VARIAZIONE DELLO STATO TROFICO ED ECOLOGICO DELLA LAGUNA DI VENEZIA

ADRIANO SFRISO
sfrisoad@unive.it

“

Università Ca' Foscari Venezia
Dipartimento di Scienze Ambientali, Informatica e Statistica
Via Torino 155, Mestre (Ve)

Dagli anni '50-'60 ad oggi si sono alternati vari scenari ambientali strettamente legati ad attività economiche

Anni '50-'60: esplosione industriale, 1961-69 scavo Canale Malamocco-Marghera per lo sviluppo del Polo Petrolchimico;

Anni '60-'70: Profondi cambiamenti dell'idrodinamica e del livello di inquinamento e di trofia della laguna centrale;

Anni '70-80: Massimo degrado ambientale con bloom di macroalghe, progressivo declino delle attività industriali;

Primi anni '90: declino delle macroalghe;

Metà-fine anni '90: esplosione della pesca incontrollata delle vongole filippine e declino della pesca tradizionale;

Anni 1995-2005: massime attività della pesca alle vongole e distruzione dei fondali con intensi processi di erosione;

Seconda metà anni '2000: declino delle vongole filippine e forte incremento commerciale e turistico via mare (grandi navi);

Inizio anni '2010: riduzione impatti antropici con progressivo recupero ambientale ed avvio di attività di rinaturalizzazione con coinvolgimento della popolazione.

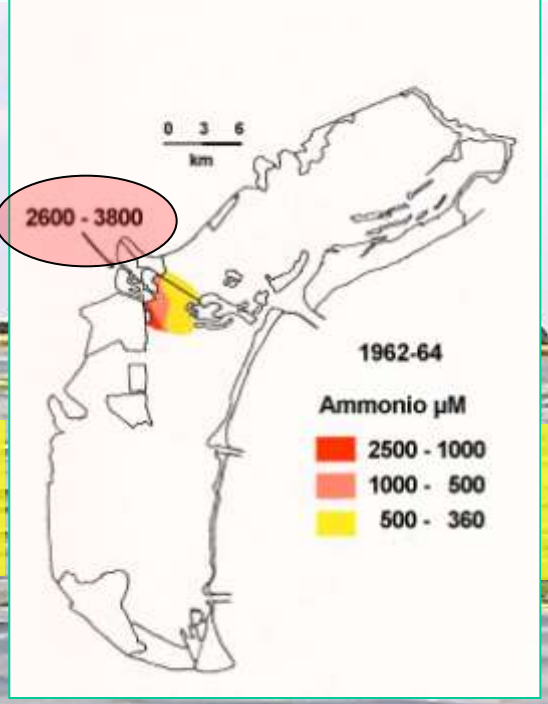
Inizio monitoraggi Direttiva 2000/60/EC.

Finanziamento LIFE12 NAT/IT/000331 – SeResto; LIFE12 NAT/IT/000663 - REFRESH e progetti regionali;

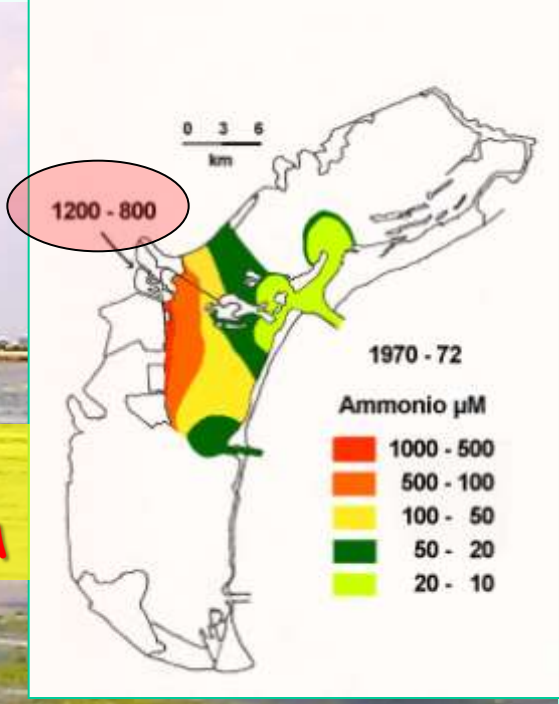
2019: inizio entrata in funzione del MOSE???.

