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# Hydrocarbon Concentrations in Sediments and Clams (*Rangia cuneata*) in Laguna de Pom, Mexico

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Laguna de Pom is a coastal lagoon within the Laguna de Términos system in southern Gulf of Mexico. It belongs to the Grijalva-Usumacinta basin, and is located between 18° 33' and 18° 38' north latitude and 92° 01' and 92° 14' west longitude, in the Coastal Plain physiographic Province of the Gulf (Gutiérrez-Estrada *et al.*, 1982). It is ellipsoidal and approximately 10 km long, with a surface area of 5,200 ha and a mean depth of 1.5 m (Fig. 1). Water salinity and temperature ranges are 0 to 13 ‰ and 25° to 31°C, respectively (Peña-Jiménez 1992).

Benthic macrofauna is dominated by bivalves such as the clams *Rangia cuneata, R. flexuosa,* and *Polymesoda carolineana.* These clams provide the basis of an artisanal fishery, which is the main economic activity in the region. The presence of several oil-processing facilities around the lagoon is very conspicous, which together with decreasing yields (Alvarez-Legorreta 1991) has created social conflicts, with the fishermen blaming the mexican state oil company (PEMEX) for the decrease in the clam population. This work aims to determine if the concentration of hydrocarbons in the clams (*R. cuneata*) and sediments of Laguna de Pom are responsible for the declining clam fishery.

## MATERIALS AND METHODS

Clams (*R. cuneata*) were collected at seven sampling stations (Fig. 1) on Laguna de Pom once a year during three years (March 1987,April 1988 and March 1989). Sediments were also taken in the last two years. Clams were collected with a net, and sediments with a 0.1 $m^2$ Van Veen grab. All samples were transported under refrigeration to CINVESTAV in Merida for further analysis.

Hydrocarbon concentrations in sediments were determined according to IOC/UNESCO (1982), and organisms following the method adopted by IOCARIBE (1987). The organisms were pooled at each station. The optimum number of individuals in a pooled sampled was determined by analyzing six groups of 5, 10, 15 and 20 individuals each and looking for the sample size with minimum standard deviation and coefficient of

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variation (Flores and Galindo 1989).

Clams were digested with 6 M NaOH and the non-saponifiable material extracted with dimethyl-ether. The extract was purified and divided into the aliphatic and aromatic fractions by column chromatography with eight grams each of partially deactivated (with 5% water) silica gel/alumina. The fractions were analyzed by capillary gas chromatography with a Varian 3700 gas chromatograph equipped with a flame ionization detector, a J&W Scientific 530 µm *i.d.* x 30 m, 1.5 µm film DB-5 (5 % phenyl-methyl-silicone) column. Chromatographic conditions were: initial temperature 60°C for one minute, then at 6°C/min to 290°C and held for 20 minutes. The aliphatic fraction was quantified with a n-$C_{24}$ standard and the aromatics with chrysene.

Sediments were refluxed for 1.5 hr with 3 % KOH in methanol, and the non-saponifiable material extracted with hexane. The extract was purified and divided into the aliphatic and aromatic fractions by column chromatography with totally activated alumina. Gas chromatographic analysis was the same as for organisms.

## RESULTS AND DISCUSSION

The minimum values for both the standard deviation (6.17) and the coefficient of variation (3.6 %) correspond to pooled samples of 10 individuals (Fig. 2), and it was decided to use this number for all the analysis. The mean total hydrocarbon concentrations for each group were found to be statistically the same according to the Kruskal-Wallis non-parametric analysis of variance ($H_{3,24}$=16.27; P≤0.001).

Hydrocarbon concentrations, in µg/g dry weight, for the marsh clam, *Rangia cuneata*, are summarized in Table 1. It is well known that *R. cuneata* is a good bioaccumulator of hydrocarbons, especially aromatic hydrocarbons (DeLeon *et al.* 1988), although they are not as efficient as the oysters *Crassostrea virginica* under similar conditions (Neff and Anderson 1981).

