INHABIT

Local hydro-morphology, habitat and RBMPs: new measures to improve ecological quality in South European rivers and lakes

Habitat control on Ecological Status: the example of the lentic-lotic character in Sardinian streams

CNR-IRSA, RAS, ARPA Piemonte, UniTuscia-DEB

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Use of Habitat information: the INHABIT approach

Habitat → combination of selected Hydro-morphological (*and physiochemical*) features

Habitat information crucial for:

- **Quantifying reference conditions e.g. to model REF values as a function of habitat diversity;**
- **Refining river typologies e.g. sub-types definition or accounting for expected seasonal and/or interannual variability;**
- **Interpreting biological data e.g. to discriminate between different sources of variation;**
- **Refining biological classification systems e.g. to select metrics, weights and habitat-specific approaches for stressor-specific evaluations**

Current ecological assessment method - Invertebrates

- As part of the Inter-calibration exercise for the WFD, Intercalibration Common Metrics (ICMs) and the STAR_ICMi were used (Buffagni et al., 2005, 2006, 2007) → standard in Italy for river classification
- → Permanent to Temporary rivers (R-M5)

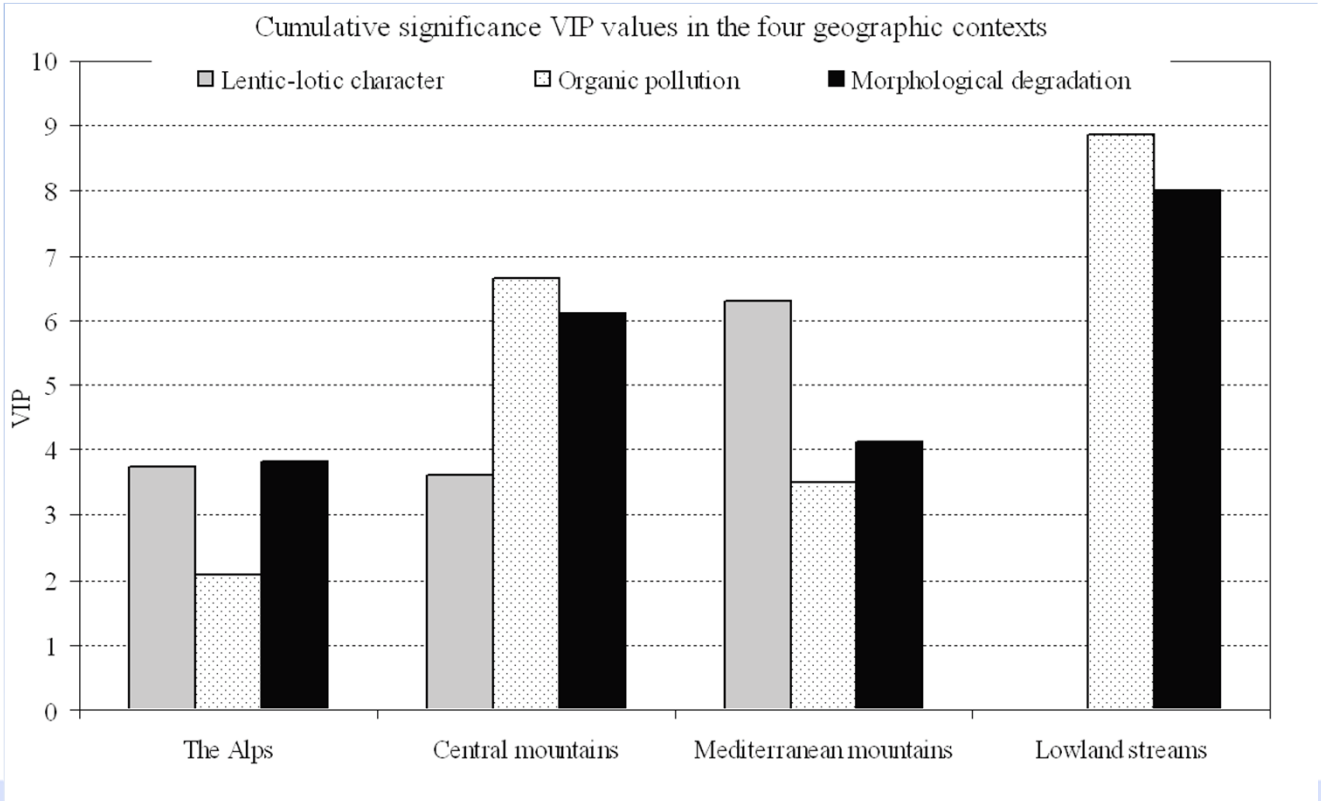
Intercalibration Common Metrics (ICMs) used in the STAR ICMi

Type	Metric type	Metric name	Taxa considered in the metric	Literature reference	weight
Tolerance	Index	ASPT	Whole community (Family level)	e.g. Armitage et al., 1983	0.333
Abundance/ Habitat	Abundance	Log_{10} (Sel_EPTD +1)	Log(sum of Heptageniidae, Ephemeridae, Leptophlebiidae, Brachycentridae, Goeridae, Polycentropodidae, Limnephilidae, Odontoceridae, Dolichopodidae, Stratyomidae, Dixidae, Empididae, Athericidae & Nemouridae)	Buffagni et al., 2004; Buffagni & Erba, 2004	0.266
	Abundance	1-GOLD	1 - (relative abundance of Gastropoda, Oligochaeta and Diptera)	Pinto et al., 2004	0.067
Richness and Diversity	Taxa number	Total number of Families	Sum of all Families present at the site	e.g. Ofenböch et al., 2004	0.167
	Taxa number	number of EPT Families	Sum of Ephemeroptera, Plecoptera and Trichoptera taxa	e.g. Ofenboch et al., 2004; Böhmer et al., 2004.	0.083
	Diversity index	Shannon-Wiener diversity index	$D_{S-W} = -\sum_{i=1}^{s}\left(\frac{n_i}{A}\right)\cdot\ln\left(\frac{n_i}{A}\right)$	e.g. Hering et al., 2004; Böhmer et al., 2004.	0.083

Habitat information for Ecological status: is that useful??

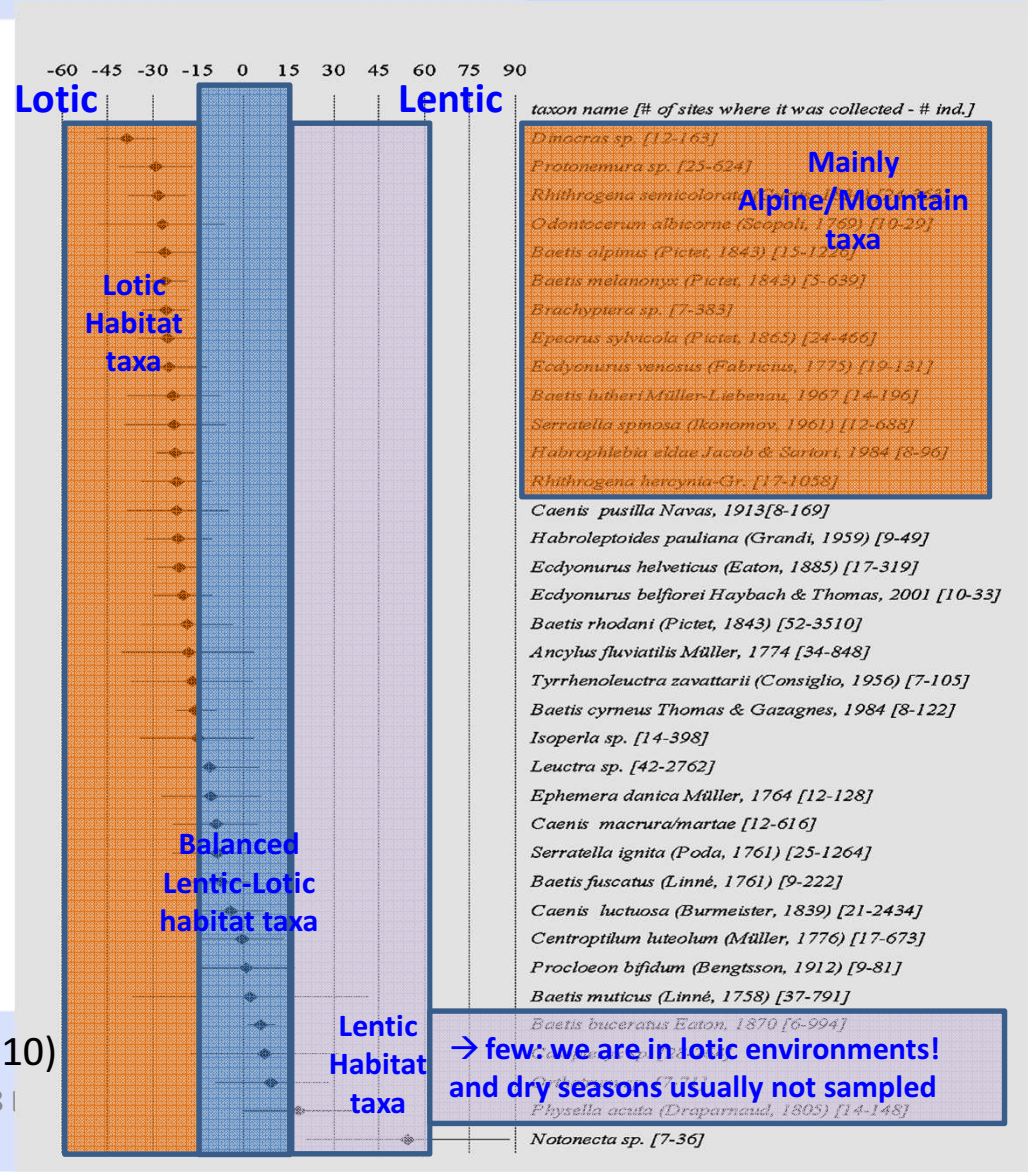
INHABIT: the main theme

- **Relative importance of different pressures (stressors) in European rivers**
- **HMS: Morphological degradation; OPD: Physiochemical pollution**
- **The contribution of the Lentic-lotic River Descriptor (LRD)**



