rence of *Circulina meyeriana* Klaus, *Patinasporites densus* Leschik, and *Paracirculina quadruplicis* Scheuring with the uppermost range of the bisaccate species *Alisporities minutisaccus* Clarke, *Minutosaccus potoniei* Mädler, and *Protodiploxypinus gracilis* Scheuring (*23*) restricts the geologic age of the Moroccan material to from middle to early late Carnian and defines the *Minutosaccus-Patinasporites* Concurrent Range Zone (*18*). This age and its suggested radiometric equivalent of 205 million years for the Carnian (*7*) are congruent with a radiometric date of 196 ± 20 million years for the basalts overlying the Oukaimeden Sandstone.

The presence of the *Minutosaccus-Patinasporites* Concurrent Range Zone in European localities is indicated in the English Arden Sandstone (by concurrence of *Circulina meyeriana* Klaus, *Patinasporites densus* Leschik, and *Protodiploxypinus gracilis* Scheuring) (*13*), in the Swiss upper Gipskeuper and lower Schilfsandstein beds (by concurrence of *Paracirculina quadruplicis* Scheuring, *Patinasporites densus* Leschik, and *Protodiploxypinus gracilis* Scheuring) (*10*), and in several North Sea localities (by the range overlap of *Circulina meyeriana* Klaus and *Minutosaccus potoniei* Mädler) (*8*). Its presence in the North American Dockum Group of Texas is also indicated, by the concurrence of *Minutosaccus potoniei* Mädler (*16*) and *Patinasporites densus* Leschik (*14*).

Thus, the pollen data indicate that the upper part of the Triassic section in Morocco is a time-stratigraphic equivalent of the European upper Gipskeuper and Schilfsandstein Formations of the Alpine Forelands (*9, 10*), the type Carnian section of Austria (*11*), and the Arden Sandstone and Keuper Marls of England (*12, 13*). Because of the common occurrence of age-diagnostic palynomorphs, it is also a time-stratigraphic equivalent of lower portions of the Newark Group in the Taylorsville and Richmond basins of Virginia and the Deep River basin in North Carolina, as well as the Dockum Group of Texas and New Mexico, and the Chinle Formation of Arizona and New Mexico (*14*). Preliminary data suggest that it is also of comparable age to the lower and middle New Oxford Formation, Gettysburg basin, Pennsylvania (*15*), and is older than most Newark Group sediments in New Jersey and New England, which are of Rhaetic to Liassic age (*15, 21*).

Because the Triassic beds are syntectonic and were laid down in zones of active rifting (*1*), these data demonstrate that rifting began no later than middle Carnian time. It is significant that the oldest dated Triassic rocks in the widely separated basins along the margins of the North Atlantic between Africa and North America were deposited at a time of active rifting during the Carnian stage. Clearly, an important large-scale tectonic event occurred during Carnian time that is related to the subsequent breakup of Pangea and the opening of the Protoatlantic basin.

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17. A. F. Mattis, thesis, Rutgers University (1975). Mattis supplied us with six samples collected during the summer of 1973, of which only two proved to be productive. Sample 5 carries the diverse palynoflorule reported on here, which is of low frequency and required study of 25 strew slides in order to pick and identify the number of specimens recorded on the histogram. Sample 6 yielded only a few poorly preserved bisaccate grains. Both of these samples come from a gray-green siltstone lens stratigraphically about 200 m below the base of a basalt sequence, which has been eroded from the summit of the mountain, but is present elsewhere and yields radiometric dates of 196 ± 15 million years. We collected 56 additional samples for palynological analysis from Triassic sections exposed in the High Atlas, Middle Atlas, and Meseta of Morocco during the summer of 1974. The units sampled were thin gray shales and siltstones in predominantly red-bed sequences; however only the original Mattis locality yielded productive material.
18. The localities cited in Fig. 2 include the following stratigraphic units: English and German standard sections and many subsurface sections in the North Sea area (*8*); upper Gipskeuper and Schilfsandstein formations (subsurface samples) (*9*); entire Swiss Keuper excluding Rhaetic, exposed in tunnel (*10*); Austrian type Carnian (*Halobia, Cardita* Lunzer beds), Norian, and Rhaetic (*11*); entire English Triassic correlated with Alpine subdivisions (*13*); North American Newark Group, Dockum Group, and Chinle Formation (*14*); North American Newark Group in Connecticut and New Jersey (*15*); Moroccan Ourika Valley Triassic section, Oukaimeden Sandstone (*17*); Dockum Group, Texas (*16*); Lettenkohle, France (*19*); entire type Germanic Triassic (*20*); lower portion of the Brunswick Formation exposed near Newark and Milford, N.J. (*21*); Triassic strata drilled in the Algerian and Tunisian Sahara region (*22*).
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23. *Alisporites minutisaccus* Fisher and *Protodiploxypinus gracilis* Scheuring are considered to be possible junior synonyms of *Minutosaccus potoniei* Mädler, which is the name used for recording these forms in Fig. 1.
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Field Evaluation of Benzopyrene Hydroxylase Induction as a Monitor for Marine Petroleum Pollution

