Hydrocarbons in Marine Organisms and Sediments off West Greenland

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PREFACE

Canada shares her northern waters with several neighbors. There is a common concern in this community of interests that undue haste in development and in exploiting natural resources may adversely affect vital renewable resources such as fisheries. Many of these fishery resources are shared geographically between Canada and Greenland. The Halifax Laboratory is therefore pleased to sponsor this record of research executed by our Danish colleagues as a contribution to the successful future development of fishery and other resources of mutual interest.

E. Graham Bligh

ABSTRACT

Johansen, Poul, Vibeke B. Jensen, and Arne Büchert. 1977. Hydrocarbons in Marine Organisms and Sediments off West Greenland. (Edited by R. G. Ackman). Fish. Mar. Serv. Tech. Rep. 729: 33 p.

Examination of the hydrocarbons in invertebrates, fish, and sediments from the West Greenland marine area has been performed by means of gas chromatography and gas chromatography/mass spectrometry.

As the area off West Greenland must be considered almost unpolluted until now, we have taken the opportunity to establish the natural levels of biogenic hydrocarbons.

Isolation and identification of the hydrocarbons showed that pristane (2,6,10,14-tetramethylpentadecane) and/or squalene (a non-cyclic dihydrotriterpene, $C_{30}H_{50}$) were the main components in the analytical material. Three other hydrocarbons were isolated in smaller quantities, one of which was identified as a *n*-alkene with the formula $C_{19}H_{38}$. The position of the double bond is probably between C_4 and C_5. Another hydrocarbon had the formula $C_{20}H_{38}$ and a branched and unsaturated structure. Presumably, the component could be phytadiene (2,6,10,14-tetramethylhexadecadiene), which has previously been found in zooplankton. The last component isolated had a branched and highly unsaturated structure, which probably caused an unstable character as in the case with squalene. The incidence and the level of biogenic hydrocarbons are discussed.

RÉSUMÉ

Johansen, Poul, Vibeke B. Jensen and Arne Büchert. 1977. Hydrocarbons in Marine Organisms and Sediments off West Greenland. (Edited by R. G. Ackman). Fish. Mar. Serv. Tech. Rep. 729: 33 p.

L'analyse chimique des hydrocarbures présents dans les invertébrés, les poissons et les sédiments marins de l'Ouest du Groenland s'est faite par chromatographie en phase gazeuse et par spectrométrie de masse couplée à la chromatographie en phase gazeuse.

Comme, jusqu'à ce jour, cette partie du globe peut encore être considérée comme presque non polluée, il a été possible de déterminer les concentrations naturelles des hydrocarbures synthétisés par la matière vivante.

Après avoir isolé et identifié les hydrocarbures contenus dans les échantillons prélevés, nous avons établi que les deux composés suivants étaient les plus répandus: le pristane (tétraméthyl-2,6,10,14 pentadécane) et le squalène (un dihydrotriterpène acyclique, $C_{30}H_{50}$). Trois autres hydrocarbures ont été isolés en petites quantités. L'un deux était un alcène linéaire de formule $C_{19}H_{38}$ avec la double liaison probablement située entre les carbones 4 et 5. L'autre ($C_{20}H_{38}$) présentait une structure ramifiée et non saturée; on présume qu'il s'agit du phytadiène (tétraméthyl-2,6,10,14 hexadécadiène) dont la présence a déjà été décelée dans le zooplancton. Le dernier possède une structure ramifiée et fortement insaturée, ce qui explique sans doute son caractère instable apparenté à celui du squalène. Le rapport traite des concentrations d'hydrocarbures chez les organismes vivants et de leur incidence sur ceux-ci.

INTRODUCTION

The occurrence of hydrocarbons in marine organisms and sediments off West Greenland is being investigated in order to obtain baseline data for the area. The investigations on the background were started in 1975, the same year that petroleum exploration licences were issued for an area between 63° and 68° N lat. (Fig. 1).

The studies were initiated principally because of the extreme vulnerability of the arctic environment to petroleum pollution. This is a result of the effect of the low temperature on both the physical nature of petroleum and on biological processes. For example biodegradation is known to be a slow-acting process in the arctic compared to biodegradation in temperate areas. Also more petroleum may be dissolved/dispersed at higher than at lower temperatures, and evaporation is less at lower than at higher temperatures. Further, arctic marine organisms grow slower than the same species in more southern latitudes. Finally the biological production, especially the plankton production, is concentrated in a short period of the year, compared to temperate areas. All facts mentioned here indicate that pollution by petroleum will affect the marine environment more severely in arctic than in temperate areas, as more petroleum will remain in the environment for longer periods, and as the biomass will regenerate more slowly, once affected.

In addition to the concern expressed above, which is general for the arctic, a specific concern exists for the concession area off West Greenland, namely that an important commercial fishery takes place within the concession area. A large oil spill would probably affect the fishery. Finally the concession area hosts important populations of sea birds (guillemots and others), which may be affected by a spill.

The general and the specific concern expressed here points to the need for thorough control of the effect of oil spills, and the study reported here aims at obtaining information on existing hydrocarbon concentrations and to develop methods that will delineate the impact on the environment of a spill, should it occur.

MATERIALS AND METHODS

SAMPLING AND PRESERVATION

Samples of invertebrates, fish and sediments were obtained during a cruise with the Danish research vessel DANA in the period 28 July to 13 August 1975. Sampling was done over a considerable depth range, from approx. 20 m to approx. 600 m, and in a relatively large area (Fig. 2). Various gear was used: dredges, grabs, trawls, plankton-nets, and handlines.

Contamination of samples by fuel oil, lubricants etc. on board a ship involves considerable difficulties. Attempts were made to avoid contamination, for example by solvent-rinsing equipment such as grabs and knives before use, and by shutting off the discharge of water from the engine room (cooling water and bilge water) during sampling, as this discharge obviously was the source of an oil film spreading around the vessel.

Most samples were stored in glass jars, and aluminium foil was put between the edge of the jar and the plastic lid, to avoid contamination from the lid. Some samples, i.e. whole fish, were stored in plastic bags. Contamination was not expected to arise from the bags, since the tissue actually used for analysis had not been in contact with the bag. Samples were frozen within few hours of collection and kept frozen until analyses were made.

LIPID ANALYSIS

Total lipid of the samples was determined by Soxhlet extraction overnight of dried material with pentane. The pentane phase was dried (Na_2SO_4), evaporated to dryness, and the residue was estimated by weighing.

DRY-WEIGHT ANALYSIS

Dry-weight of the samples was determined by drying the material at 105°C to constant weight.

HYDROCARBON ANALYSIS

In general the procedures of Farrington and Tripp (1975) and Farrington and Mederias (1975) were applied for extraction and isolation of the C_{14}-C_{36} hydrocarbons. All solvents were distilled before use. Solid reagents were pre-extracted with distilled solvents, and all glassware was solvent-rinsed. Blanks were routinely run through the entire procedure to check for contamination from reagents or handling.

Clean-up Procedure

Approximately 20 g (including liquids) of biological material (liver tissue only 2.5 g) or 50 g of a sediment sample was used for analysis. After homogenization in a blender, the sample was refluxed for two hours with 80% methanol containing 67 g KOH/ℓ. There must be at least 25% of water in the saponification mixture. After cooling, the mixture was filtered with suction, if solid materials were found (e.g. sediments and shells). The residue was washed on the filter with a small volume of pentane. The saponification mixture, if filtration was unnecessary, or the whole filtrate, was extracted three times with pentane. The extract was evaporated on a rotary evaporator until reduced to 1-2 ml. Column chromatography of the extract was performed by using a column of equal amounts of alumina (Al_2O_3) packed on top of silica (SiO_2). The Al_2O_3 and SiO_2 were activated overnight at 250°C and 150°C respectively, and then both were de-activated with 5% of water. The ratio of column material to non-saponifiable lipid had to be 100:1 or more. The extract was eluted with 1.5 column volumes (from 15 to 75 ml) of pentane + benzene (80 + 20). The eluate was

evaporated nearly to dryness on a rotary evaporator and then redissolved in a small volume of CCl_4. A few microlitres were injected into the gas chromatographic column.