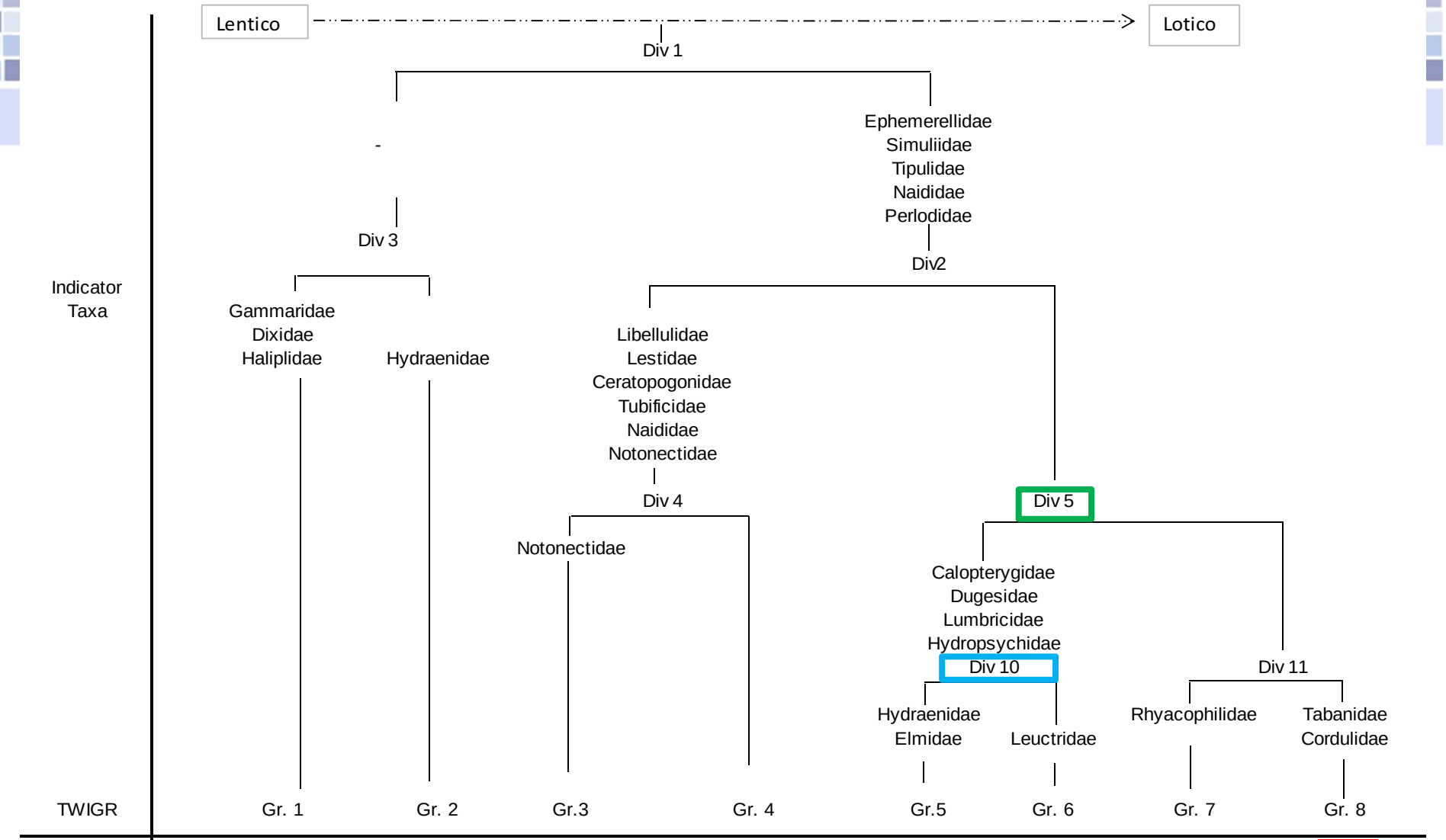
Buffagni A., Erba S. & Armanini D.G. 2010. The lentic–lotic character of Mediterranean rivers and its importance to aquatic invertebrate communities *Aquatic sciences*.

Response of invertebrate taxa to the lentic-lotic character - LRD



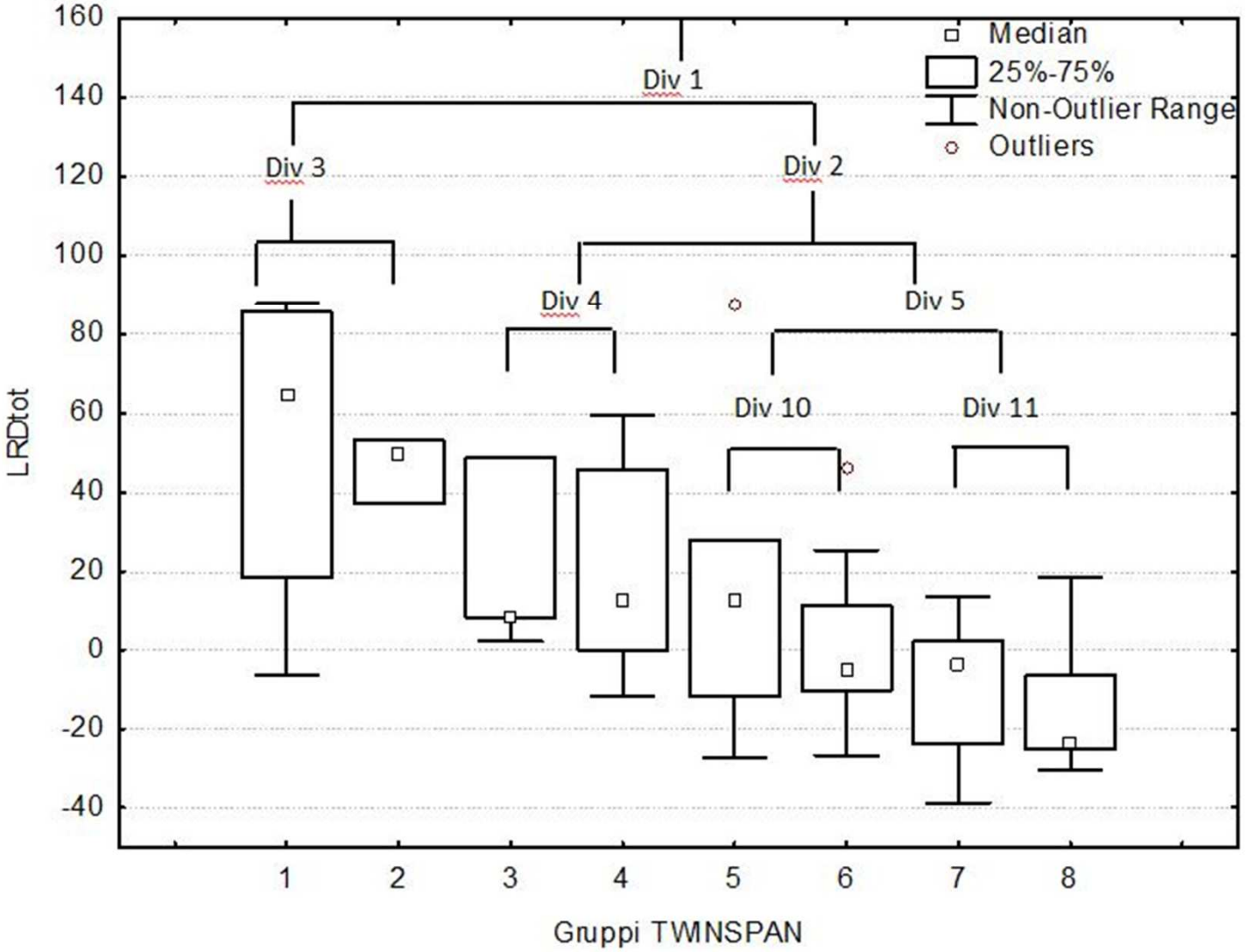
(from Buffagni et al., 2010)

