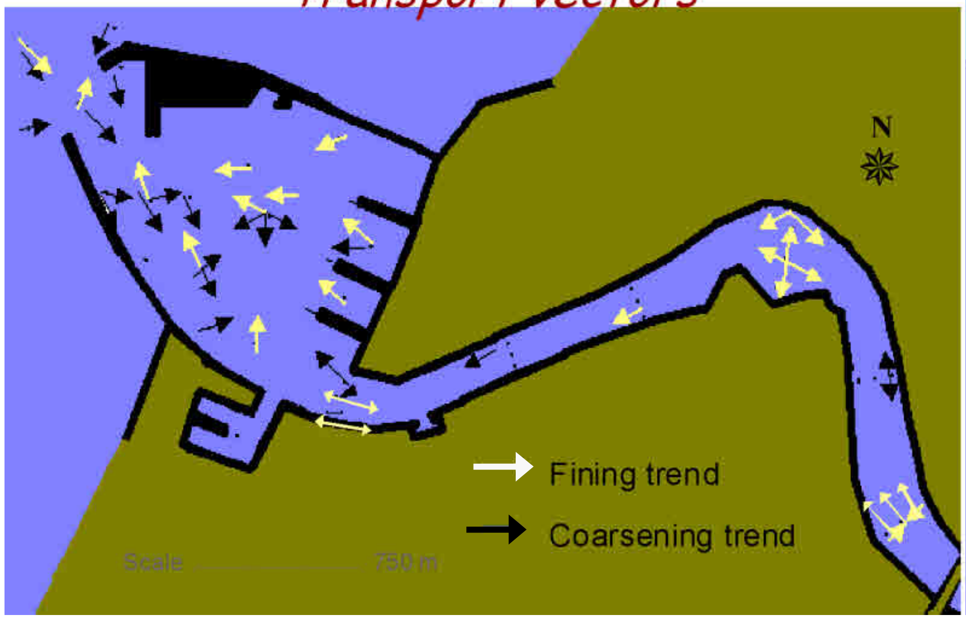


depth →

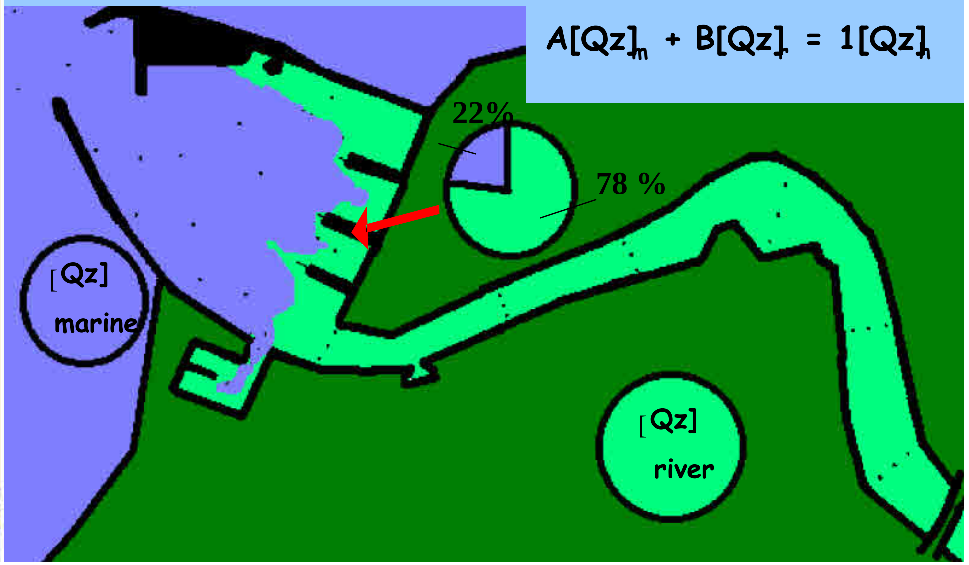

1898
River and coastal supply
Ventspils
1932
5-10
cm/yr
1942



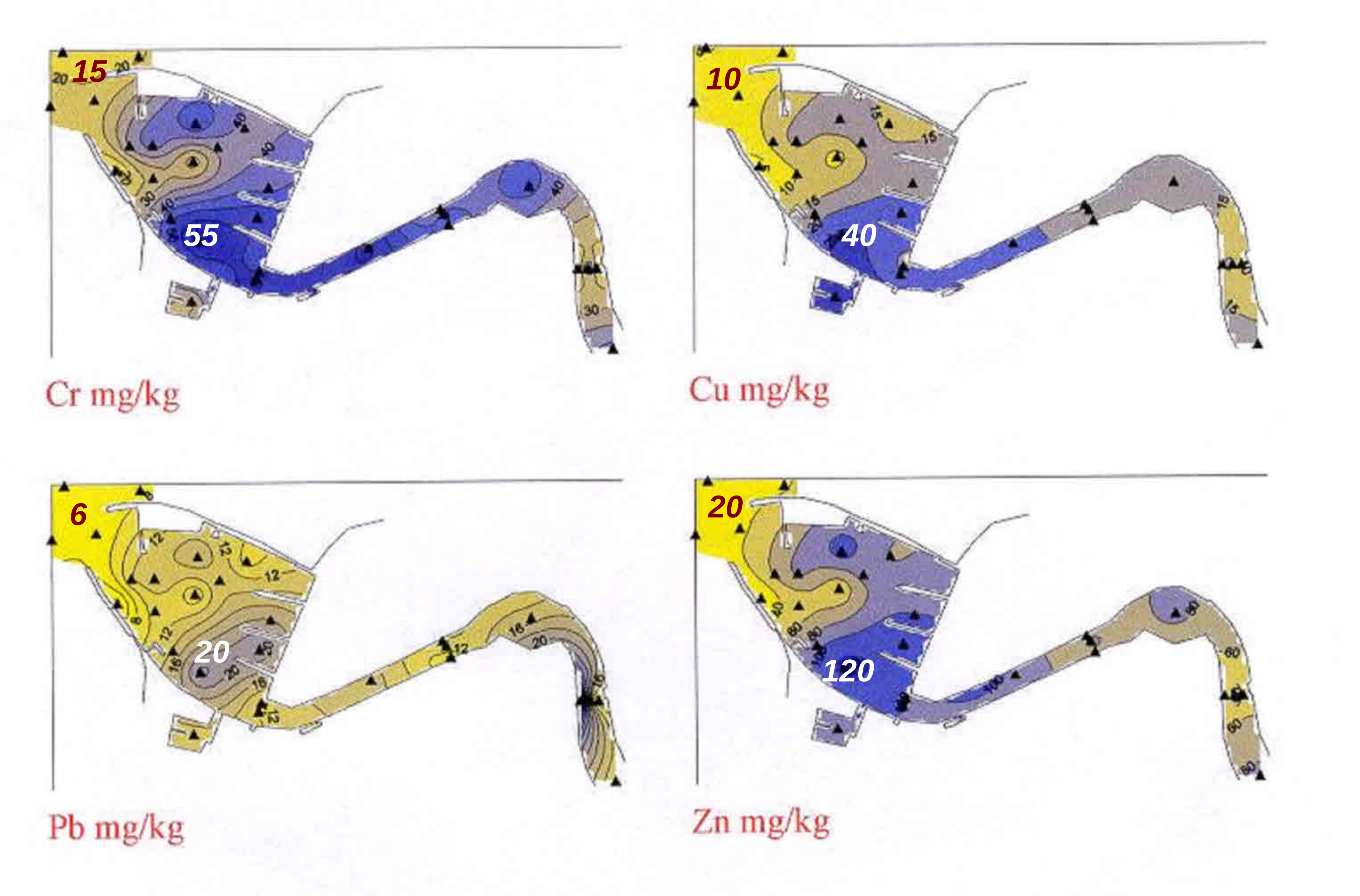
Transport vectors



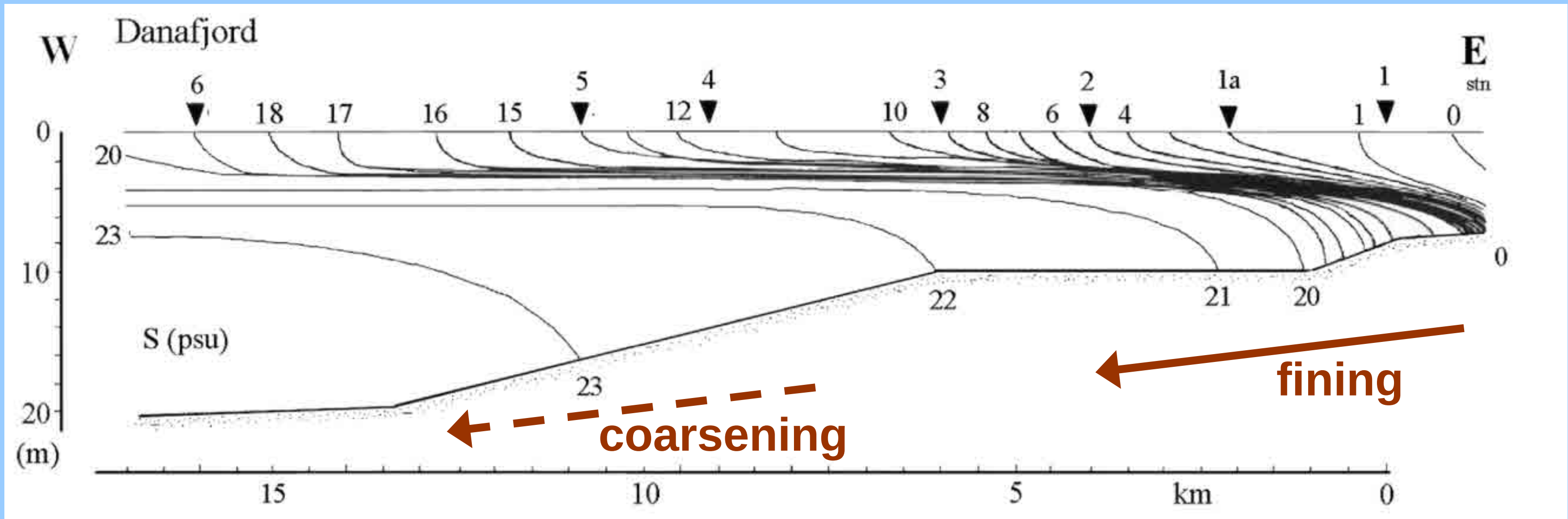
Sediment source contributions



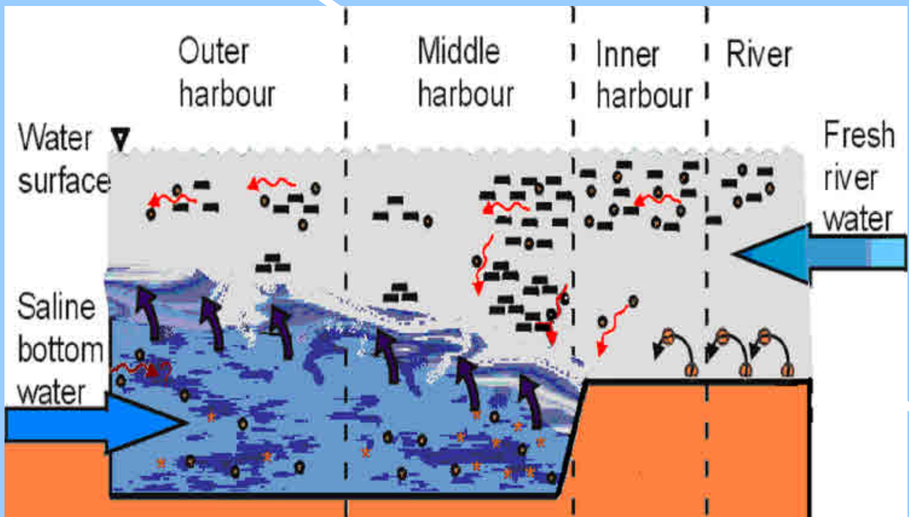
