Residence time influences on phytoplankton diversity and eutrophication response in estuaries and coastal waterbodies

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http://www.eutro.org

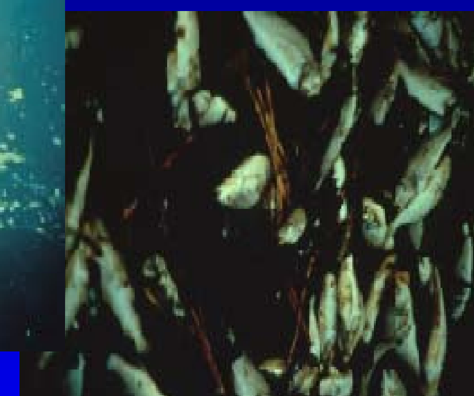
S.B. Bricker — NOAA
J.G. Ferreira — IMAR
W. J. Wolff — University of Groningen
T.C. Simas — IMAR

The Assessment Approach

Symptoms and Consequences of Nutrient Enrichment

Nutrient Inputs and Processing	Primary Impacts	Secondary Impacts	Consequences of Symptoms
Increased N and P concentration	High algal production Loss of water clarity Macroalgal problems	Loss of SAV Low D.O Nuisance/Toxic blooms	Fish kills Loss of habitat Human health risks Loss of tourism Closed fishing grounds



ASSETS: Pressure - State - Response

P: Overall Human Influence (OHI) – Natural processing + Human Nutrient Load
S: Overall Eutrophic Condition (OEC) – Condition of waterbody
R: Determination of Future Outlook (DFO) – What will happen in the future?