Ammoniaca

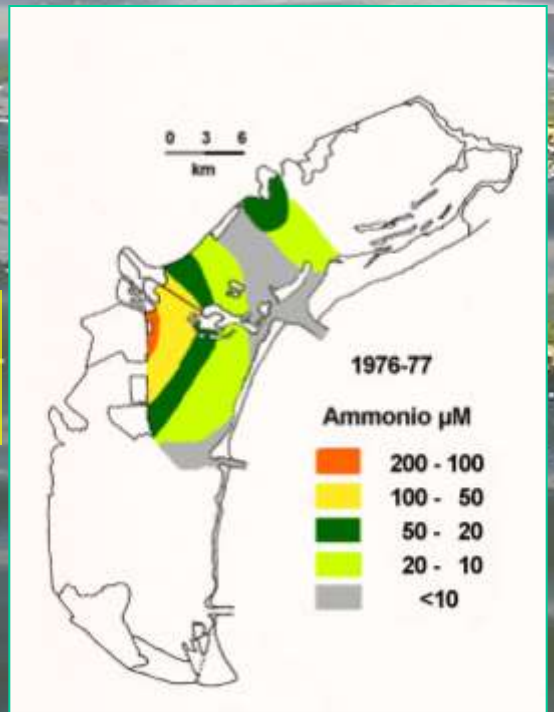
1962-64
2600-3800 µM



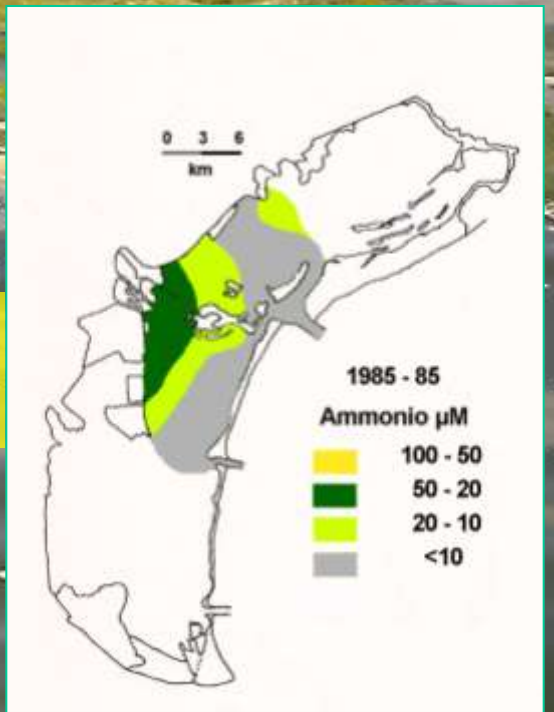
1970-72
1200-800 µM

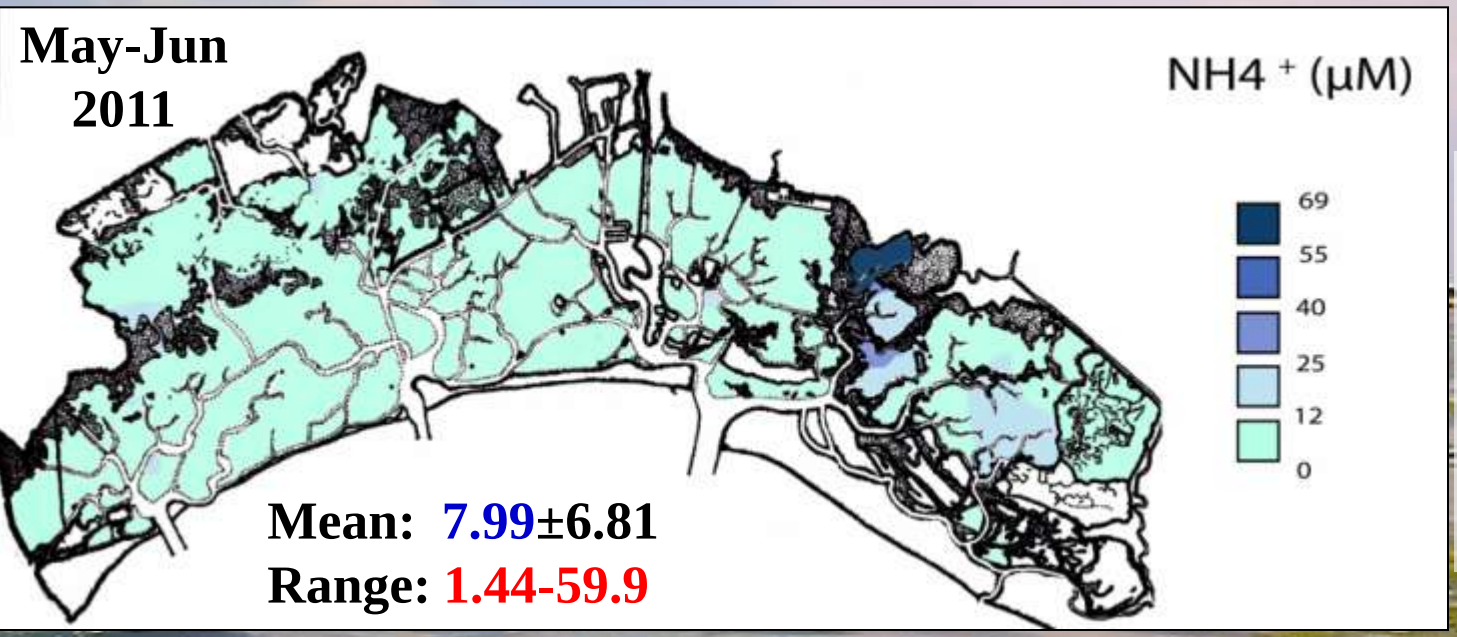


1976-77
100-200 µM

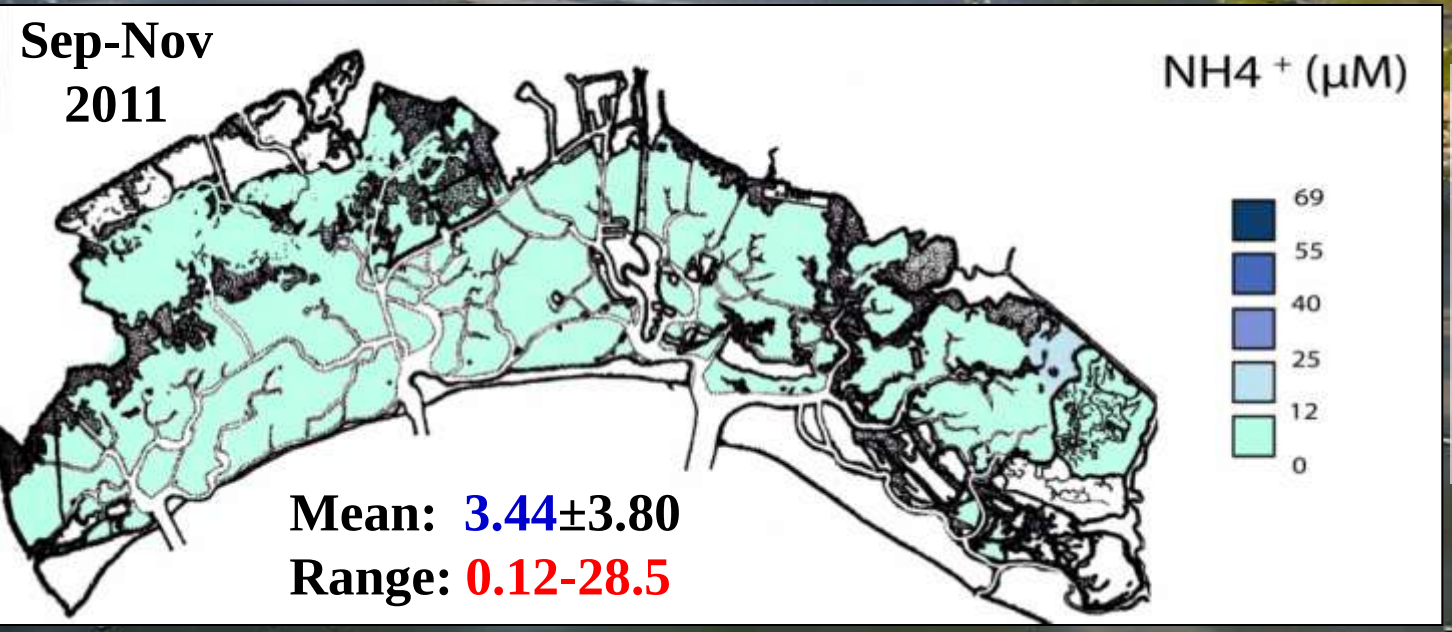


1985-86
50-100 µM





118 stazioni

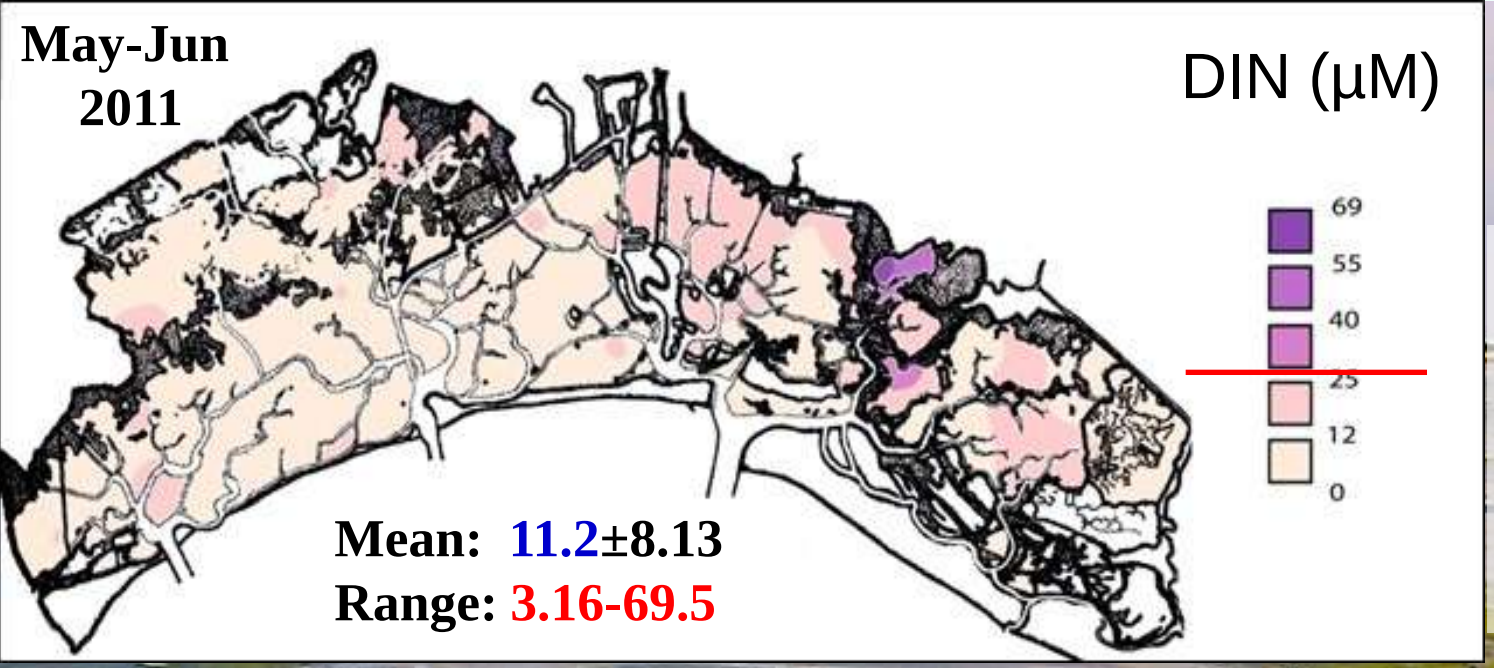


May-Jun 2014

Mean: 2.22± 1.90
Range: 0.09 -12.6

Sep-Nov 2014

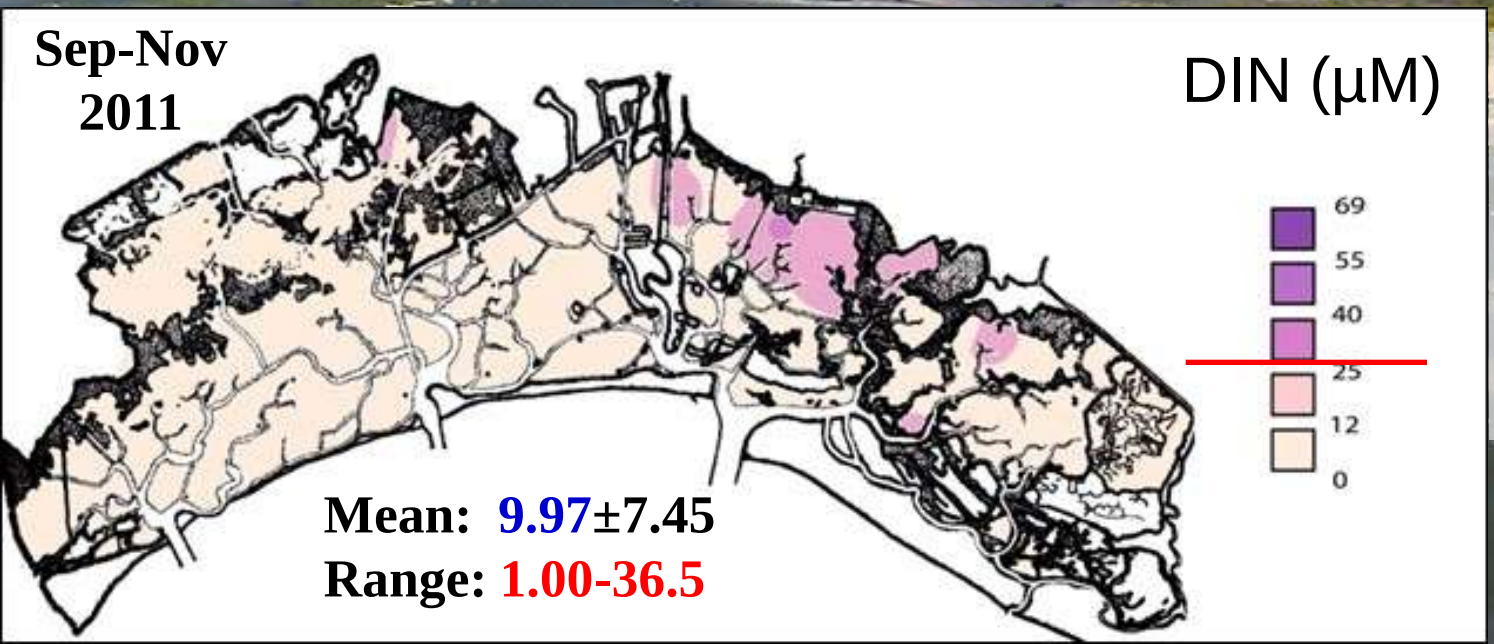
Mean: 1.46± 2.12
Range: 0.04 -17.5



May-Jun
2014

Mean: 5.65±2.62
Range: 1.68-18.0

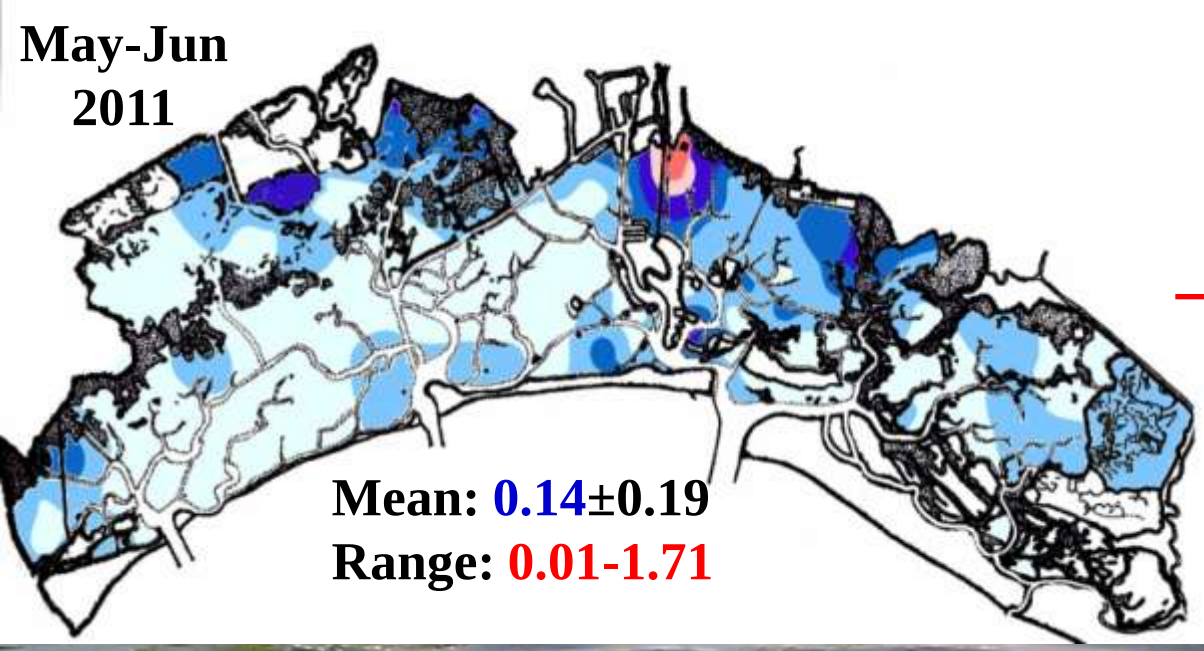
Limite DIN Ronchi-Costa: 25 µM



Sep-Nov
2014

Mean: 14.7±14.0
Range: 0.61-58.6

May-Jun
2011



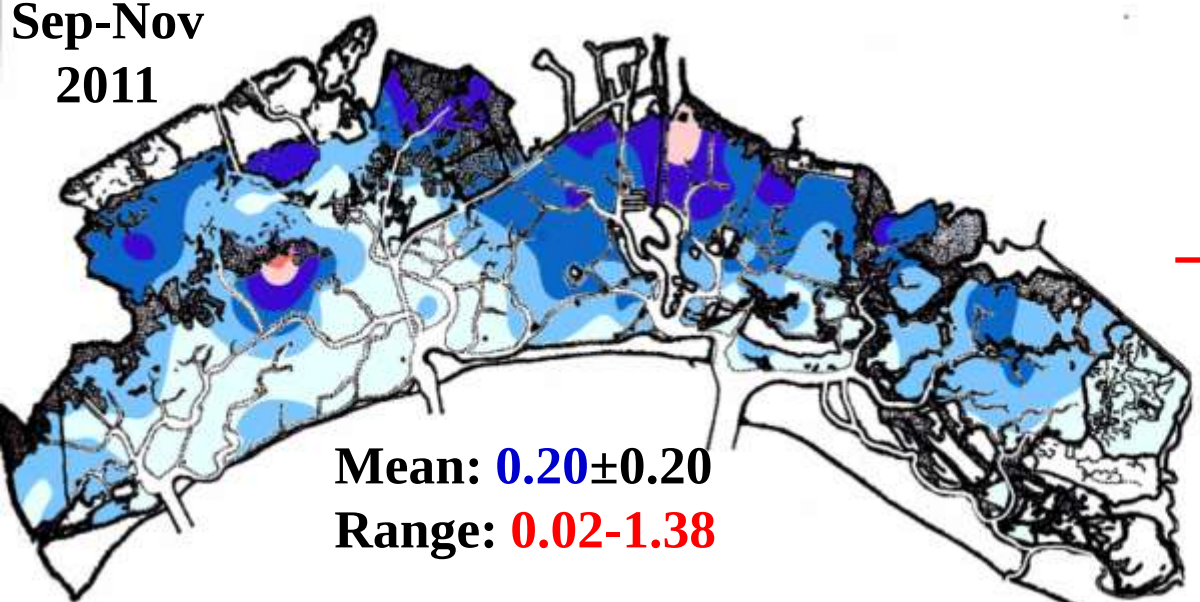
Mean: 0.14±0.19
Range: 0.01-1.71

May-Jun
2014

Mean: 0.20±0.20
Range: 1.68-18.0

Limite Ronchi-Costa: 0.8 µM

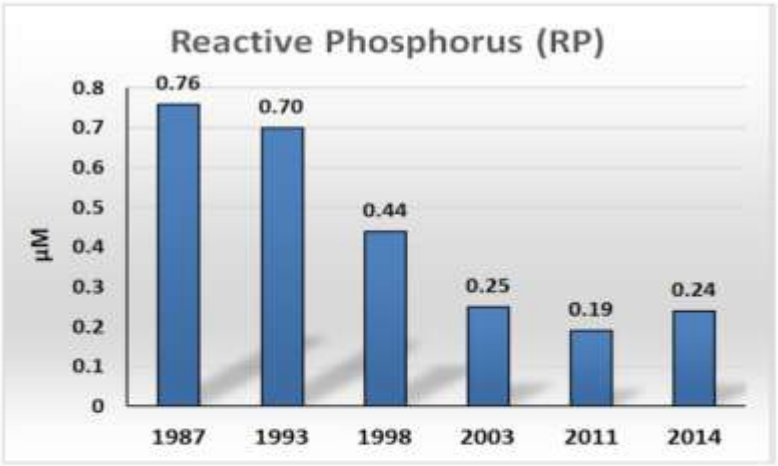
Sep-Nov
2011

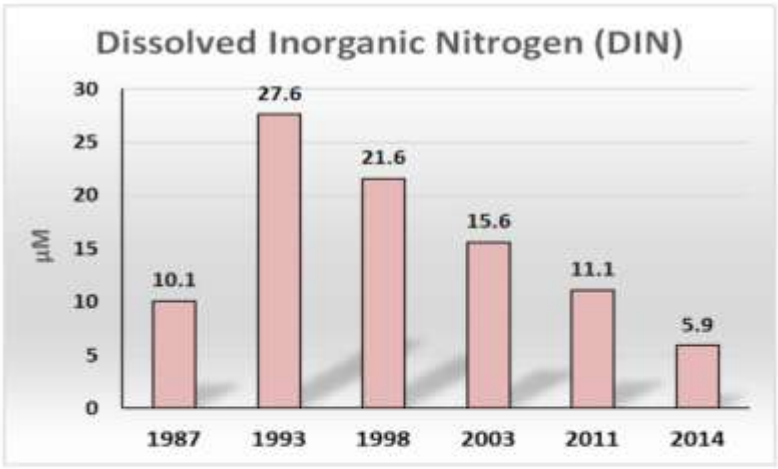


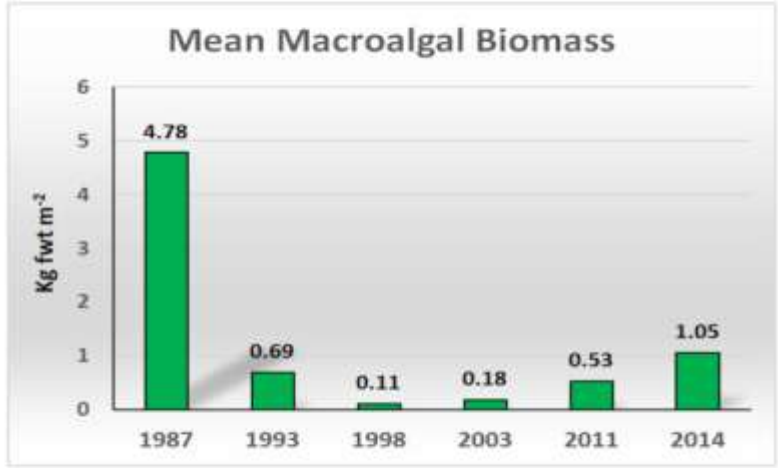
Mean: 0.20±0.20
Range: 0.02-1.38

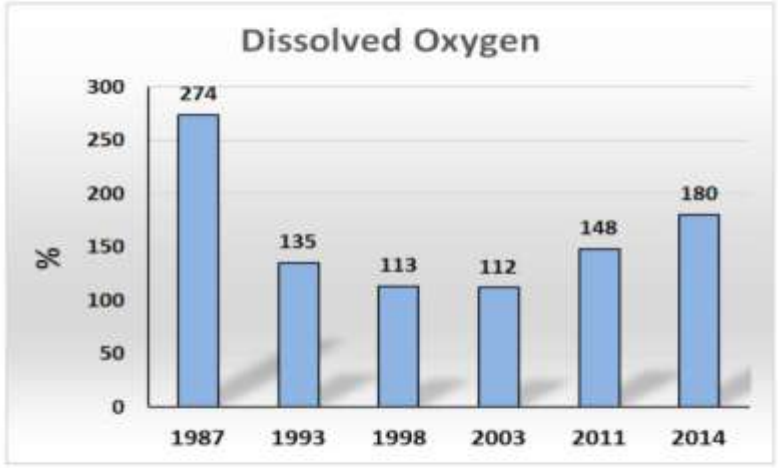
Sep-Nov
2014

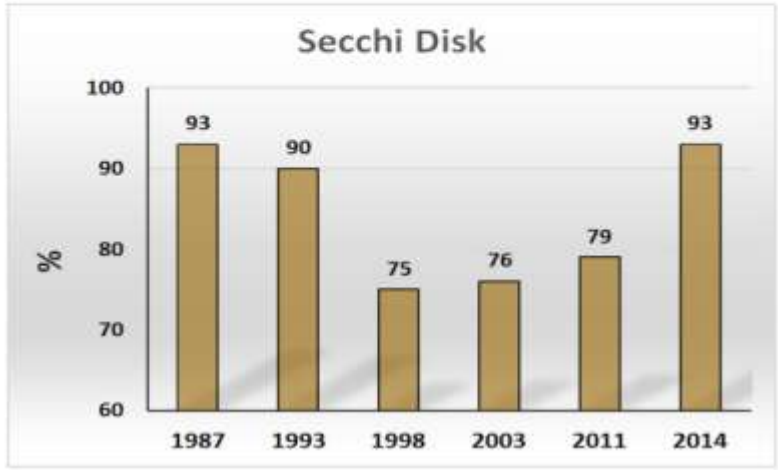
Mean: 0.16±0.15
Range: 0.01-0.73

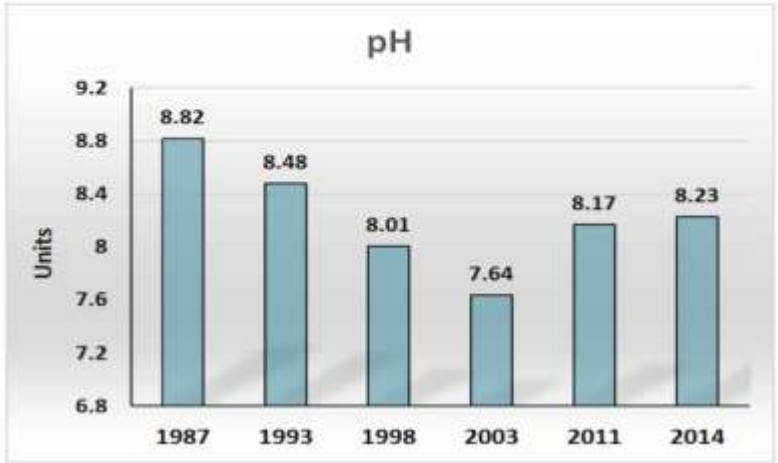












Variazione di alcuni parametri ambientali nel bacino centrale della laguna di Venezia dal 1987 al 2014

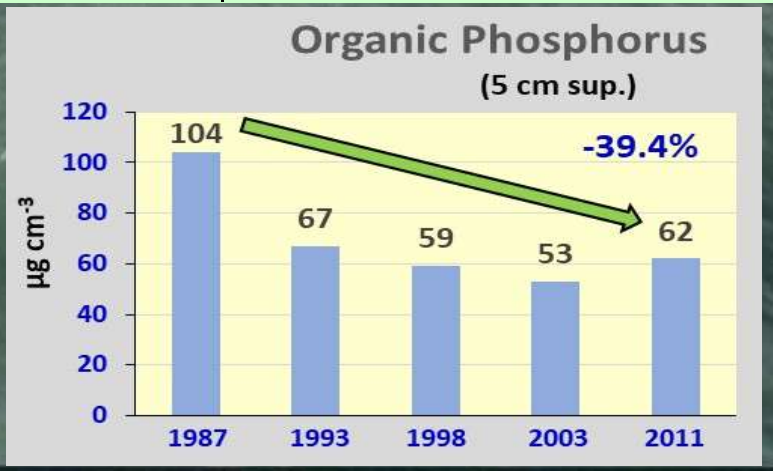
Media 34-65 stazioni

Variazioni fosforo nei sedimenti 1987-2003 (Laguna centrale)

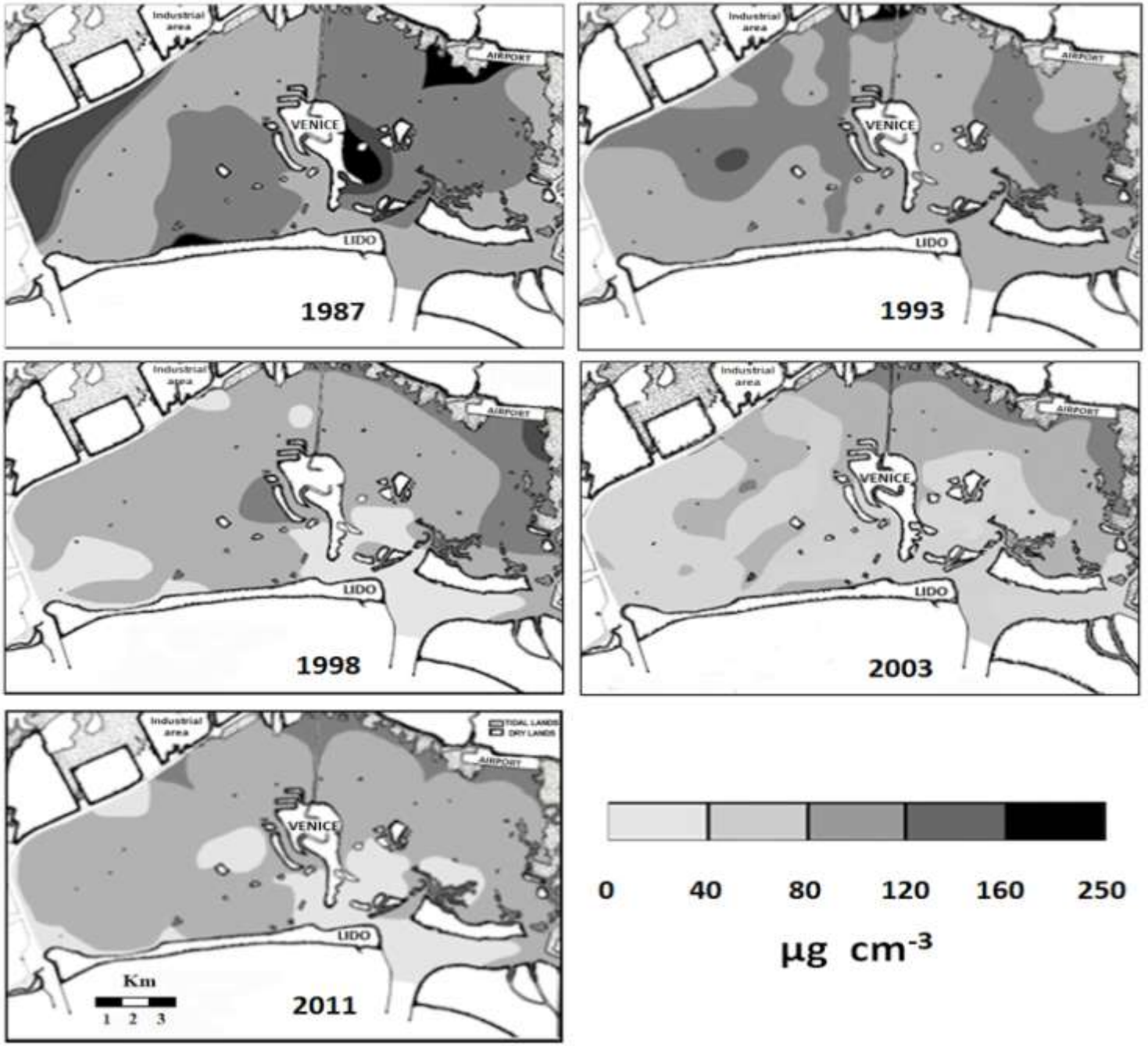
	Total Phosphorus					Organic Phosphorus					Organic/Total				
	1987	1993	1998	2003	2011	1987	1993	1998	2003	2011	1987	1993	1998	2003	2011
	µg/cm³					µg/cm³					%				
stations N°	34	34	34	34	31	34	34	34	34	31	34	34	34	34	31
Mean	386	361	375	358	383	104	67	59	53	62	26.9	18.6	15.7	14.8	16.3
STD	96	80	65	99	50	42	28	31	53	24					
Min	227	184	257	201	281	49	27	16	2	13					
Max	720	682	541	635	473	246	210	167	150	113					
Difference 2003-1987	-7.3%					-49.0%					-44.9%				
2003-2011	≈					-40.4%					-39.4%				