Surface sediment samples

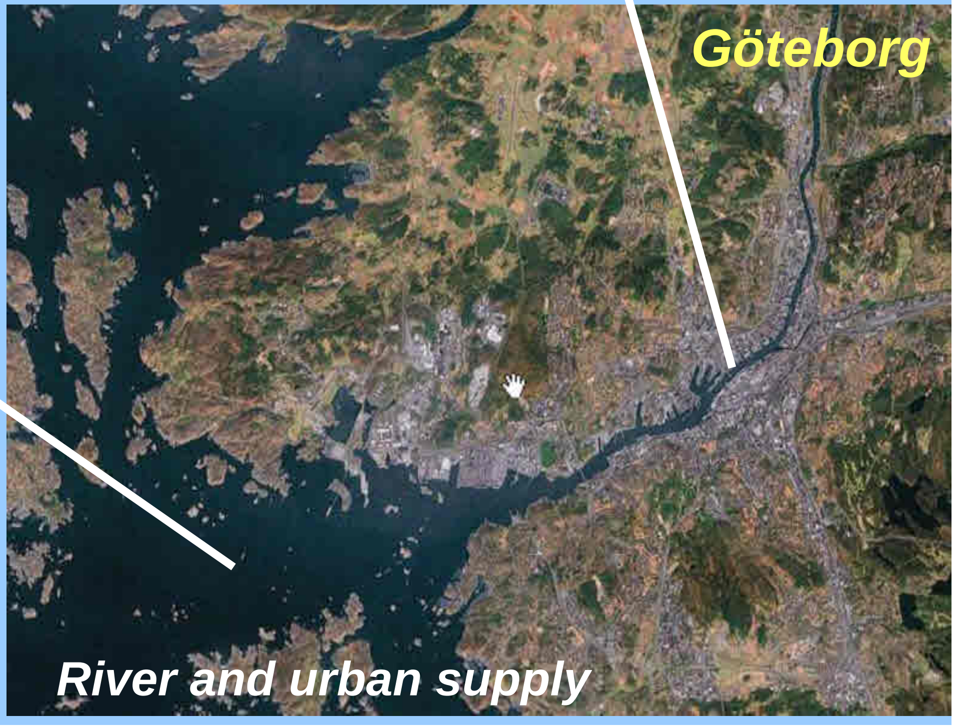


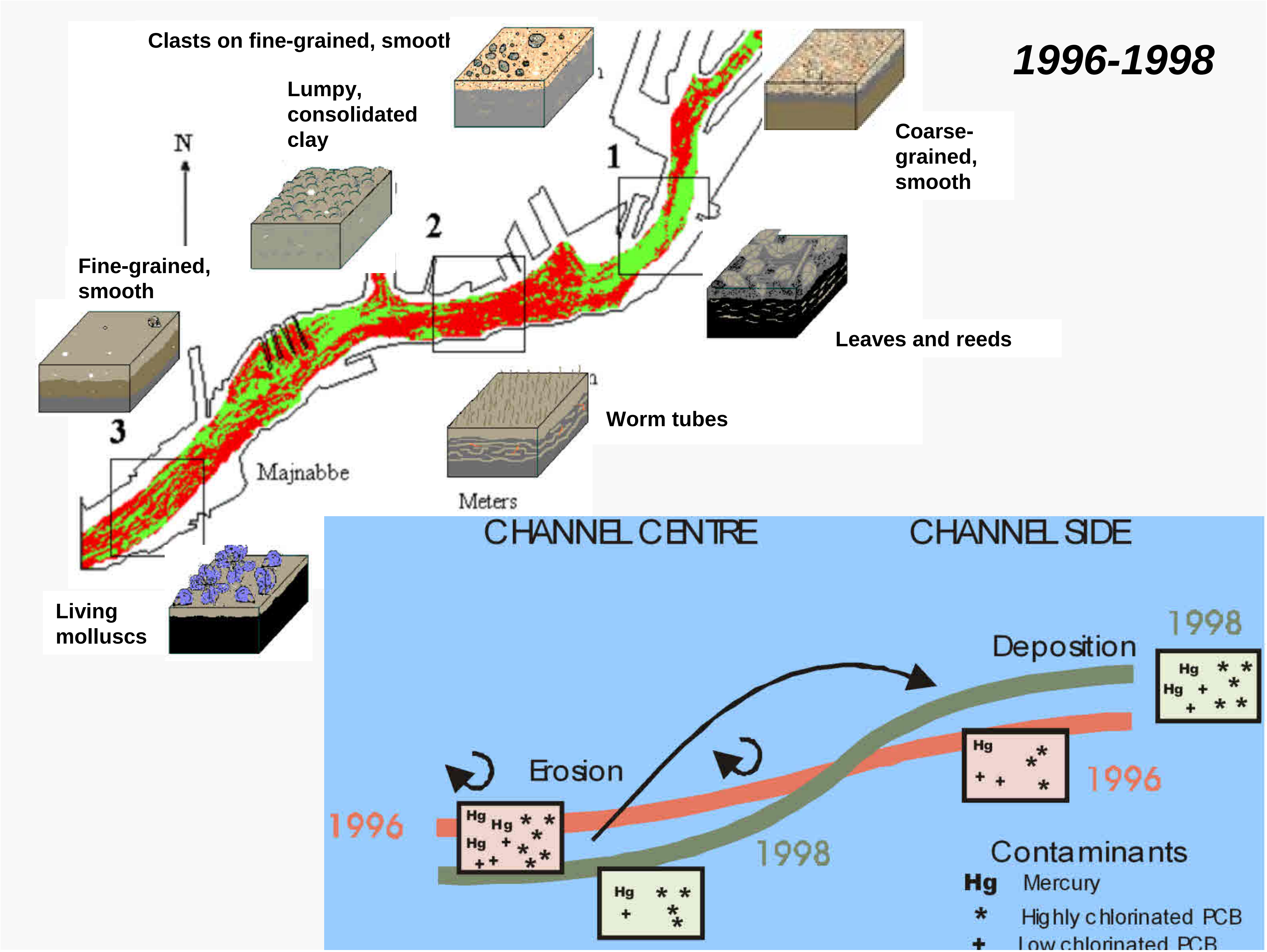
Müller-Karulis et al. 2003



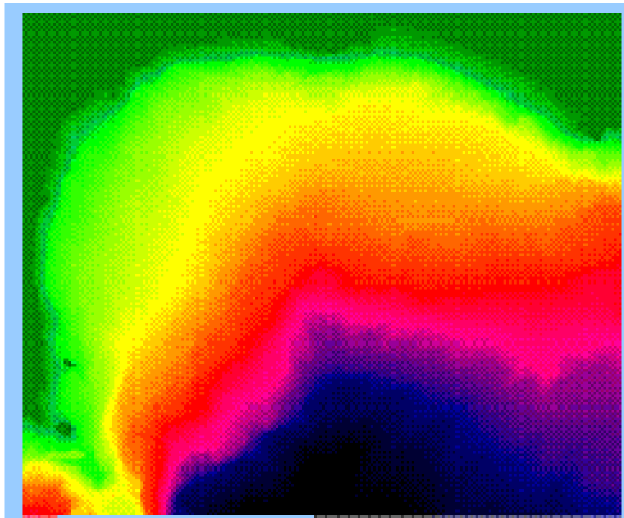
Salinity profile of the Göta älv estuary.



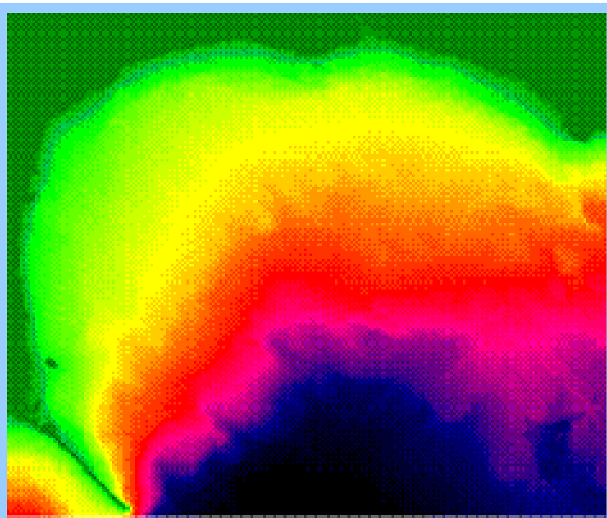




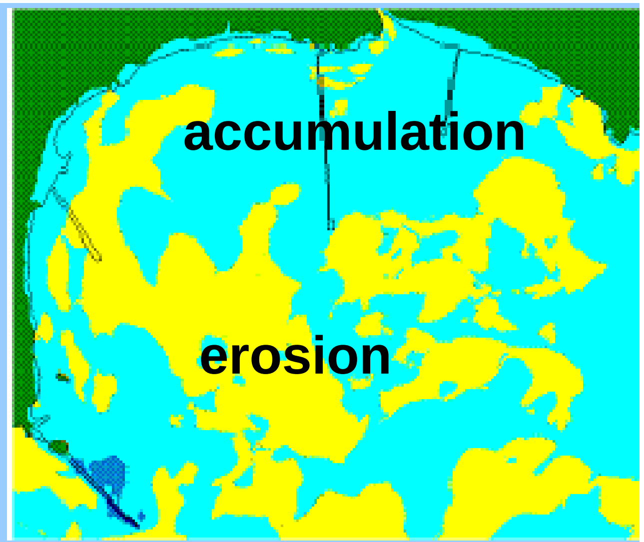
1996-1998
Clasts on fine-grained, smooth
Lumpy, consolidated clay
Coarse-grained, smooth
Fine-grained, smooth
Leaves and reeds
Worm tubes
Living molluscs
N
1
2
3
Majnabbe
Meters
CHANNEL CENTRE
CHANNEL SIDE
Deposition
Erosion
1996
1998
Hg
Contaminants
Hg Mercury
* Highly chlorinated PCB
+ Low chlorinated PCB