Gas Chromatography (GC)

The equipment used was a Hewlett-Packard Model 5830 A with a flame ionization detector (FID). The oven was programmed from 85°C to 275°C at 4°C/min. One glass column of 1.8 m in length packed with 3% OV-1 was used. Nitrogen (N_2) was used as carrier-gas at a flow rate of about 30 ml/min.

A standard n-alkane mixture of known concentration was used to measure detector response per unit weight of alkane. C_{22} was used as an internal standard.

GAS CHROMATOGRAPHY/MASS SPECTROMETRY (GC/MS)

The GC/MS analyses were made by using glass columns packed with either 3% Dexsil 300 or 3% OV-17. The oven was programmed from 150°C to 320°C at 10°C or 15°C/min. The column was coupled to a Varian MAT 311 mass spectrometer through a Biemann-Watson separator kept at 250°C. With the ion source temperature at 200°C, mass spectra of the eluted components were recorded at an accelerating voltage of 3 KV and an electron energy of 70eV.

RESULTS

Results from the analytical estimation of the hydrocarbons, lipid analyses and dry weight analyses are presented in Tables 1-16. "Position" in the tables refers to the number position shown in Fig. 2. The hydrocarbons estimated in each case are indicated by the retention time relative to C_{22}, obtained on an OV-1 column. The mean values and the sum (total) of the identifiable hydrocarbons are calculated and mentioned in the tables. A list of the relative retention times for n-alkane standards (C_{14}-C_{36}, C_{33} is lacking) are given in Table 17. The figures are mean values of several determinations. Normally the retention times alone were used to determine unknown hydrocarbons. In a few cases, hydrocarbons were identified by gas chromatography/mass spectrometry (see below).

At the beginning of the analytical work attention was focussed on the range of concentration of hydrocarbons higher than 0.05 µg/g in samples of low lipid content and higher than 0.5 µg/g in samples of high lipid content. Later an attempt was made to reduce the detection limits by a factor of five. This has been taken into account in the tables under "detection limit".

Squalene is very unstable and the quantitative estimations are therefore doubtful because of degradation of the hydrocarbon during the analytical procedure. Presumably, this is also the case for other hydrocarbons of an unsaturated structure. This fact reduces the accuracy of the analytical results of some of the hydrocarbons. Also analytical estimations of concentrations near the detection limits are subject to a relatively high degree of uncertainty. Several of the unidentified hydrocarbons found in the sample material are probably the same components (i.e., have the same or nearly the same retention time). Through gas chromatography it is only possible to distinguish between hydrocarbons that have a difference in the relative retention time of more than 0.03.

GAS CHROMATOGRAPHY/MASS SPECTROMETRY ANALYSIS

A list of results from the GC/MS analysis is given in Table 18. Isolation and identification of the hydrocarbons showed that pristane (2, 6, 10,14-tetramethylpentadecane) and/or squalene (a non-cyclic dihydrotriterpene, $C_{30}H_{50}$) were the major components in the analytical material. Identification of pristane and squalene was based on spectra of standard solutions. Therefore, the detection of those two hydrocarbons is unequivocal.

Three more hydrocarbons were isolated in small quantities. One of those hydrocarbons was found in redfish (*Sebastes marinus*). Fig. 3 shows the mass spectrum of the component (retention time relative to C_{22}:0.76). The peak m/e = 278 a.m.w. (probably the molecular peak) gives the molecular weight corresponding to the formula $C_{20}H_{38}$. The pattern of the spectrum indicates that the component is a branched unsaturated hydrocarbon, presumably with two double bonds instead of one triple bond. The spectrum suggests the following formula:

$$C_7H_{11} - C_2H_4 - C_{11}H_{23}$$

The C_7H_{11}-part contains the two double bonds and is possibly of a branched structure. The C_2H_4-part may have a methyl-substitute, and the $C_{11}H_{23}$ -part has at least two branching points.

The peaks of the mass spectrum at m/e = 179 and 193 a.m.w. indicate the following possibilities for the $C_{11}H_{23}$-part:

The isolated components might be phytadiene (2, 6, 10, 14-tetramethyl hexadecadiene), which has previously been detected in zooplankton by Blumer et al. (1969).

Fig. 4 shows the mass spectrum of one of the components (retention time relative to C_{22}: 0.77) isolated from capelin (*Mallotus villosus*). The peak m/e = 266 a.m.w. (probably the molecular peak) indicates the formula $C_{19}H_{38}$. The pattern of the spectrum indicates that the component is an alkene without branching. The position of the double bond is difficult to estimate, but the peak m/e = 238 a.m.w. may be explained by a double bond between C_4 and C_5.

A component (retention time relative to C_{22}: 1.24), was isolated from capelin (*Mallotus villosus*) and seems to be of an unstable structure similar to that of squalene. This is based on a reduction in

the concentration of the components from that initially observed in the GC analysis to the time when the GC/MS analysis was made. The mass spectrum shows no molecular peak, for which reason it is impossible to give a formula of the component. The spectrum seems to indicate a polyunsaturated structure with conjugated double bonds. Presumably, the molecule is branched.

SEDIMENTS AND INVERTEBRATES

A summary of the content of pristane, squalene and the total amount of hydrocarbons in sediments and invertebrates is presented in Table 19.

On a wet weight basis the hydrocarbon levels are low in all sediments and invertebrates, except in shrimp (*Pandalus borealis*) and zooplankton. Pristane is found in a considerable amount in shrimp. It is notable that the pristane concentration in shrimp varies considerably, depending on the position of sample collection (Table 6). The variation of the pristane concentration in shrimp collected at the same position indicates a considerable difference between the concentration of pristane in the individual shrimp. In zooplankton pristane is found in a relatively high concentration in one sample from position 42 (Table 3). The total concentrations of hydrocarbons in all other invertebrates analysed are below 1.5 µg/g wet weight. As dry weight and lipid content of most invertebrates are very low, the total amount of hydrocarbons on dry weight and lipid basis can be considerable, in spite of the low level on wet weight basis. The mean value of the total amount of hydrocarbons in sediments is 0.40 (range 0.06-1.30) µg/g dry weight. Pristane and squalene are frequently found in both invertebrates and sediments.

FISH

A summary of the content of pristane, squalene and the total amount of hydrocarbons in liver and muscle samples from fish is presented in Table 20.

In most cases squalene is the dominating hydrocarbon, especially in Greenland halibut (*Reinhardtius hippoglossoides*) (Table 12). Pristane is also frequently found in fish. In redfish (*Sebastes marinus*) and capelin (*Mallotus villosus*) pristane is the most prominent hydrocarbon (Tables 15 and 16). The bulk of the pristane and squalene is found in the liver tissue, but muscle tissue of high lipid content may also contain a considerable amount. It has only been possible to detect hydrocarbons other than pristane and squalene in smaller quantities. Therefore practically the total amount of hydrocarbons in many of the samples is the sum of the squalene and the pristane concentration. As is the case with shrimp, the concentrations of the single hydrocarbons vary considerably from fish to fish of the same species.

DISCUSSION

HYDROCARBON SOURCES

Hydrocarbons in the marine environment are derived from different sources such as biosynthesis (by living organisms in the water, on the sea floor and in sediments), advection (through land run-off), precipitation (from the atmosphere, and accidental or intentional release of fossil fuels during production, transportation and use (Anon, 1975; Farrington et al., 1975; McAuliffe, 1976).

BIOGENIC HYDROCARBONS

Marine organisms make their own hydrocarbons (Blumer et al., 1971; Youngblood et al., 1971; Ehrhardt and Blumer, 1972; Farrington et al., 1973; Mackie et al., 1974; Whittle et al., 1974; Anon, 1975; Yen, 1975).