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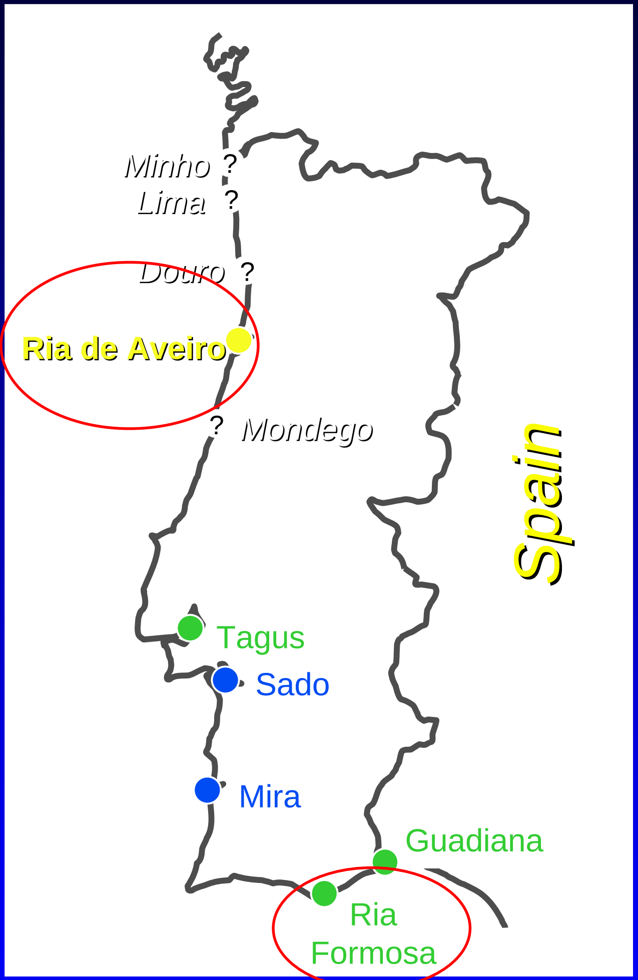
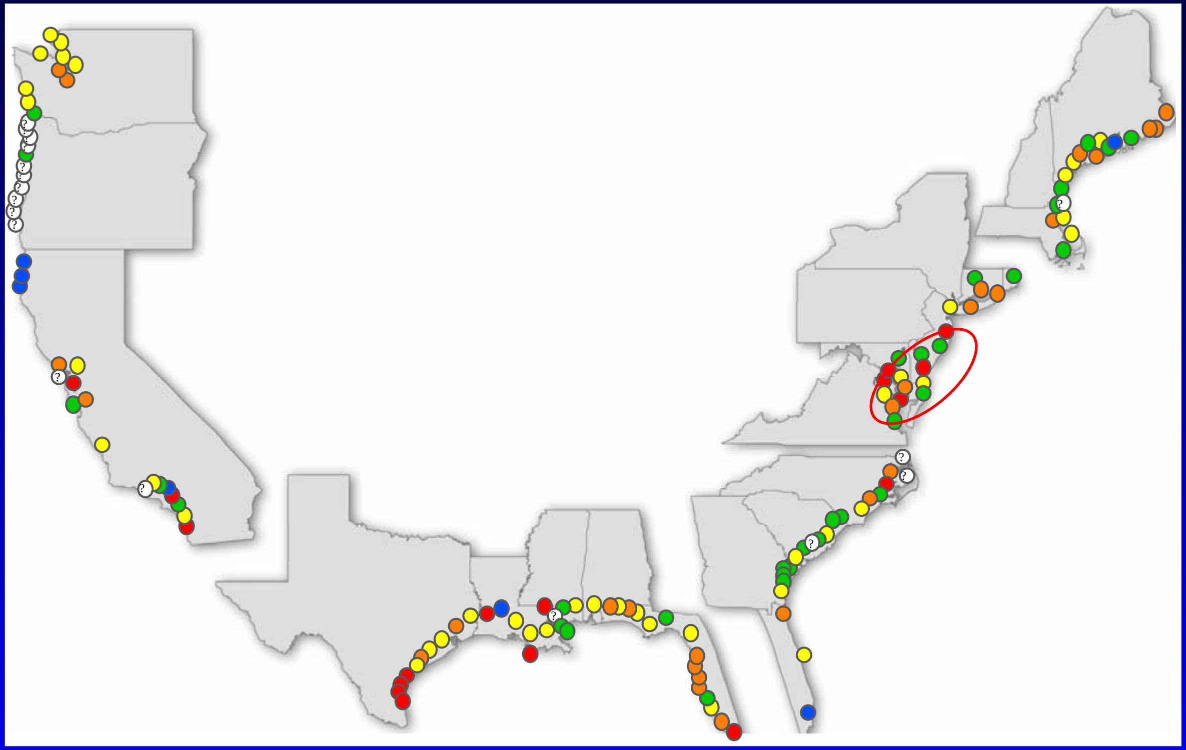
Five lagoon systems





<u>Portugal</u>
Ria Formosa
Ria de Aveiro

<u>United States</u>
Barnegat Bay
Chincoteague Bay
Marland Coastal Bays

Five lagoon systems

Key descriptors for five lagoon systems

	Barnegat Bay	MD Inland Bays	Chincoteague Bay	Ria de Aveiro	Ria Formosa
Pressure					
Population ($X10^3$)	588-800	19-171	12-108	250-300	124-211
N load (tN y^{-1})	720	550	913	2760	1028
State					
Volume (10^6 m^3)	688	56	267	84	92
Mean depth (m)	1.4	1.1	1.2	1.4	1.9
Mean tidal range (m)	0.9	0.7	0.5	2	2
Water temp (ºC)	0-31.8	2.0-32	-1-33	10.5-24.5*1	14.0-23.8*1
Salinity	28	28	29	0.7-35.5*1	34.9-37.0*1
Res time (days)	27-71	10-21	63	4	0.5-2
Impact					
Main impact Factors	Chlorophyll *a* HABs Macroalgae	Chlorophyll *a* HABs Macroalgae	HABs Macroalgae	SAV loss Red tides	Macroalgae Intertidal O_2 Bivalve death