ANOVA 34 stazioni

1987-93	p< 4.27E-05	Assenza macroalghe
1993-98	n.s	Pesca vongole
1998-03	n.s	
1987-03	p< 8.97E-07	in toto

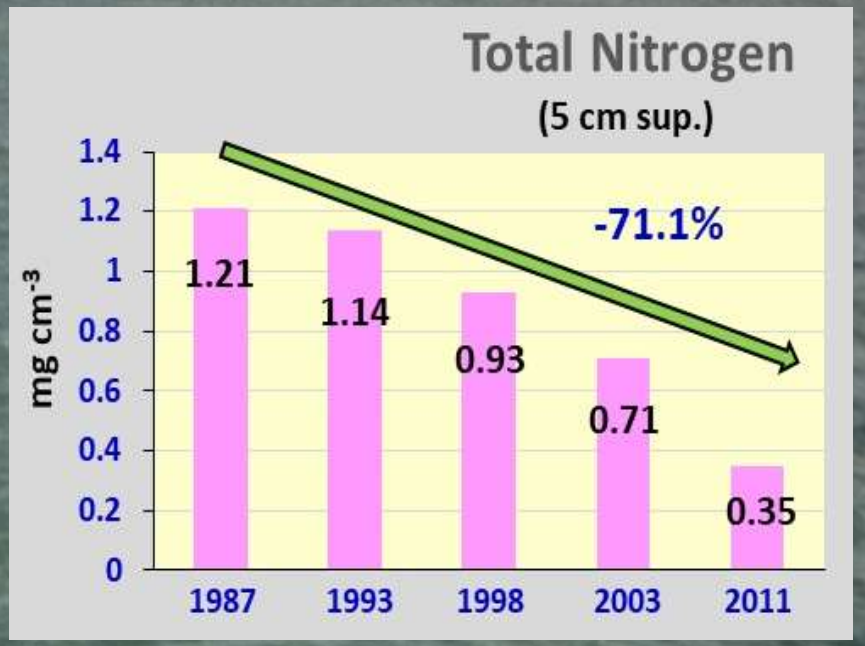


Organic Phosphorus



Variazioni Azoto nei sedimenti 1987-2003 (Laguna centrale)

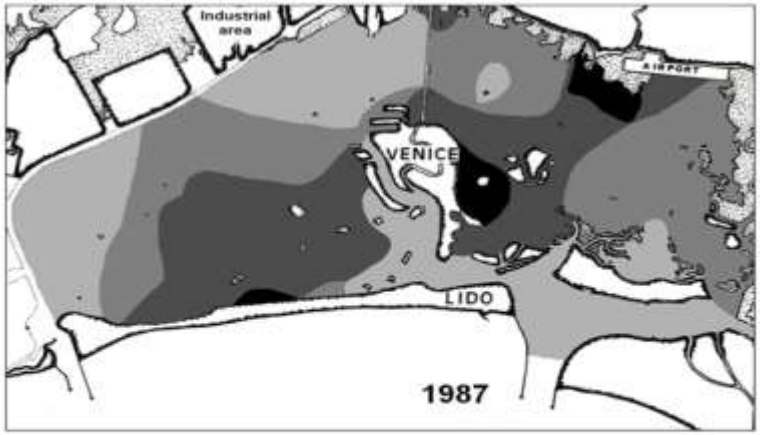
Total Nitrogen	1987	1993	1998	2003	2011
	mg/cm³				
stations N°	34	34	34	34	31
Mean	1.21	1.14	0.93	0.71	0.35
STD	0.60	0.48	0.48	0.36	0.48
Min	0.22	0.33	0.10	0.09	0.04
Max	3.00	2.62	1.37	1.48	0.48
Difference 2003-1987	-41.3%				
2003-2011	-71.1%				

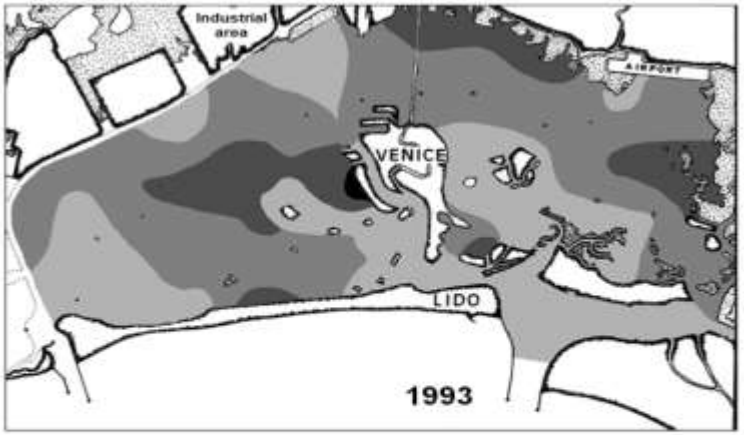


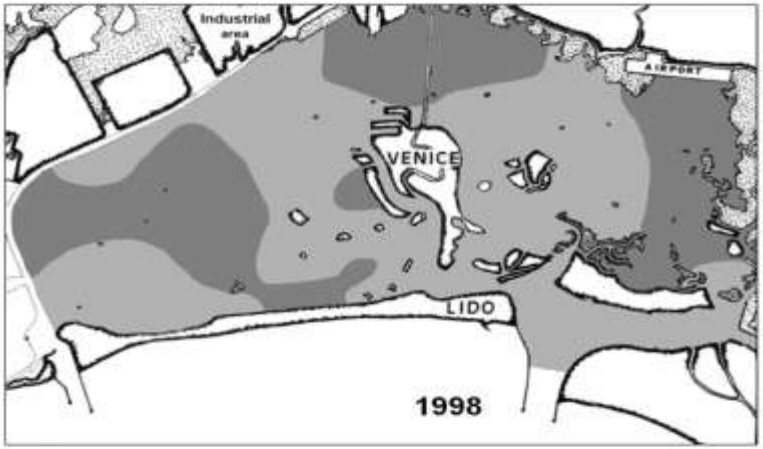
Anova 34 stazioni			
1987-93	n.s.	Assenza macroalghe	
1993-98	n.s.	Pesca vongole filippine	
1998-03	p < 0.017		
1987-03	p< 3.09E-05	in toto	

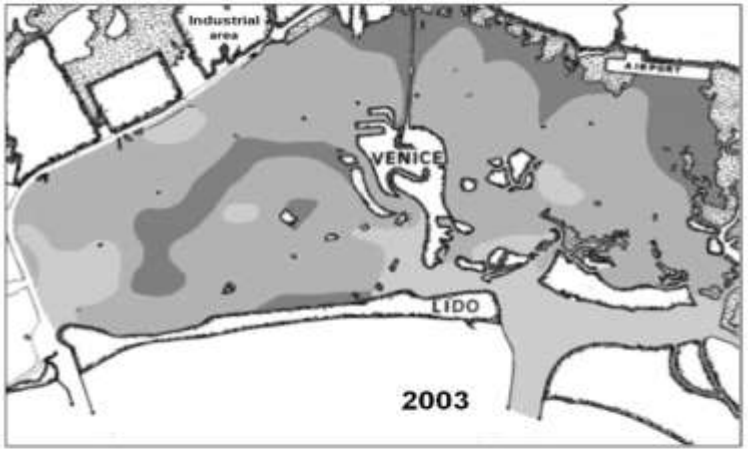
Liberato in acqua come ammoniaca

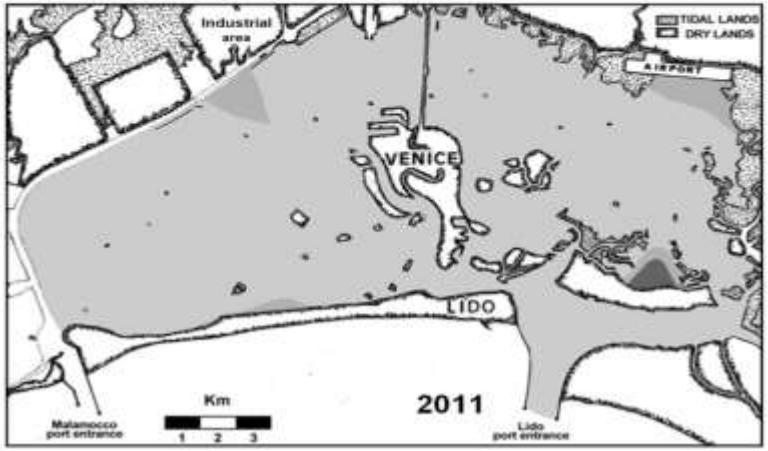
Total Nitrogen

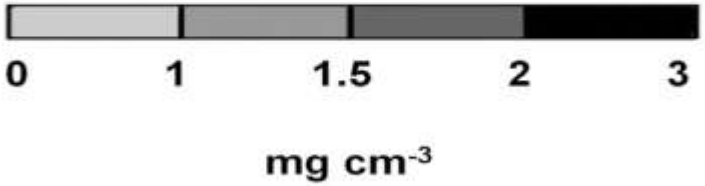








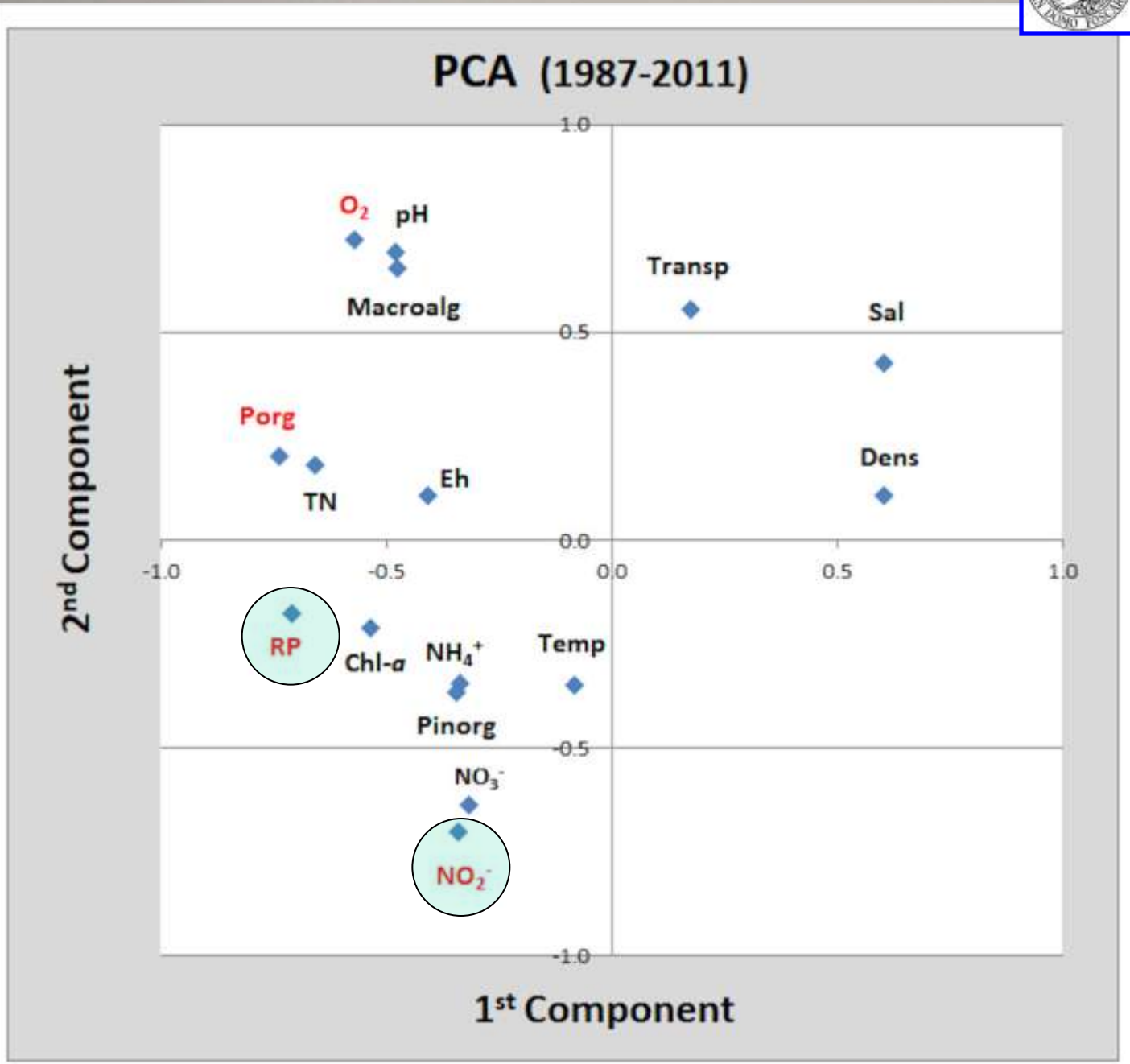


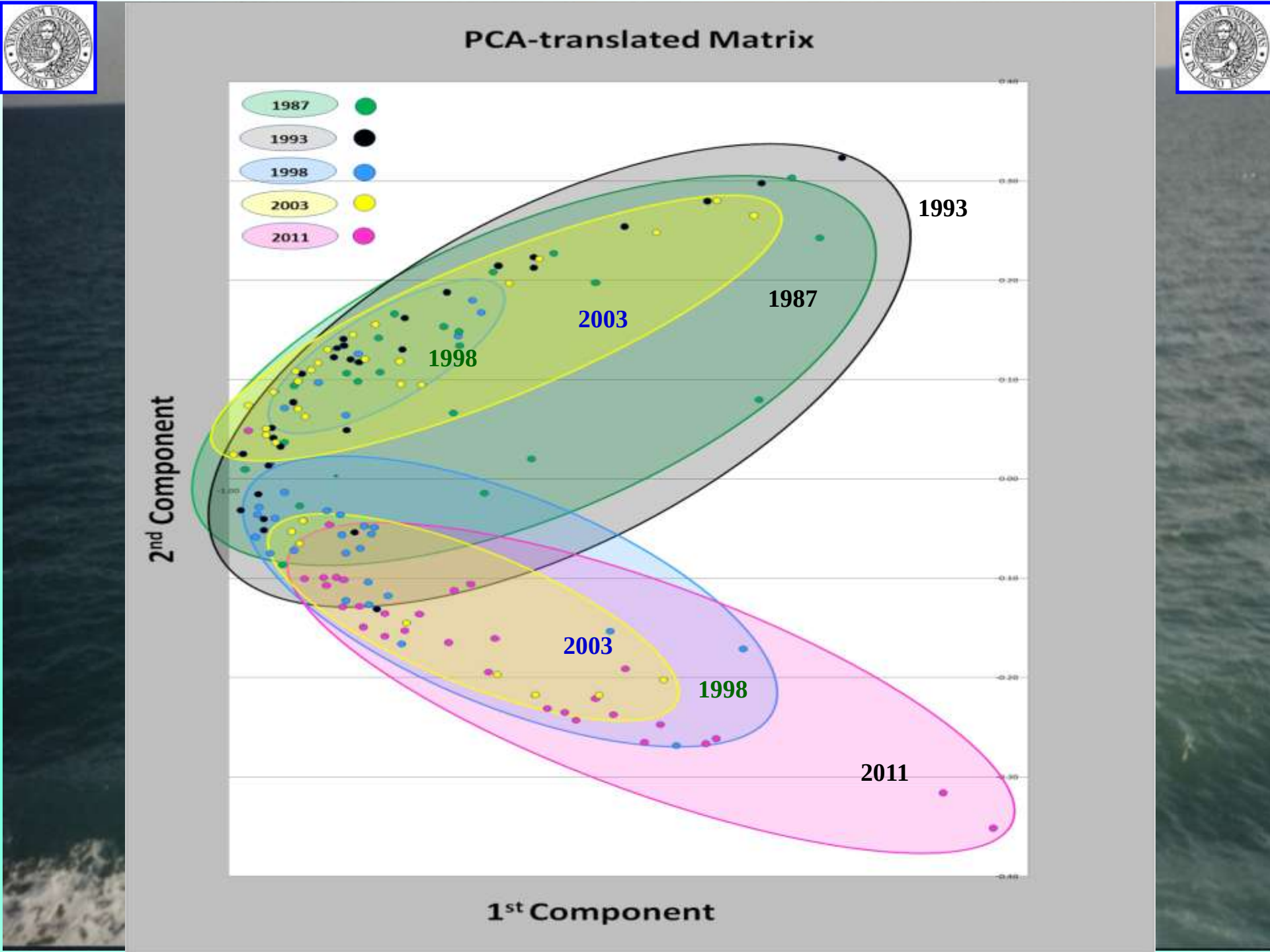


Waters and Sediments

1987 = 34 sites
1993 = 34 sites
1998 = 52 sites
2003 = 65 sites
2011 = 45 sites
2014 = 34 sites