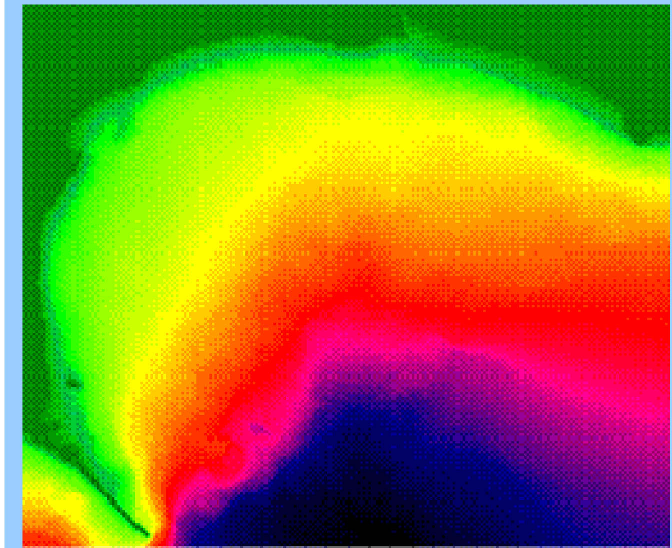


1875



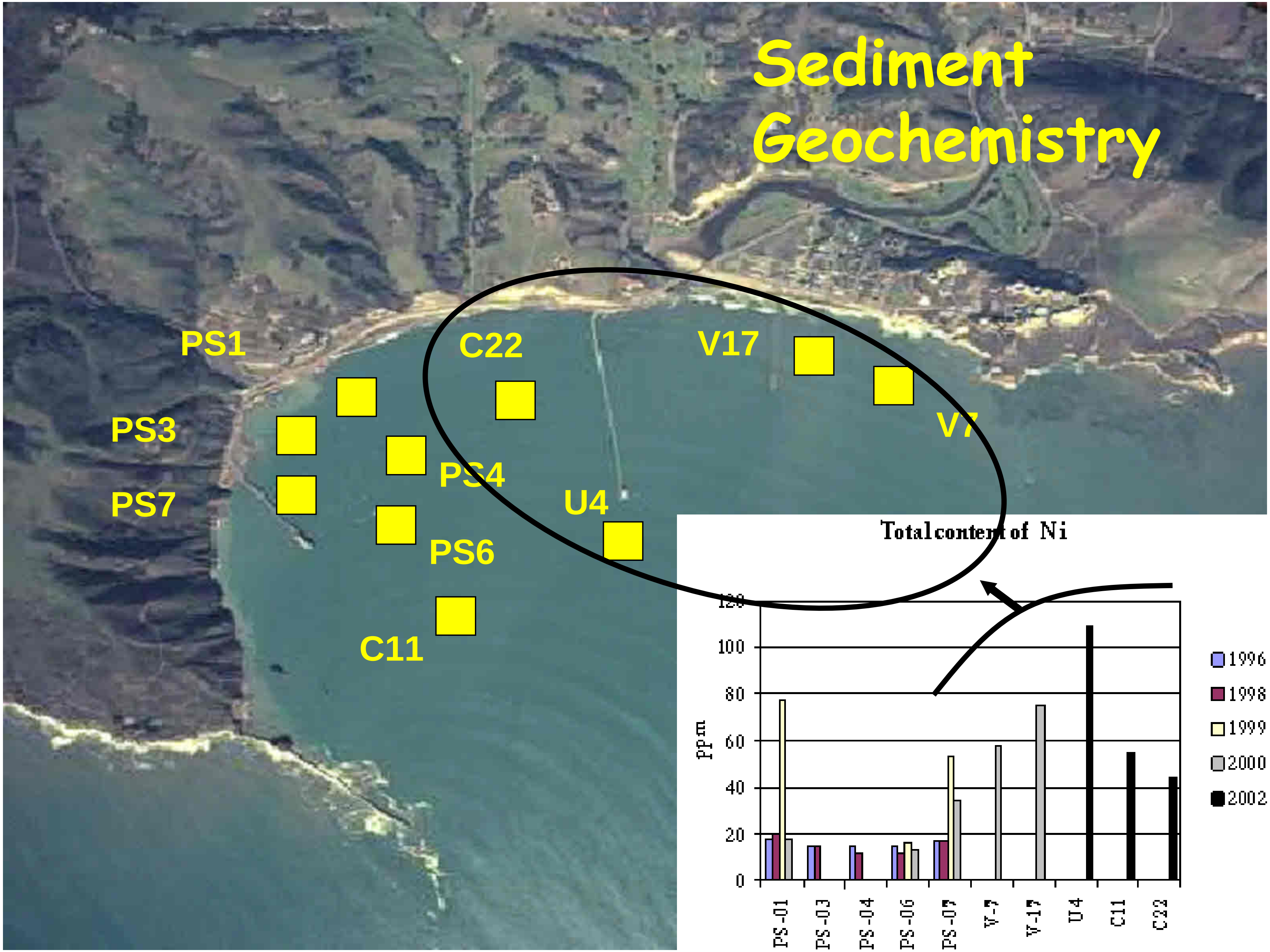
1934



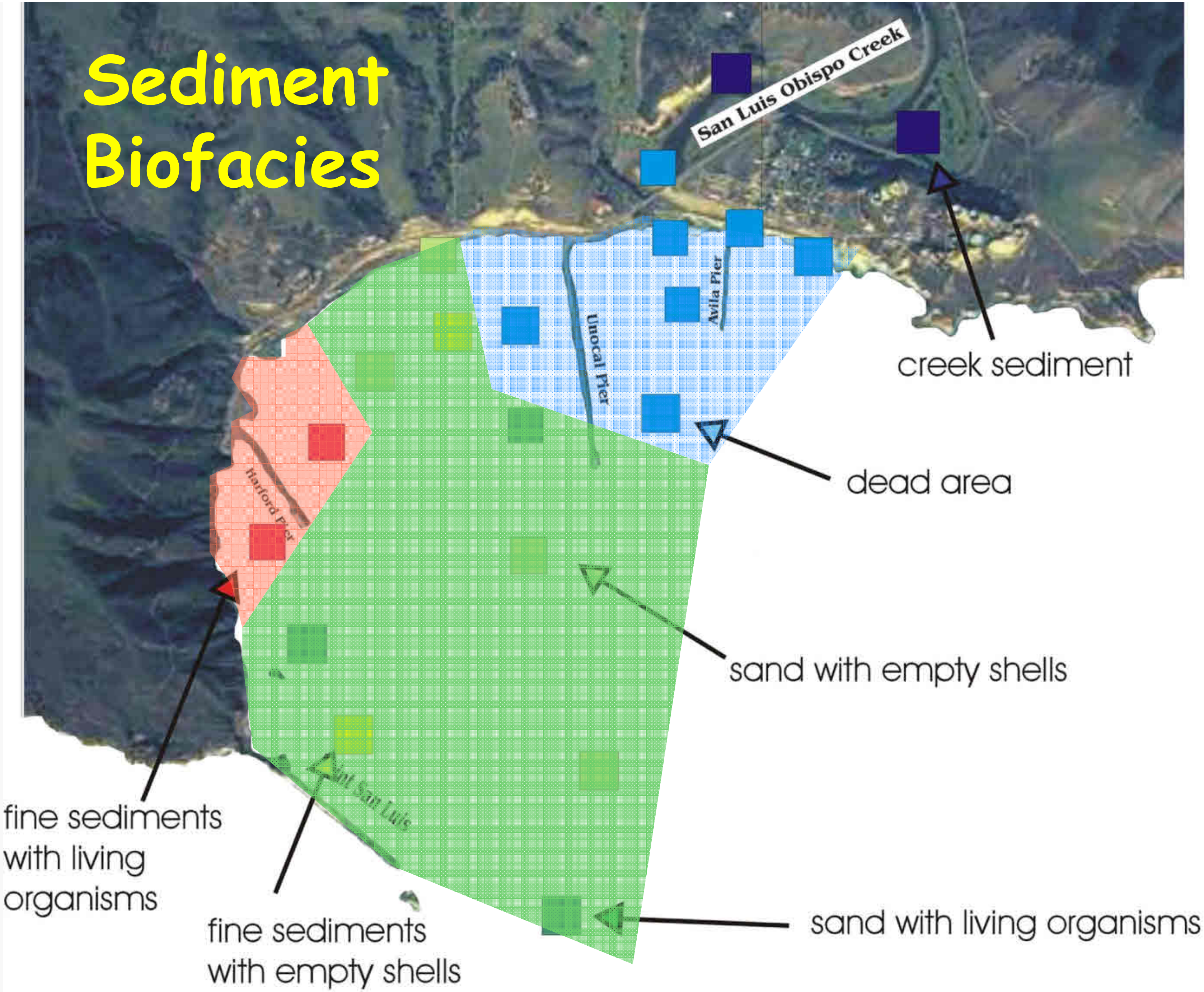


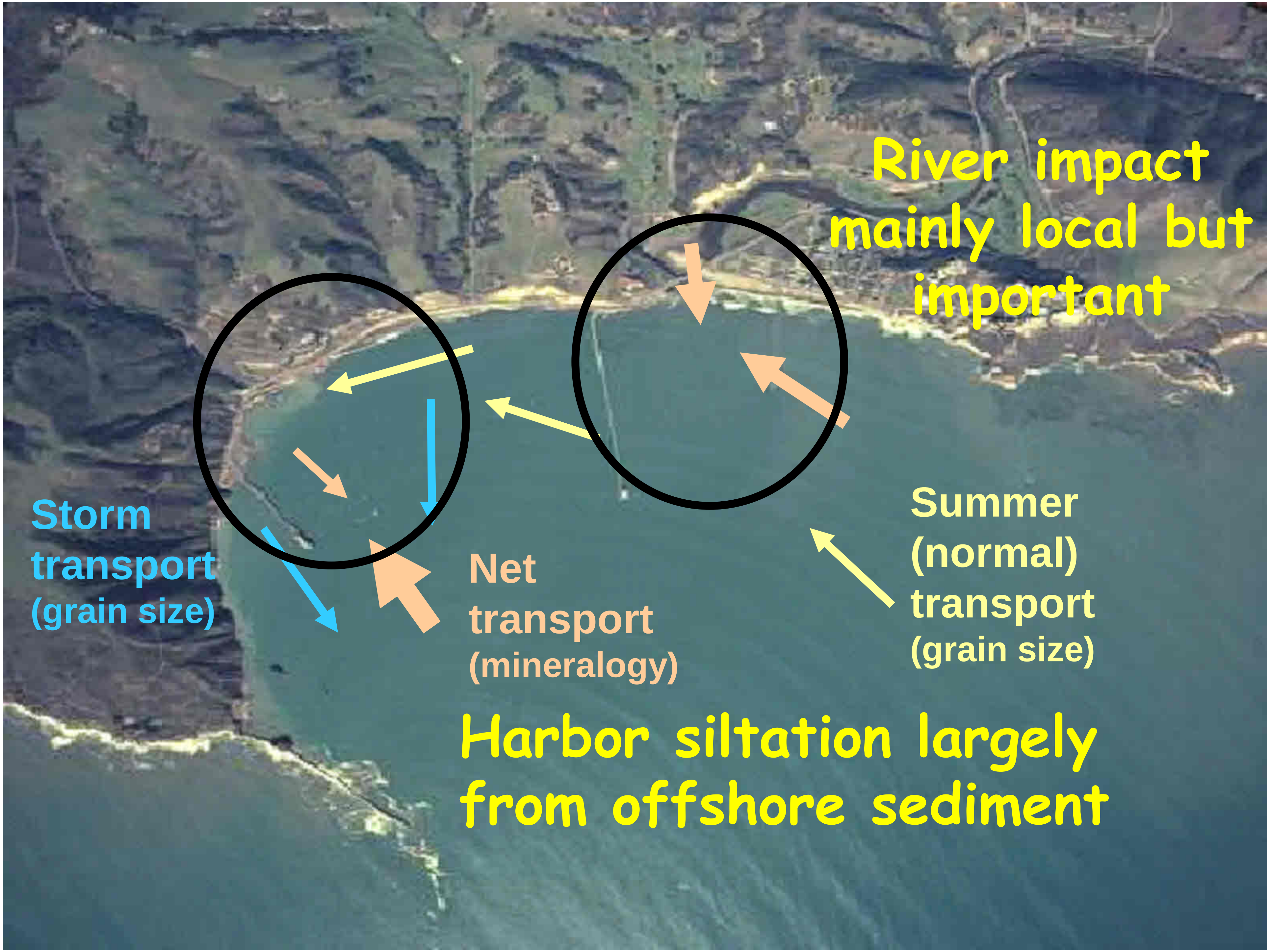