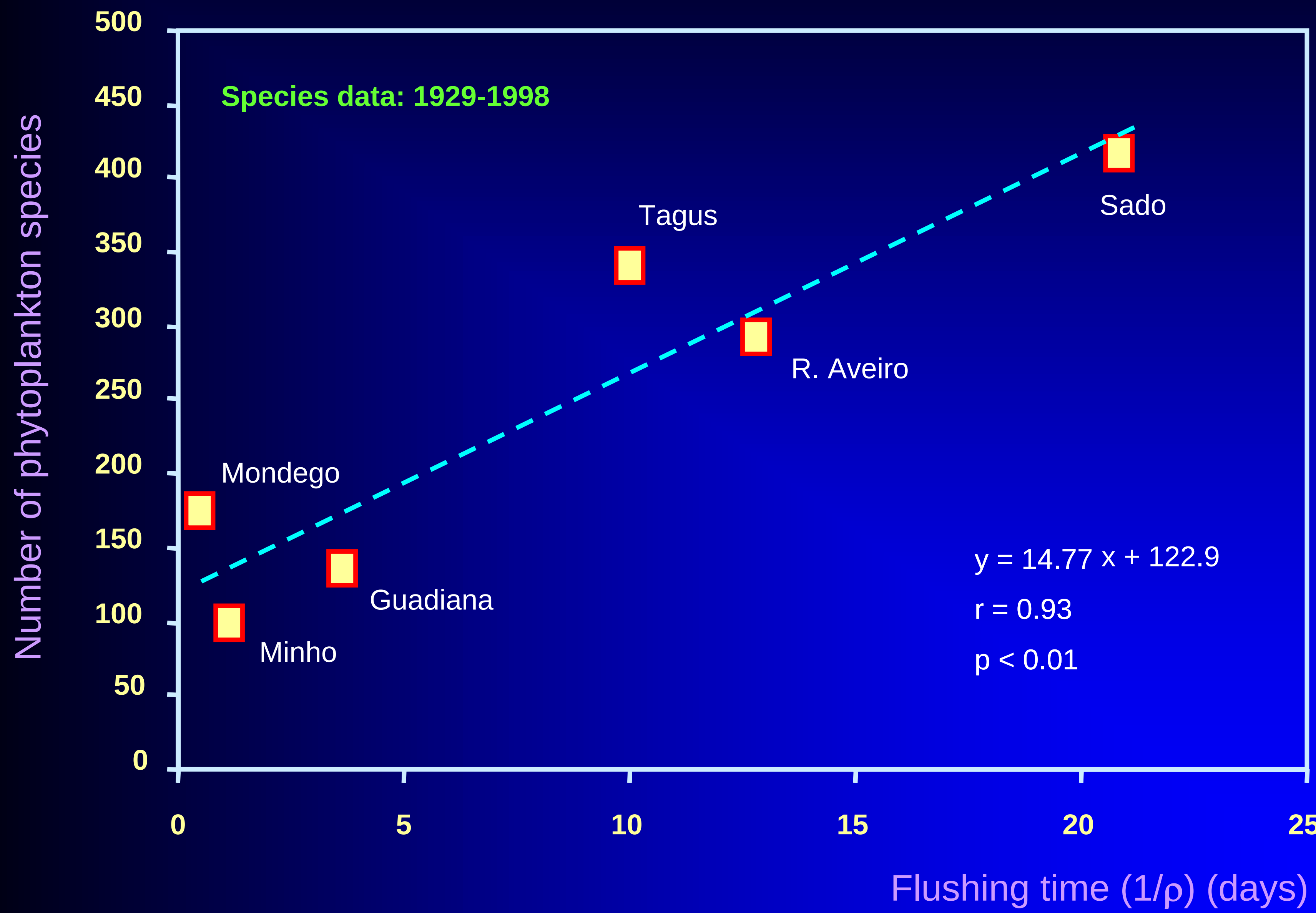
*1 : 5th – 95th percentile

Assessment results for five lagoon systems

	Barnegat Bay	MD Inland Bays	Chincoteague Bay	Ria de Aveiro	Ria Formosa
Residence time (days)	27-71	10-21	63	4	0.5-2
Susceptibility	H	MH	M	L	ML
Primary Symptoms					
Chlorophyll *a*	H	H	H	H	L
Macroalgae	M	H	H	NP	H
Secondary Symptoms					
Dissolved Oxygen	NP	M	M	NP	NP
SAV loss	M	I	I	M	L
HABs	H	H	H	NP	NP
Overall Eutrophic Condition	H	H	H	M	ML