Total 264 sites




PCA-translated Matrix
1987
1993
1998
2003
2011
1993
1987
2003
1998
2003
1998
2011
2nd Component
1st Component

MaQI

È un indice volutamene CATEGORICO e non continuo

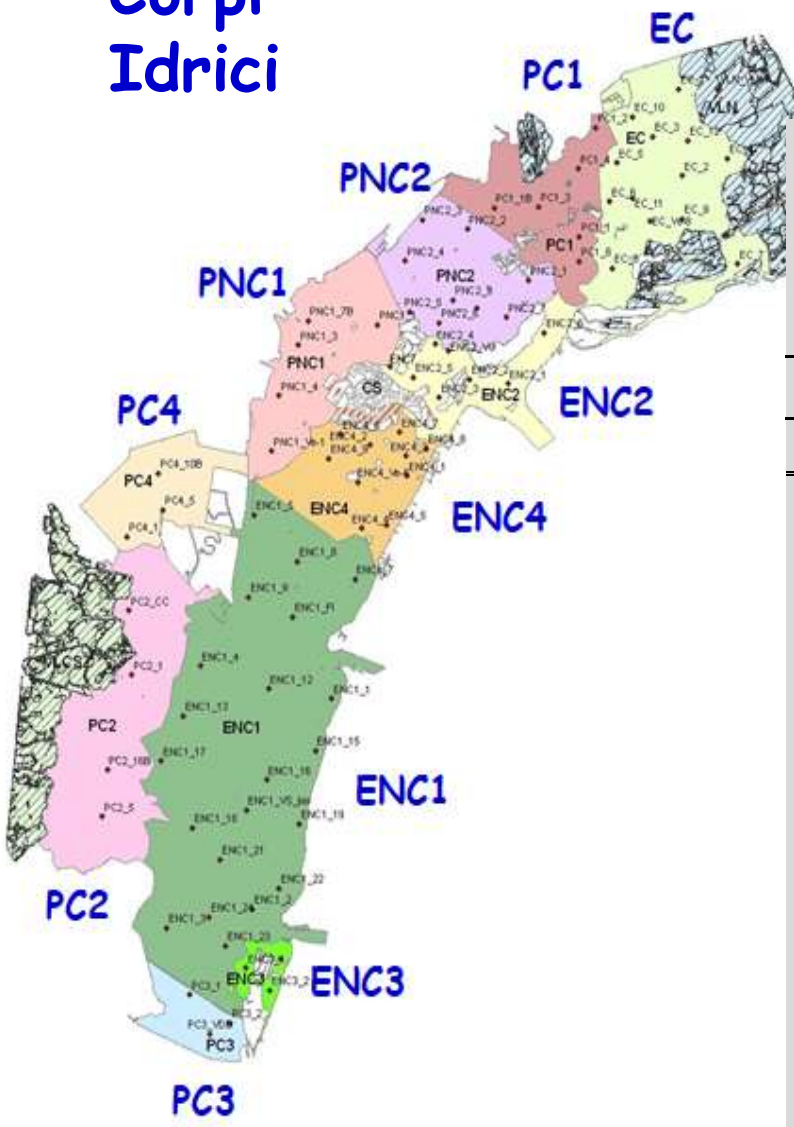
Macrophyte Quality Index (MaQI)

	Taxa				Ecological Status (EQR)			
	Opportunistic score 0	Indifferent score 1	Sensitive score 2					
			N°	%				
Macroalgae (1)	Any cover		>2	≥25	0.85			1
				15-25	0.65		0.75	0.85
				≤15	0.55	0.55	0.65	
	Total cover ≤5%		2	-	0.45			
	Total cover >5%	Wet Abundance Rhodophyta > Chlorophyta	≤2		0.35			
		Wet Abundance Chlorophyta > Rhodophyta			0.25			
	Total coverage ≤5%		1		0.15			
	Absent		0		0			
Aquatic angiosperms	*Ruppia cirrhosa, R. maritima, Nanozostera noltii*				Absent	<50%	50-75%	>75%
	Zostera marina					<25%	25-75%	>75%
	Cymodocea nodosa				Absent		<25%	≥25%
	Posidonia oceanica				Absent			Present
					Taxa cover %			

(1) The Xanthophycea *Vaucheria* spp. should not be taken into account in the total cover

MaQI Assessment

Corpi Idrici



Comparison of MaQI EQR 2011-2018 in the 11 water bodies and in three lagoon fisching ponds

MaQI EQR changes

sites	118	88	88	Difference
Water bodies	2011	2014	2018	
EC	0.408	0.631	0.842	0.434
ENC1	0.698	0.769	0.762	0.064
ENC2	0.479	0.656	0.750	0.271
ENC3	0.417	0.483	0.750	0.333
ENC4	0.520	0.490	0.530	0.010
PC1	0.317	0.292	0.533	0.216
PC2	0.325	0.350	0.373	0.048
PC3	0.317	0.317	0.350	0.033
PC4	0.317	0.338	0.317	0.000
PNC1	0.330	0.350	0.330	0.000
PNC2	0.261	0.250	0.406	0.145
Zappa valley	0.250	0.250	0.250	0.000
Dogà valley	0.850	0.850	1.000	0.150
Cavallino valley	1.000	1.000	0.850	-0.150
Total	0.464	0.502	0.575	0.111

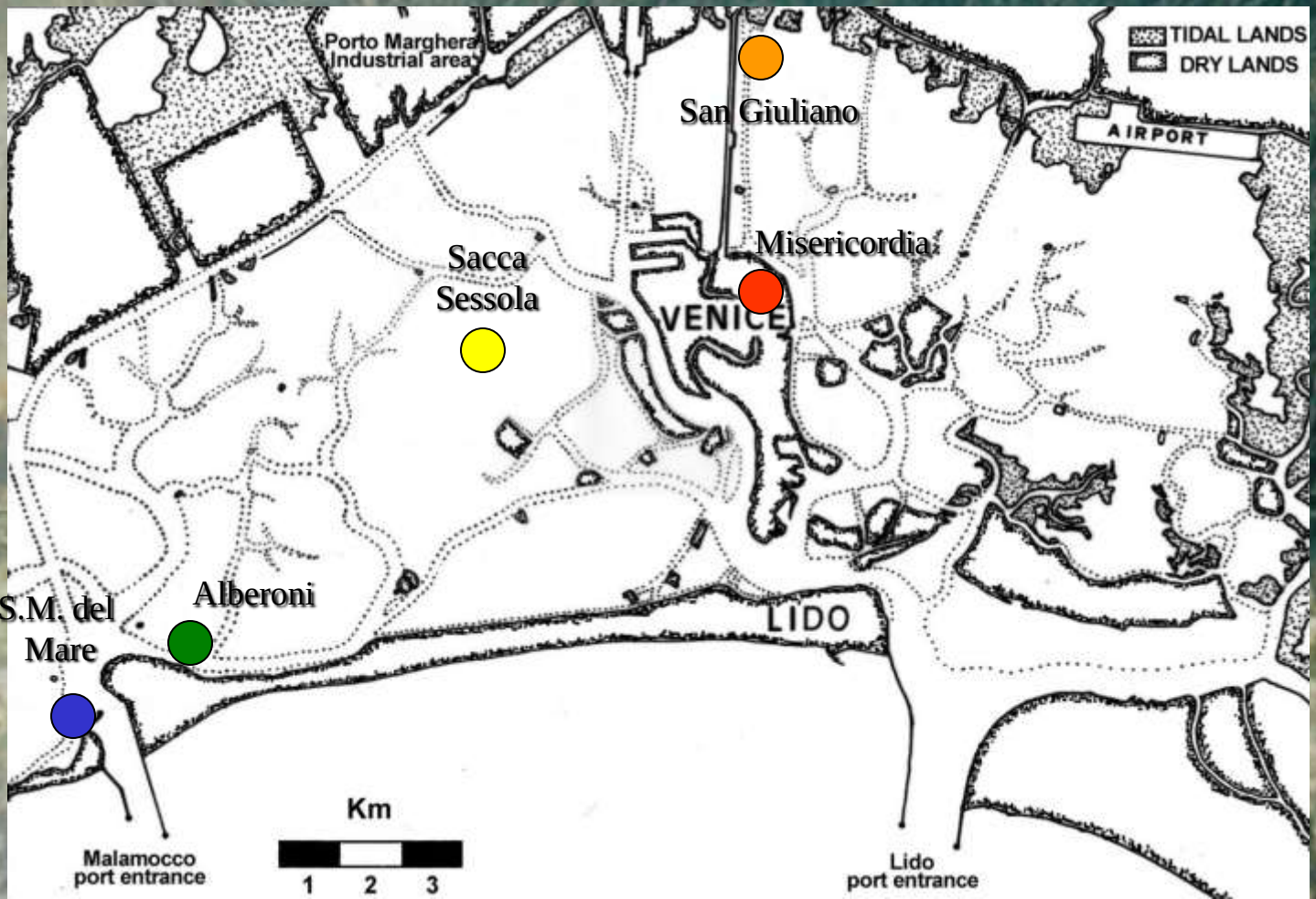
Validatione del MaQI con parametri idrologici in 20 stazioni

Pearson's correlation matrix for 20 Venice stations sampled monthly during one year

	Temp.	Chlorinity	Oxygen	FPM	Chl. *a*	Phaeo. *a*	Chl. *a*	RP	Ammonium	Nitrites	Nitrates	DIN
N° Taxa	0.07	0.56	0.24	-0.48	-0.37	-0.46	-0.43	-0.60	-0.58	-0.30	-0.62	-0.70
N° Chlorophyceae	0.13	0.52	0.14	-0.40	-0.35	-0.43	-0.41	-0.50	-0.53	-0.25	-0.66	-0.67
N° Rhodophyceae	0.05	0.56	0.27	-0.49	-0.37	-0.46	-0.43	-0.61	-0.59	-0.30	-0.60	-0.69
N° Phaeophyceae	0.07	0.56	0.18	-0.50	-0.35	-0.46	-0.43	-0.60	-0.57	-0.33	-0.61	-0.68
% Chlorophyceae	0.01	-0.46	-0.40	0.34	0.29	0.38	0.36	0.68	0.85	0.24	0.56	0.86
% Rhodophyceae	0.01	0.44	0.43	-0.28	-0.27	-0.34	-0.32	-0.63	-0.83	-0.18	-0.54	-0.84
% Phaeophyceae	-0.11	0.30	0.06	-0.37	-0.26	-0.36	-0.33	-0.50	-0.48	-0.37	-0.32	-0.49
R/C	0.00	0.53	0.39	-0.43	-0.35	-0.43	-0.41	-0.66	-0.71	-0.28	-0.58	-0.76
E-MaQI	0.03	0.51	0.29	-0.45	-0.33	-0.40	-0.38	-0.65	-0.66	-0.27	-0.56	-0.72

In red significant values P <0.05 for r > |0.45|

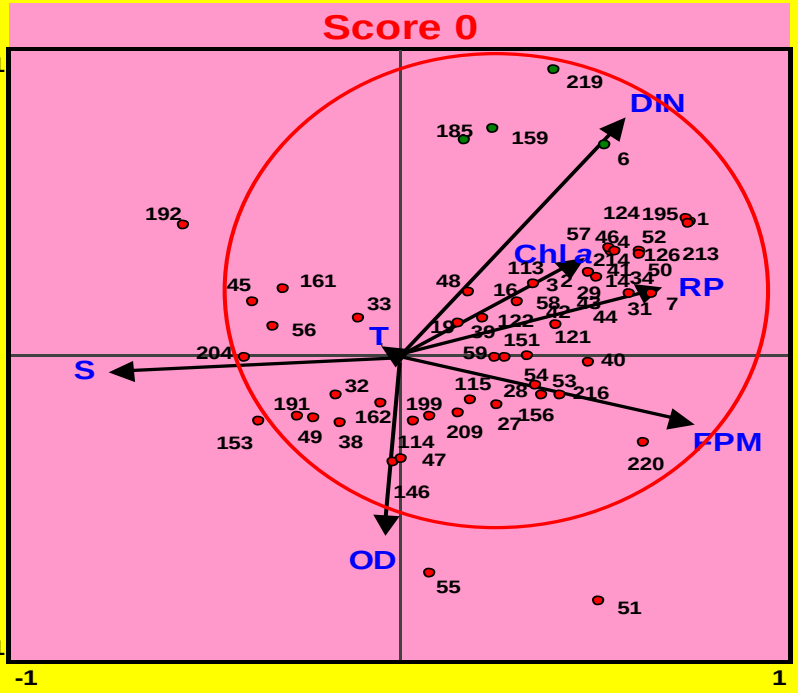
In 2005 MaQI was validated in 5 areas of different ecological status where nutrient and contaminant concentrations in surface sediments were also available

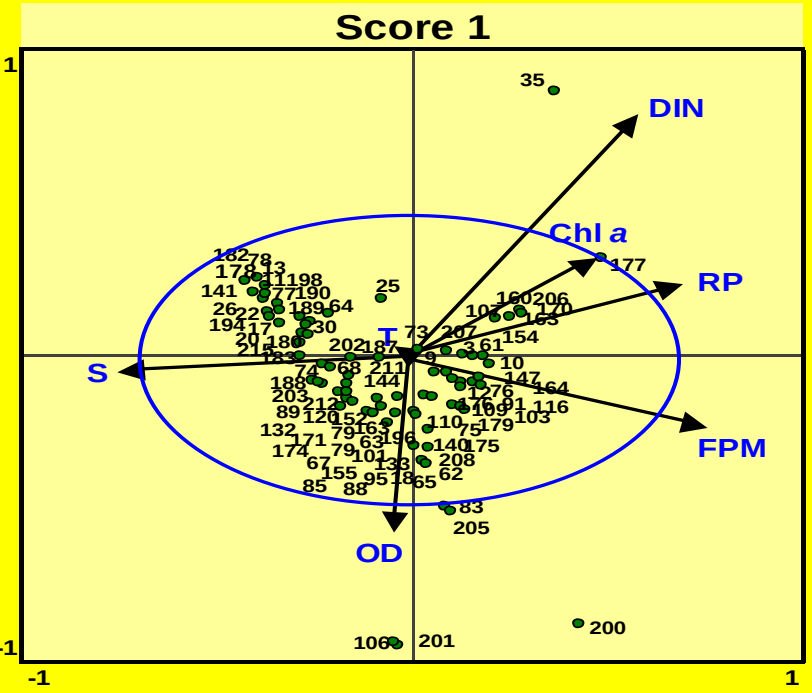


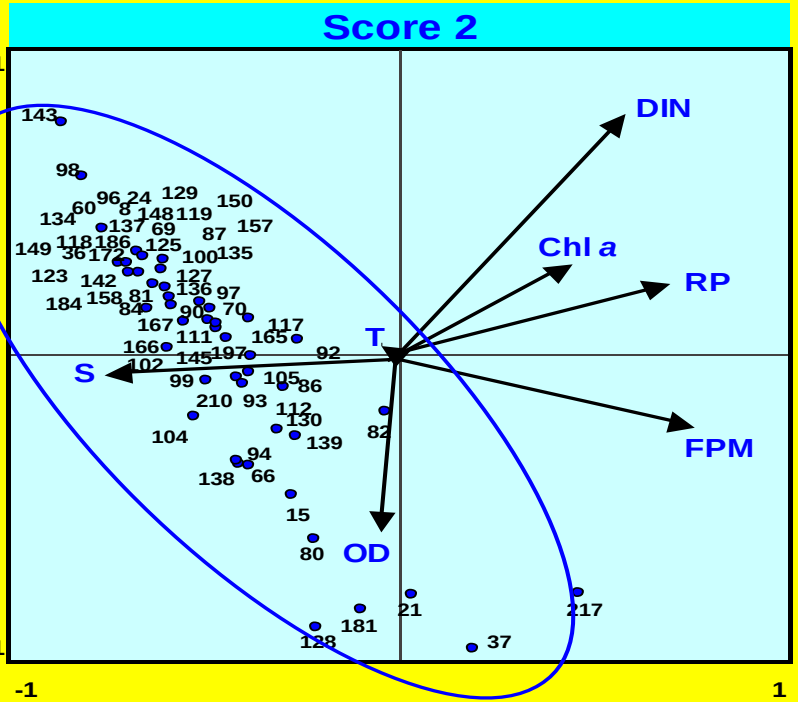
Environmental parameters and pollutants in 5 stations of different Ecological Status in the Venice lagoon

