Submarine springs and sewage

as nutrient sources to tropical lagoons with no riverine inputs

Thalassia testudinum in Nichupte Lagoon

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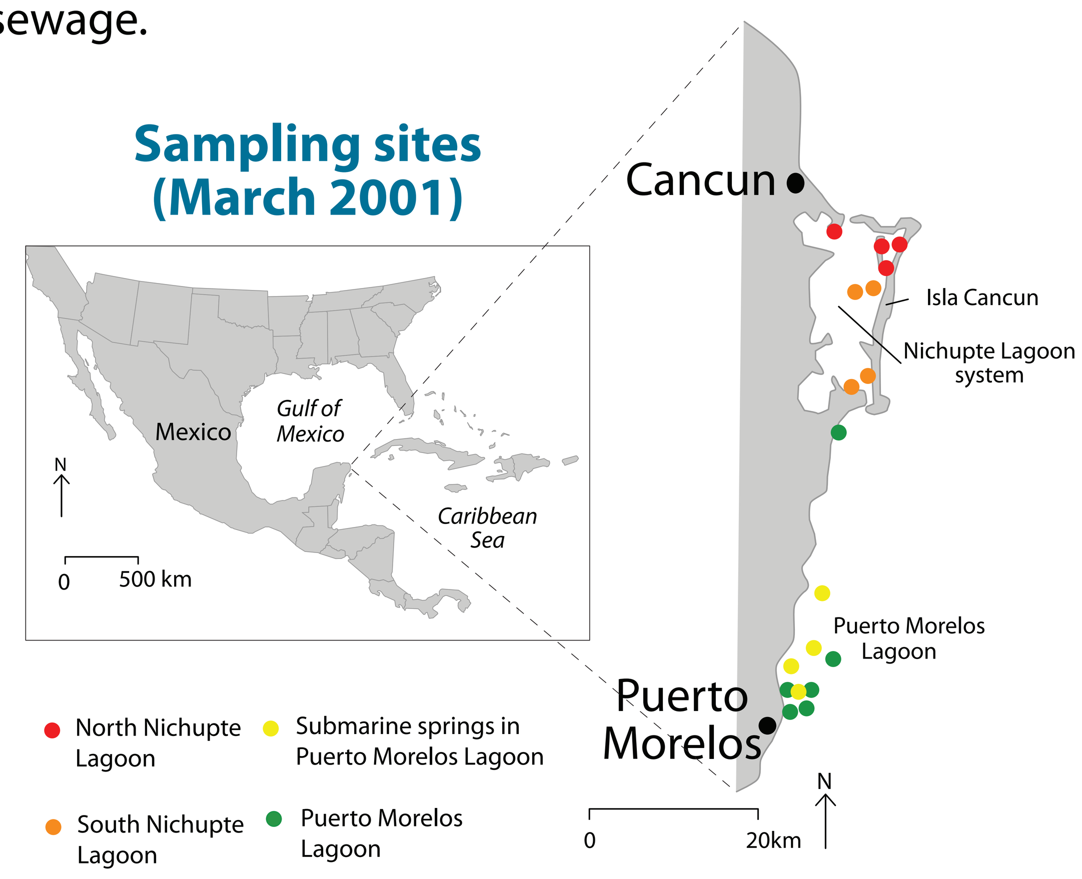
Thalassia testudinum as a bioindicator

Seagrass can be used as a bioindicator of nutrient sources and loads. Because seagrass can persist over years and grows slowly, it provides an integrated picture of nutrient input over weeks/months. Samples of *Thalassia testudinum* were taken from northern and southern sections of Nichupte Lagoon as well as Puerto Morelos Lagoon, during the dry season (March 2002). Within Puerto Morelos Lagoon, four samples were taken adjacent to submarine springs (*ojos de agua*, or 'eyes of water').

New leaf tissue was dried, ground, and analysed for percent carbon, nitrogen and phosphorus. Leaf tissue was also analysed for $\delta^{15}N$, a heavy nitrogen isotope concentrated in sewage.