The organisms synthesize n-alkanes, predominantly with odd-numbered carbon chains. In many instances, one or two odd-numbered, n-alkanes are predominant. Branched alkanes, including pristane, have been found in several organisms. In some species of fish pristane is the most abundant hydrocarbon. Alkenes often make up a major proportion of the hydrocarbons found in marine organisms. An example is squalene, which is found in livers of some species of fish. Isoprenoid C_{19} and C_{20}, mono, di, and tri-olefins are present in copepods and some species of fish. Straight-chain mono- to hexa-olefins have been found in considerable quantities in many organisms. It has been suggested that polynuclear, aromatic hydrocarbons may be synthesized by marine microorganisms. Until now aromatic hydrocarbons have been found in extremely low concentrations, generally less than 1 per cent of the total hydrocarbons of marine organisms.

Only a limited number of marine species from a few geographic locations have been analysed for their native hydrocarbons, and many investigators have limited their analytical techniques to searching for only one or two classes of hydrocarbons, usually alkanes and alkenes. Thus other classes of hydrocarbons might be more prevalent in nature than the limited analyses suggest.

PETROLEUM HYDROCARBONS

Petroleum and biogenic hydrocarbons may be distinguished in several ways: (Ehrhardt and Blumer, 1972; Farrington et al., 1973; Anon, 1975; Farrington et al., 1975)

- Petroleum contains a much more complex mixture of hydrocarbons with much greater ranges of molecular structure and weight.
- Petroleum contains several homologous series of hydrocarbons.
- Petroleum contains more kinds of cycloalkanes and aromatic hydrocarbons; also alkylsubstituted aromatic and naphthenoaromatic hydrocarbons. The last-mentioned compounds have not been reported as biogenic.

A criterion of gas chromatographic screening for identifying petroleum contamination in marine samples is the presence or absence of signal for an unresolved complex mixture of a "distillation envelope", due to overlapping series of homologous and isomeric hydrocarbons. Petroleum normally shows little or no predominance of n-alkanes with an odd number of carbon atoms.

UPTAKE AND FATE OF HYDROCARBONS IN MARINE ORGANISMS

Marine organisms receive hydrocarbons from their food source and the water, or convert precursor compounds obtained with their food or the water (Lee et al., 1972a, 1972b; Farrington and Quinn, 1975; Stegeman and Teal, 1973; Mackie et al., 1974; Whittle and Mackie, 1974; Anderson, 1975; Anon, 1975; Clark and Finley, 1975; Corner, 1975' DiSalvo et al., 1975; Ehrhardt and Heinemann, 1975; Lee, 1975; Neff and Anderson, 1975; Boehm and Quinn, 1976; Burns, 1976; Corner et al, 1976; Fossato and Canzonier, 1976; Giam et al., 1976; Lee et al., 1976; Thompson and Eglinton, 1976; Vandermeulen and Gordon, 1976; Wong et al., 1976). Much attention has been given to the concentrations of petroleum hydrocarbons in marine organisms, especially filter-feeding marine bivalves. Uptake of petroleum hydrocarbons in molluscs has been identified as a result of acute and chronic inputs into natural waters. Experimental studies on the uptake of petroleum hydrocarbons have also been undertaken.

Among other factors that influence the uptake of hydrocarbons from seawater is the lipid content of the organism, as well as the concentration of hydrocarbons in the water (Stegeman and Teal, 1973). The effect of dissolved organic matter in seawater on the uptake of mixed individual hydrocarbons is discussed in a paper by Boehm and Quinn (1976). Feeding experiments show that the dietary route of entry is quantitatively more important than direct uptake from solution (Corner et al., 1976).

Recent reports have discussed the fate of hydrocarbons in a variety of marine animals (Lee et al., 1972a, 1972b; Stegeman and Teal, 1973; Anderson, 1975; Clark and Finley, 1975; Ehrhardt and Heinemann, 1975; Lee, 1975; Neff and Anderson, 1975; Burns, 1976; Fossato and Canzonier, 1976; Lee et al., 1976). Several studies demonstrate that fish and some crustaceans (crabs and shrimps) may metabolize hydrocarbons. The evidence to date suggests that mussels are unable to metabolize hydrocarbons (Lee et al., 1975). Although some bivalves store hydrocarbons, most of those taken up are excreted during depuration experiments.

HYDROCARBONS IN SEDIMENTS

Aquatic sediments receive small amounts of organic matter originating from a variety of sources, e.g. hydrocarbons can be released during metabolism and decomposition of the organisms (Farrington and Quinn, 1973; Sackett and Brooks, 1975; Walker et al., 1975; Palacas et al., 1976; Starnes and Brown, 1976; Vandermeulen and Gordon, 1976; Walker et al., 1976; Wakeham, 1976; Wakeham and Carpenter, 1976; Wong et al., 1976). Field studies have shown that petroleum hydrocarbons from oil spills are able to persist in sediments for a long period of time due to a very slow biodegradation (Vandermeulen and Gordon, 1976). The most readily degraded compounds, and hence those lost first from the sediments, are the n-alkanes, while the cyclic, branched and aromatic compounds are left behind. Hydrocarbons incorporated in the sediment can enter the food web through deposit-feeding organisms.

EVALUATION OF THE ANALYTICAL RESULTS

The absence of a homologous series of resolved peaks of n-alkanes above an unresolved complex mixture signal in the gas chromatograms indicates the absence of petroleum contamination in all the analysed samples collected offshore Greenland 1975. Isolation and identification of some of the total hydrocarbons from the sample material in all cases show typical biogenic hydrocarbons.

Total hydrocarbon concentration, including biogenic compounds in surface sediment samples determined by a variety of techniques, covers the range 100-1200 µg/g in highly polluted coastal areas, usually 70 µg/g in unpolluted coastal areas and deep marginal seas or basins and 1-4 µg/g (including about 90 per cent biogenic) in deep sea areas (Farrington and Mederias, 1975). Compared with other data, the level of hydrocarbons in sediment samples from West Greenland marine areas seems to be extremely low. This supports the assumption that the area is at present uncontaminated by petroleum hydrocarbons, and thus that all the existing hydrocarbons in the sediments are of biogenic origin.

As mentioned earlier, all marine organisms are in a state of continuous interchange of hydrocarbons with their environment. Hydrocarbons found in organisms may originate from their food sources. The supply of hydrocarbons may vary considerably if the majority is derived from the food. In "selective" predators the intake is based on the actual hydrocarbon level in a single species, whereas in omnivores (e.g. some shrimp and starfish) the hydrocarbons derive from several species. Hydrocarbon synthesis by the organism may be influenced by several conditions (season, sexual stage, and age of the organism among others). The actual hydrocarbon level in the individual organisms seems very much to depend on the ability to metabolize hydrocarbons.

These factors may explain the considerable variations in the concentration of single hydrocarbons which are found in the organisms.

EVALUATION OF THE SAMPLE MATERIAL

The most important objective of the analytical work on the sample material from West Greenland is to control the inputs (and fate) of petroleum in this area.

Certain investigations indicate that some marine organisms are well suited as indicator organisms for evaluation of pollution by petroleum hydrocarbons (DiSalvo et al., 1975; Ehrhardt and Heinemann, 1975). The blue mussel (*Mytilus edulis*), because of its widespread distribution and easy accessibility, has been used as an indicator organism in several investigations. Among the criteria which must be fulfilled by organisms used as indicators of petroleum pollution are that they are abundant in the area and that the organisms retain hydrocarbons due to a very slow, or complete absence,

of hydrocarbon metabolism and excretion. At present, however, our knowledge is insufficient as regards the occurrence and abundance of species in the marine environment of West Greenland, and incomplete as regards metabolisms and excretions of hydrocarbons in marine organisms. It thus seems reasonable that, for the time being, interest be focussed on sediment analyses, in spite of the difficulty in obtaining a homogeneous mixture of the wet sediment and reproducable subsampling. An analytical estimation of the most volatile and most soluble hydrocarbons in water samples, might, however, give valuable supplementary information about petroleum contamination, especially in arctic areas (Sackett and Brooks, 1975).