1996

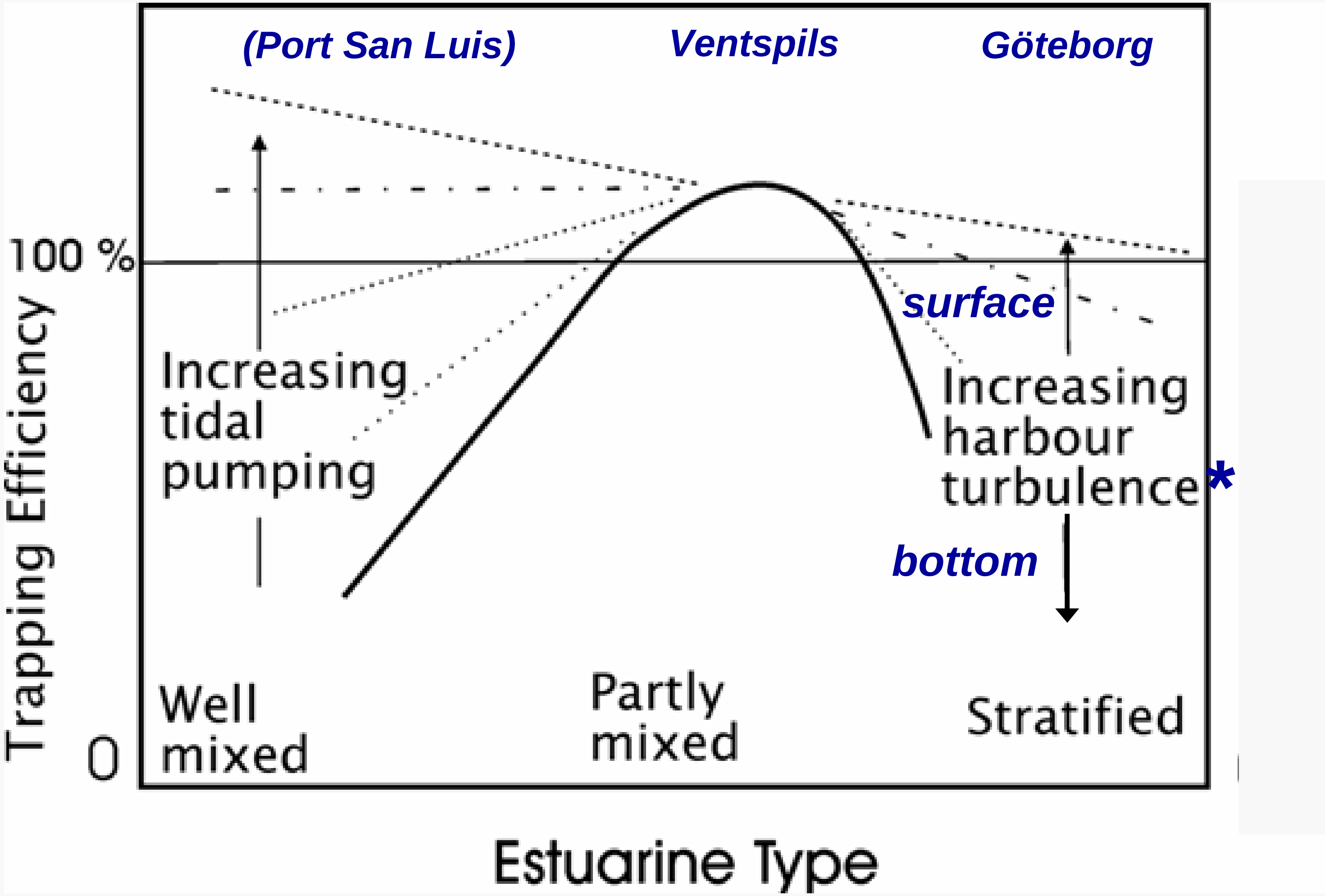
Sediment Geochemistry



Sediment Biofacies



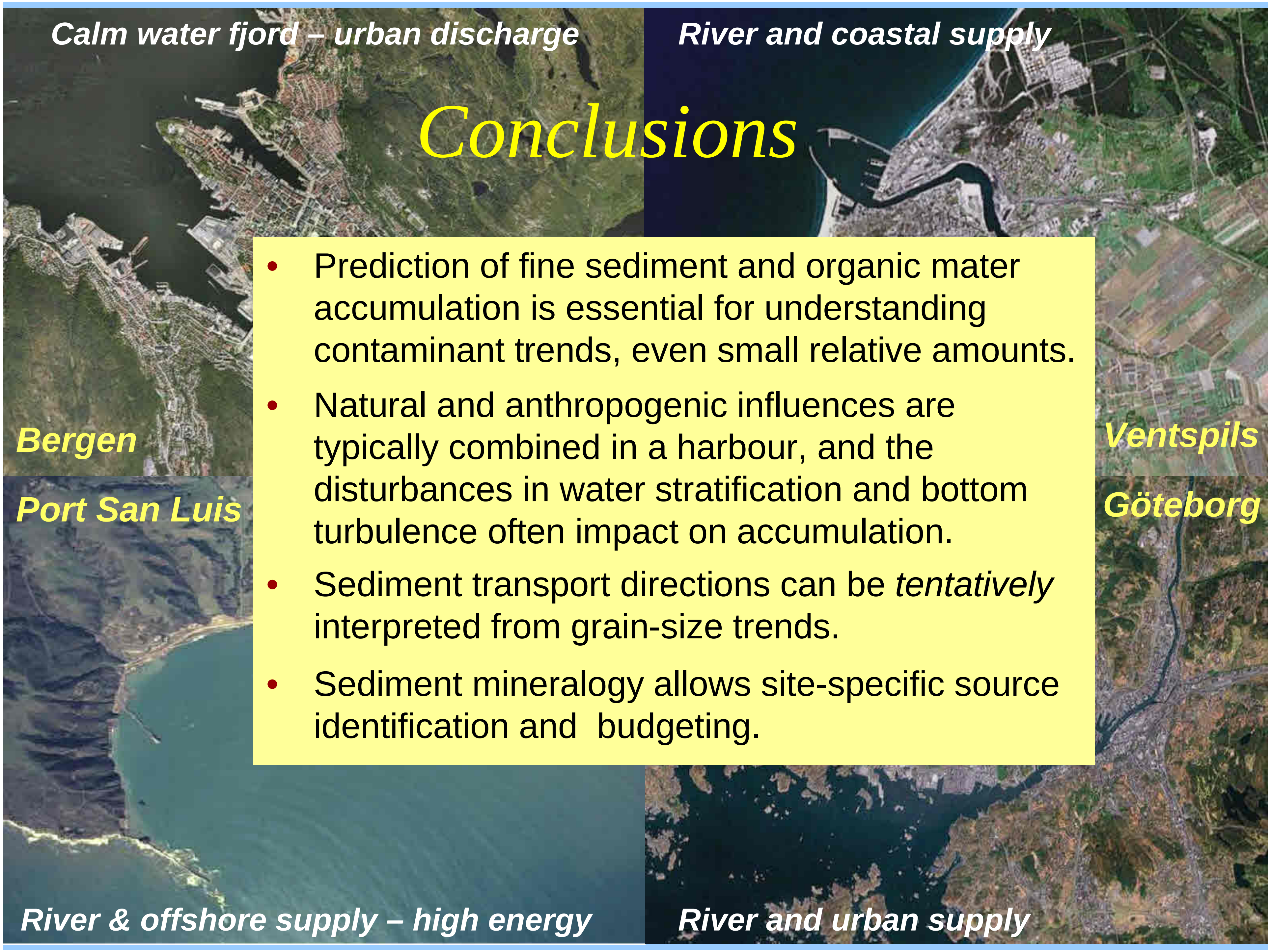

River impact mainly local but important
Storm transport (grain size)
Net transport (mineralogy)
Summer (normal) transport (grain size)
Harbor siltation largely from offshore sediment