Sampling sites (March 2001)



Nichupte and Puerto Morelos Lagoons

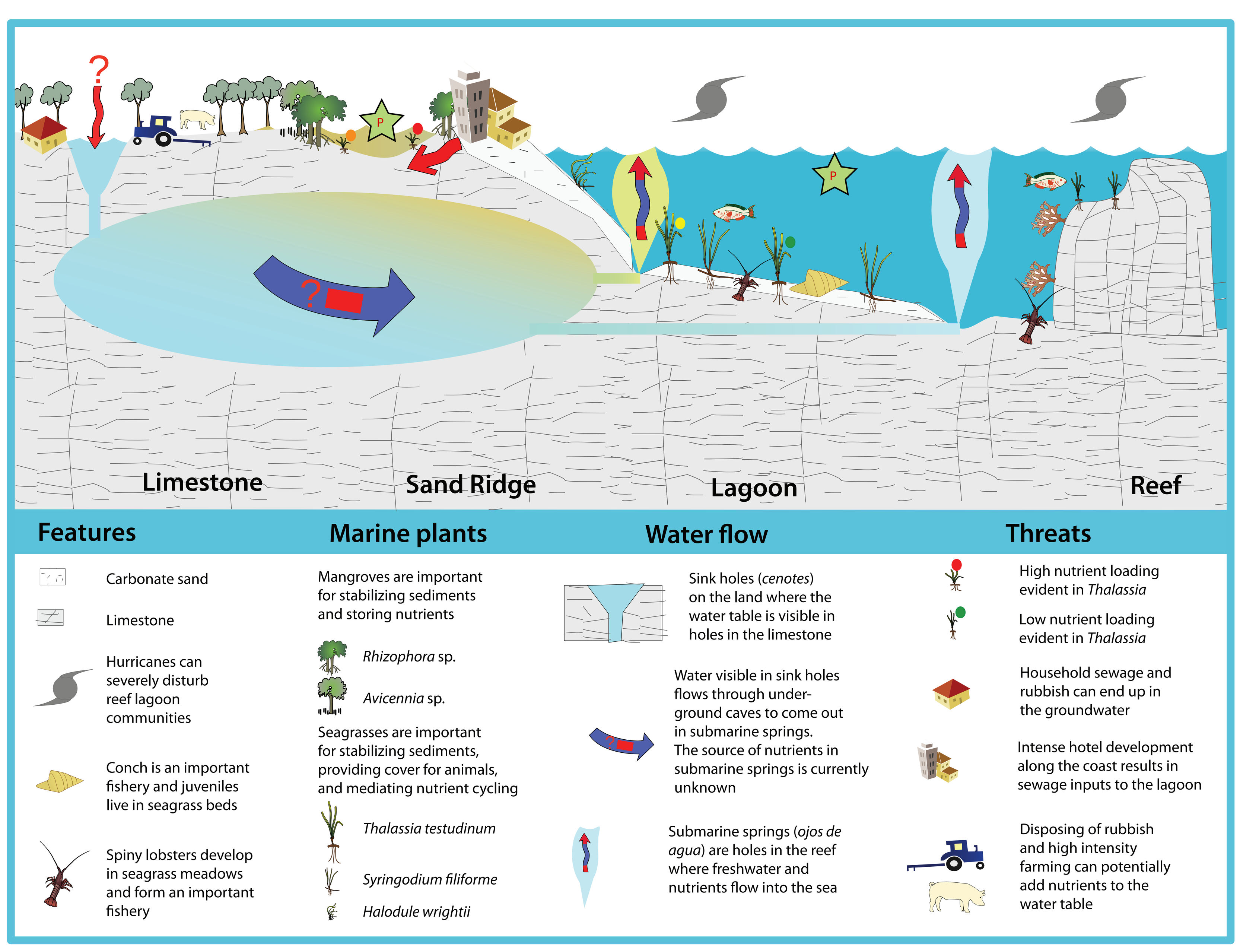
The northeast Yucatan Peninsula is highly permeable limestone, therefore the 1,100–1,300 mm of annual rainfall results in no surface runoff (Merino et al, 1990). The Nichupte Lagoon system has a mean flushing time of 1.9 years, and freshwater inputs to the lagoon are rainfall and groundwater flow (Merino et al, 1990). Currently there are no estimates of sewage nutrient inputs to the lagoon from the city of Cancun or the development on the Isla Cancun 'Hotel Zone' (Smith et al, 1999).

The Puerto Morelos Lagoon has a strong longshore current, and rapidly increasing coastal development (INE, 2000). Freshwater inputs are rainfall and groundwater as well as submarine springs (*ojos de agua*) which are linked to sink holes (*cenotes*) on the Peninsula via submarine caves. These freshwater inputs are potential sources of the nutrients nitrogen (N) and phosphorus (P).