Natural variability: benthic bio-types in Sardinia

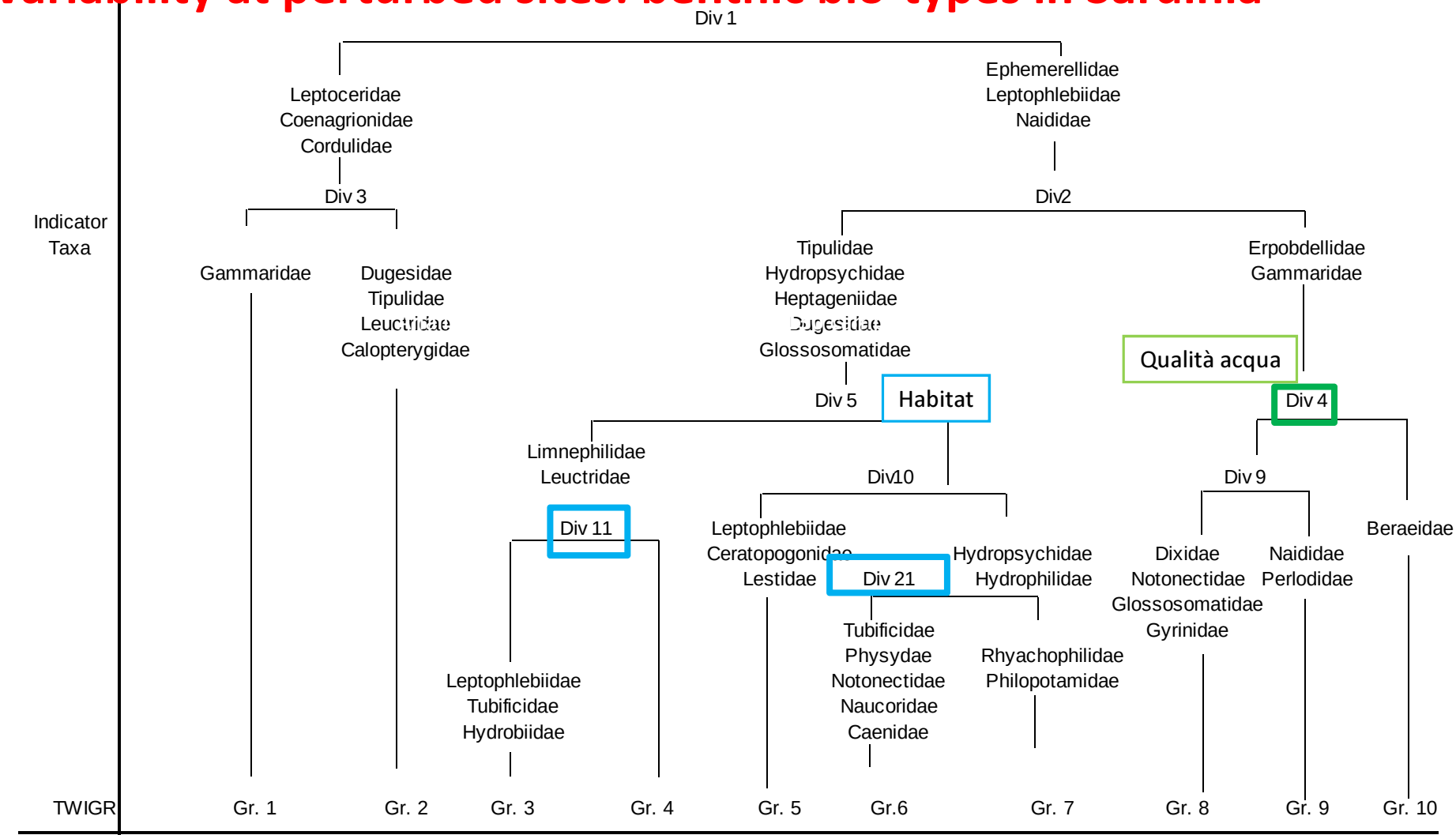


TWIGR	Gr. 1	Gr. 2	Gr.3	Gr. 4	Gr.5	Gr. 6	Gr. 7	Gr. 8
LRD	57.1	46.6	19.5	19.4	18.4	-0.3	-8.6	-16.6
Altitudine (m s. l. m.)	151.3	329.4	108	121.9	92.7	96.4	280.6	296.6
Dist. Sorg. (km)	11.30	11.20	10.90	11.9	12.9	11.5	10.5	9.1
Largh. Alveo (m)	5.4	13.2	13.8	11.6	27.2	9.3	12.5	7.1
Perennità	IN	IN	EF/IN	SS/IN/EF	IN	IN/EF	EF/IN/SS/SR	IN
Mesohabitat	Pool	Pool&Riffle	Pool	Pool	Riffle	Riffle	Riffle	Pool&Riffle

Natural variability: benthic bio-types in Sardinia
LRD vs TWINSPAN groups



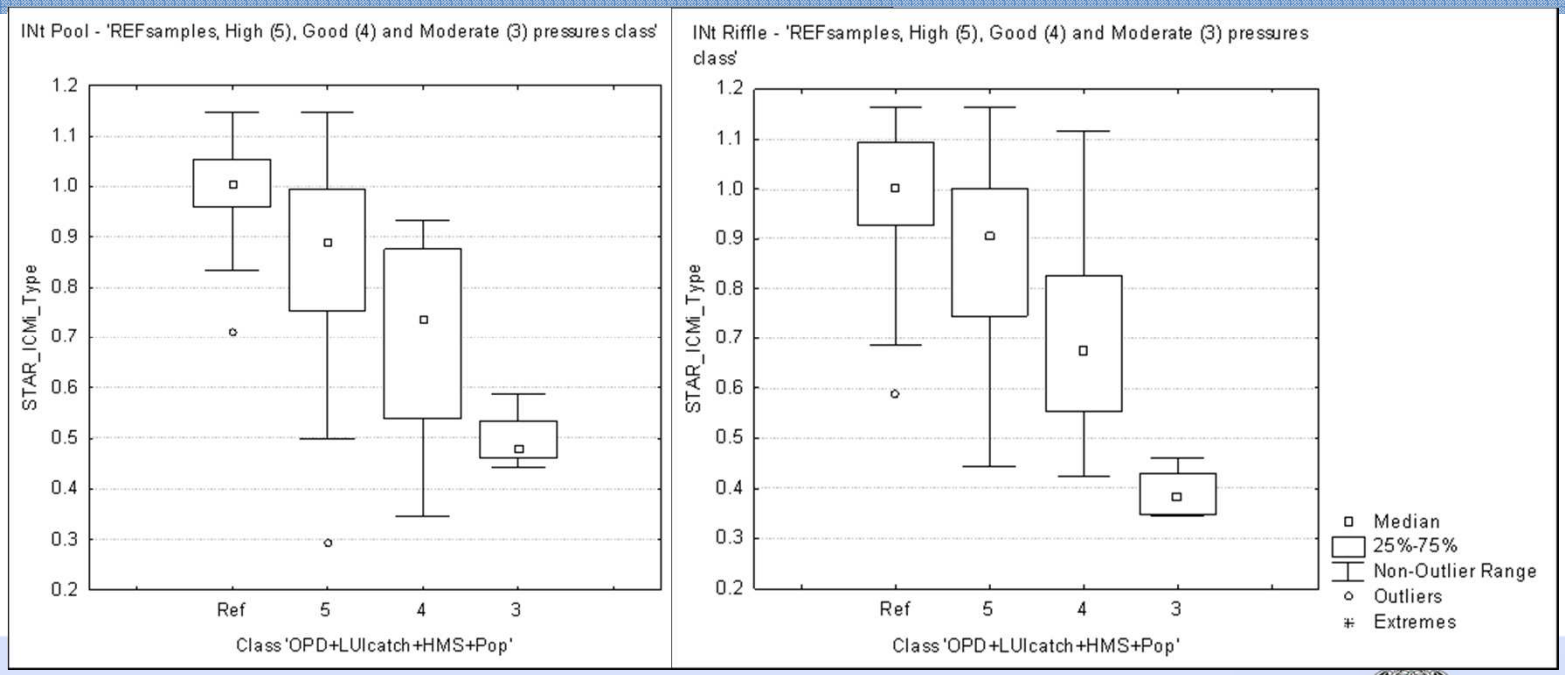
Variability at perturbed sites: benthic bio-types in Sardinia