The annual mean hydrocarbon concentrations, for each fraction analyzed, in *R. cuneata* are presented in Fig. 3. The average (± standard deviation) concentrations of total hydrocarbons ranged from 276 ± 57 µg/g in 1987, to 69 ± 40 µg/g in 1988 and 76 ± 16 µg/g in 1989. The observed differences were found to be highly significant by the non-parametric (Kruskal-Wallis) analysis of variance ($H_{2,20}$=12.25; P≤0.0022). Similar results were found for the other hydrocarbon fractions. The average Carbon Preference Index (CPI), ranged from 0.87 ± 0.04 in 1987 to 3.46 ± 1.81 in 1988, and 0.99 ± 0.88 in 1989. The observed differences are highly significant ($H_{2,20}$=10.83; P≤0.0045). The CPI value for 1988 corresponds to hydrocarbons of biological origin (UNEP/IOC/IAEA 1991).

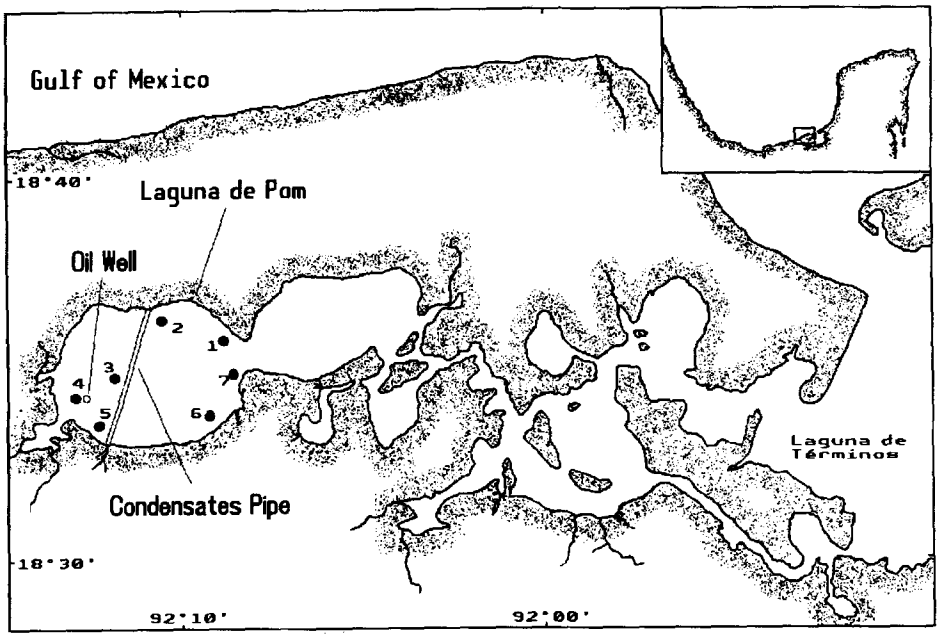


Figure 1. Location of the sampling stations at Laguna de Pom, Mexico.

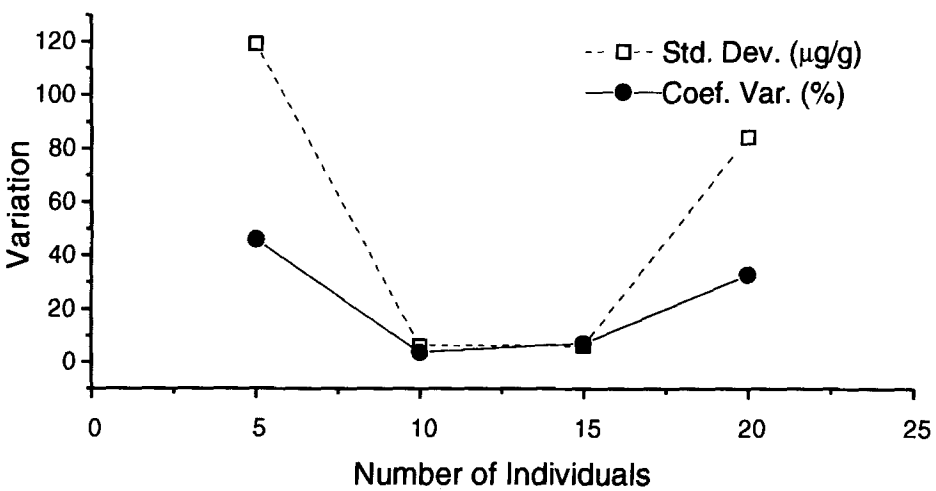


Figure 2. Variability of the total hydrocarbon analysis of the clam *Rangia cuneata* as a function of the number of individuals in a pooled sample. Each data point represents the standard deviation (open squares) or the coefficient of variance (full circles) of six analyses.