Nutrient characteristics of *Thalassia testudinum* leaf tissue

	%N (SE)	%P (SE)	C:N:P	$\delta^{15}N$ (SE)
Nichupte north	2.93 (0.12)	0.17 (0.01)	541:42:1	9.06 (0.73)
Nichupte south	2.50 (0.18)	0.13 (0.02)	794:50:1	5.49 (0.77)
Submarine springs	2.11 (0.16)	0.18 (0.02)	528:26:1	1.77 (0.92)
Puerto Morelos	1.80 (0.07)	0.13 (0.01)	740:32:1	1.37 (1.01)

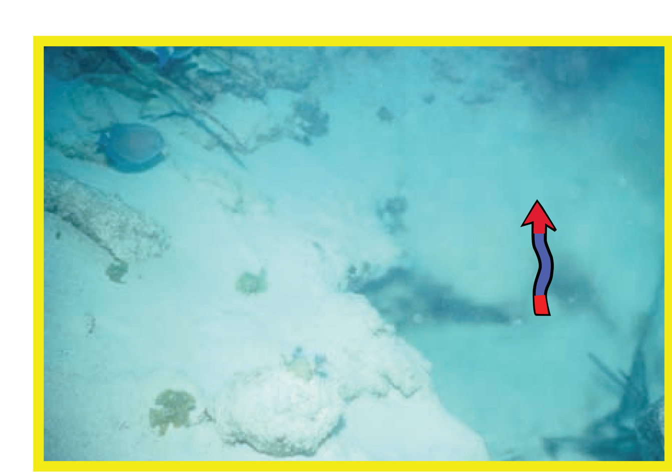
Isla Cancun (Hotel Zone) has undergone 30 years of intense development and is a source of sewage nitrogen to Nichupte Lagoon.



Conceptual diagram of water flow and nutrient sources into Nichupte and Puerto Morelos Lagoons.

Sink holes (*cenotes*) on the Yucatan Peninsula.

Vegetated shorelines along Puerto Morelos Lagoon are being rapidly developed.



Submarine spring (*ojo de agua*)—source of freshwater and nutrients to the Puerto Morelos Lagoon.

Nichupte and Puerto Morelos Lagoons are P-limited

Assessment of nitrogen or phosphorus limitation can be important in assessing potential threats to an ecosystem as well as setting management priorities. An indirect way to assess limitation is to measure tissue nutrient content of a dominant macrophyte such as *Thalassia testudinum*.

	%N (SE)	%P (SE)
All sites	2.28 (0.12)	0.15 (0.01)
Limitation threshold (Duarte, 1990)	1.80	0.20

Limitation can be inferred if percentage of leaf biomass is below 1.8% N or 0.2% P (Duarte, 1990). Overall, sites in Nichupte and Puerto Morelos Lagoons had abundant nitrogen (2.28%) but were phosphorus-limited (0.15%). This agrees with previous studies in Caribbean carbonate sediments (Short, 1990).

Sewage N evident in Nichupte Lagoon and N load is increasing

Nichupte Lagoon had higher total N loading than Puerto Morelos Lagoon, as C:N ratios in *Thalassia* leaf tissue had lower (ie more N) (13:1 and 16:1) in Nichupte than Puerto Morelos (20:1 and 23:1) Lagoon. The N entering Nichupte Lagoon is from sewage, evidenced in the high $\delta^{15}N$ values (9.06 and 5.49) relative to Puerto Morelos Lagoon (1.77 and 1.37). Studies of *Zostera capricornii* in Australia show the same response to known sewage inputs (Udy and Dennison, 1997).

	1991 (van Tussenbroek et al. 1996)	2002 (current study)
%P	0.16 (0.01)	0.15 (0.01)
%N	2.07 (0.10)	2.71 (0.13)
%C	38.05 (0.21)	33.92 (0.64)

N loading in Nichupte Lagoon has increased since 1991. *Thalassia* leaf tissue sampled in 1991 had a mean of 2.07% N which has now increased to a 2002 mean of 2.71%.

Submarine springs are a source of N and P to Puerto Morelos Lagoon

Total loading of N and P are higher adjacent to submarine springs than background levels in Puerto Morelos Lagoon. *Thalassia* leaf % N and % P were both higher near submarine springs (2.11% N and 0.18% P vs. 1.80% N and 0.13% P), providing an integrated measure of nutrient inputs. Even in the dry season, some freshwater flow results in lower salinity adjacent to the submarine springs (33.29 ± 0.29 ‰) than background values for the Puerto Morelos Lagoon (36.24 ± 0.01 ‰).

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