TWIGR	Gr. 1	Gr. 2	Gr. 3	Gr. 4	Gr. 5	Gr.6	Gr. 7	Gr. 8	Gr. 9	Gr. 10
LRD	53.8	17.9	25.3	-2.3	14.6	15.7	4.9	1.58	-0.7	-22.6
Altitudine (m s. l. m.)	301.6	67.1	71.6	73.4	149.1	65.6	120.2	336.1	387.1	292
Dist. Sorg. (km)	16.56	16.20	9.63	18.06	9.99	12.2	12.02	14.06	14.89	6.22
Largh. Alveo (m)	7.5	18.9	8.7	27.5	10.7	16.7	21.5	8.4	7.5	6.5
Mesohabitat	Pool&Riffle	Pool&Riffle	Pool&Riffle	Riffle	Pool	Pool&Riffle	Riffle	Pool&Riffle	Pool&Riffle	Pool&Riffle
HMS	15	22.8	6.3	31.25	6.7	40.9	15.3	8.6	25.3	0.25
HQA	44.2	53.6	60	51.6	51.3	42.6	50.2	47.4	47.9	67.7
LUI	3.99	2.02	1.15	2.4	0.51	5.83	2.14	1.2	3.74	0.04
LIM	0.71	0.77	0.83	0.82	0.9	0.73	0.95	0.58	0.42	0.86

The contribution of Habitat-oriented methods (1) Quantifying pressures

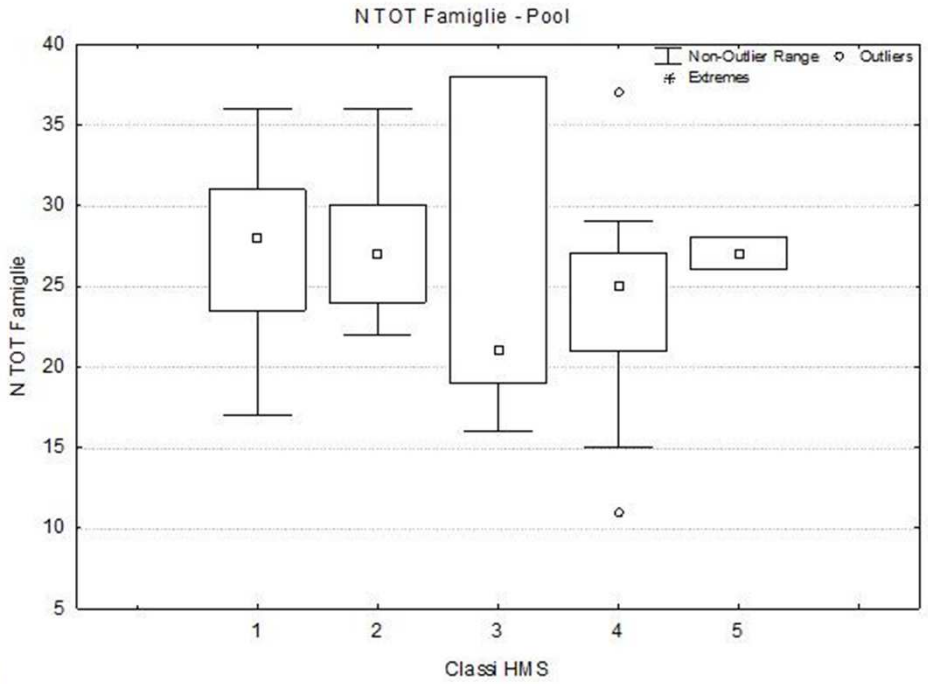
- **Can we implement an ecological assessment system able to detect anthropogenic impact in a hydrological driven environment?**
- **CARAVAGGIO indices, catchment & water chemistry → Clear separation between pressure classes for STAR_ICMi in Intermittent river type (INt, CY example, WDD), for both Pools and Riffles**

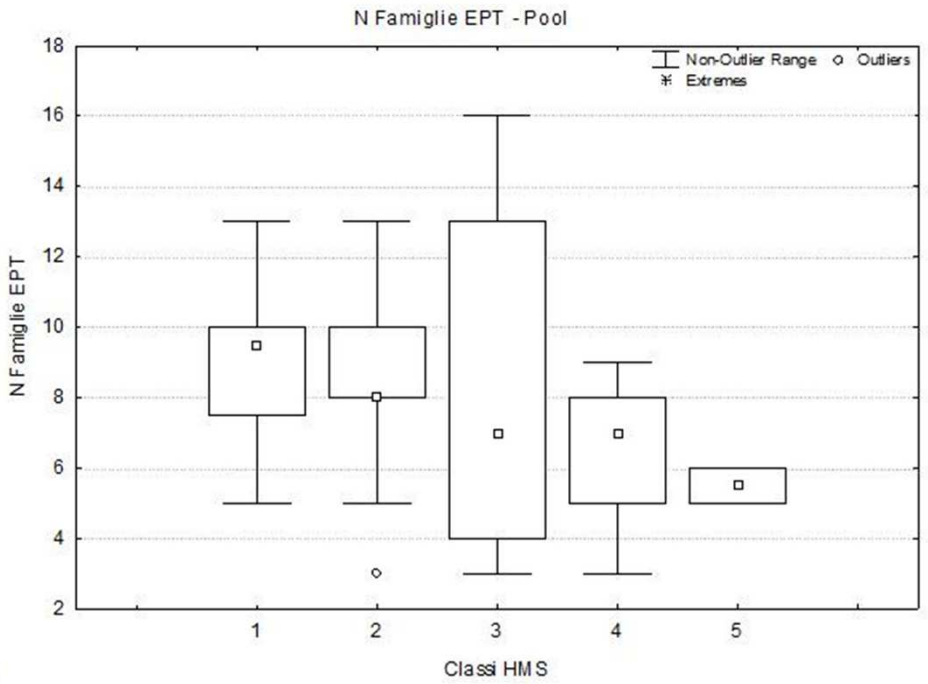


Increasing pressures

Increasing pressures

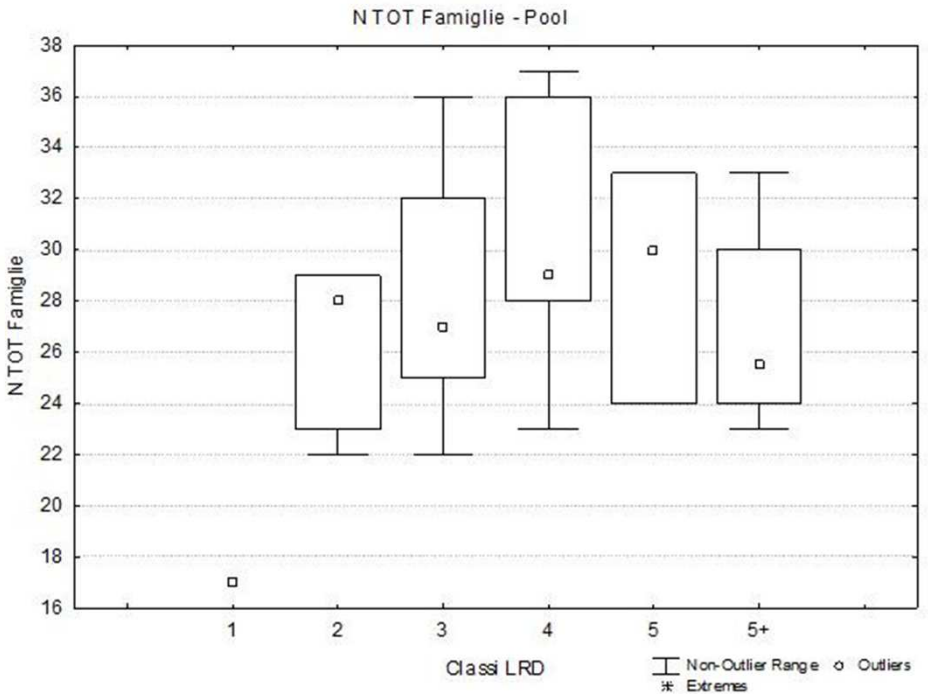
Assessment of variability in perturbed sites - single pressures vs benthic metrics Sardinia Med rivers