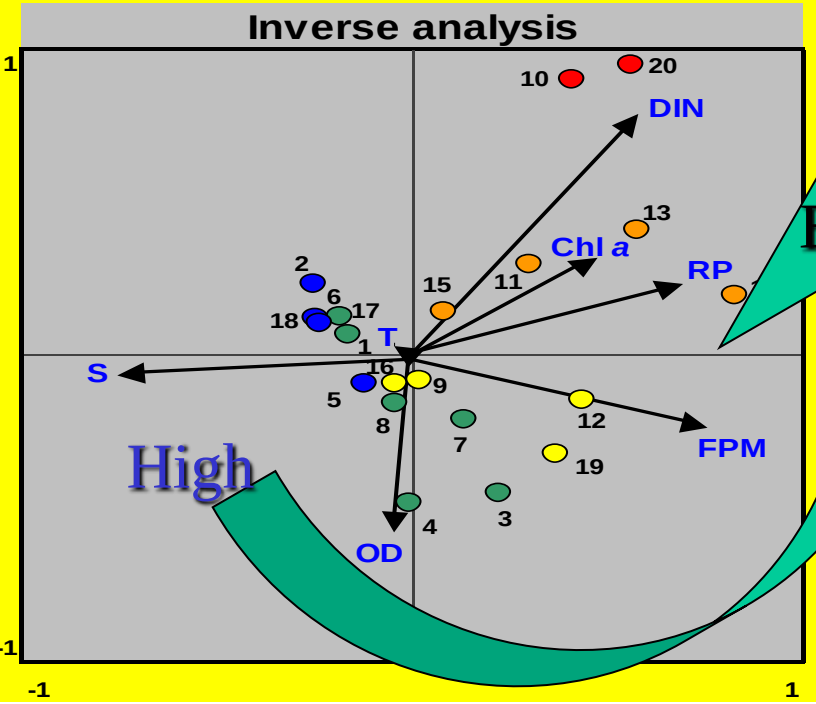
Validation in 5 stations of Venice lagoon

Parameters		High	Good	Moderate	Low	Bad
		SMM	Alberoni	S. Sessola	S. Giuliano	Misericordia
OD	%	200	140	138	117	88
FPM	mg DWT L^{-1}	24	52	64	70	75
SPM	g DWT m^{-2} d^{-1}	180	625	2073	1963	2150
Chl a tot	µg L^{-1}	0.52	0.94	1.59	1.33	7.55
RP	µM	0.69	0.46	0.66	0.91	2.45
DIN	µM	14.3	16.5	24.1	41.0	122.5
C org (sed.)	mg DWT g^{-1}	8.3	7.6	7.9	11.2	26.0
Ntot (sed.)	mg DWT g^{-1}	0.89	0.67	0.89	1.47	2.7
Ptot (sed.)	µg DWT g^{-1}	568	350	360	544	645
Porg (sed.)	µg DWT g^{-1}	70	56	58	132	257
Water Transparency	cm	100	100	90	88	65
Sed. fraction < 63 µr	%	33	42	78	89	96
Salinity	PSU	33.7	32.5	31.2	26.5	27.2
PCDD/F (sed.)	pg DWT g^{-1}	47	44	115	750	604
PAHs (sed.)	ng DWT g^{-1}	100	252	582	925	10000
Pesticides (sed.)	ng DWT g^{-1}	0.50	0.39	0.90	5.82	20.3
PCBs (sed.)	ng DWT g^{-1}	2.00	0.52	1.18	6.51	661
Pb (sed.)	µg DWT g^{-1}	13	19	26	63	214
As (sed.)	µg DWT g^{-1}	7	9	11	28	37
Hg (sed.)	µg DWT g^{-1}	0.4	0.27	0.053	0.83	4
Cu (sed.)	µg DWT g^{-1}	6	13	18	44	296
Zn (sed.)	µg DWT g^{-1}	26	81	162	413	1152
Cd (sed.)	µg DWT g^{-1}	0.5	0.4	1.00	2.4	5.66
Cr (sed.)	µg DWT g^{-1}	20	54	26	37	84.1
Ni (sed.)	µg DWT g^{-1}	13	64	41	36	38
TOTAL TAXA		175	108	80	61	38
Chlorophyceae	N°	44	35	32	29	23
Rhodophyceae	N°	102	57	37	23	9
Phaeophyceae	N°	29	16	11	9	6
R/C		2.32	1.63	1.16	0.79	0.39
E-MaQI		1.00	0.70	0.46	0.39	0.15
Rhodophyceae	%	58.3	52.8	46.3	37.7	23.7
Chlorophyceae	%	25.1	32.4	40.0	47.5	60.5
Phaeophyceae	%	16.6	14.8	13.8	14.8	15.8


Score 0
DIN
Chl a
RP
T
S
FPM
OD


Score 1
DIN
Chl a
RP
T
S
FPM
OD


Score 2
DIN
Chl a
RP
T
S
FPM
OD


Inverse analysis
DIN
Chl a
RP
T
S
FPM
OD
High
Bad

CANOCO

Blidingia spp.

Laminar *Ulva* spp.

Blidingia spp.

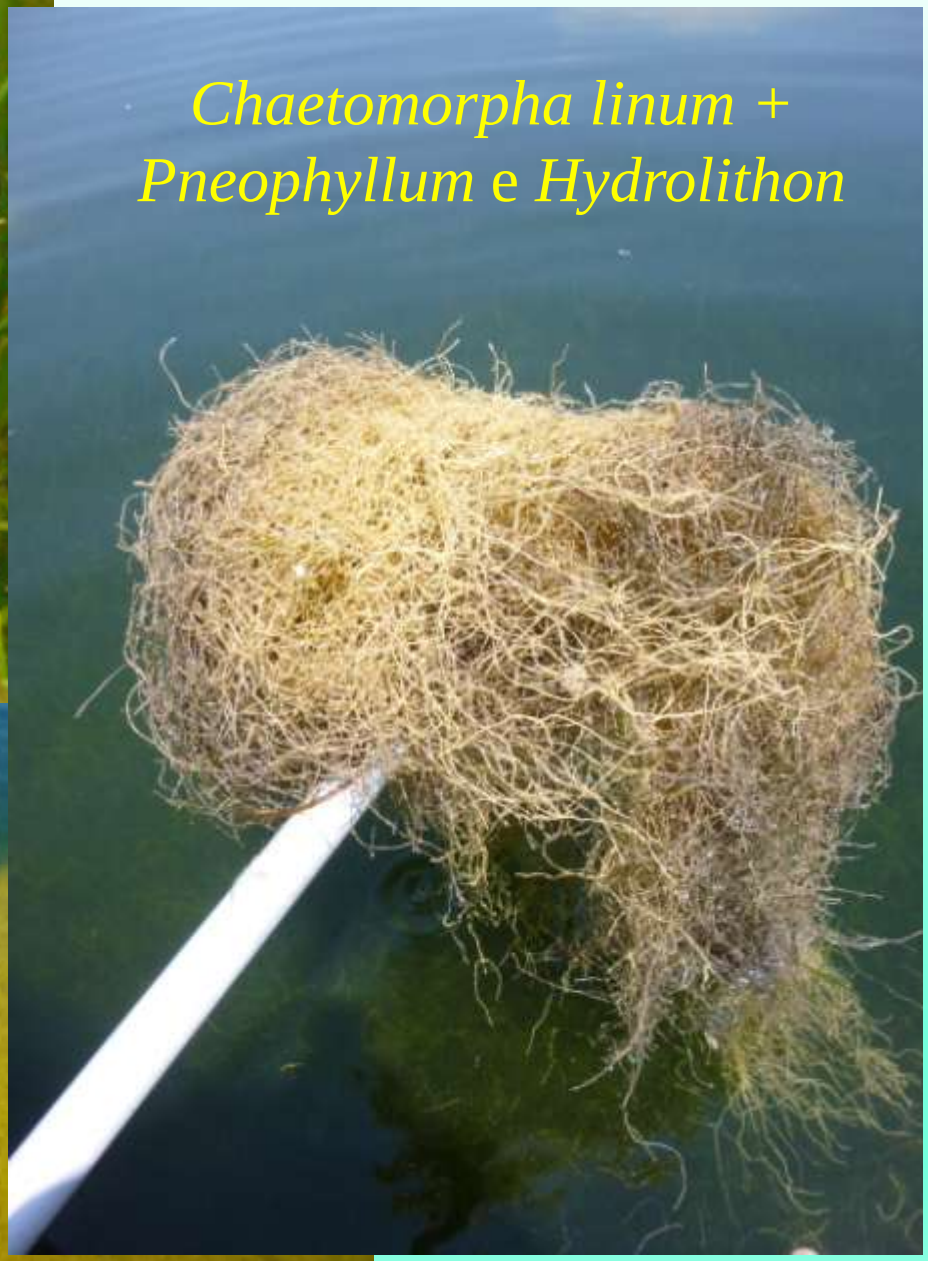
Filamentous *Ulva* spp.

Filamentous *Ulva* spp.

Ulvaceae (Bad-Low environments)


Corallina spp.
Chaetomorpha linum
Cryptonemia lomation
Heterosiphonia japonica
Valonia aegagropila
High Quality species

Cymodocea + Lamprothamnion



Chaetomorpha linum +
Pneophyllum e *Hydrolithon*

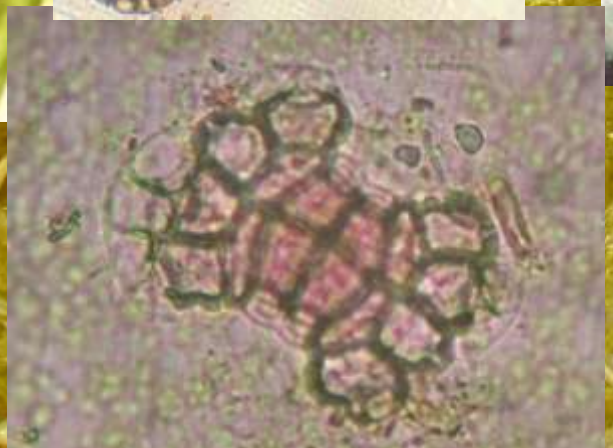
High Quality species

Specie Calcarizzate



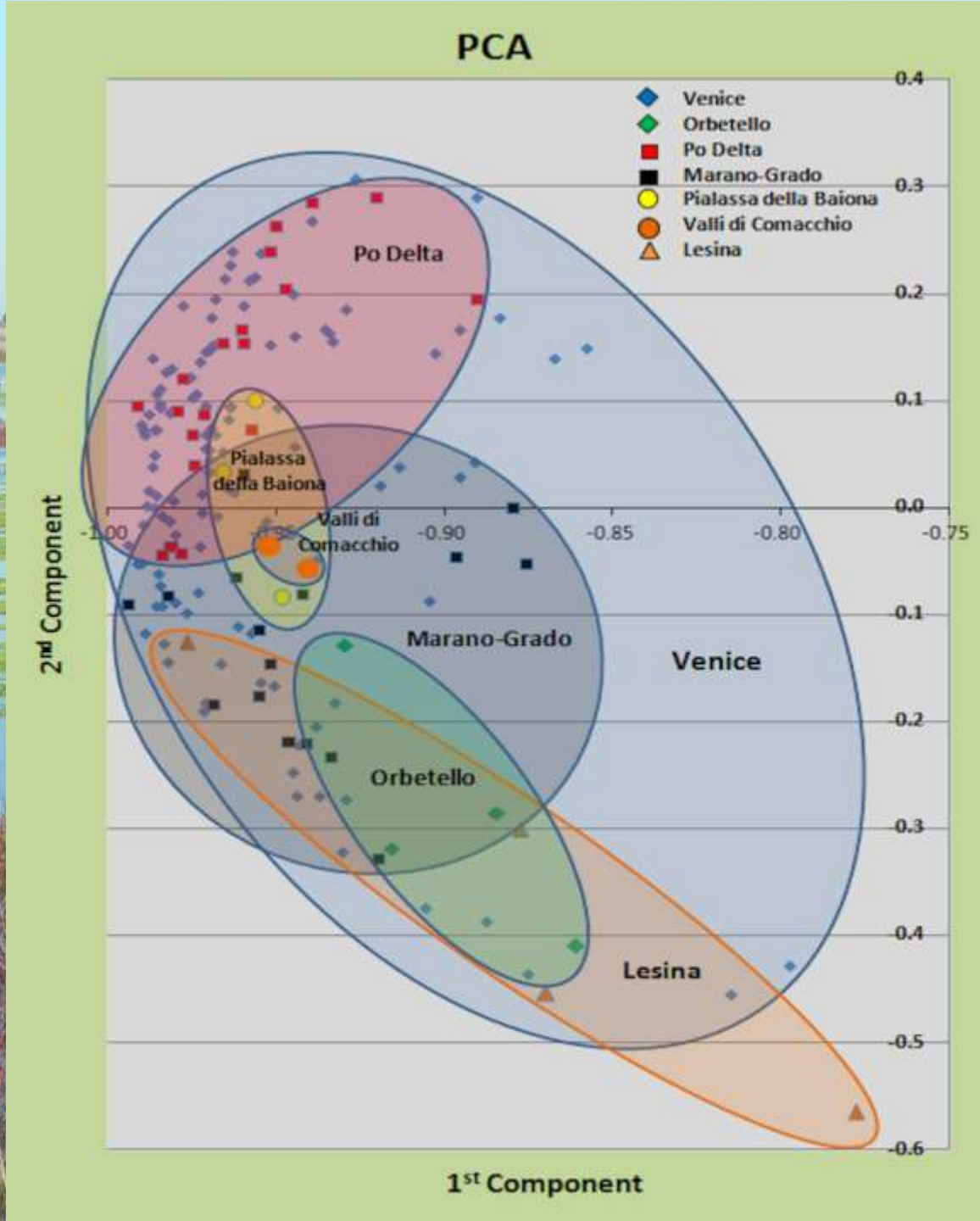





Classificazione Lagune Italiane (169 stazioni)

Sfriso *et al.* (2017)



LIFE12 NAT/IT/000331

"Habitat 1150* (Coastal lagoon) recovery by SEagrass RESTOration (SeResto). A new strategic approach to meet HD & WFD objectives" (Habitat Directive & Water Framework Directive)

Il Progetto gode del contributo dello strumento finanziario Life dell'Unione Europea e contribuisce al miglioramento ecologico di un sito di interesse comunitario della rete Natura 2000 (SIC IT3250031 – Laguna di Venezia Settentrionale)

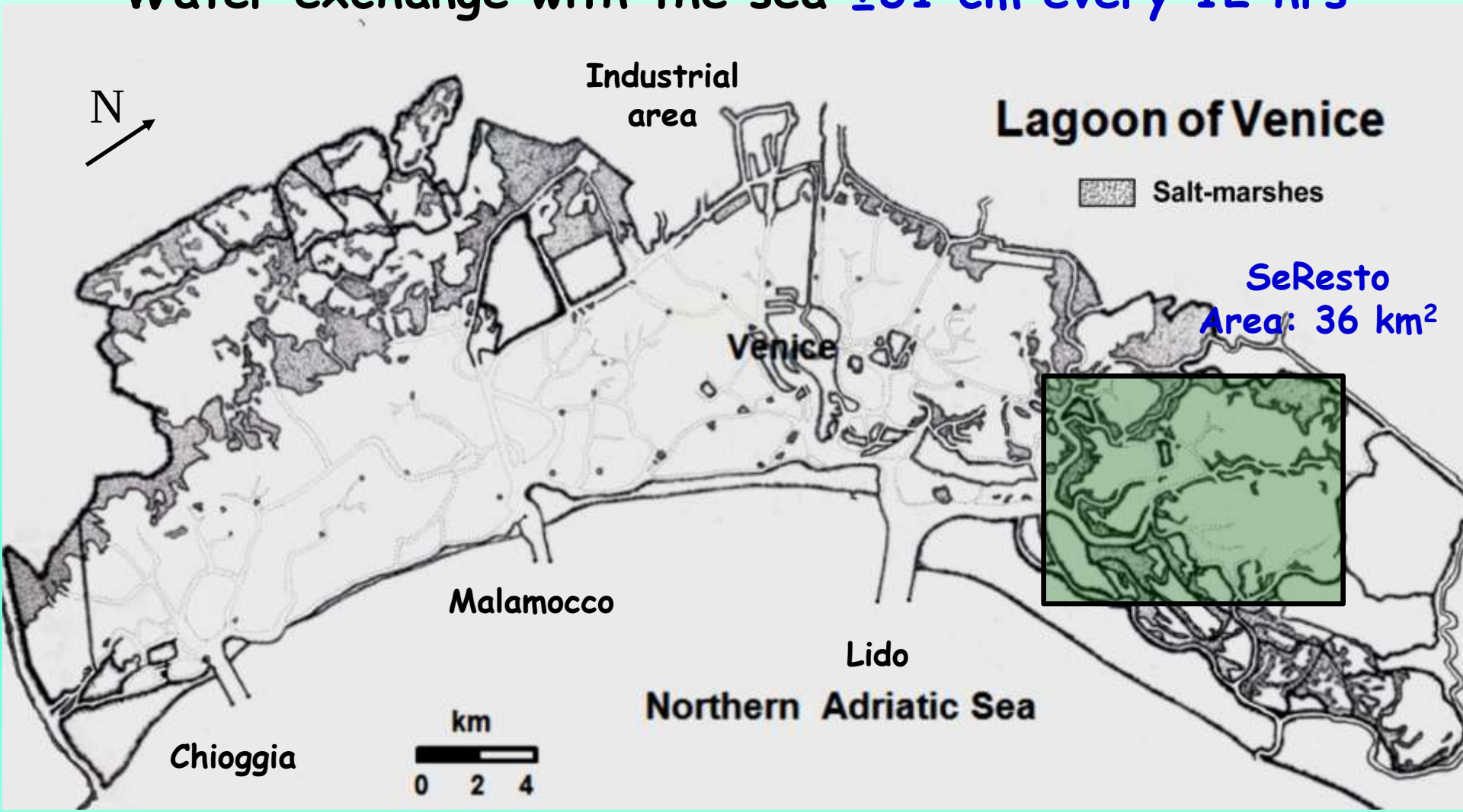
Lagoon of Venice:

total surface: ca. 549 km^2

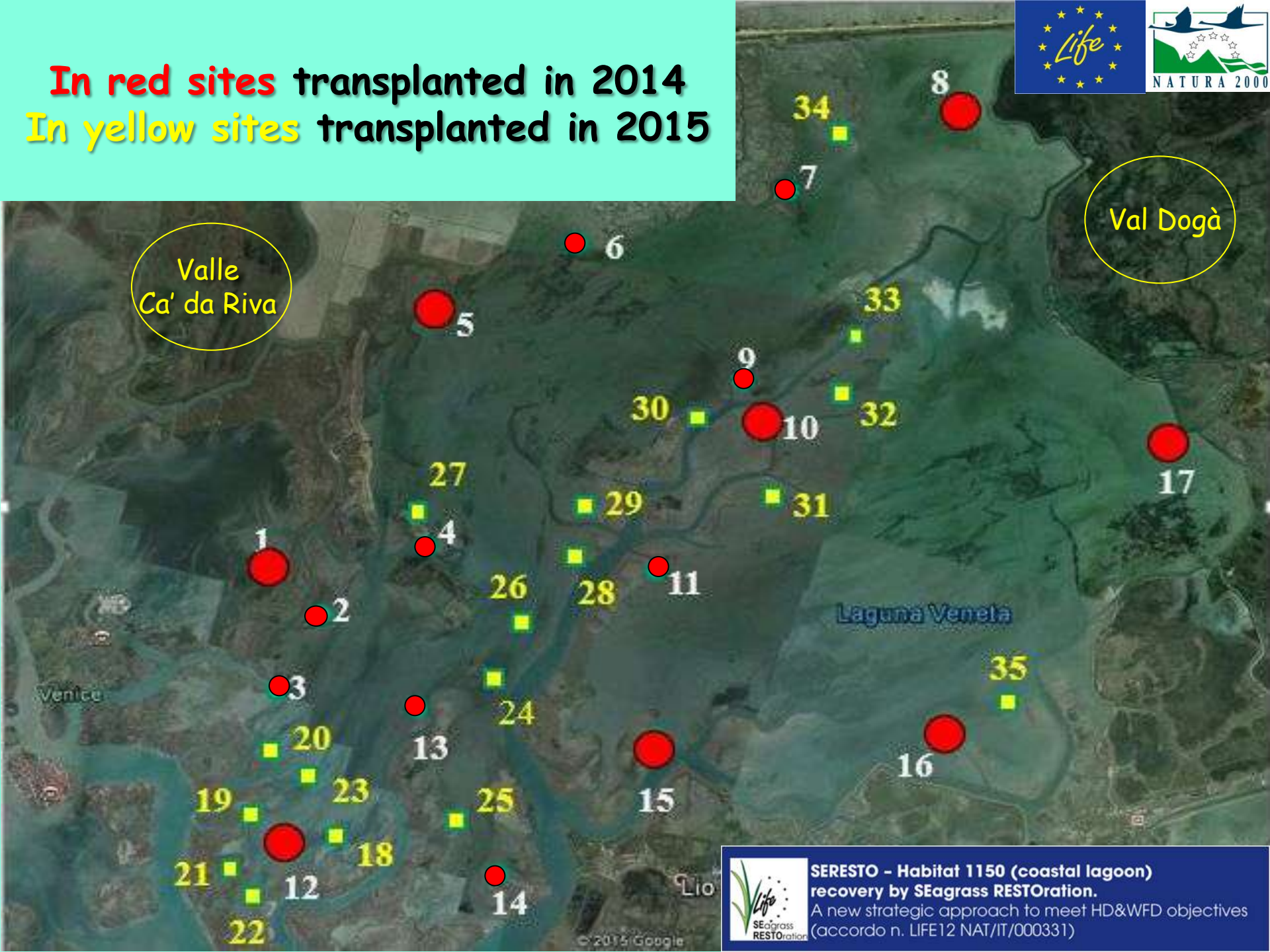
water surface: ca. 432 km^2

mean water depth: ca. 1m

Water exchange with the sea ±31 cm every 12 hrs



In red sites transplanted in 2014
In yellow sites transplanted in 2015



SERESTO – Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

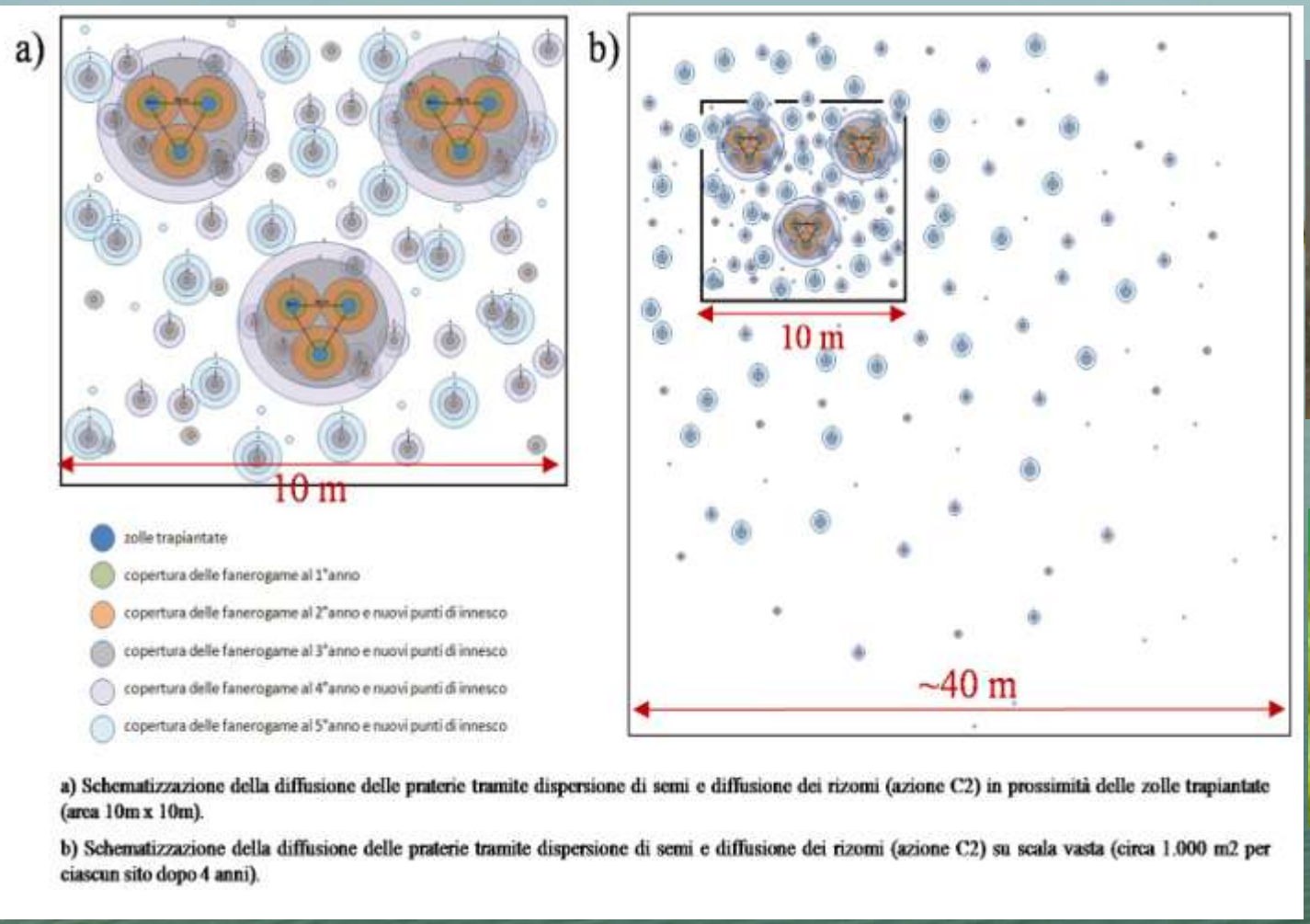
C1- Sods transplantation

Corer with a diameter of ca.30 cm

Sods in perforated buckets

SERESTO – Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

Expected growth



a) Schematizzazione della diffusione delle praterie tramite dispersione di semi e diffusione dei rizomi (azione C2) in prossimità delle zolle trapiantate (area 10m x 10m).

b) Schematizzazione della diffusione delle praterie tramite dispersione di semi e diffusione dei rizomi (azione C2) su scala vasta (circa 1.000 m2 per ciascun sito dopo 4 anni).

C2- Rhizome transplantation

It is possible to operate directly from the boat with pliers in all tide conditions or by manually operating while diving.

The spread of some species can also be done by transplanting seeds or by diffusion of those produced by transplanted plants.

Seeds of *Zostera marina*

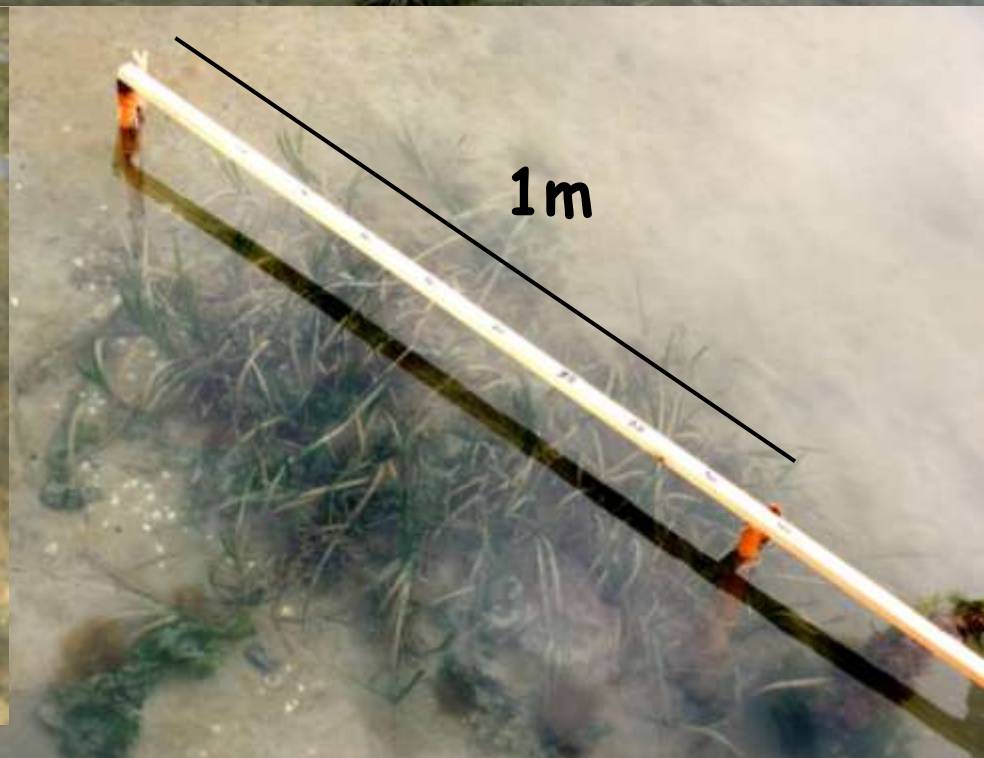
Rhizome transplantation

A minimum of 400 rhizomes have been transplanted in each station every year, especially in spring and autumn in order to promote the spread of plants.

The rhizomes are collected with a rake or manually and transplanted by means of pliers directly from the boat

In the case of *Zostera noltei* and *Ruppia cirrhosa*, due to the small size of the rhizomes, it is preferable to carry out transplants using small sods of 15 cm easily made by means of a small size corer. Each sod corresponds to a minimum of approx. 15 rhizomes for *Z. noltei* and 17 for *Ruppia cirrhosa*