H = High MH = Moderate High M = Moderate ML = Moderate Low L = Low
NP = No Problem I = Increase

Number of phytoplankton species as a function of flushing time



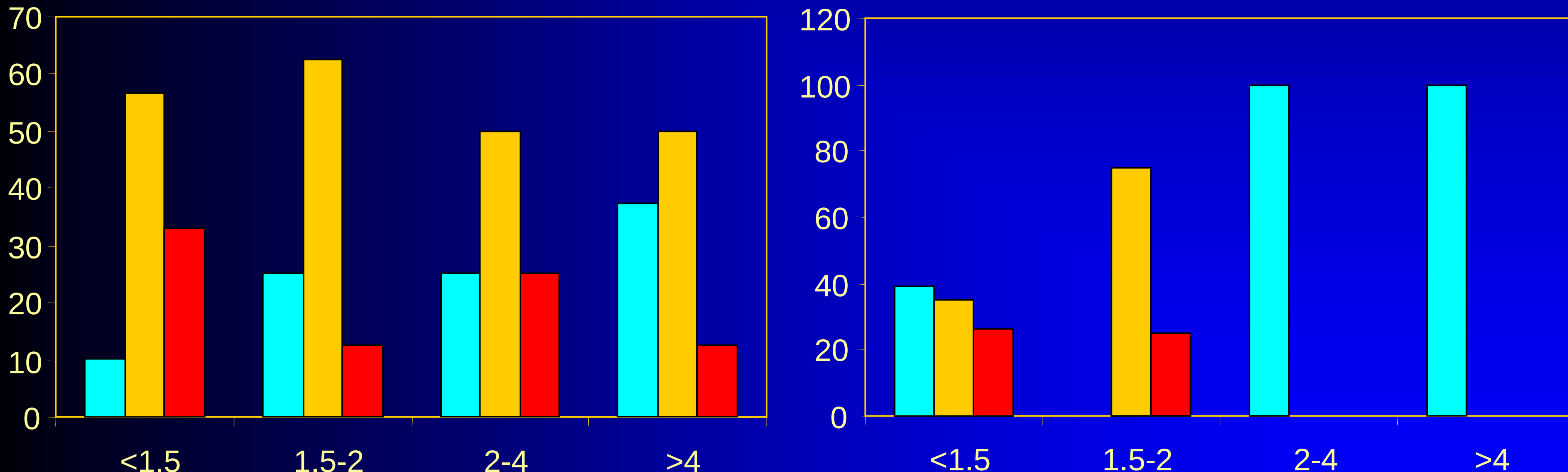
NEEA/ASSETS chlorophyll *a* and HAB

Frequency distribution according to required P_{max}

$$\ln\left(\frac{b_{max}}{b_{ini}}\right) = \left[P - \frac{Q}{V}\left(1+ \frac{S_e}{\Delta S}\right)\right] t$$

OEC Chlorophyll *a* | OEC Nuisance and toxic blooms

Frequency (% of each P_{max} class) | Frequency (% of each P_{max} class)