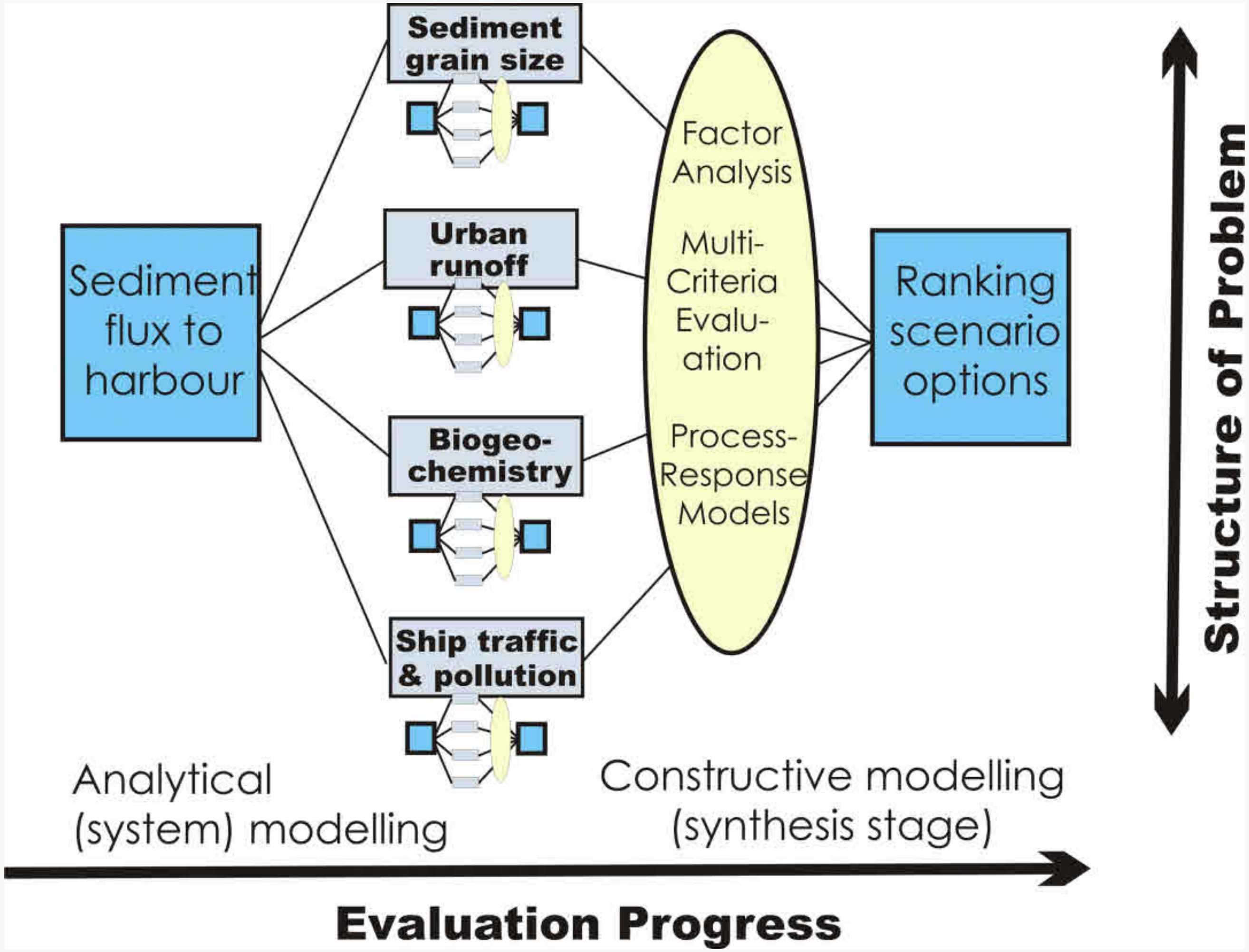
* *Includes influence by ship traffic, harbour structures and dredging*

Conclusions

- Prediction of fine sediment and organic mater accumulation is essential for understanding contaminant trends, even small relative amounts.
- Natural and anthropogenic influences are typically combined in a harbour, and the disturbances in water stratification and bottom turbulence often impact on accumulation.
- Sediment transport directions can be *tentatively* interpreted from grain-size trends.
- Sediment mineralogy allows site-specific source identification and budgeting.



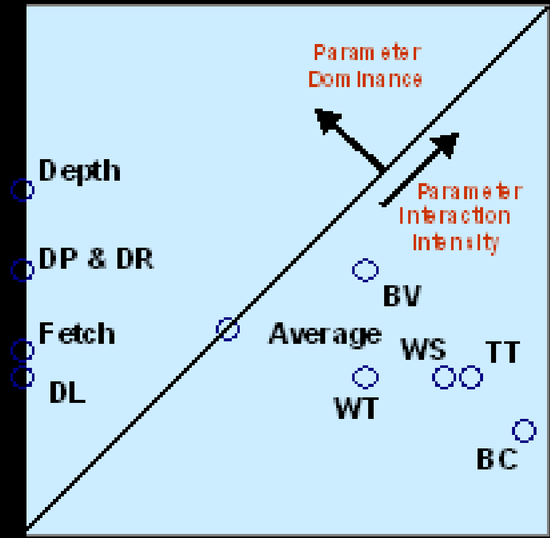
Modelling Tools



Multi-criteria Evaluation Modelling

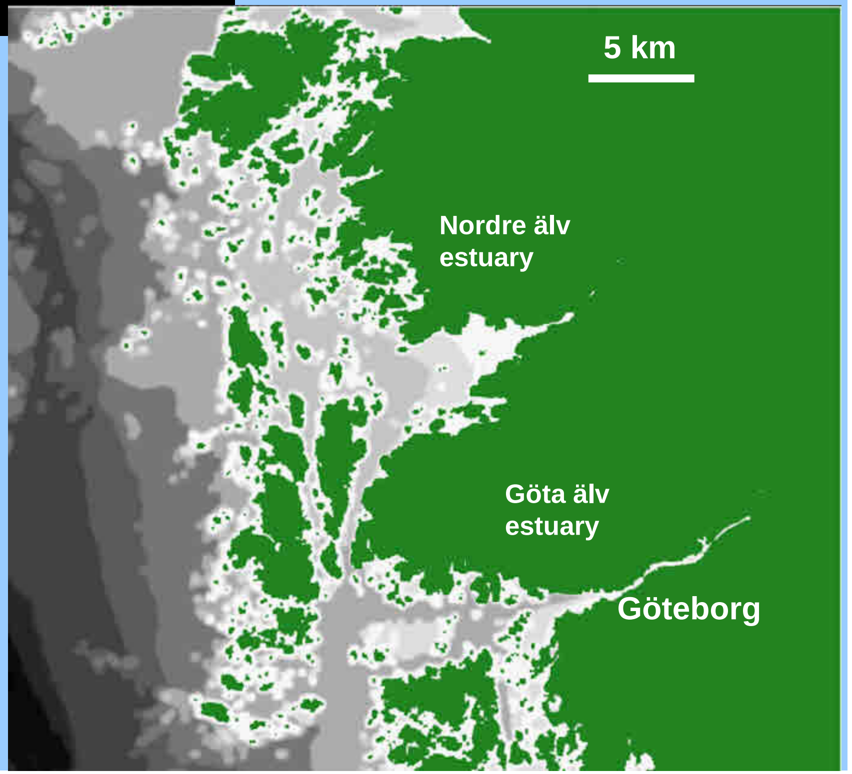
	WT	BC	TT	WS	BV	D	DR	DP	F	DL	TOTAL
Wave Turbulence											6
Bottom Currents											4
Traffic Turbulence											6
Water Stratification											6
Bottom Vegetation/Fauna											10
Depth											13
Distance River											10
Distance Plume											10
Fetch											7
Distance Land											6
TOTAL	13	19	17	15	13	0	0	0	0	0	7.8 7.8