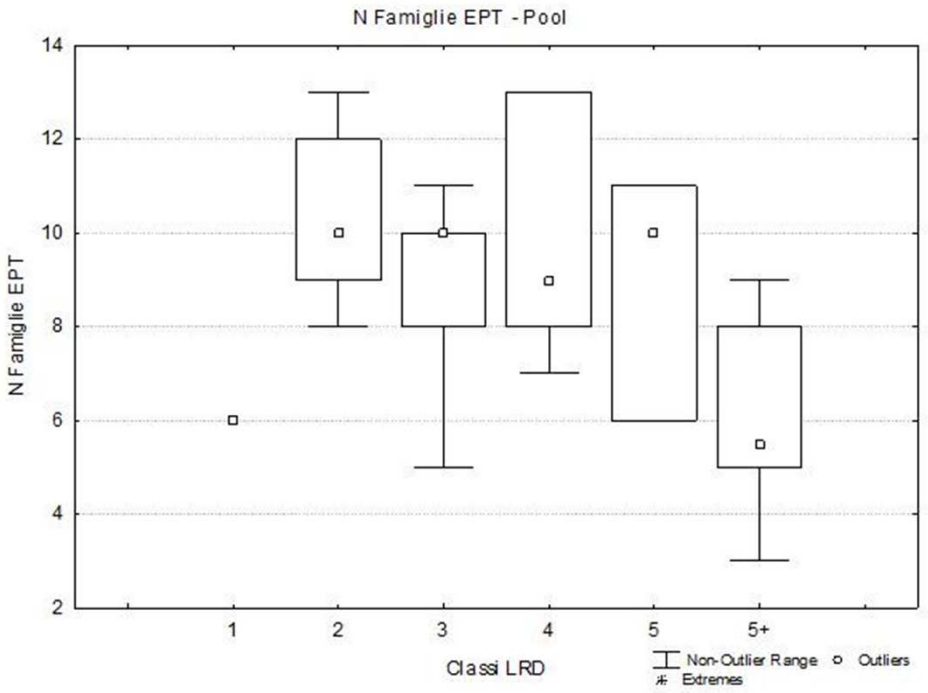


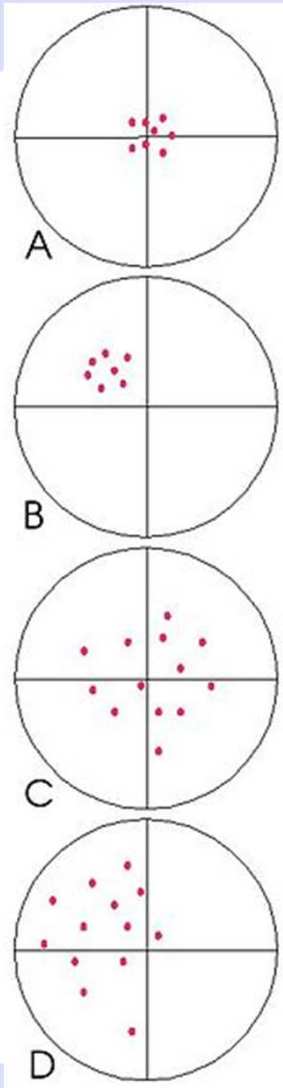


The contribution of Habitat-oriented methods (2)
Quantifying natural variability

Assessment of natural variability (only REF/sligthly perturbed sites), benthic metrics Sardinia Med rivers







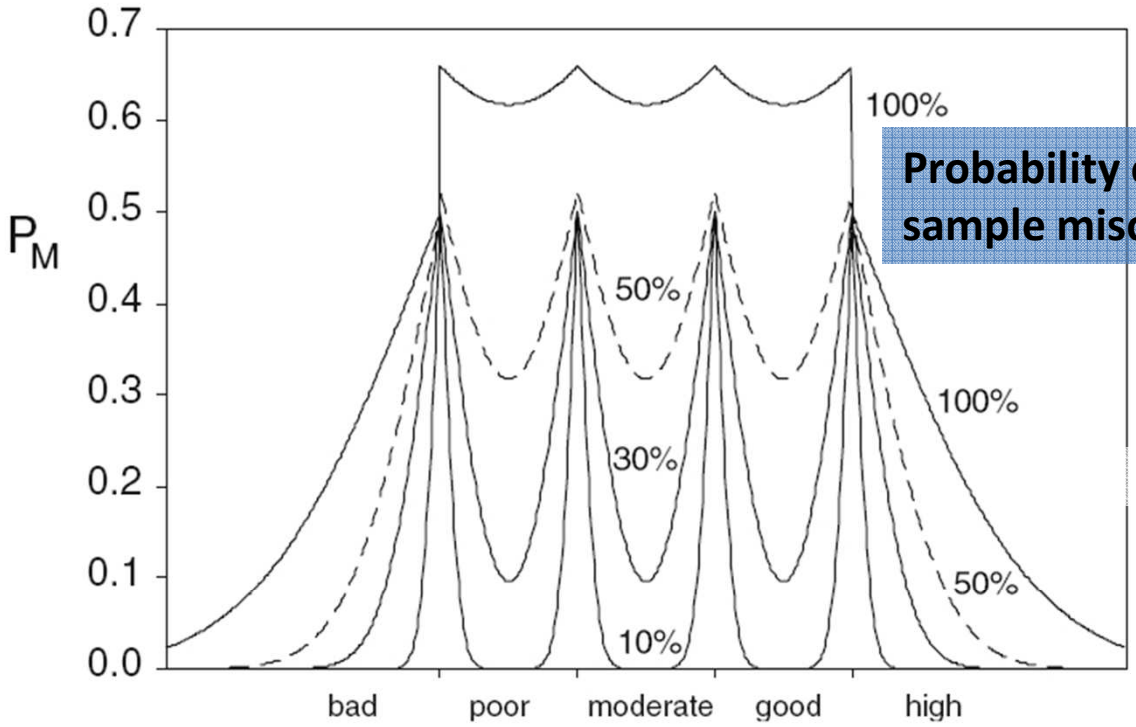
WFD: uncertainty in estimating Ecological Status: what is really relevant?

What about 'uncertainty' in defining reference conditions??

A conceptual example of accuracy and precision of a series of data (red dots).

A- Precise and accurate
B- Precise but not accurate
C- Accurate but imprecise
D- Not accurate nor precise

http://it.wikipedia.org/wiki/File:Accuracy_and_precision_example.jpg



Probability of sample misclassification

Clarke & Hering. 2006. Hydrobiologia 566:433–439

INHABIT –precision estimate → STARBUGS (Clarke)

06 SS XX - Classificazione: valori medi per sito

SITO	Stato Ecologico	%high	%good	%moderate	%poor	%bad	%HG	livello di rischio MI
1	BUONO	0.3	56.2	43.4	0.1	0	**56.5**	probabilmente a rischio
2	ELEVATO	58.8	41.2	0.1	0	0	**100**	non a rischio
3	BUONO	37.9	61.8	0.3	0	0	**99.7**	non a rischio
4	BUONO	34.7	64.8	0.5	0	0	**99.5**	non a rischio
5	BUONO	0.3	57.5	42.2	0.1	0	**57.8**	probabilmente a rischio

width W. Plots are shown for $\sigma = 10$, 30, 50 and 100% of W, where the broken line indicates the 50% plot.

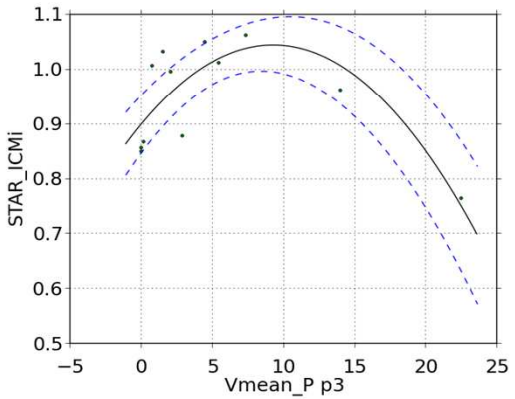
REGIONE AUTONOMA DELLA SARDEGNA

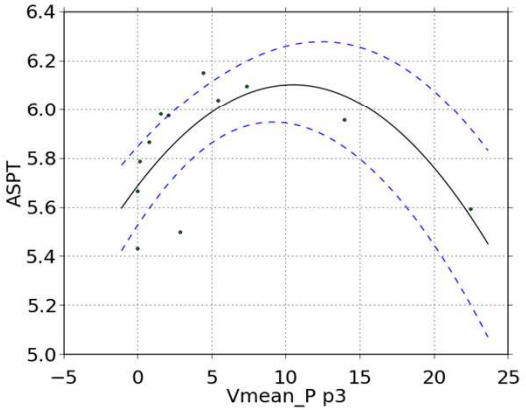
IRSA CNR

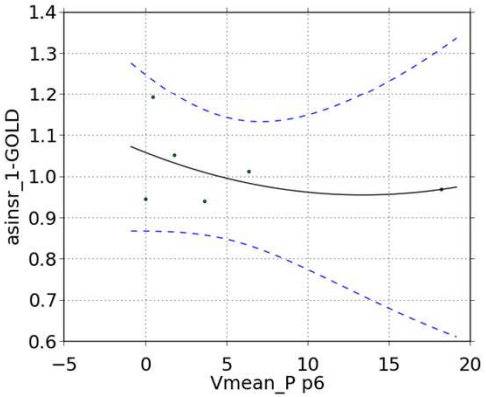
Influence of habitat on invertebrate metrics:

Water Velocity (local)

			STAR_ICMi	ASPT	n_FAM²	n_EPT²	1-GOLD³	Shannon	log(SelEPTD+1)
			n samples/group=6						
'Pool' mesohabitat / Sardinia REF&slightly perturbed sites (REF RAS)		STAR_ICMi	0.126	0.259	0.675	0.342	0.790	0.151	0.757
			NS	NS	NS	NS	NS	NS	NS
			4.478	2.2	0.4	1.6	0.3	3.8	0.3
		all	0.58	0.32	-0.28	0.19	-0.42	0.53	-0.38
		samples	-2.9	-0.7	-0.1	0.4	-1.2	-1.7	0.7
		(n=36)	1.6	3.2	3.9	4.3	0.2	2.2	0.5
V_mean ('Pool' mesohabitat	p		0.022	0.009	0.058	0.232	0.081	0.336	0.113	0.193
	sl		*	**	(*)	NS		NS	NS	NS
	F		4.3	8.3	4.0	1.7	3.4	1.2	2.8	2.0
								25	0.15
								.5	1.2
								.0	1.7