Sod growth after 8-9 months

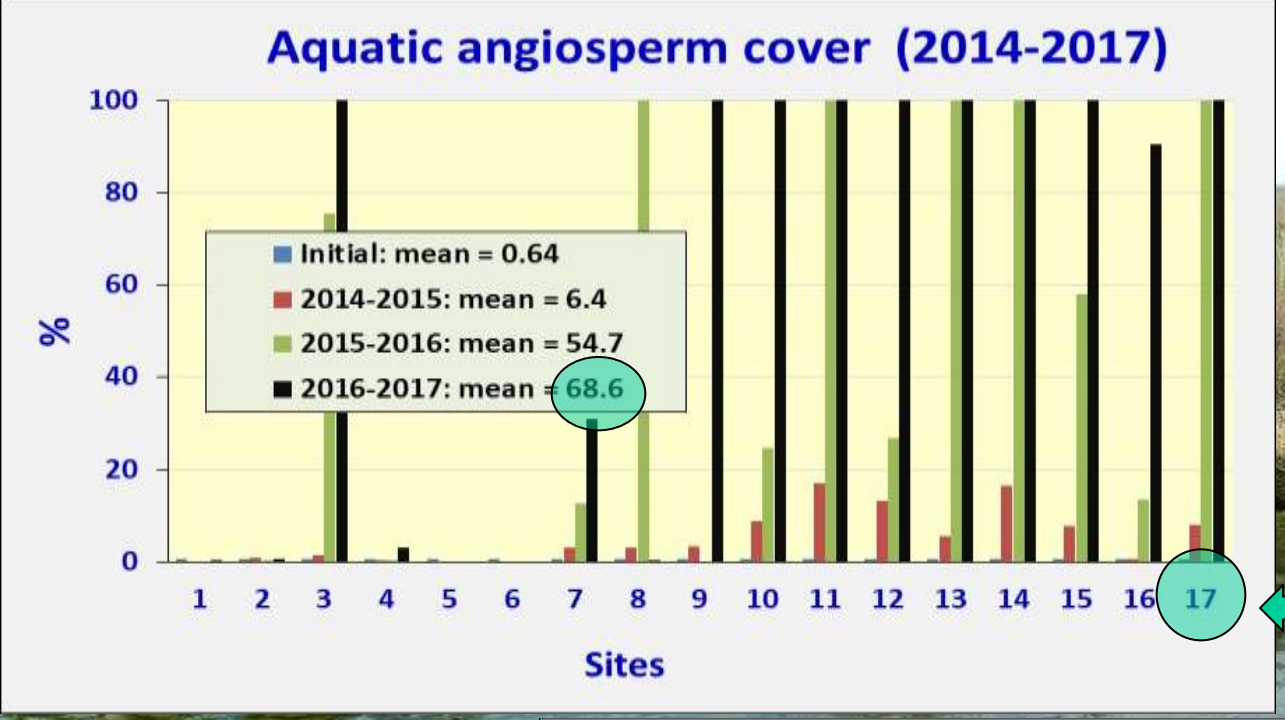


SERESTO – Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

Rhizome growth after 6 months

SERESTO – Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

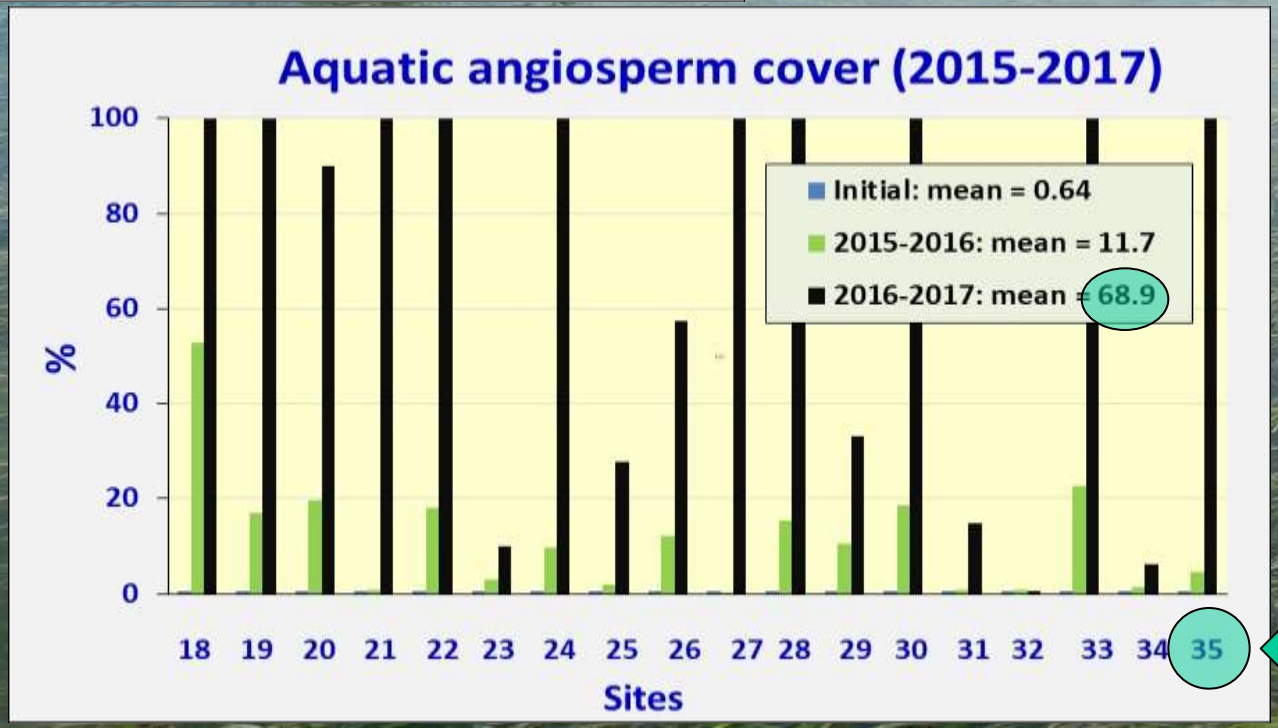
Plant growth after 18-30 mesi



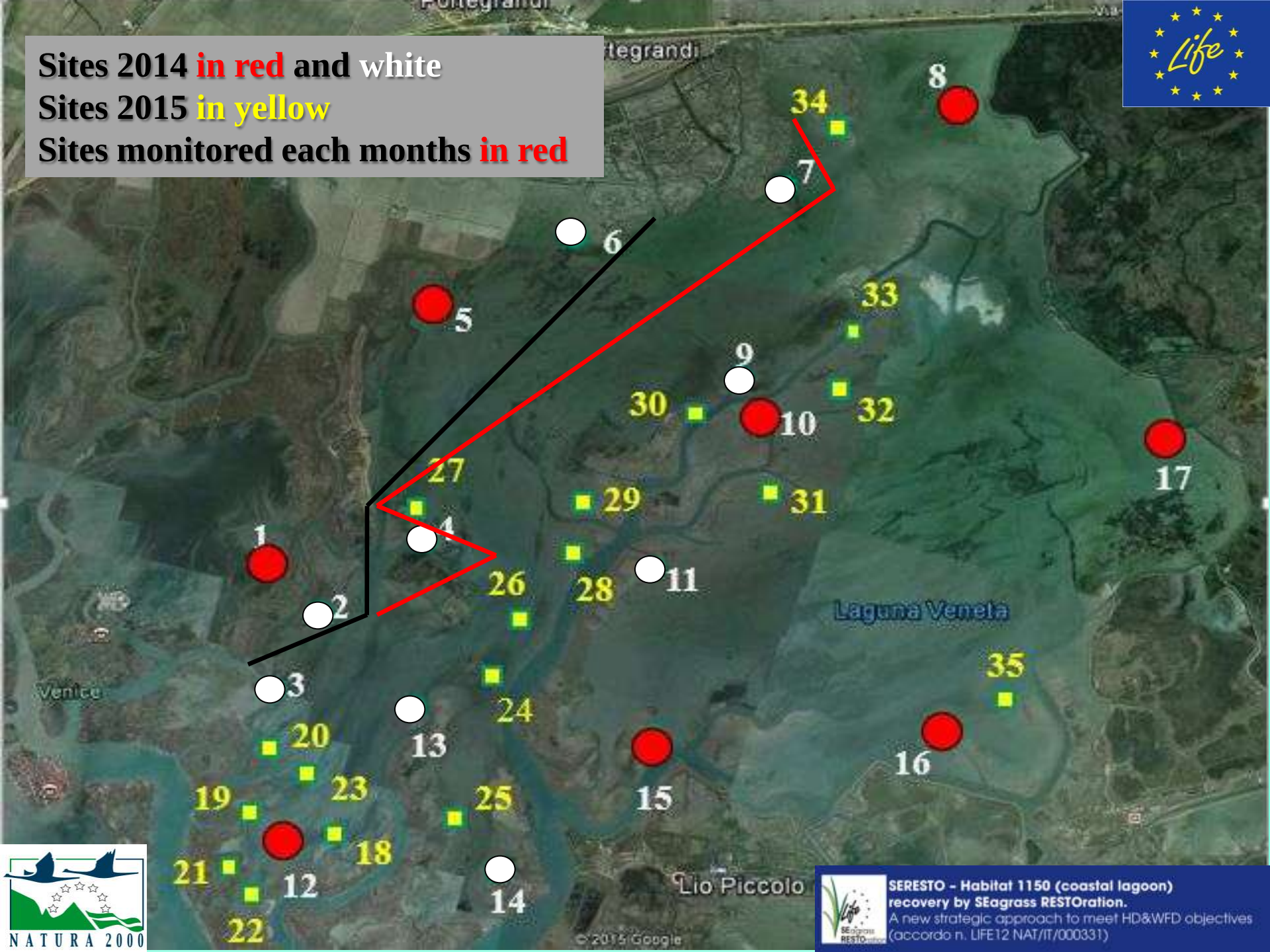
NATURA 2000

2014-2017
3 years + 8 months

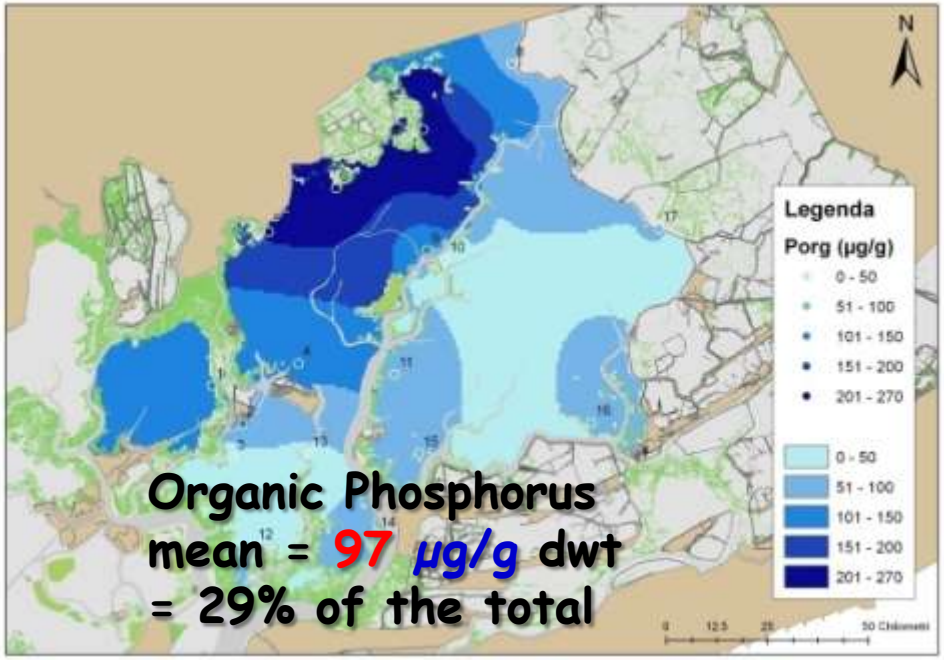
2015-2017
2 years + 8 months

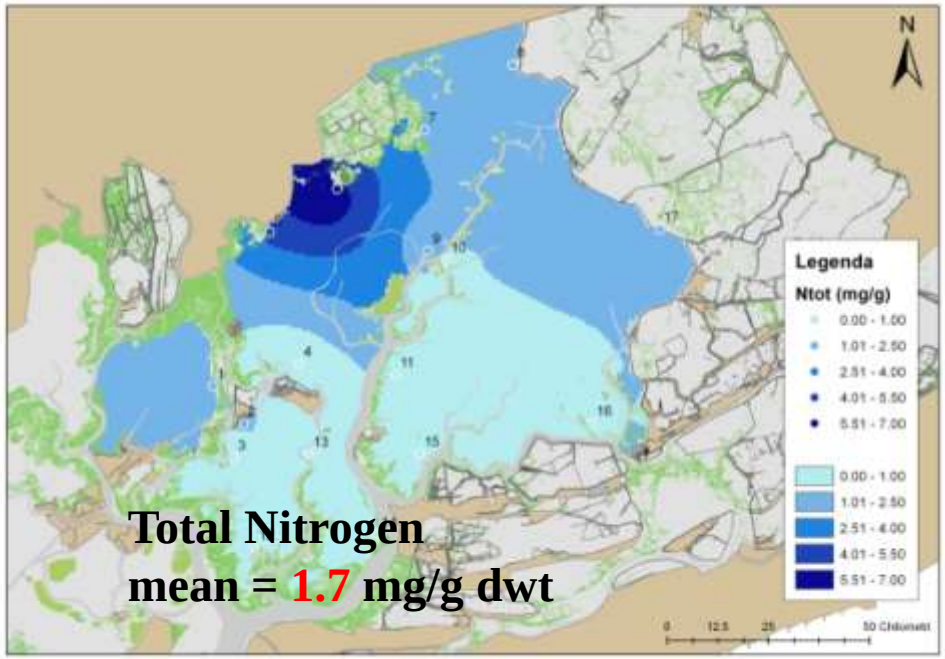


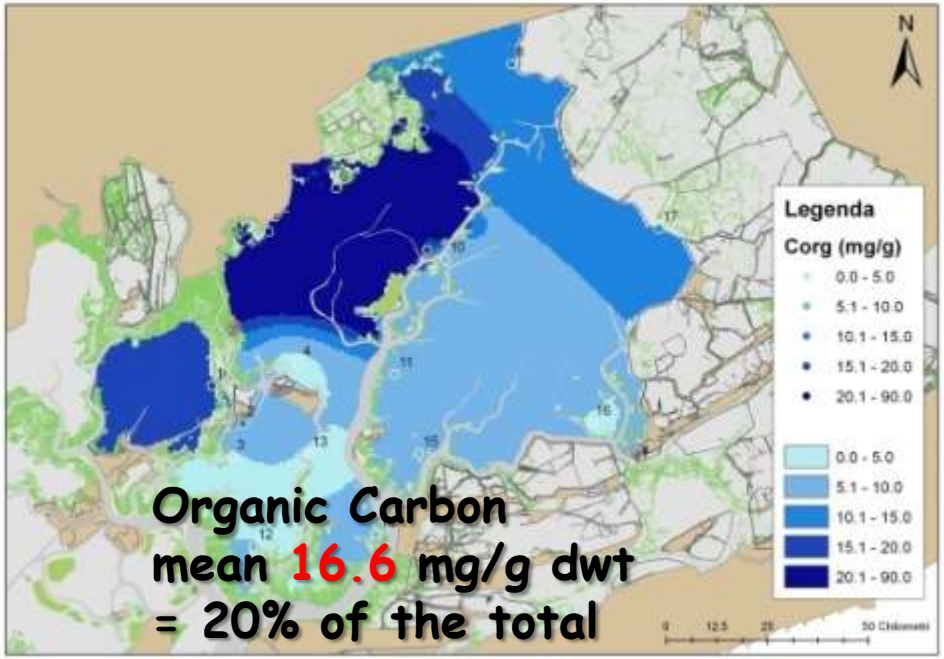
Life


Sites 2014 in red and white
Sites 2015 in yellow
Sites monitored each months in red
Laguna Veneta
Venice
Lio Piccolo
© 2015 Google
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
NATURA 2000
SERESTO - Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

Nutrients (2014)





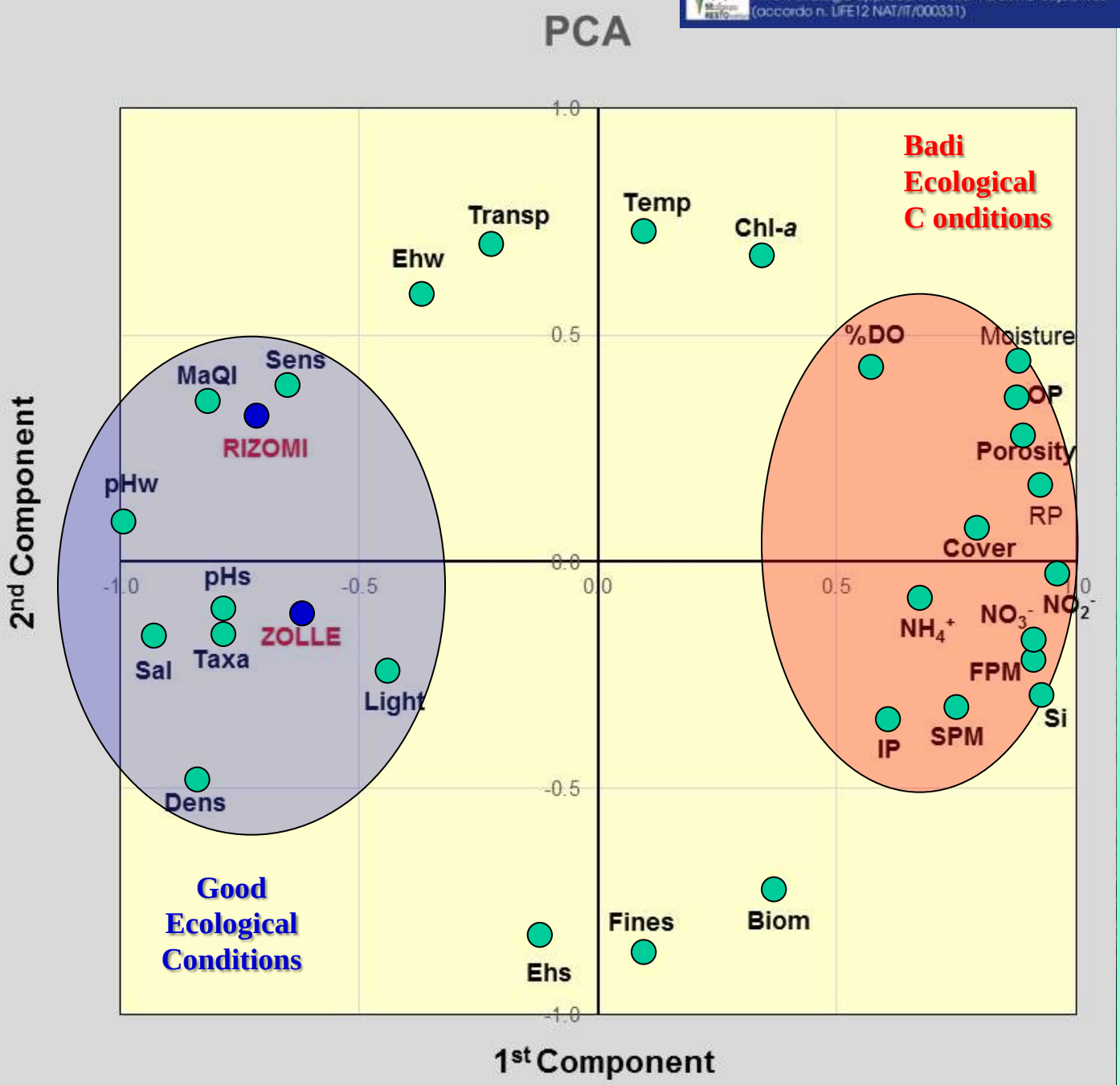


Ca. 10 km² with aquatic plants with different cover and 4 km² of total cover

December 2017

SERESTO – Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

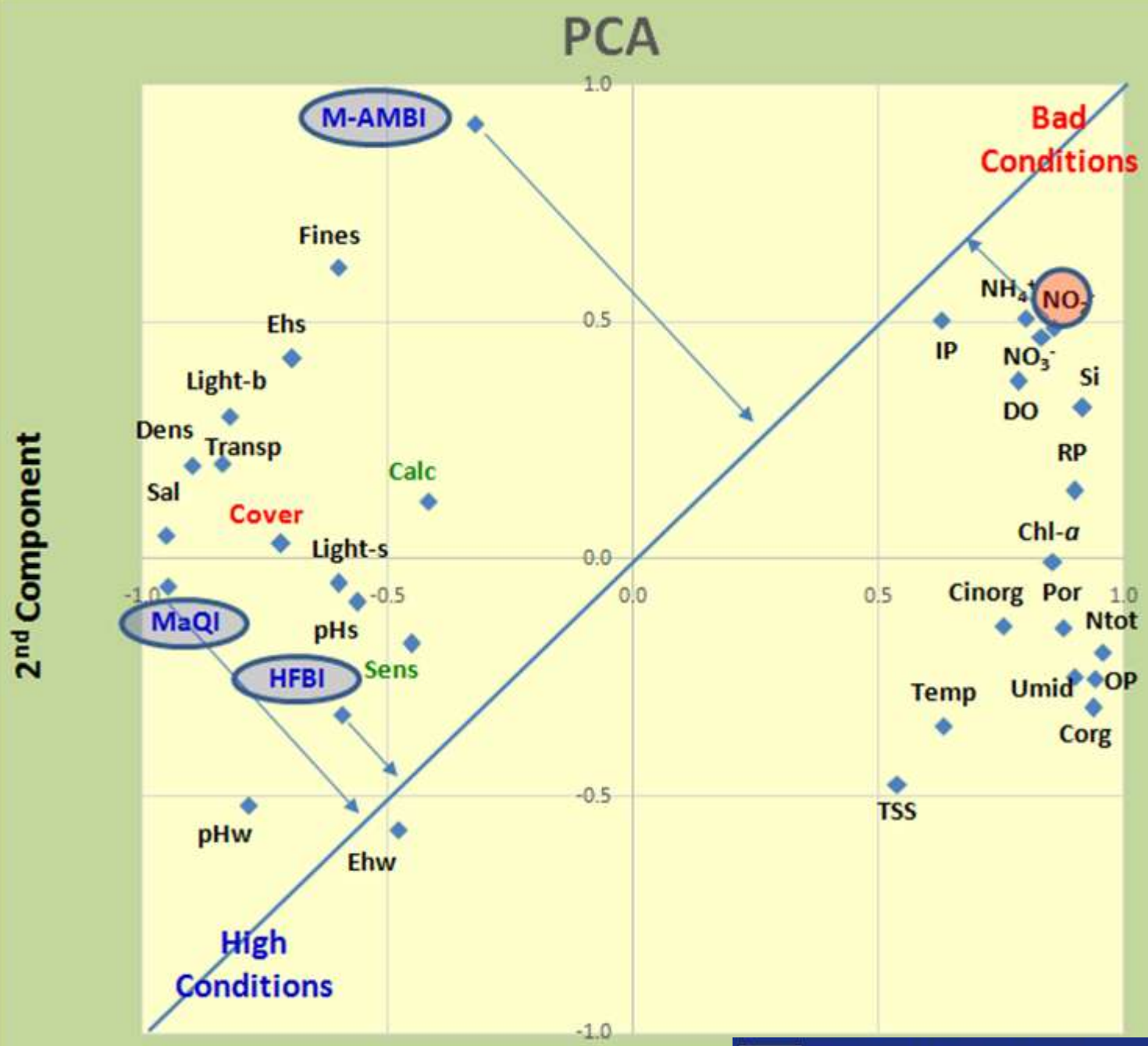
Environmental Quality and Aquatic Angiosperms