Abstract. *Fish from petroleum-contaminated sites in the marine environment have elevated levels of benzopyrene hydroxylase activity in liver and gill tissue. This sublethal response appears to be a practical biological monitor for marine petroleum pollution.*

We recently demonstrated that benzopyrene hydroxylase (E.C. 1.14.14.2) is induced in fish by exposure to petroleum (*1*). Besides establishing a directly measurable sublethal response, we speculated on the potential of enzyme induction as a biological monitor for petroleum hydrocarbons in the sea. A field trial has now been carried out.

The cunner (*Tautogolabrus adspersus* Walbaum, 1792) was selected as a suitable species for the trial (*2*). This nonmigrant fish stays near its home territory throughout the year (*3*) and is plentiful and easy to trap. Its range extends from Newfoundland to Chesapeake Bay (*4*). Cunners were collected at four sites (Fig. 1). Livers and gills were immediately removed from the fish and frozen in Dry Ice for transport to the laboratory. Extracts were prepared and benzopyrene hydroxylase activity was measured as previously described (*1*). Site

1 was within 200 m of the outfall of a modern oil refinery, whose effluents satisfy current Canadian government guidelines. Site 2 was a small-craft harbor (*5*) where traces of oil were occasionally visible on the water surface. As far as we could determine, petroleum contamination of sites 3 and 4 was minimal or nonexistent; these are considered "clean" for the purpose of this report.

Liver hydroxylase activity was significantly higher in fish from petroleum-contaminated sites (Table 1). Hydroxylase activity was generally low in gill tissue, but was readily detectable in all fish from site 1; in contrast, hydroxylase activity was indistinguishable from zero in fish from control site 3. We have found similar low or nondetectable hydroxylase activities in gill tissue of other marine fish that have varying levels of liver enzyme activities (*6*).

Table 1. Benzopyrene hydroxylase specific activity in liver and gills of cunner. Sites are described in the text. Specific activity refers to arbitrary units of fluorescence of alkali-soluble reaction product (3-hydroxybenzo[*a*]pyrene) per milligram of protein (*1*); values are means ± standard deviations. Average fish weights did not vary among sites; fish were not sexed. Sites 1 and 2 differed significantly from controls (*t*-test; $P < .005$ for liver activity between sites 1 and 4; $P < .025$ for gill activity between sites 1 and 3). There was no significant difference between control sites 3 and 4.

Site	*N*	Specific activity (units per milligram of protein)	
		Liver	Gill
1 (Refinery)	10	53.2 ± 25.2	0.27 ± 0.23
2 (Harbor)	8	46.6 ± 6.7	
3 (Control)	10	16.0 ± 7.6	0.0
4 (Control)	9	19.9 ± 6.6	