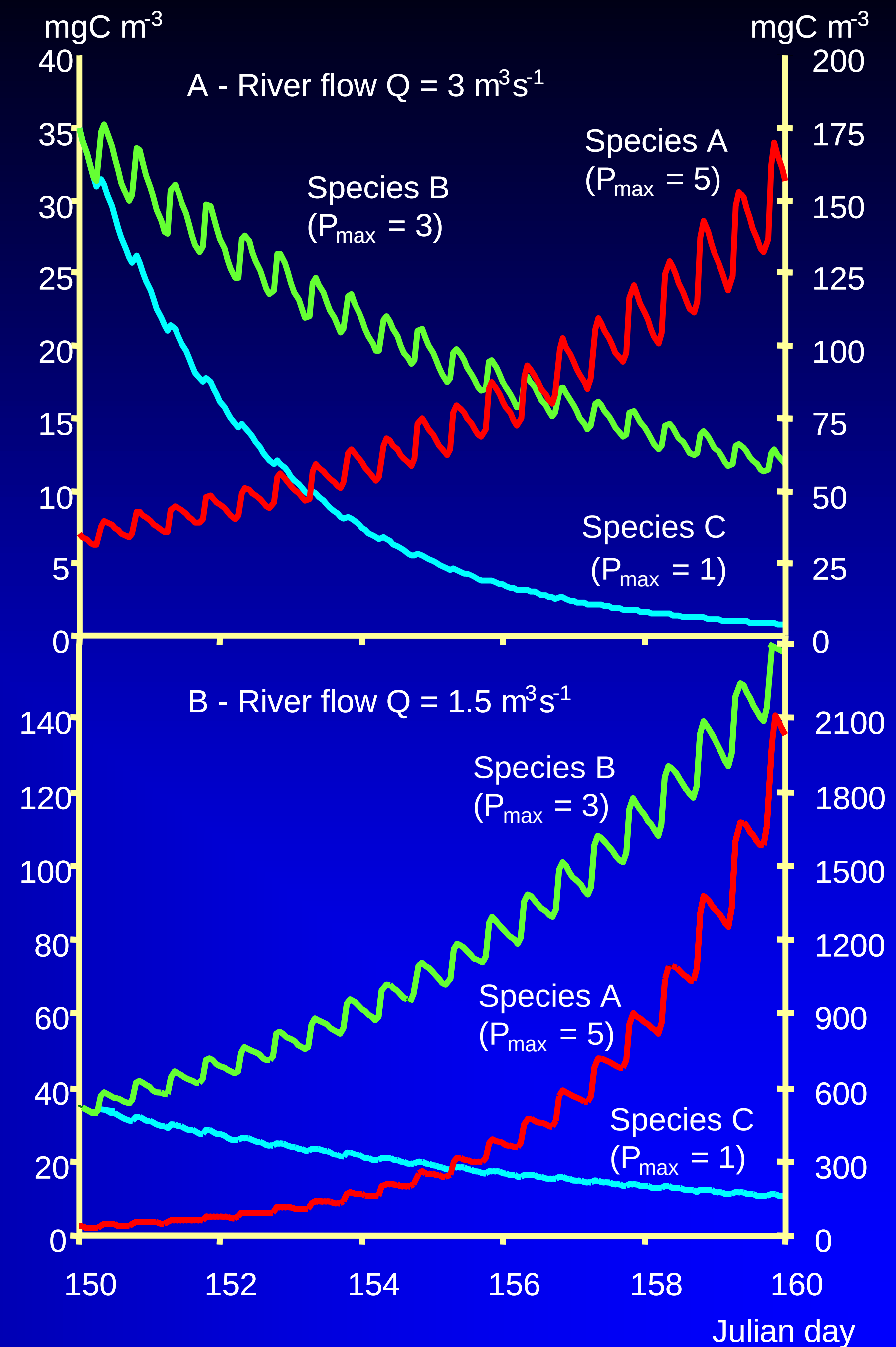


Pmax (d^{-1}) required for phytoplankton to bloom in the estuary

NEEA Low | NEEA Moderate | NEEA High