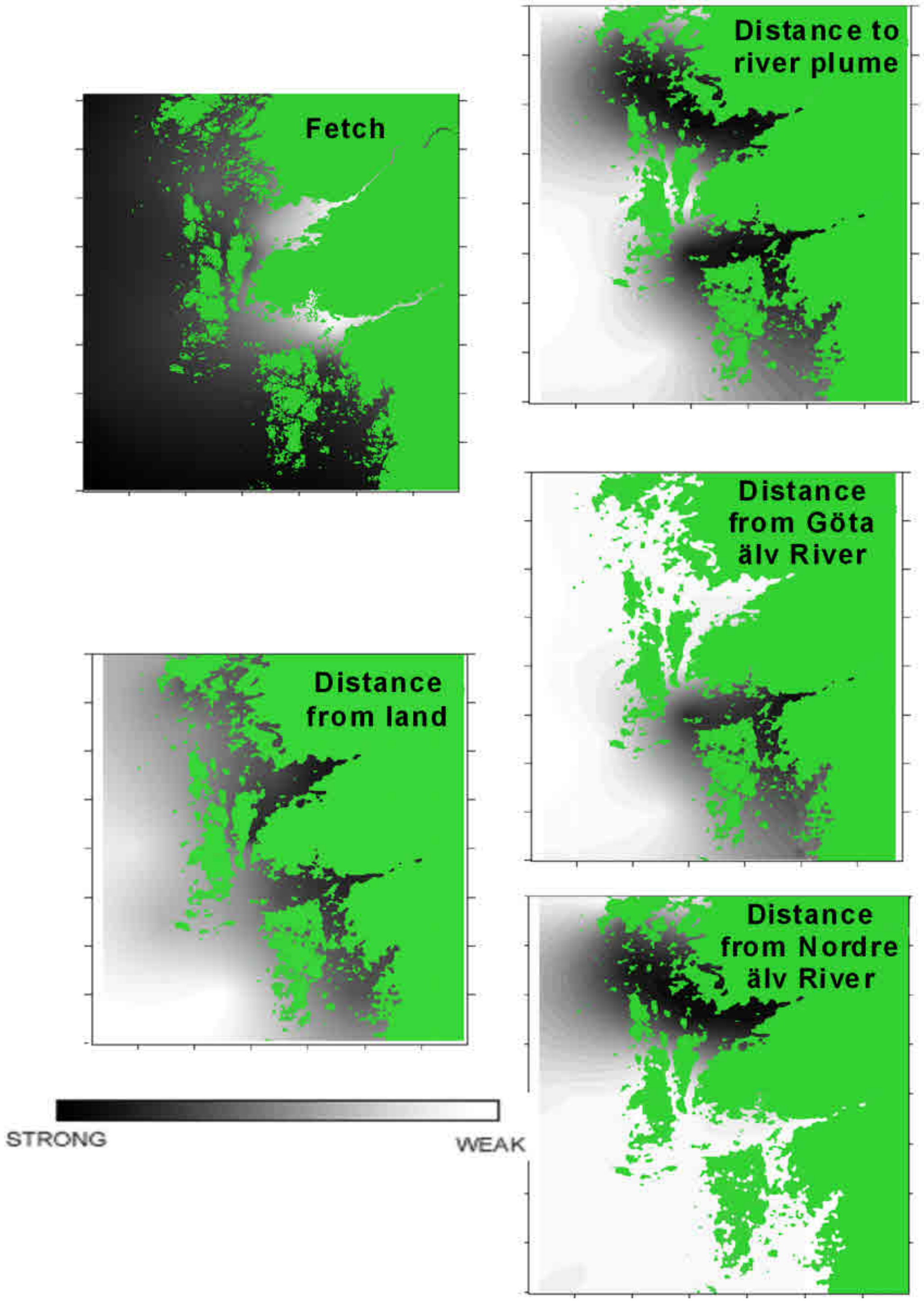
Cross-impact Matrix



Relative parameter importance for sedimentation

	Depth	Distance River A	Distance River B	Distance Plume	Fetch	Distance Land
Depth	1	1/3	1/3	1/4	1/4	1/7
Distance River A	3	1	1	1	1/5	1/7
Distance River B	3	1	1	1	1/4	1/7
Distance Plume	4	1	1	1	1/3	1/5
Fetch	4	5	4	3	1	1/3
Distance Land	7	7	7	5	3	1

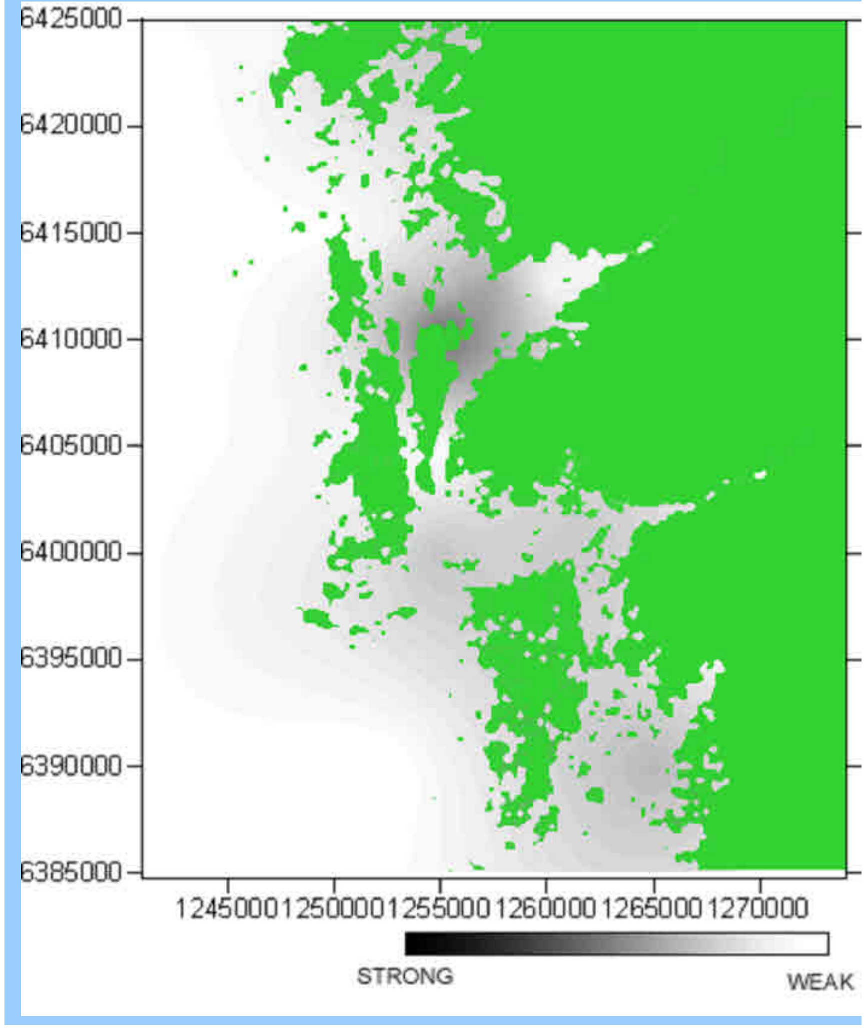




[redacted] value

factor weight

Resulting map of predicted sedimentation trends




Tack!
Foto: Johnny Nylander