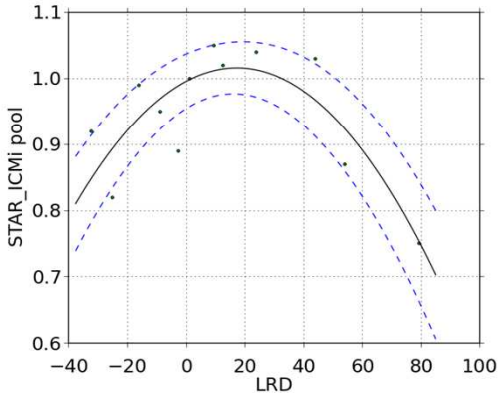


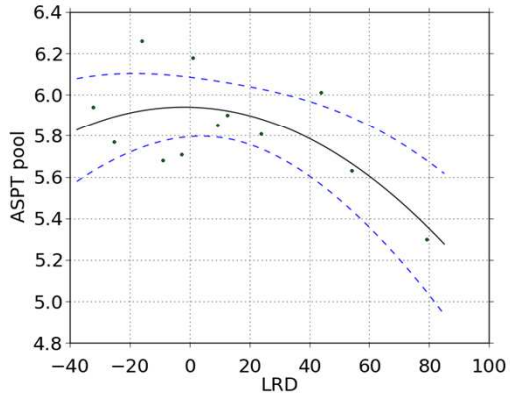


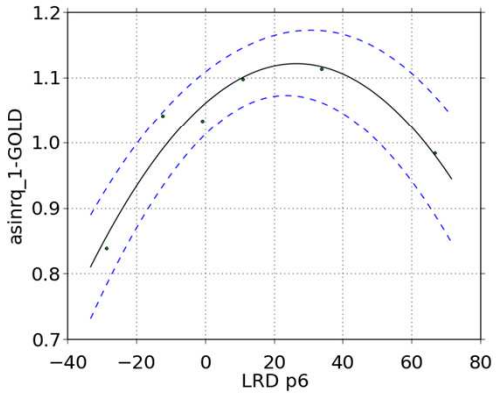
Influence of habitat on invertebrate metrics:

LRD (river stretch)

			STAR_ICMi	ASPT	n_FAM[2]	n_EPT[2]	1-GOLD[3]	Shannon	log(SelEPTD+1)
			n samples/group=6						
'Pool' mesohabitat / Sardinia REF&slightly perturbed sites (REF RAS)		STAR_ICMi	0.048	**0.017**	0.045	**0.003**	**0.020**	0.342	**0.060**
			*	*	*	***	*	NS	(*)
			9.9	**20.9**	10.3	**71.6**	**19.1**	1.6	**8.3**
		all samples (n=36)	0.78	0.89	0.79	0.97	0.88	0.18	0.74
			-3.2	-2.4	-1.1	-2.9	-3.6	-1.1	-1.5
			3.1	8.7	9.2	24.5	5.3	1.5	5.6
LRD[1] (Reach scale, 500 m)	p		0.025	**0.006**	0.066	**0.002**	0.006	0.223	0.319	0.222
	sl		*	**	(*)	***	**	NS	NS	NS
	F		4.1	**9.8**	3.7	**14.3**	9.8	1.8	1.3	1.8
									.05	0.12
									0.4	-0.1
									3.5	29.9

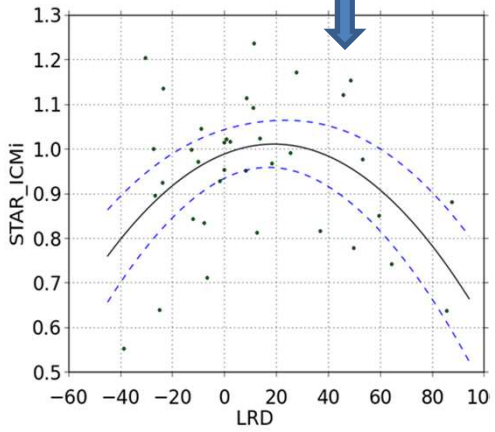


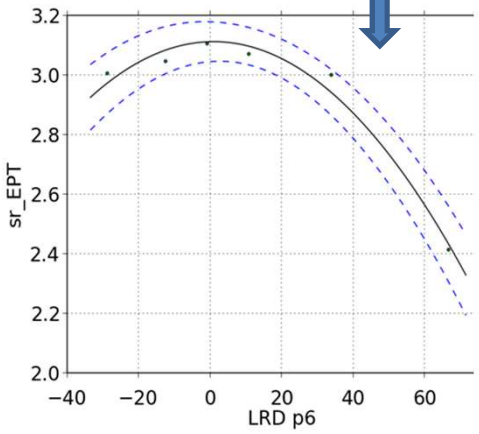


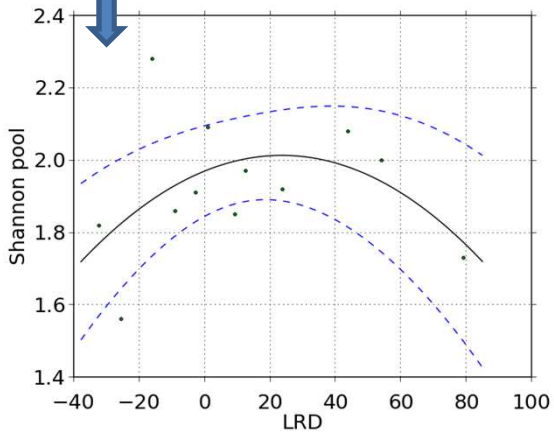


Habitat control on biota: Lentic-Lotic character - Summary

'Pool' mesohabitat / Sardinia REF&slightly perturbed sites		STAR_ICMi	STAR_ICMi	ASPT	sr_FAM	sr_EPT	arcsinsr_1-GOLD	Shannon	log(SelEPTD+1)
		all samples						NS	
LRD (Reach scale, 500 m)	p	0.025	**0.006**	**0.017**	**0.002**	**0.003**	**0.020**	0.319	**0.060**
	sl	*	**	*	***	***	*	NS	(*)
	F	4.1	**9.8**	**20.9**	**14.3**	**71.6**	**19.1**	1.3	**8.3**
	R-sq adj	0.15	0.61	0.89	0.71	0.97	0.88	0.05	0.74
	AIC	-0.9	-2.6	-2.4	-0.7	-2.9	-3.6	-0.4	-1.5
	F/ass_AIC	4.8	3.8	8.7	19.4	24.5	5.3	3.5	5.6

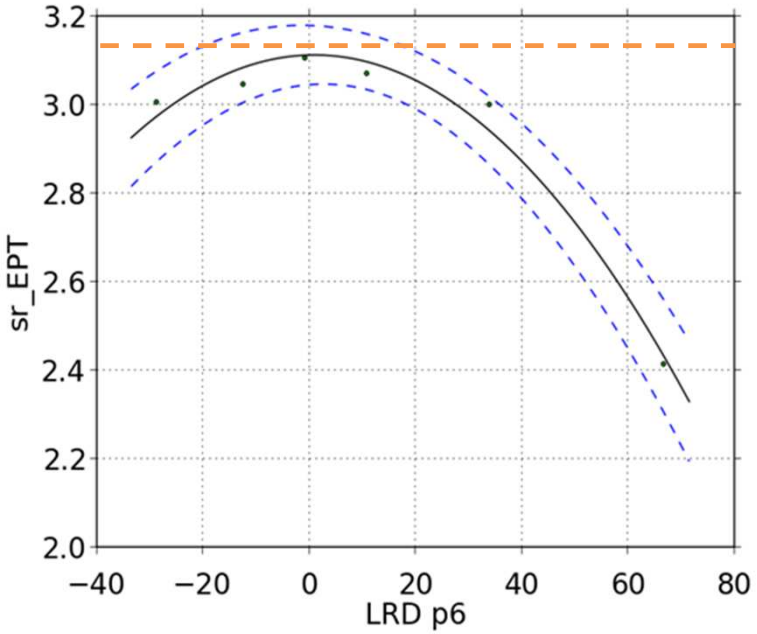




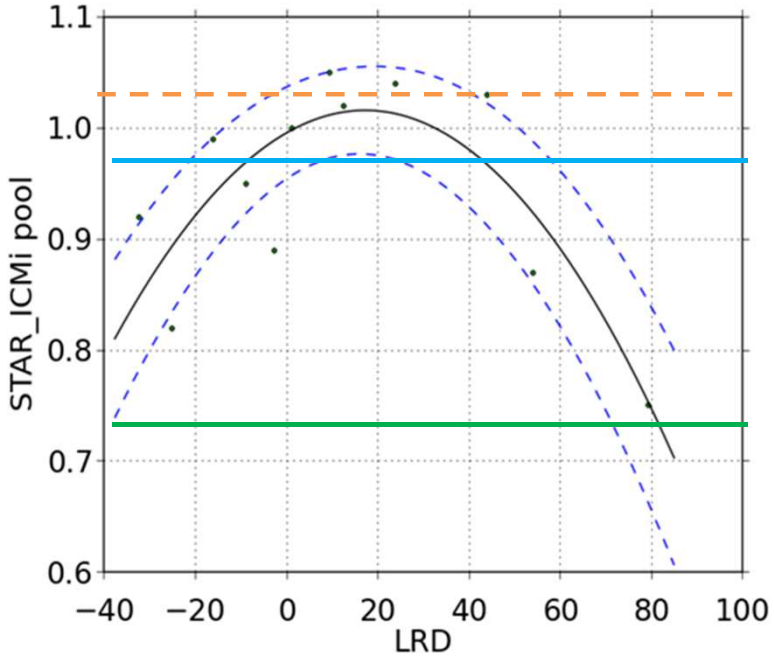


What about accuracy in Ecological Status classification ??