A study of the natural level and distribution of hydrocarbons in the marine environment is a necessary prerequisite to the identification of low level contamination by petroleum hydrocarbons.

EVALUATION OF THE ANALYTICAL METHOD

A number of analytical techniques are available for measuring low and high molecular weight and total hydrocarbons in samples of sediments and marine organisms. Gas chromatography seems to be superior to other analytical techniques in differentiating hydrocarbons.

In all probability the gas chromatographic method could advantageously be supplemented with a simple routine method to estimate the toxic aromatic hydrocarbons (e.g. fluorescence spectroscopy) when the concern is pollution control, and the numbers of samples can then be considerable. Generally, when designing an analytical method for hydrocarbon base-line study requiring determinations of single components at the µg/kg(ppb) level, it is of prime importance to develop a contamination-free procedure.

Estimation of pollution can be effected by chemical analysis of the compounds concerned, or by measuring some specific biological effects of the compounds. However, it is not possible to identify and measure specific biological effects of pollutants dispersed in the environment at low concentrations, and possibly associated with other pollutants, unless the effect of the substance is extremely specific. Therefore chemical analytical techniques seem to be preferable when controlling petroleum pollution. The analytical results obtained give information on the exposure of the marine environment which may then be compared with experimentally determined dose/response factors.

So far the number of estimations of dose/response relationships are limited. Our knowledge is too incomplete to give a detailed interpretation of analytical results obtained on sample material collected with the view of controlling petroleum pollution in the marine environment.

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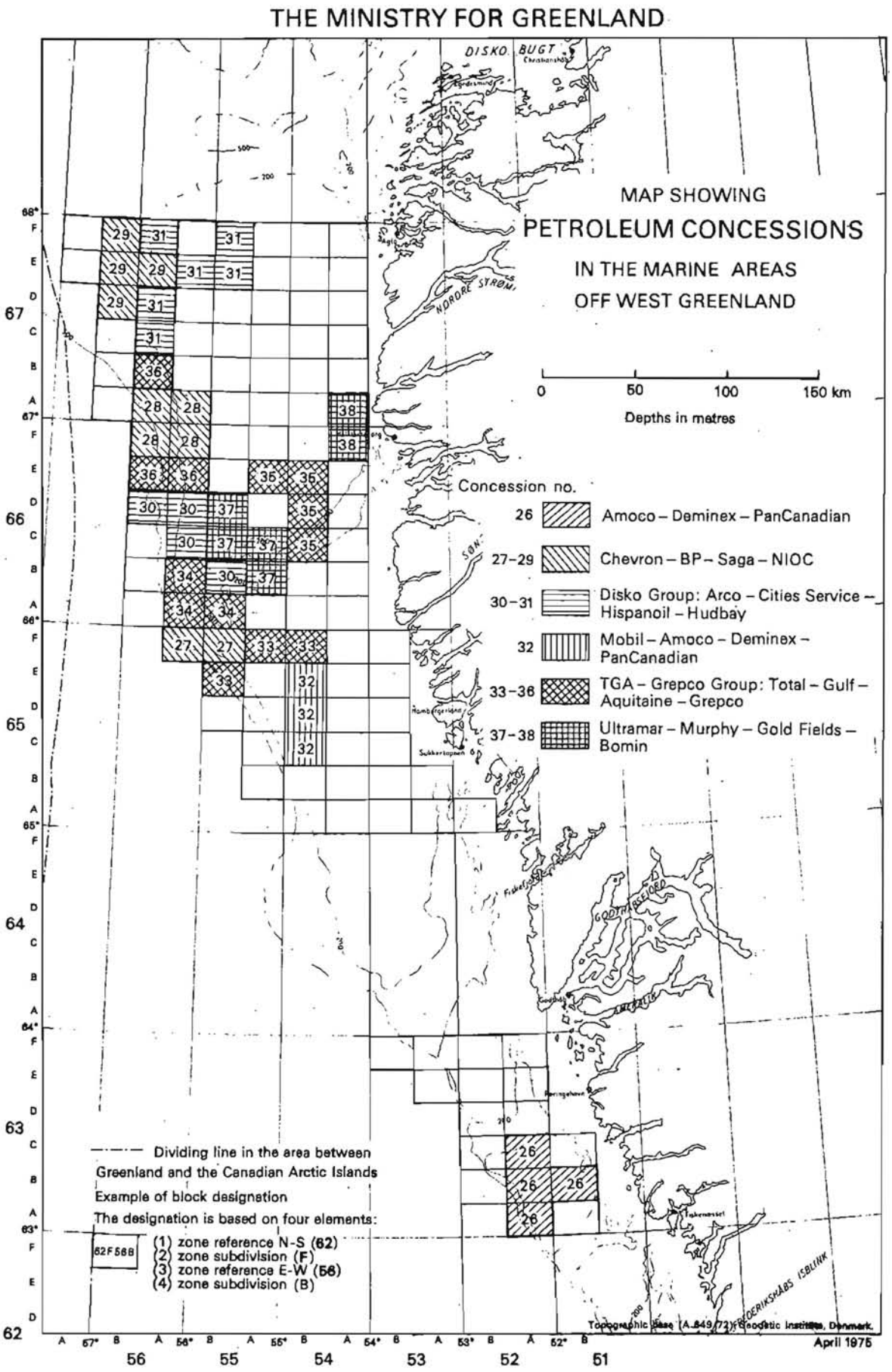

Fig. 1. Greenland offshore concessions.