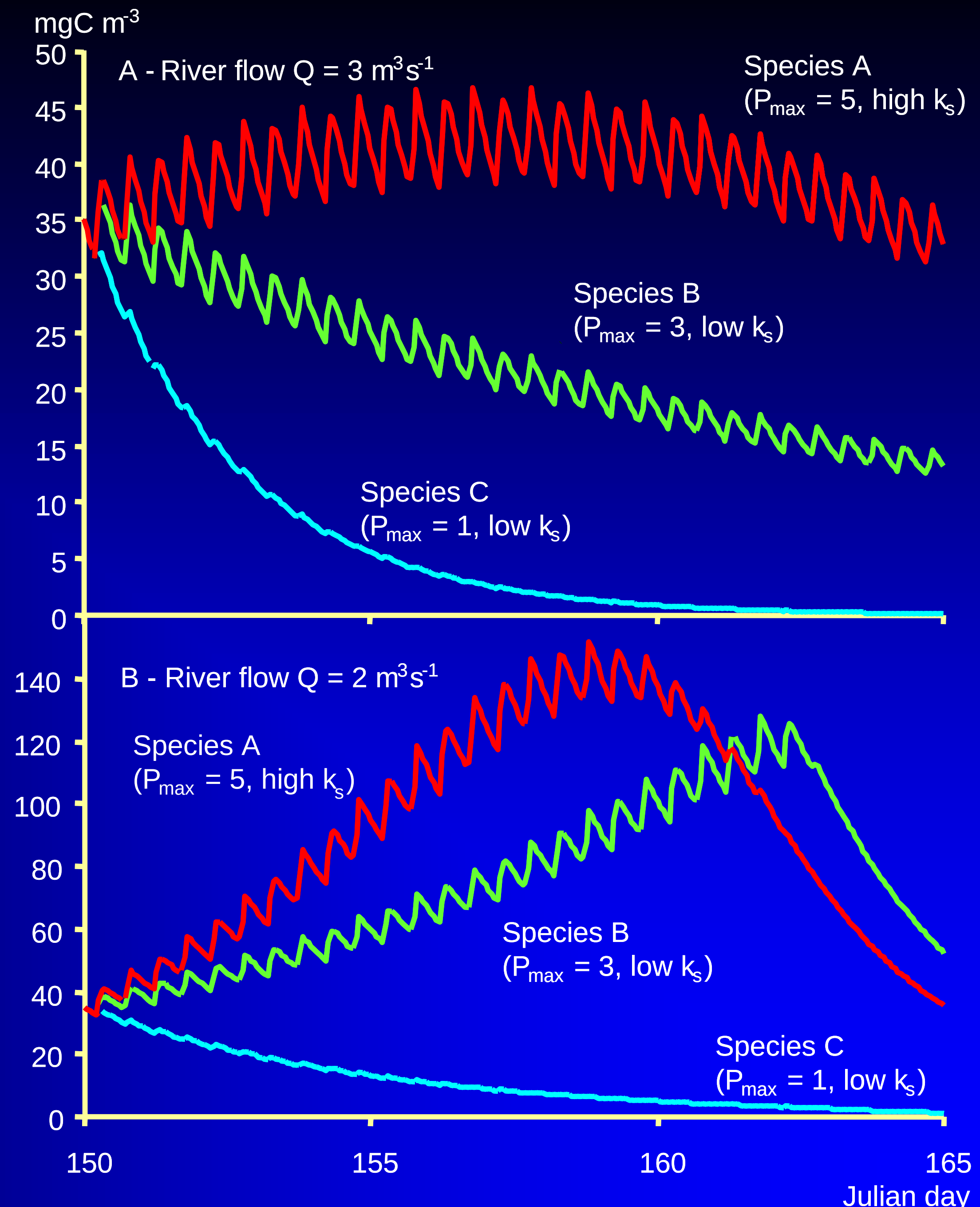
Simulation of growth for three hypothetical phytoplankton species

(species A shown on the right axis)