REF value
EPT: 10 (3.16 [2])
STAR_ICMi: 1.019



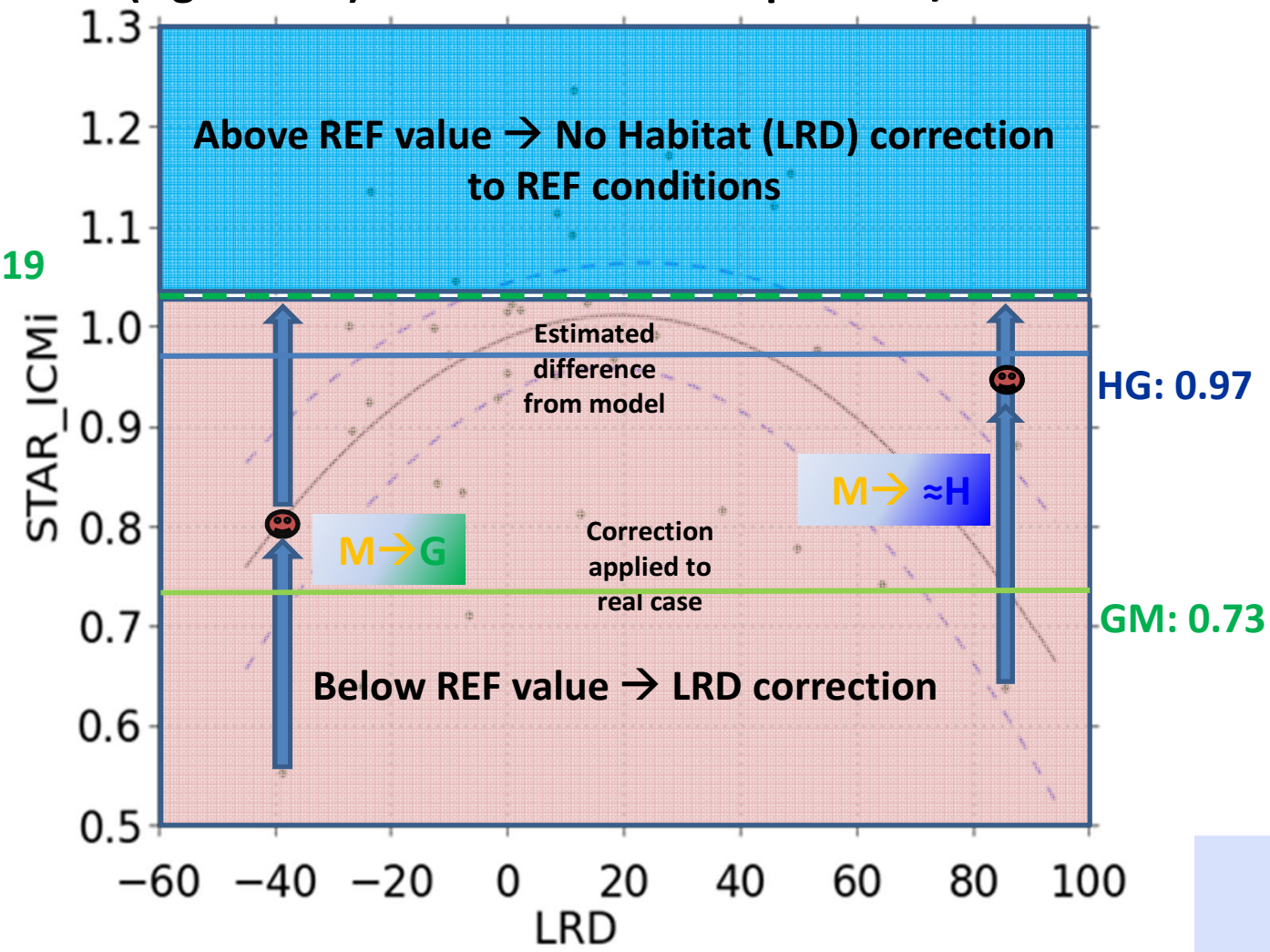
Class boundaries (Italy – R-M5)
HG: 0.97
GM: 0.73



Direct use of Habitat information
Case 1 – Modeling reference conditions

No (significant) water abstraction upstream/flow increase

REF value
STAR_ICMi: 1.019



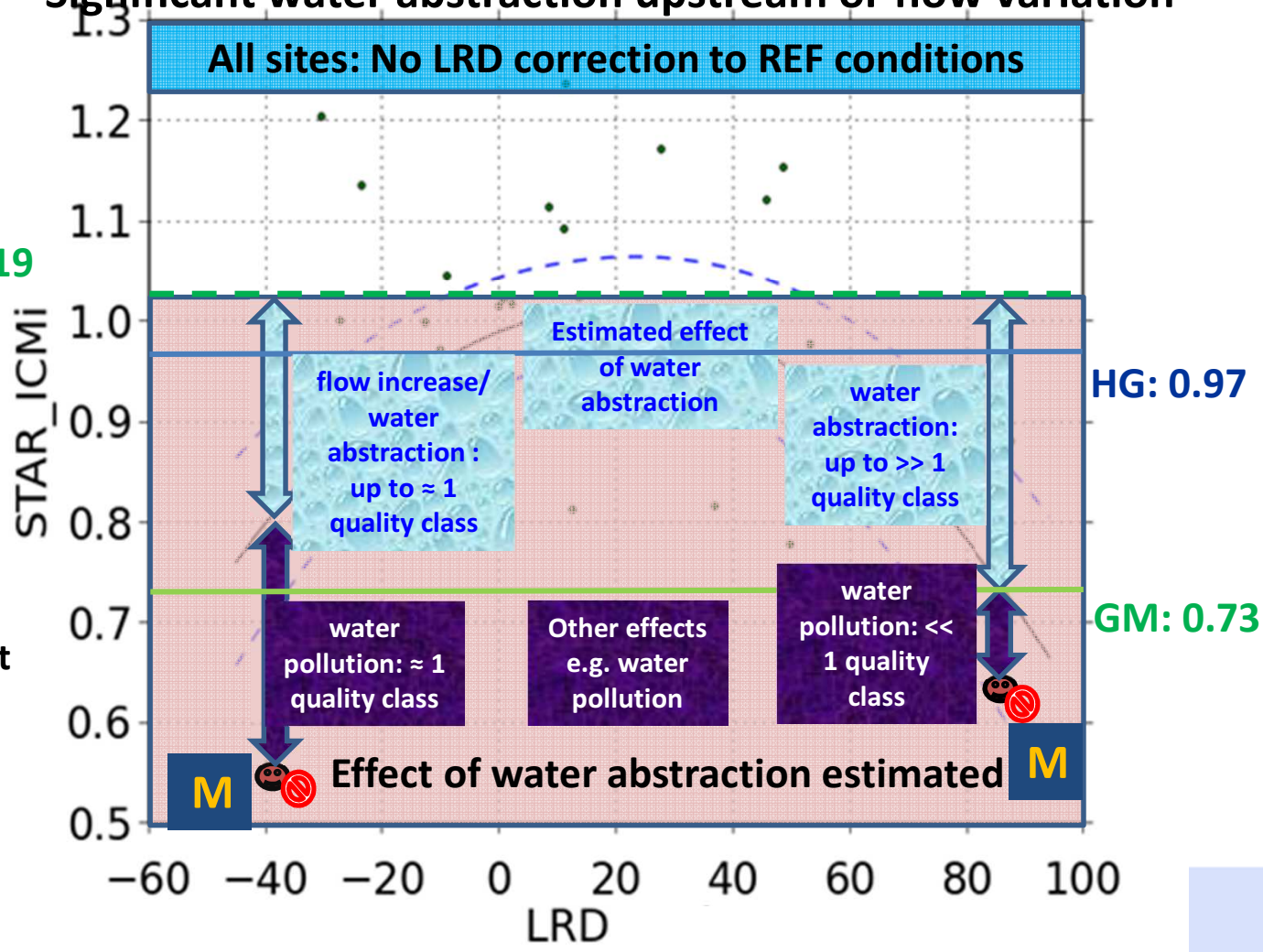
e.g. different sites in the same area, type, season, year