NATURA 2000

Environmental Parameters on the 8 sites

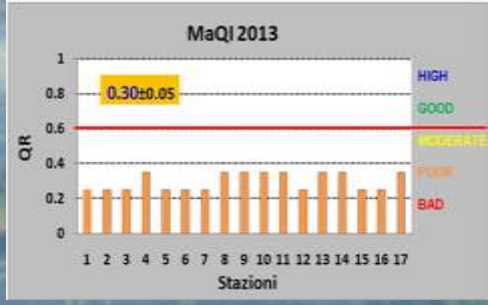
2017

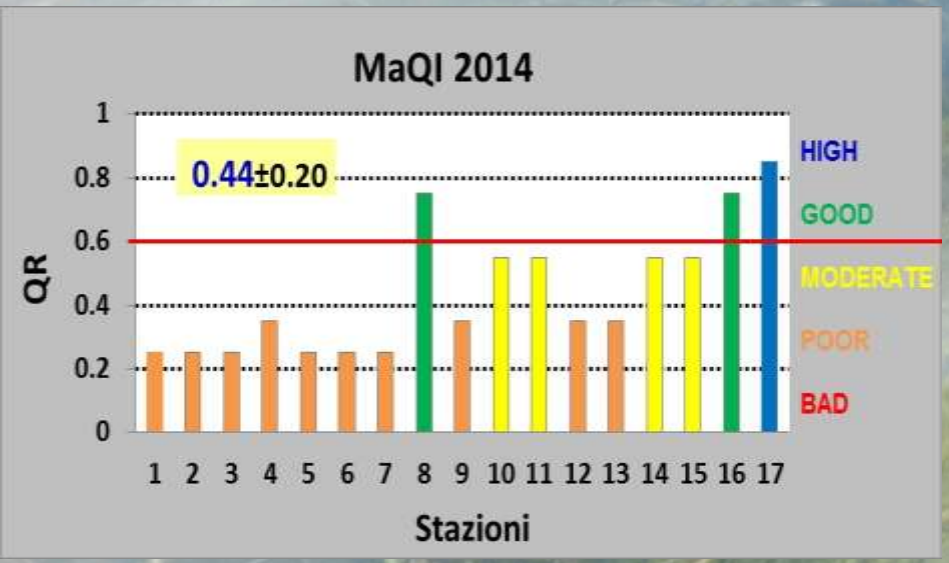


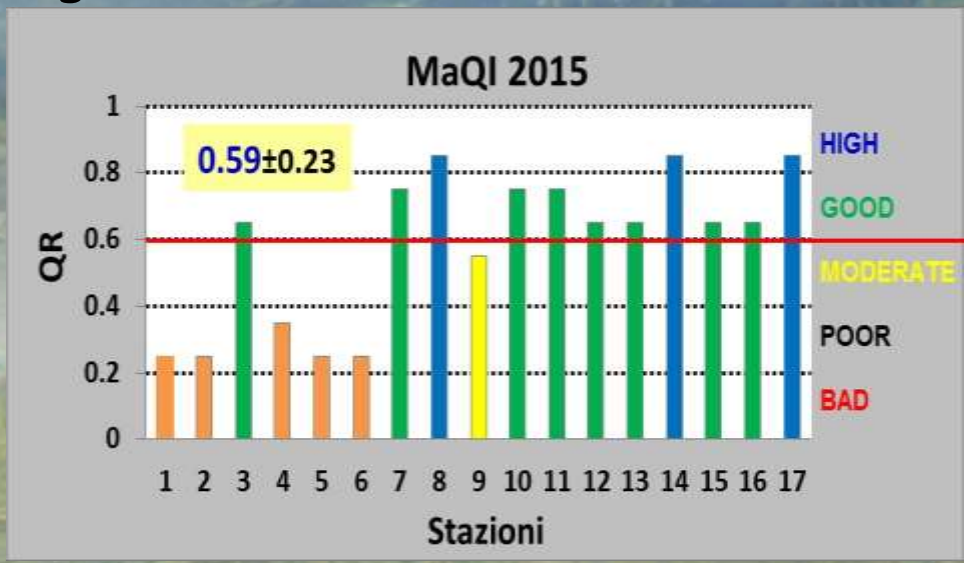
SERESTO - Habitat 1150 (coastal lagoon) recovery by SEagrass RESTOration.
A new strategic approach to meet HD&WFD objectives
(accordo n. LIFE12 NAT/IT/000331)

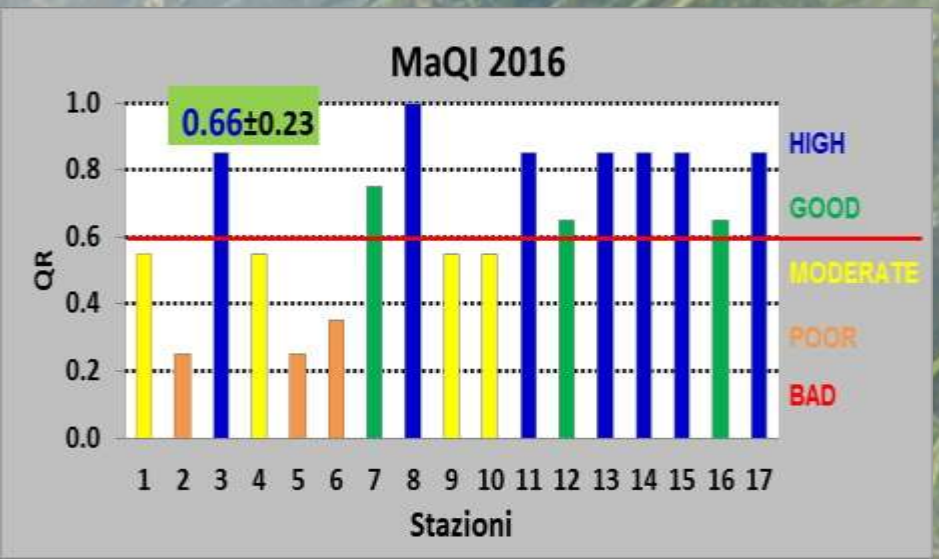
Macrophyte Quality Index (2014)

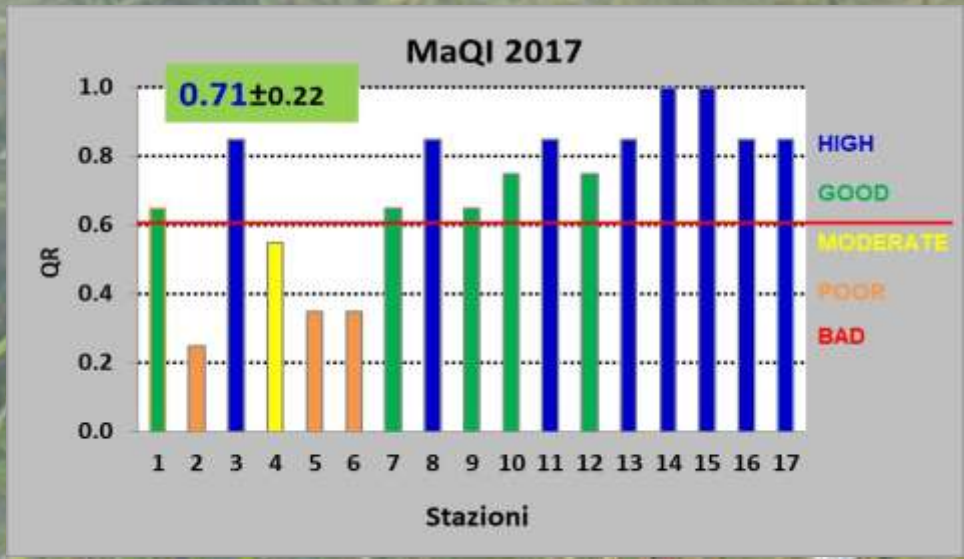
The BQI that responds more quickly to environmental changes

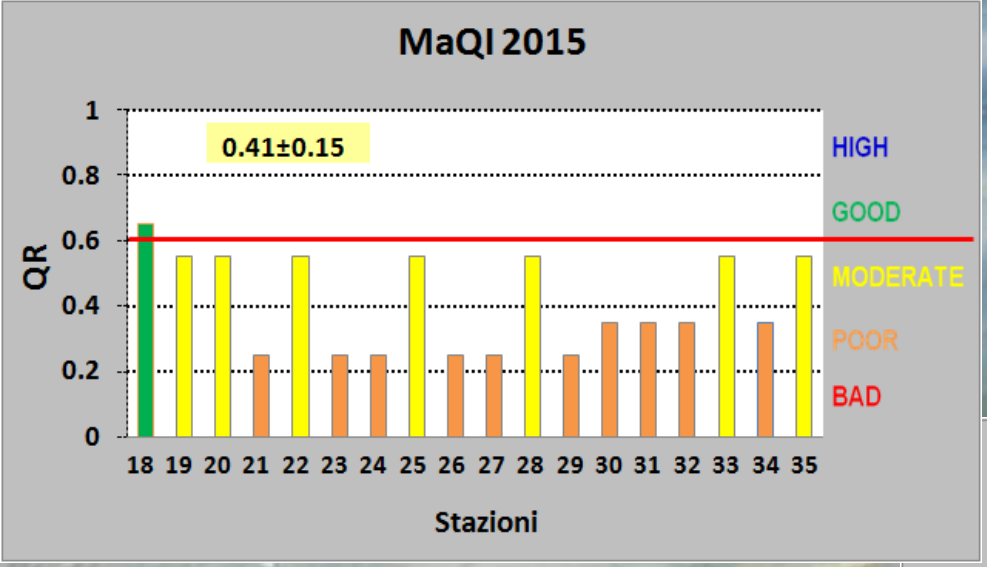


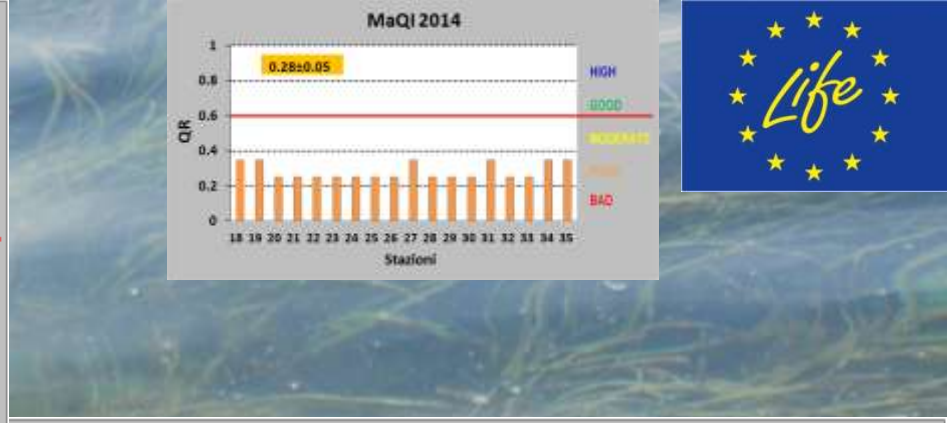




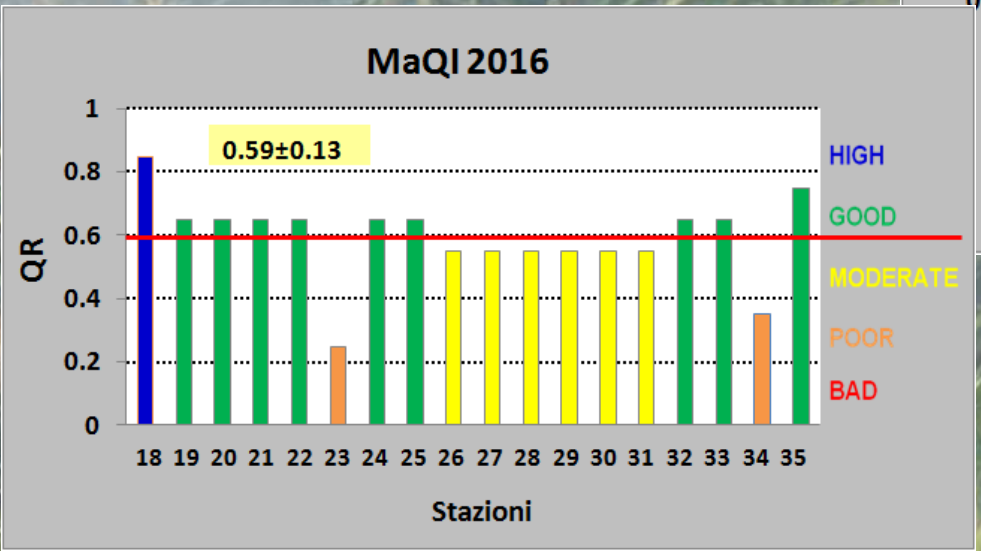


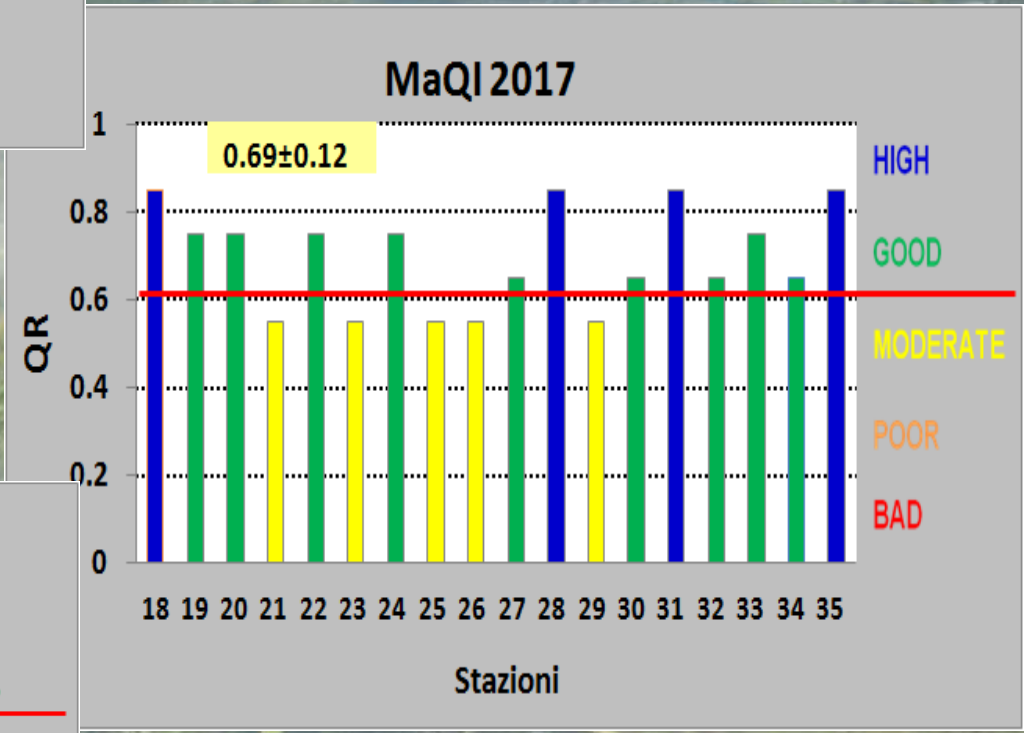






Macrophyte Quality Index





Macrophyte Quality Index (MaQI)

Stazione \ Anno	2013	2014	2015	2016	2017
St. 1	0.25	0.25	0.25	0.55	0.65
St. 5	0.25	0.25	0.25	0.25	0.35
St. 8	0.35	0.75	0.85	1.00	0.85
St. 10	0.35	0.55	0.75	0.55	0.75
St. 12	0.25	0.35	0.65	0.65	0.75
St. 15	0.25	0.55	0.65	0.85	1.00
St. 16	0.25	0.75	0.65	0.65	0.85
St. 17	0.35	0.85	0.85	0.85	0.85
Valore medio	0.29	0.54	0.61	0.67	0.76

Habitat Fish Bioindicator Index (HFBI)

Stazione \ Anno	2014	2015	2016	2017
St. 1	0.14	0.92	0.68	0.44
St. 5	0.09	0.59	0.58	0.12
St. 8	0.21	0.44	0.69	0.58
St. 10	0.51	0.42	0.64	0.42
St. 12	0.05	-0.04	0.63	0.25
St. 15	0.53	0.25	0.81	0.87
St. 16	0.27	0.16	0.74	0.55
St. 17	0.46	0.64	0.99	1.00
Valore medio	0.28	0.42	0.72	0.53

Multivariate AZTI's (HFBI) Marine Biotic Index (M-AMBI)

Stazione \ Anno	2014	2015	2016	2017
St. 1	0.72	0.91	0.69	1.08
St. 5	0.63	0.96	0.65	1.00
St. 8	0.53	0.51	0.80	0.61
St. 10	0.53	0.68	0.66	1.04
St. 12	0.71	0.95	0.61	0.74
St. 15	0.59	0.69	0.68	0.49
St. 16	0.62	0.46	0.55	0.42
St. 17	0.66	0.76	0.55	0.67
Valore medio	0.62	0.74	0.65	0.76

The phases and results of the SeResto project are shown i in

2 Integral Videos of ca. 20 minutes
2 Short Videos of ca. 5 minutes

SEagrass
RESTOration

SERESTO

Habitat 1150* (Coastal lagoon) recovery
by SEagrass RESTOration

A new strategic approach to meet HD & WFD objectives

Conclusioni

Attualmente lo stato trofico della laguna veneta è in forte declino

mentre

lo stato ecologico sta progressivamente aumentando.

La nuova variabile sarà la regolamentazione con le chiusure del Mose:

la trofia tornerà ad aumentare??

Grazie per l'attenzione