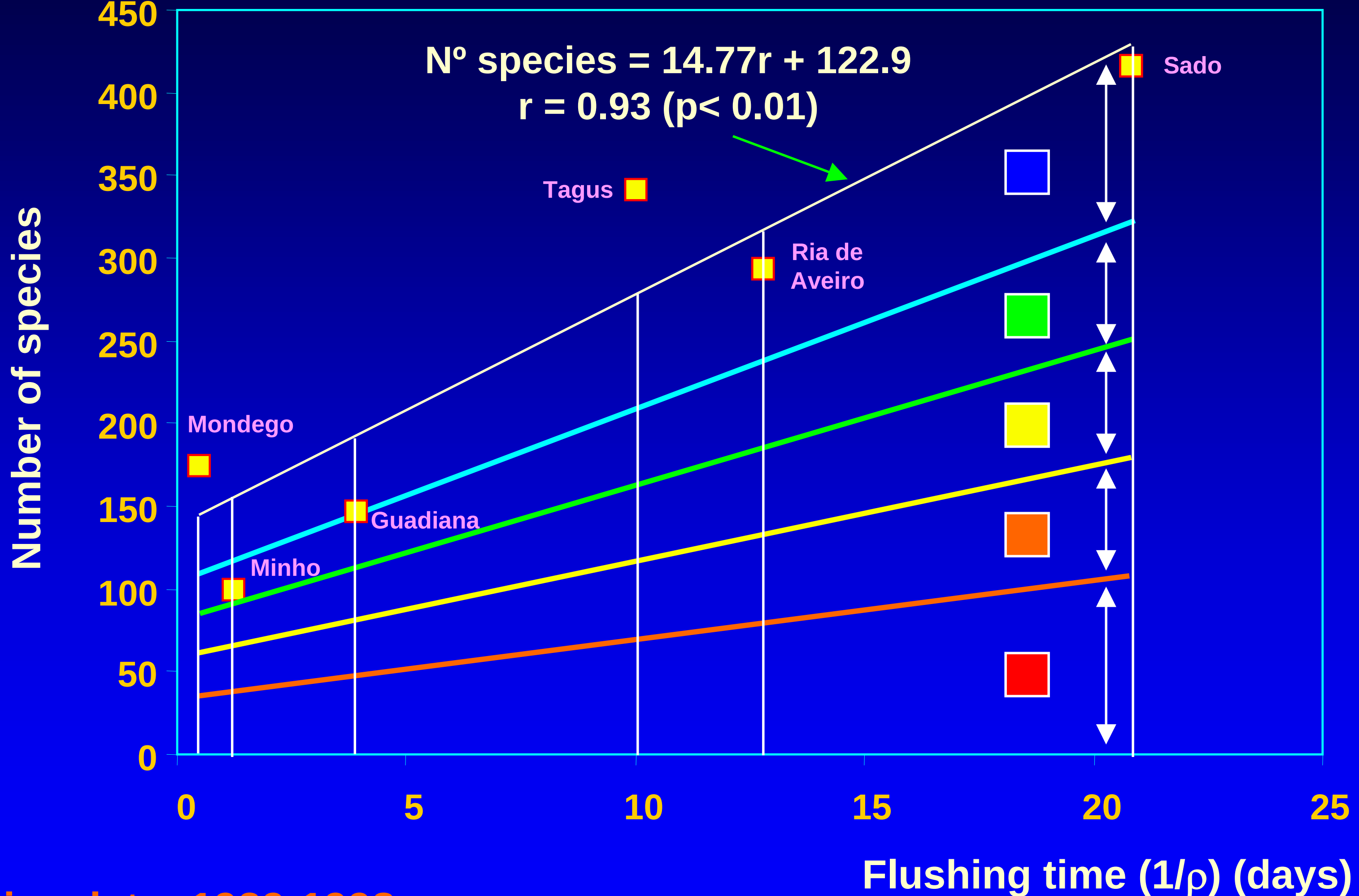
Simulation of nutrient limited growth for three hypothetical phytoplankton species

(species A shown on the right axis)



Residence time and species number

Correlation and ranges



Species data: 1929-1998

Ferreira et al. 2005 Ecol. Model. 187: 513-523

Concluding Remarks

• Residence time influences the diversity of phytoplankton in estuaries

• It also influences the retention of particulate and dissolved pollutants and exerts an influence on the development of eutrophication

• Comparison of five lagoons shows that systems of the same type can develop different symptoms and levels of eutrophication dependent upon residence time

• These results should provide a basis for development of type-specific eutrophication indicators and type-specific management of nutrient related problems