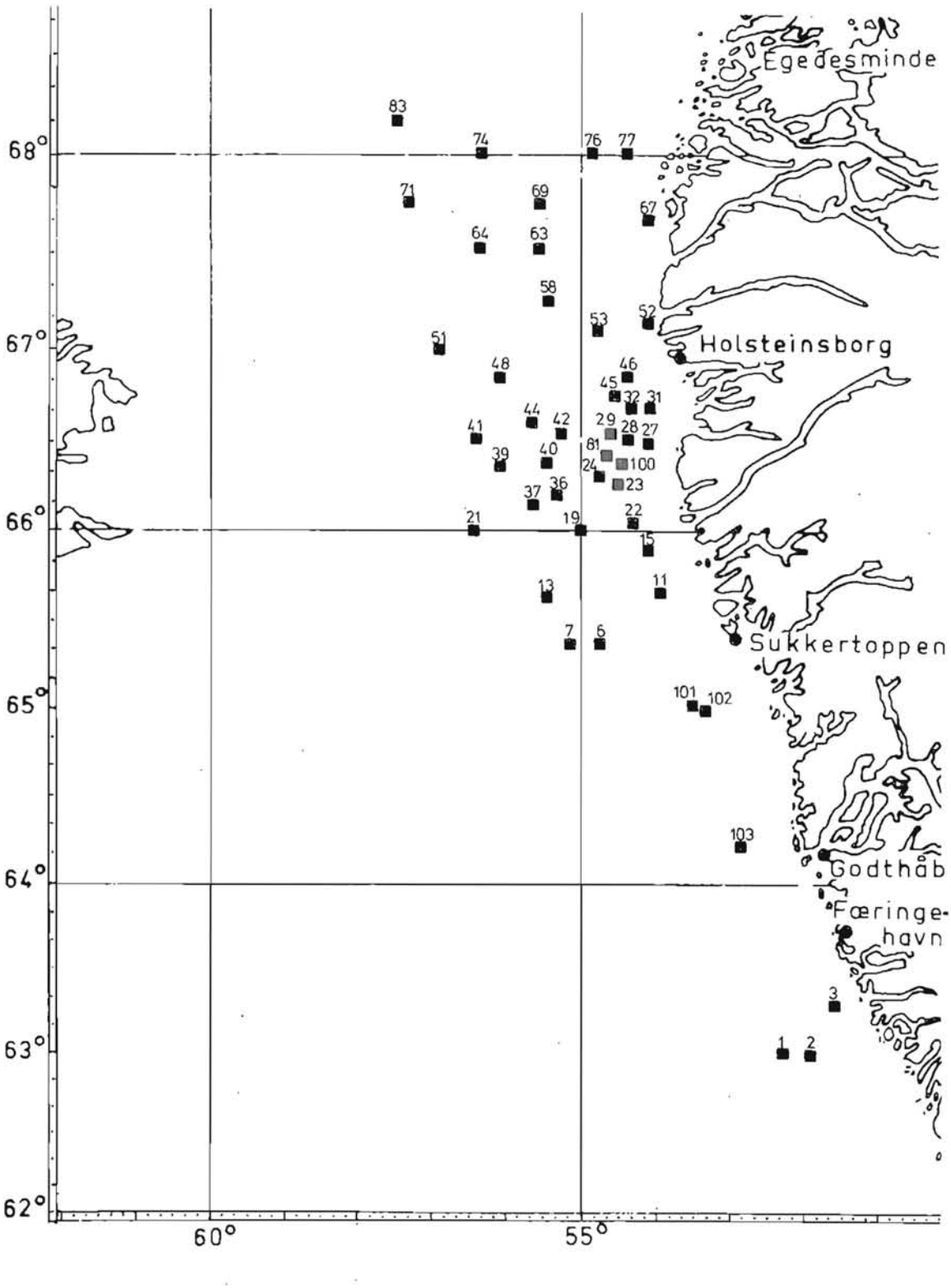

Fig. 2. Positions at which samples for chemical analyses were taken during the cruise with the DANA in 1975.

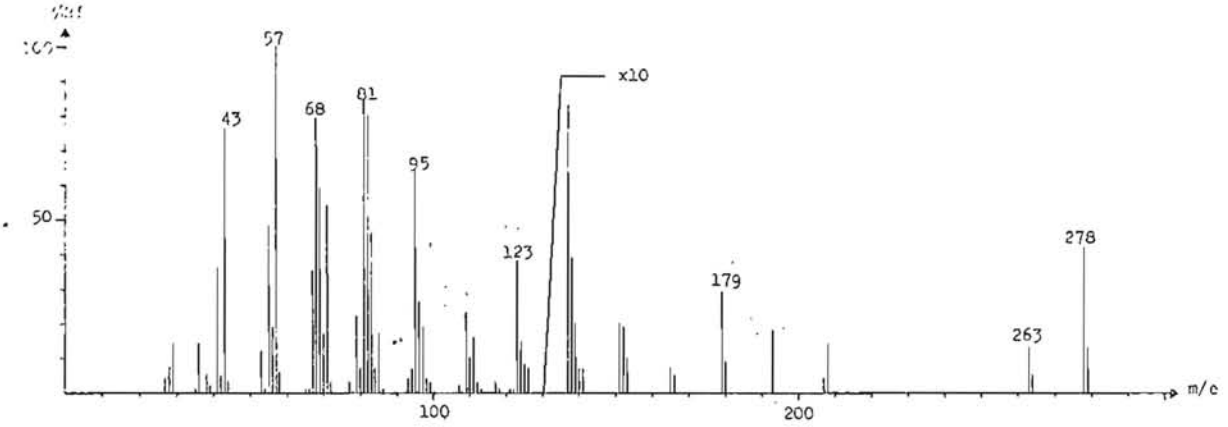

Fig. 3. Mass spectrum of a hydrocarbon (Retention time relative to C_{22}:0.76) isolated from redfish (*Sebastes marinus*).

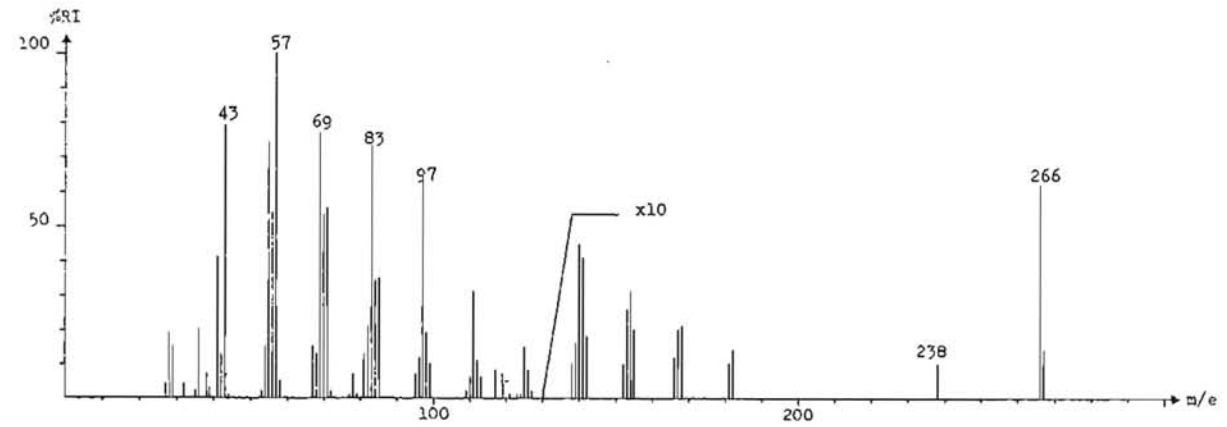

Fig. 4. Mass spectrum of a hydrocarbon (Retention time relative to C_{22}:0.77) isolated from capelin (*Mallotus villosus*).

TABLE 1: HYDROCARBON COMPOSITION (DRY WEIGHT BASIS) OF SEDIMENTS

POSITION	3	3	6	6	15	31	32	37	37	40	41	51	58	64	71	74	76	MEAN
SAMPLE NO.	F1	F2	B1	B2	B2	C1	A1	A1	A2	A1	A1	A1	B1	B1	B1	A1	A1	
DRY WEIGHT mg/g	481	538	847	812	793	435	762	730	603	650	867	846	837	819	705	805	809	733
RETENTION TIME RELATIVE TO C_{22}	µg/g DRY WEIGHT																	µg/g DRY WEIGHT
0.64 PRISTANE	-	-	-	-	-	-	0.04	0.08	0.08	-	0.02	-	-	0.02	-	-	-	0.014
0.73	0.08	0.11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.012
0.88	0.18	0.35	-	-	-	-	0.01	0.99	0.86	-	-	0.20	-	0.05	-	-	-	0.155
0.91	0.06	0.21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.016
0.94	0.04	0.17	-	-	-	-	0.04	-	-	-	-	-	-	-	-	-	-	0.015
1.14	-	-	-	-	0.05	-	-	-	-	-	0.10	-	-	-	-	-	-	0.009
1.24	-	-	-	-	-	-	-	0.05	0.05	-	-	-	-	-	0.03	0.01	-	0.004
1.30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	0.001
1.35 SQUALENE	0.10	-	0.30	0.12	0.04	1.13	0.04	0.10	0.10	0.14	0.05	-	0.19	0.07	0.03	0.12	0.10	0.176
1.44	-	-	-	-	-	-	-	0.08	0.08	-	-	0.05	-	-	-	-	-	0.012
1.53	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.01	-	-
TOTAL	0.46	0.84	0.30	0.12	0.09	1.13	0.13	1.30	1.17	0.14	0.20	0.25	0.19	0.14	0.06	0.15	0.10	0.40
DETECTION LIMIT	0.01	0.01	0.05	0.05	0.01	0.05	0.01	0.01	0.01	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.05	

TABLE 2: HYDROCARBON COMPOSITION (WET WEIGHT AND DRY WEIGHT BASIS) OF BRYOZOAN (ACYONIDIUM GELATINOSUM)