**Table 1.** Hydrocarbon concentrations, in µg/g dry weight, in the clam *Rangia cuneata*, from Laguna de Pom, Términos, México.

| Station # | Aliphatics (µg/g) | U C M* (µg/g) | Aromatics (µg/g) | Total (µg/g) |
|---|---|---|---|---|
| **1987** | | | | |
| 1 | 14.20 | 142.69 | 82.01 | 238.90 |
| 2 | 10.98 | 138.50 | 70.97 | 220.45 |
| 3 | 8.92 | 154.83 | 54.12 | 217.87 |
| 4 | 15.93 | 186.21 | 147.14 | 349.28 |
| 5 | 16.14 | 240.86 | 69.31 | 326.31 |
| 6 | 16.91 | 226.20 | 60.08 | 303.19 |
| **1988** | | | | |
| 1 | 0.61 | 9.62 | 15.78 | 26.01 |
| 2 | 2.36 | 40.35 | 33.06 | 75.77 |
| 3 | 3.57 | 44.18 | 96.35 | 144.10 |
| 4 | 4.63 | 82.41 | 8.68 | 95.72 |
| 5 | 1.73 | 33.73 | 4.30 | 39.76 |
| 6 | 1.34 | 32.77 | 12.41 | 46.52 |
| 7 | 1.79 | 25.76 | 29.97 | 57.52 |
| **1989** | | | | |
| 1 | 2.10 | 67.48 | 4.42 | 74.00 |
| 2 | 2.68 | 51.26 | 36.82 | 90.76 |
| 3 | 2.00 | 66.37 | 11.28 | 79.65 |
| 4 | 2.46 | 58.57 | 11.34 | 72.37 |
| 5 | 3.00 | 66.80 | 4.95 | 74.75 |
| 6 | 12.64 | 76.71 | 6.79 | 96.14 |
| 7 | 2.88 | 39.42 | 2.90 | 45.20 |

* Unresolved Complex Mixture

These hydrocarbon values for *R.. cuneata* are higher than the reported mean concentrations, 37 µg/g, for the american oyster (*Crassostrea virginica*) in neighboring Laguna de Términos in 1982 by Vázquez-Botello and Mendelewiecz (1988), but lower than the values of 400 to 12000 µg/g found in oysters in Carmen-Machona, a lagoon system in Tabasco, Mexico (Alvarez *et al.* 1982).

The annual mean hydrocarbon values, for each fraction analyzed, in the recent sediments of Laguna de Pom are presented in Fig. 4. The average (± standard deviation) concentrations of total hydrocarbons ranged from 4.4 ± 2.1 µg/g in 1988 to 69 ± 35 µg/g in 1989. The difference is highly significative ($t$=23.85; P≤0.00038). Similar results were obtained for the other hydrocarbon fractions. This increase in the sediments is associated with the observed increase of hydrocarbons in *R. cuneata*.

The hydrocarbon values in sediments found in this study were lower than the widely accepted limit of 70 µg/g for coastal sediments (Vázquez-Botello *et al.* 1992). Vázquez-Botello and Mendelewicz (1988) reported a mean value of 37 µg/g in 1982, 79 µg/g in 1985, and 48 µg/g in 1986 for Laguna de Términos.