Direct use of Habitat information

Case 2 – Quantifying the potential impact of water abstraction

Significant water abstraction upstream or flow variation

REF value
STAR_ICMi: 1.019

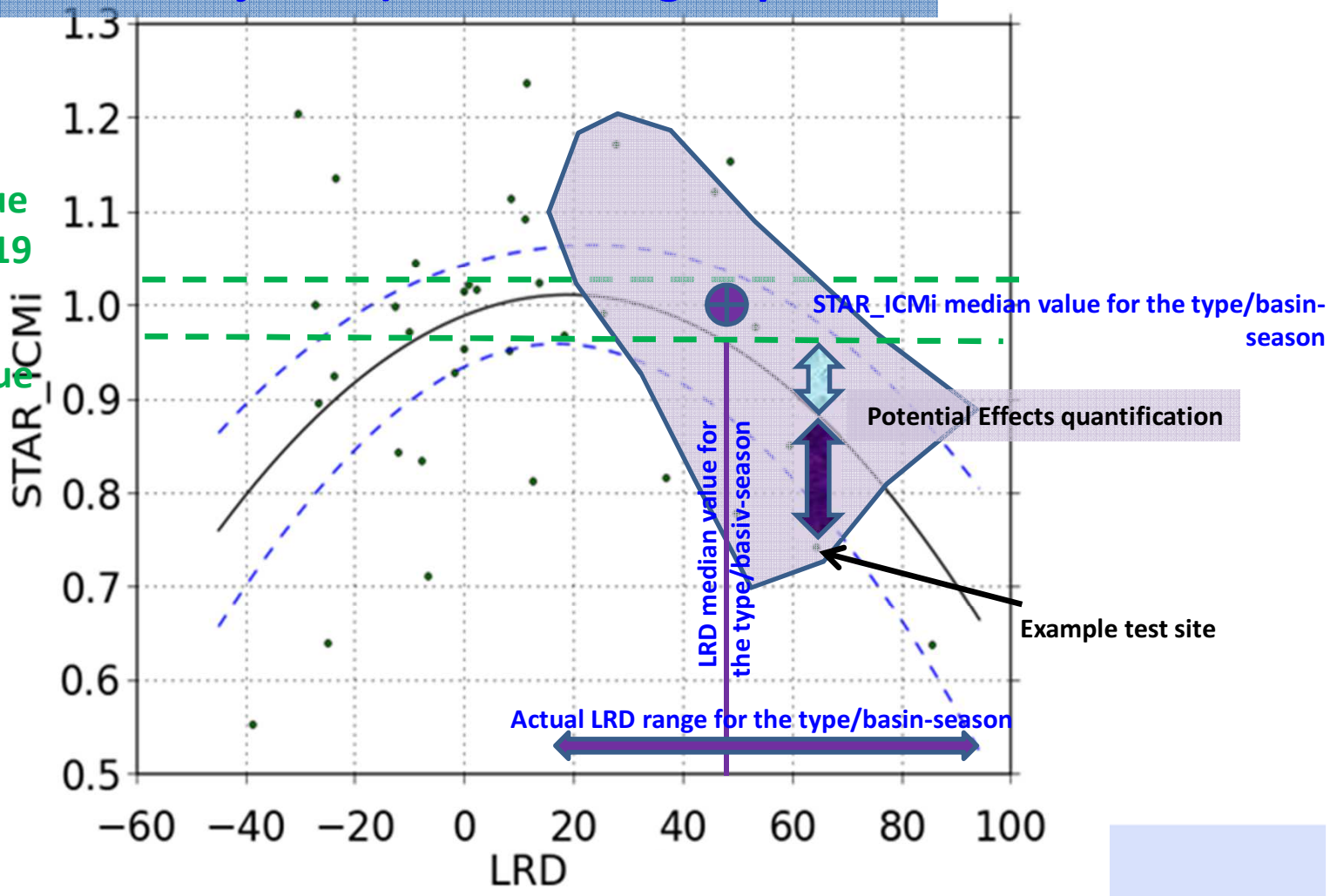


e.g. same site, different management options

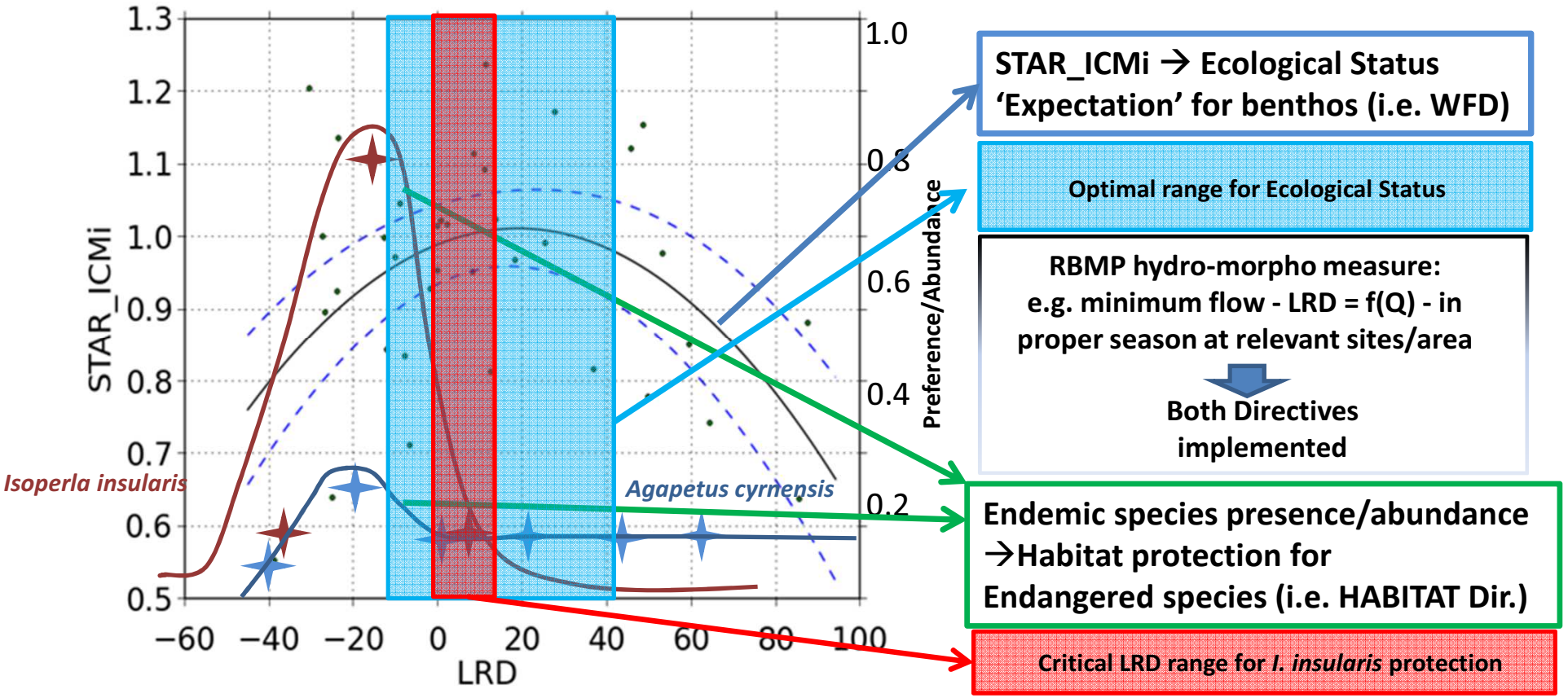
Direct use of Habitat information
Case 3 – Refining Reference conditions (type/season adjusted) & Assessing Impacts

Overall REF value
STAR_ICMi: 1.019

Refined REF value
STAR_ICMi:
e.g. 0.970



Direct use of Habitat information
Case 4 – Habitat is a bridge between the WFD and the Habitat Directive..



STAR_ICMi → Ecological Status 'Expectation' for benthos (i.e. WFD)

Optimal range for Ecological Status

RBMP hydro-morpho measure: e.g. minimum flow - LRD = f(Q) - in proper season at relevant sites/area

Both Directives implemented

Endemic species presence/abundance →Habitat protection for Endangered species (i.e. HABITAT Dir.)

Critical LRD range for *I. insularis* protection

Some INHABIT conclusions – Habitat biota issue

- **River typologies in Med rivers very weak.**
- **Influence of Habitat features on communities very strong.**
- **Lentic-lotic character accounting for general trends in benthic metrics and classification indices.**
- **Accuracy of present methods for Ecological Status classification potentially very poor.**
- **Corrections to classification systems possible (and needed!), based on habitat information.**
- **Simple functions defined e.g. Metrics f(LRD).**
- **REF conditions refined (for whole areas, types, seasons, etc.).**
- **Potential effects of water abstraction estimated.**
- **Habitat as a 'bridge' between the WFD and the HABITAT Directive.**

→ **Links to hydrology to be more explicitly defined**


Thanks for your attention!!
Barcelona, 17 October 2012