POSITION	2	19		29		MEAN
DRY WEIGHT mg/g	-	95		91		
LIPID mg/g	< 1	-		-		
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g wet weight
0.64 PRISTANE	-	0.05	0.5	-	-	0.017
1.35 SQUALENE	0.50[a]	0.16	1.7	0.11	1.2	0.213
TOTAL	0.50	0.21	2.2	0.11	1.2	0.23
DETECTION LIMIT	0.05	0.01		0.01		

a) IDENTIFIED BY MASS SPECTROMETRY

TABLE 3: HYDROCARBON COMPOSITION (WET WEIGHT AND DRY WEIGHT BASIS) OF ZOO-PLANKTON

POSITION	11		13		42		42		MEAN	
SAMPLE NO.	D1		C1		C1		C2			
DRY WEIGHT mg/g	41		56		56		56		56	
LIPID mg/g	-		< 1		< 1		-			
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight
0.64 PRISTANE	0.90	22	1.00[a]	17.8	9.85[a]	175	0.69	12.1	3.11	56.7
0.88	-	-	-	-	-	-	0.08	1.4	0.02	0.35
1.35 SQUALENE	0.01	0.24	0.19	3.4	0.06	1.1	0.02	0.35	0.07	1.26
TOTAL	0.91	22.2	1.19	21.2	9.91	176	0.78	13.9	3.2	57
DETECTION LIMIT	0.01		0.05		0.05		0.01			

a) IDENTIFIED BY MASS SPECTROMETRY

TABLE 4: HYDROCARBON COMPOSITION
(WET WEIGHT, DRY WEIGHT AND LIPID BASIS)
OF HOLOTHURIAN (CUCUMARIA FRONDOSA)

POSITION	45		
DRY WEIGHT mg/g	96		
LIPID mg/g	9.9		
	µg/g		
RETENTION TIME RELATIVE TO C_{22}	wet weight	dry weight	lipid
1.35 SQUALENE	0.09	0.82	8.0
TOTAL	0.08	0.82	8.0
DETECTION LIMIT	0.01		

TABLE 5: HYDROCARBON COMPOSITION (WET WEIGHT AND LIPID BASIS) OF BIVALVES

SPECIE	ASTARTE CRENATA						MYTILUS EDULIS	
POSITION	1		69		MEAN		67	
LIPID mg/g	8.3		8.3		8.3		12.5	
	µg/g		µg/g		µg/g		µg/g	
RETENTION TIME RELATIVE TO C_{22}	wet weight	lipid	wet weight	lipid	wet weight	lipid	wet weight	lipid
0.92	0.07	8.4	-	-	0.035	4.2	-	-
0.94	0.23	28	-	-	0.115	14.0	-	-
1.07	-	-	0.02	2.4	0.010	1.2	0.04	3.2
1.14	-	-	0.02	2.4	0.010	1.2	0.04	3.2
1.18	0.04	4.8	-	-	0.020	2.4	-	-
1.35 SQUALENE	0.06	7.0	-	-	0.030	3.5	0.02	1.6
TOTAL	0.40	48.2	0.04	4.8	0.22	27	0.10	8.0
DETECTION LIMIT	0.01		0.01				0.01	

TABLE 6: HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF SHRIMP (PANDALUS BOREALIS)

POSITION	81			83		MEAN	
DRY WEIGHT mg/g	238						
LIPID mg/g	18			25		22	
	µg/g			µg/g		µg/g	
RETENTION TIME RELATIVE TO C_{22}	wet weight	dry weight	lipid	wet weight	lipid	wet weight	lipid
0.56	0.04	0.15	2.0	-	-	0.02	1.0
0.64 PRISTANE	0,93	3.9	52	37[a)]	1480	25.5	766
0.72	0.02	0.07	0.9	-	-	0.01	0.5
1.18	0.38	1.59	21	-	-	0.19	10.5
1.35 SQUALENE	0.23	0.98	12.9	0.68	27	0.46	20.0
1.39	0.03	0.12	1.56	-	-	-	-
TOTAL	1.65	6.8	91.7	37.7	1507	27	798
DETECTION LIMIT	0.01			0.01			

a) SEVERAL ANALYSES ARE MADE. THE RESULTS ARE 24, 36 AND 50 µg/g WET WEIGHT. THE MEAN VALUE IS ENTERED IN THE TABLE. IDENTIFIED BY MASS SPECTROMETRY.

TABLE 7: HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF STARFISH

SPECIE	SOLASTER ENDECA							LEPTASTERIAS POLARIS									HIPPASTERIA PHRYGIANA	
POSITION	2		23			MEAN VALUES		15			45			MEAN			7	
DRY WEIGHT mg/g	264		305			285		297			285			291			267	
LIPID mg/g	-		104					37			12.9			25			-	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g dry weight
0.46	0.30	1.14	-	-	-	0.150	0.570	-	-	-	-	-	-	-	-	-	-	-
0.55	-	-	-	-	-	-	-	0.01	0.04	0.37	-	-	-	0.005	0.020	0.185	-	-
0.64 PRISTANE	0.10	0.38	0.16	0.5	1.6	0.130	0.440	0.10	0.34	2.7	-	-	-	0.050	0.170	1.35	0.01	0.04
0.77	0.09	0.34	-	-	-	0.045	0.170	-	-	-	-	-	-	-	-	-	-	-
0.88	-	-	-	-	-	-	-	0.13	0.44	3.5	-	-	-	0.065	0.220	1.75	-	-
0.94	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.02	0.08
1.24	0.05	0.19	-	-	-	0.025	0.095	-	-	-	-	-	-	-	-	-	-	-
1.33	0.09	0.34	-	-	-	0.045	0.170	-	-	-	-	-	-	-	-	-	-	-
1.35 SQUALENE	0.50	1.94	0.54	1.8	5.2	0.520	1.89	0.07	0.24	1.9	0.10	0.35	7.8	0.085	0.295	4.85	0.45	1.69
1.37	0.24	3.76	-	-	-	0.120	1.88	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1.37	8.12	0.70	2.3	6.8	1.04	5.2	0.31	1.06	8.5	0.01	0.35	7.8	0.21	0.71	8.1	0.48	1.81
DETECTION LIMIT	0.01		0.01					0.01			0.01						0.01	

TABLE 8 : HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF ASCIDIAN (BOLTENIA OVIFERA)

POSITION	23		23		23		MEAN
SAMPLE NO.	A 4		A 5		A 6		
DRY WEIGHT mg/g	-		84		69		
LIPID mg/g	2		-		-		
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	wet weight
0.45	-	-	0.12	1.4	-	-	0.040
0.64 PRISTANE	-	-	0.05	0.6	0.03	0.43	0.027
0.94	-	-	0.01	0.1	-	-	0.003
1.35 SQUALENE	0.06	30	0.10	1.2	0.09	1.30	0.083
1.44	-	-	-	-	0.01	0.15	0.005
TOTAL	0.06	30	0.28	3.3	0.13	1.88	0.16
DETECTION LIMIT	0.01		0.01		0.01		

TABLE 9: HYDROCARBON COMPOSITION (WET WEIGHT AND LIPID BASIS) OF HAGFISH (MYXINE GLUTINOSA)

POSITION	21	
LIPID mg/g	31	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid
0.64 PRISTANE	0.38	11.7
1.35 SQUALENE	9.75	313
TOTAL	10.13	324
DETECTION LIMIT	0.05	

TABLE 10: HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF COD (GADUS MORHUA)

TISSUE	LIVER						MUSCLE							
POSITION	101	101		102		MEAN	101	101		102			MEAN	
SAMPLE No.	A 33	A 57		A 4			A 33	A 60		A 4				
LENGTH cm	55	49		90		65	49	49		90			65	
WEIGHT kg	1.5	1.3		7.0		3.3	1.5	1.3		7.0			3.3	
AGE year	4	4		9		5.7	4	4		9			5.7	
DRY WEIGHT mg/g	-	-		-			-	170		187				
LIPID mg/g	-	436		464			4	-		-				
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight
0.45	-	-	-	-	-	-	-	-	0.03	0.18	-	-	-	0.01
0.64 PRISTANE	17.1	31[a]	72	32	69	26.7	0.15	36	0.08	2.7	-	-	-	0.08
0.72	-	-	-	0.6	1.2	0.2	-	-	-	-	-	-	-	-
1.24	-	-	-	1.4	2.9	0.5	-	-	-	-	-	-	-	-
1.35 SQUALENE	265	106[a]	243	256	553	216	2.2	510	0.83	4.9	0.56	3.0	522	1.20
1.45	-	-	-	14.1	30	4.7	-	-	-	-	-	-	-	-
TOTAL	302	137	315	304	656	248	2.35	546	0.94	5.8	0.56	3.0	522	1.29
DETECTION LIMIT	0.5	0.5		0.10			0.05		0.01					

a) IDENTIFIED BY MASS SPECTRMETRY

TABLE 11: HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF GREENLAND COD (GADUS OGAC)