There are strong indications of pollution by hydrocarbons in Laguna de Pom. Peña-Jiménez (1992) found that, for the period 1988-1990, the monthly instantaneous fishing mortality for *R. cuneata* was 0.28, whereas

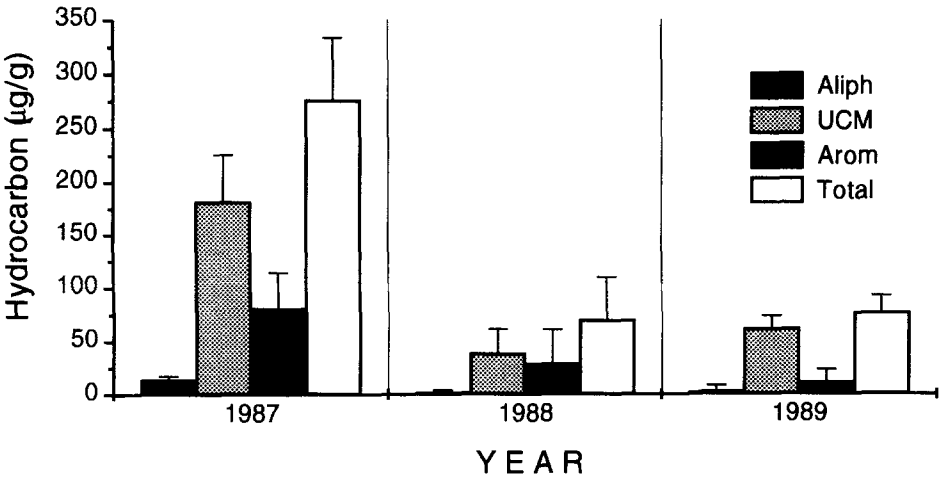


Figure 3. Average annual concentrations of hydrocarbons, in µg/g dry weight, in the clam *Rangia cuneata* in Laguna de Pom, Mexico. The error bars represent one standard deviation.

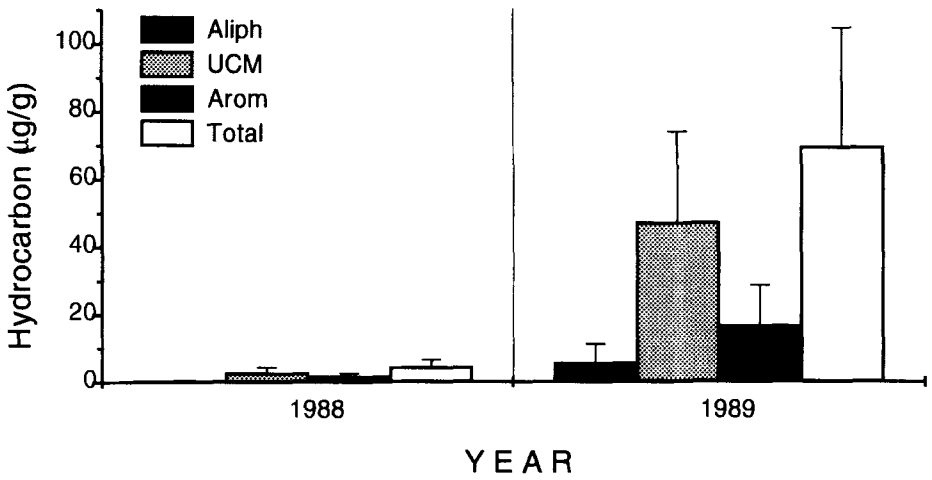


Figure 4. Average annual concentrations of hydrocarbons, in µg/g dry weight, in sediments of Laguna de Pom, Mexico. The error bars represent one standard deviation.

natural mortality was 0.1. That is, fishing accounts for almost three times the natural mortality, which is a strong evidence of overfishing. Baqueiro and Medina (1988) reported a total mortality of 0.4, meaning that less than 1 % of the individuals survive after one year. Fishermen traditionally dived for the clams in Pom, but in the mid seventies the clam net was introduced, almost tripling the annual catch from 607 ton in 1972 to 1784 ton in 1984 (Peña-Jiménez 1992). The annual catch then collapsed to less than 400 ton/year in the 90's.

The present work indicates that overfishing, rather than hydrocarbon pollution, has been the cause of the decline in marsh clam fisheries in Laguna de Pom. However, the high hydrocarbon concentrations found in the clams, and the remarkable increase in hydrocarbons in the sediments in 1989 are cause for alarm with respect to effects on clam fisheries in the future.