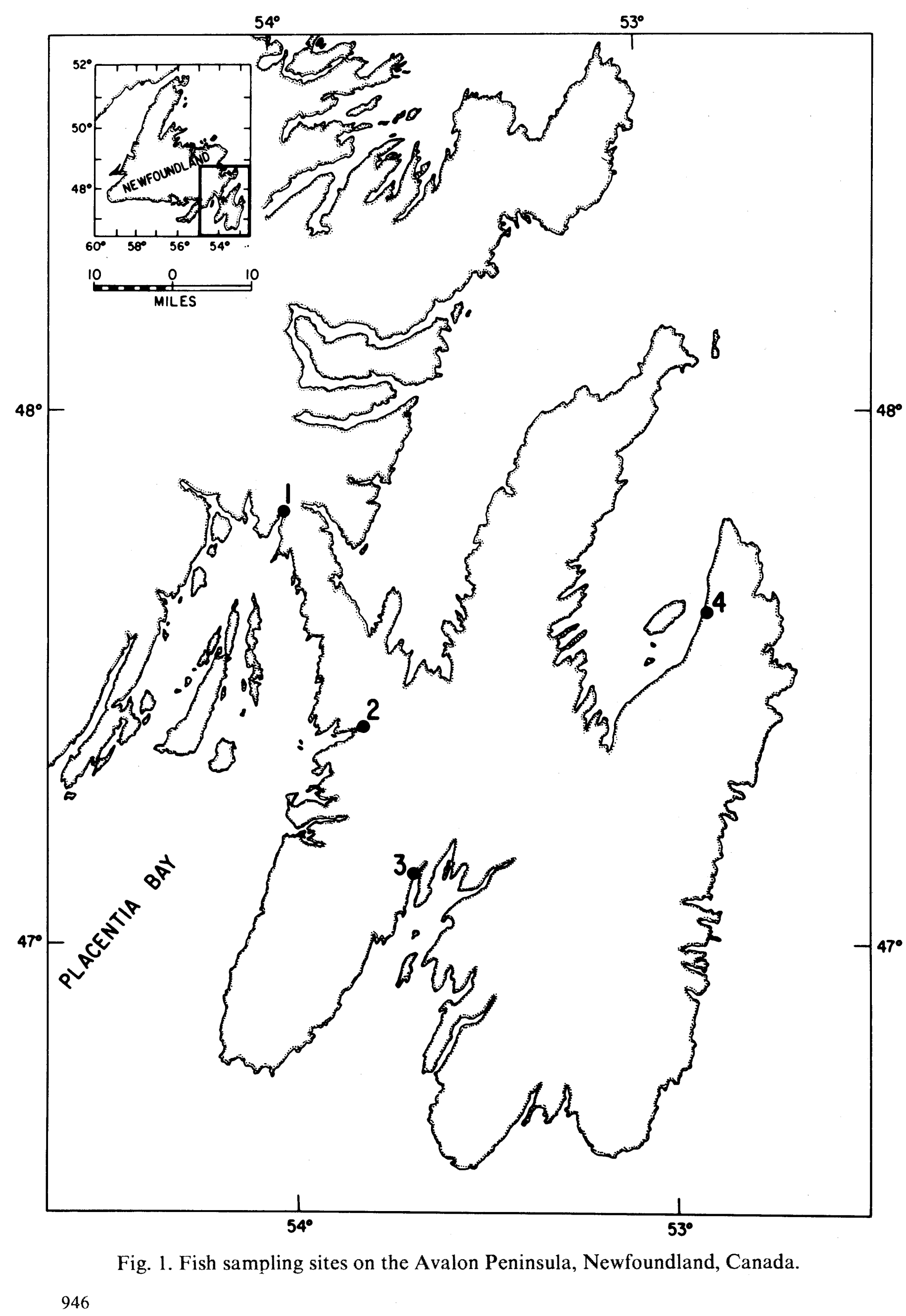

Fig. 1. Fish sampling sites on the Avalon Peninsula, Newfoundland, Canada.

We suggest that petroleum hydrocarbons were acting as inducers at sites 1 and 2. In view of the difficulties encountered in monitoring petroleum compounds in the marine water column (*7*), benzopyrene hydroxylase induction may be considered a monitor for petroleum contamination to complement direct chemical measurement. Induction also represents a sublethal response that can be rapidly and easily monitored from such point sources of petroleum as oil refineries, tanker operations, and offshore drilling rigs, and thus may be of interest to environmental agencies (*8*). The lethal effects of petroleum have been documented for many aquatic organisms, but recommendations on the permissible levels of petroleum in the marine environment should also involve knowledge of specific effects at sublethal concentrations. We believe that this field study supports our earlier thesis that benzopyrene hydroxylase measurement has practical application in the study of the effects of petroleum hydrocarbon pollutants in the sea.

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4. A. H. Leim and W. B. Scott, *Fisheries of the Atlantic Coast of Canada* (Queen's Printer, Ottawa, 1966), p. 269.
5. When fish were collected, four craft (4- to 5-foot beam) were using the harbor.
6. Drugs and other chemicals known to be benzopyrene hydroxylase inducers in mammals and birds may also be effective in fish, but can often be ruled out as marine pollutants because of effective dilution and decomposition. It is not known if more stable compounds such as pesticides, continually entering coastal waters, have contributed to "basal" enzyme levels in marine fish. The possibility of interference may be real near such point sources as agricultural runoff or forest spraying. We have screened representative pesticides (fenitrothion, carbaryl, and DDT) and a polychlorinated biphenyl (Aroclor 1016) for the capacity to induce benzopyrene hydroxylase in rainbow trout. Even among the survivors of poisoning to 50 percent kill by these agents, no induction has been noted.
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