TISSUE	LIVER															
POSITION	11		11		11		11		81		100	100		101		MEAN
SAMPLE NO.	F 4		F 5		F 8		F 11		S 2		A 1	A 5		A 25		
LENGTH cm	59		54		45		55		57		62	50		50		54
WEIGHT kg	2.9		2.2		1.5		2.2		2.3		2.5	1.3		1.9		2.1
LIPID mg/g	355		406		484		402		299		-	112		350		
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight
0.64 PRISTANE	-	-	-	-	-	-	-	-	-	-	-	-	-	22	63	2.75
0.72	-	-	-	-	-	-	-	-	-	-	-	-	-	0.26	0.74	0.03
1.24	-	-	-	-	-	-	-	-	-	-	-	-	-	0.24	0.69	0.03
1.35 SQUALENE	86	241	106	260	35	72	21	53	9.3	31	8.2	10.9	97	36	103	39.1
1.45	-	-	-	-	-	-	-	-	-	-	-	-	-	3.7	10.5	0.46
TOTAL	86	241	106	260	35	72	21	53	9.3	31	8.2	10.9	97	62	178	42
DETECTION LIMIT	0.5		0.5		0.5		0.5		0.5		0.5	0.5		0.1		

TABLE 11 (CTD.)

TISSUE	MUSCLE											
POSITION	11		11		81		100		101		MEAN	
SAMPLE No.	F 8		F 12		S 2		A 5		A 25			
LENGTH cm	45		55		57		50		50		51	
WEIGHT kg	1.5		1.9		2.3		1.3		1.9		1.8	
LIPID mg/g	3		3		1		2		5		3	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid
0.64 PRISTANE	-	-	-	-	-	-	-	-	-	-	-	-
0.72	-	-	-	-	-	-	-	-	-	-	-	-
1.24	-	-	-	-	-	-	-	-	-	-	-	-
1.35 SQUALENE	1.8	350	1.1	340	2.2	220	2.4	1210	9.2	1700	3.3	800
1.45	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1.8	350	1.1	340	2.2	220	2.4	1210	9.2	1700	3.3	800
DETECTION LIMIT	0.05		0.05		0.05		0.05		0.01			

TABLE 12: HYDROCARBON COMPOSITION (WET WEIGHT AND LIPID BASIS) OF GREENLAND HALIBUT (REINHARDTIUS HIPPOGLOSSOIDES)

TISSUE	LIVER									
POSITION	81		81		83		83		83	MEAN
SAMPLE NO.	K 11		K 12		A 4		A 5		A 7	
LENGTH cm	40		51		48		48		43	46
DRY WEIGHT mg/g										
LIPID mg/g	93		317		163		236		-	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g wet weight
0.64 PRISTANE	0.82	8.8	0.15	0.46	3.2	19.6	203	660	50[a)]	51.4
0.77	-	-	-	-	-	-	3.2	13.5	-	0.64
1.09	-	-	-	-	-	-	-	-	-	-
1.19	-	-	-	-	-	-	2.9	12.3	-	0.58
1.24	-	-	-	-	-	-	0.7	3.0	-	0.14
1.35 SQUALENE	156	1670	696	2190	167	1120	1170	4930	327[a)]	503
1.44	-	-	-	-	-	-	1.4	6.1	-	0.28
1.50	-	-	0.25	0.8	-	-	0.49	2.1	-	0.14
1.60	-	-	0.33	1.0	-	-	-	-	-	0.06
TOTAL	157	1679	698	2190	170	1140	1380	5630	377	556
DETECTION LIMIT	0.1		0.1		0.1		0.1		0.5	

[a)] IDENTIFIED BY MASS SPECTRPMETRY

TABLE 12 (CTD.)

TISSUE	MUSCLE											
POSITION	81			81			83		83		MEAN	
SAMPLE NO.	K 11			K 12			A 4		A 7			
LENGTH cm	40			51			48		43		46	
DRY WEIGHT mg/g	208			231			-		-		-	
LIPID mg/g	62			88			70		133		88	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid
0.64 PRISTANE	3.4	16.2	54	3.3	14.5	30	5.6	81	6.5	49	4.7	56
0.77	-	-	-	-	-	-	-	-	-	-	-	-
1.09	0.01	0.05	0.16	-	-	-	0.01	0.14	-	-	0.005	0.07
1.19	-	-	-	-	-	-	-	-	-	-	-	-
1.24	0.01	0.06	0.19	-	-	-	0.03	0.43	-	-	0.010	0.15
1.35 SQUALENE	8.2	39	132	15.9	69	182	9.5	136	20.5	154	13.5	151
1.44	-	-	-	-	-	-	0.01	0.1	-	-	0.003	0.03
1.50	-	-	-	-	-	-	-	-	-	-	-	-
1.60	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	11.6	55	186	19.2	8.4	220	15.2	218	27	203	18.3	207
DETECTION LIMIT	0.01			0.01			0.01		0.05			

TABLE 13: HYDROCARBON COMPOSITION (WET WEIGHT, DRY WEIGHT AND LIPID BASIS) OF AMERICAN PLAICE (HIPPOGLOSSOIDES PLATESSOIDES)

TISSUE	LIVER							
POSITION	2		53		81		MEAN	
SAMPLE NO.	Q		C 7		D 3			
LENGTH cm	40		-		40			
WEIGHT kg	0.7		-		-			
DRY WEIGHT mg/g								
LIPID mg/g	136		134		27		77	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	lipid	µg/g wet weight	lipid	µg/g wet weight	lipid	µg/g wet weight	lipid
0.39	-	-	0.05	0.34	-	-	0.017	0.113
0.56	-	-	0.12	0.91	-	-	0.040	0.303
0.64 PRISTANE	21	154	0.30	2.24	-	-	7.10	52
0.72	-	-	0.14	1.02	-	-	0.047	0.340
0.89	-	-	0.04	0.26	-	-	0.013	0.087
0.94	-	-	0.01	0.08	-	-	0.03	0.027
1.18	-	-	0.44	3.3	-	-	0.147	1.10
1.24	-	-	-	-	0.32	11.7	0.107	3.90
1.35 SQUALENE	20	143	41	307	1.43	53	20.8	168
1.45	0.50	3.7	0.04	0.24			0.180	1.31
1.50	0.20	1.3	-	-			0.067	0.43
TOTAL	42	302	42	315	1.75	65	29	228
DETECTION LIMIT	0.01		0.01		0.01			

TABLE 13 (CTD.)