**Table 2.** Hydrocarbon concentrations in sediments, in µg/g dry weight, from Laguna de Pom, Términos, México.

| Station # | Aliphatics (µg/g) | UCM* (µg/g) | Aromatics (µg/g) | Total (µg/g) |
|---|---|---|---|---|
| **1988** | | | | |
| 1 | 0.10 | 0.66 | 2.94 | 3.70 |
| 2 | 0.38 | 3.49 | 0.81 | 4.68 |
| 3 | 0.07 | 0.82 | 0.83 | 1.72 |
| 4 | 0.37 | 5.56 | 1.70 | 7.63 |
| 5 | 0.41 | 3.01 | 2.28 | 5.70 |
| 6 | 0.25 | 1.86 | | 2.11 |
| 7 | 0.53 | 3.32 | 1.40 | 5.25 |
| **1989** | | | | |
| 1 | 18.3 | 102.5 | 22.03 | 142.83 |
| 2 | 3.27 | 28.27 | 5.89 | 37.43 |
| 3 | 3.36 | 23.93 | 15.75 | 43.04 |
| 4 | 4.69 | 33.24 | 29.75 | 67.68 |
| 5 | 2.17 | 40.56 | 32.25 | 74.98 |
| 6 | 3.18 | 55.75 | 1.84 | 60.77 |
| 7 | 4.03 | 45.17 | 8.22 | 57.42 |

* Unresolved Complex Mixture

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REFERENCES

Alvarez C, Celis L, Floriuk ME, Mejía, JR (1982) Distribución y Concentración de Hidrocarburos Fósiles en Sedimentos y Organismos del Sistema Lagunar Carmen y Machona, Edo. de Tabasco, México. Rep. de Inv. No. 27, Div. de Ciencias Biol. y de la Salud, UAM.

Alvarez-Legorreta T (1991) Evaluación de la Contaminación por Hidrocarburos en la Población de la Almeja *Rangia cuneata* en la Laguna de Pom, Campeche. Tesis de Maestría en Biología Marina, Centro de Investigación y de Estudios Avanzados del IPN, Unidad Mérida.

Baqueiro CE, Medina M (1988) Evaluación del Recurso Almejero en las Lagunas del Pom y Atasta. Reporte Técnico del Centro Regional de Investigación Pesquera de Campeche, Secretaría de Pesca. Campeche, México.

DeLeon IR, Ferrario JB, Byrne CJ (1988) Bioaccumulation of Polynuclear Aromatic Hydrocarbons by the Clam, *Rangia cuneata*, in the Vecinity of a Cresote Spill. Bull Environ Contam Toxicol 41: 872-879.

Flores BBP, Galindo MS (1989) DDT in *Mytilus edulis*: Statistical Considerations and Inherent Variability. Mar Pollut Bull 20: 496-499.

Gutiérrez-Estrada M, Malpica-Cruz VM, Martínez-Reyes J (1982) Geomorfología y Sedimentos Recientes del Sistema Lagunar Atasta-Pom, Campeche, México. An. Inst. Cienc. Mar y Limnol. Univ Nal Auton México 9: 89-100.

IOCARIBE (1987) Manual CARIPOL para el Análisis de Hidrocarburos del Petróleo en Sedimentos y Organismos Marinos. Mimeo. Cartagena, Colombia.

IOC/UNESCO (1982) Determination of Petroleum Hydrocarbons in Sediments. Manuals and Guides No. 11. Paris.

Neff JM, Anderson JW (1981) Response of Marine Animals to Petroleum and Specific Petroleum Hydrocarbons. Applied Science Publishers, ltd.

UNEP/IOC/IAEA (1991) Determination of Petroleum Hydrocarbons in Sediments. Reference Methods for Marine Pollution Studies No. 20.

Vazquez-Botello A, Mendelewicz M (1988) Pollution and Pollutants in the Terminos Lagoon Region. In: Yáñez-Arancibia, A., Day Jr., J.W. (Eds) Ecology of Coastal Ecosystems in the Southern Gulf of Mexico: The Terminos Lagoon Region. Universidad Nacional Autónoma de México y Organización de los Estados Americanos, Mexico.

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