TISSUE	MUSCLE											
POSITION	2			53			81			MEAN		
SAMPLE NO.	Q			C 7			D 3					
LENGTH cm	40			-			40					
WEIGHT kg	0.7			-			-					
DRY WEIGHT mg/g	196			179			153			176		
LIPID mg/g	8			6			2			5		
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g dry weight	lipid	µg/g wet weight	µg/g dry weight	lipid	µg/g wet weight	µg/g dry weight	lipid	µg/g wet weight	µg/g dry weight	lipid
0.39	-	-	-	0.01	0.03	1.0	-	-	-	0.003	0.010	0.33
0.56	-	-	-	0.04	0.22	6.7	-	-	-	0.013	0.073	2.23
0.64 PRISTANE	0.45	2.3	55	-	-	-	-	-	-	0.15	0.77	18.3
0.72	-	-	-	0.02	0.11	3.3	-	-	-	0.007	0.037	1.10
0.89	-	-	-	-	-	-	-	-	-	-	-	-
0.94	-	-	-	-	-	-	-	-	-	-	-	-
1.18	-	-	-	-	-	-	-	-	-	-	-	-
1.24	-	-	-	-	-	-	-	-	-	-	-	-
1.35 SQUALENE	1.6	8.2	193	0.10	0.56	16.7	0.98	6.3	444	0.89	5.02	218
1.45	-	-	-	-	-	-	-	-	-	-	-	-
1.50	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	2.05	10.5	248	0.17	0.92	27.7	0.98	6.3	444	1.06	5.9	239
DETECTION LIMIT	0.01			0.01			0.01					

TABLE 14: HYDROCARBON COMPOSITION (WET WEIGHT AND LIPID BASIS) OF WOLFFISH (ANARHICHAS LUPUS AND ANARHICHAS MINOR)

TISSUE	LIVER							
POSITION	101		102		103		MEAN	
SAMPLE NO.	A 62		A 2		A 2			
LENGTH cm	62		63		76		67	
WEIGHT kg	-		2.2		8.1			
DRY WEIGHT mg/g	-		-		-			
LIPID mg/g	54		66		176		99	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	lipid	µg/g wet weight	lipid	µg/g wet weight	lipid	µg/g wet weight	lipid
0.64 PRISTANE	3.1	58	1.49	23	0.98	5.6	1.86	28.9
0.71	-	-	-	-	0.03	0.17	0.01	0.06
0.76	-	-	0.20	3.0	0.80	4.5	0.33	2.5
0.77	-	-	0.10	1.5	-	-	0.03	0.50
1.13	0.35	6.5	-	-	-	-	0.12	2.2
1.18	-	-	0.03	0.5	-	-	0.01	0.17
1.24	0.83	15.5	-	-	0.05	0.28	0.29	5.3
1.35 SQUALENE	41	770	51	780	56	316	49	622
1.40	-	-	-	-	0.51	2.9	0.17	0.97
TOTAL	45	850	53	808	58	329	52	663
DETECTION LIMIT	0.01		0.01		0.01			

TABLE 14 (CTD.)

TISSUE	MUSCLE												
POSITION	22			23		102			103			MEAN	
SAMPLE NO.	I			C		A 2			A 2				
LENGTH cm	-			72		63			76				
WEIGHT kg	-			3.7		2.2			8.1				
DRY WEIGHT mg/g	133			-		143			189				
LIPID mg/g	5.3			9.7		3.2			31				
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	dry weight	lipid	µg/g wet weight	lipid	µg/g wet weight	dry weight	lipid	µg/g wet weight	dry weight	lipid	µg/g wet weight	lipid
0.64 PRISTANE	0.09	0.068	17.1	-	-	0.05	0.33	14.7	0.14	0.74	4.5	0.070	9.08
0.71	-	-	-	-	-	-	-	-	0.40	2.1	13	0.100	3.25
0.76	-	-	-	-	-	-	-	-	-	-	-	-	-
0.77	-	-	-	-	-	-	-	-	-	-	-	-	-
1.13	-	-	-	-	-	-	-	-	-	-	-	-	-
1.18	-	-	-	-	-	-	-	-	-	-	-	-	-
1.24	-	-	-	-	-	-	-	-	-	-	-	-	-
1.35 SQUALENE	1.22	9.2	230	2.0	206	0.16	1.1	49	3.0	15.8	97	1.60	146
1.40	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	1.31	9.9	247	2.0	206	0.21	1.43	64	3.5	18.6	115	1.8	158
DETECTION LIMIT	0.01			0.05		0.01			0.01				

TABLE 15: HYDROCARBON COMPOSITION (WET WEIGHT AND LIPID BASIS) OF REDFISH (SEBASTES MARINUS)

TISSUE	LIVER		MUSCLE						
POSITION	83		83		83			MEAN	
SAMPLE NO.	A 16		A 15		A 16				
DRY WEIGHT mg/g	-		-		217				
LIPID mg/g	201		43		34			39	
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g lipid	µg/g wet weight	µg/g dry weight	µg/g lipid	µg/g wet weight	µg/g lipid
0.64 PRISTANE	99	494	36[a)]	830	5.0	23	145	20.5	488
0.76	-	-	0.01[a)]	0.32	-	-	-	0.005	0.16
0.78	0.09	0.44	-	-	-	-	-	-	-
0.89	2.9	14.8	0.06	1.4	0.03	0.14	0.92	0.045	1.16
1.24	0.11	0.56	-	-	-	-	-	-	-
1.35 SQUALENE	30	150	1.6[a)]	37	0.86	4.0	25	1.23	31.0
1.44	0.06	0.27	-	-	-	-	-	-	-
1.48	0.06	0.31	-	-	0.13	0.61	3.8	0.065	1.90
TOTAL	132	660	38	870	6.0	28	175	22	522
DETECTION LIMIT	0.05		0.01		0.01				

[a)] IDENTIFIED BY MASS SPECTROMETRY

TABLE 16: HYDROCARBON COMPOSITION (WET WEIGHT BASIS) OF CAPELIN (MALLOTUS VILLOSUS) (WHOLE FISHES)

POSITION	81
RETENTION TIME RELATIVE TO C_{22}	µg/g wet weight
0.64 PRISTANE	8.9[a)]
0.77	1.5[a)]
1.24	1.3[a)]
1.35 SQUALENE	5.2[a)]
TOTAL	16.9
DETECTION LIMIT	0.05

[a)] IDENTIFIED BY MASS SPECTROMETRY

TABLE 17: RETENTION TIMES OF n-ALKANES AND SOME BRANCHED HYDROCARBONS RELATIVE TO C_{22}

HYDROCARBONS	RETENTION TIME RELATIVE TO C_{22}
C_{14}	0.38
C_{15}	0.47
C_{16}	0.55
C_{17} & Pristane	0.64
C_{18}	0.72
C_{19}	0.79
C_{20}	0.86
C_{21}	0.93
C_{22}	1.00
C_{23}	1.06
C_{24}	1.13
C_{25}	1.18
C_{26}	1.24
C_{27}	1.29
C_{28} & Squalane	1.35
C_{29}	1.40
C_{30}	1.45
C_{31}	1.50
C_{32}	1.55
C_{33}	-
C_{34}	1.70
C_{35}	1.80
C_{36}	1.93

TABLE 18: MARINE ORGANISMS INCLUDED IN THE GAS CHROMATOGRAPHIC/MASS SPECTROMETRIC ANALYSES

ORGANISMS, POSITIONS, AND SAMPLE NO.		COMPONENTS IDENTIFIED
Alcyonidium gelatinosum	2	Squalene
Zooplankton	13 C1, 42 C1	Pristane
Pandalus borealis	83	Pristane
Gadus morhua	101 A57	Pristane & Squalene
Reinhardtius hippoglossoides	83 A7	Pristane & Squalene
Sebastes marinus	83 A15	Pristane & Squalene & unknown comp. (see text)
Mallotus villosus	81	Pristane & Squalene & two unknown comp. (see text)

TABLE 19: PRISTANE, SQUALENE AND TOTAL HYDROCARBON LEVEL IN SEDIMENTS AND INVERTEBRATES

	SEDI-MENTS	BRY-OZOAN	ZOO-PLANK-TON	HOLO-THU-RIAN	BIVALVES ASTARTE	BIVALVES MYTILUS	SHRIMP	STARFISH SOLAS-TER	STARFISH LEP-TASTE-RIAS	HIPPA-STERIA	ASCI-DIAN
PRISTANE											
µg/g wet weight	-	0.02	3.1	-	-	-	26	0.13	0.05	0.01	0.03
µg/g dry weight	0.014	-	57	-	-	-	-	0.44	0.17	0.04	-
µg/g lipid	-	-	-	-	-	-	766	-	1.35	-	-
SQUALENE											
µg/g wet weight	-	0.21	0.07	0.09	0.03	0.02	0.46	0.52	0.09	0.45	0.08
µg/g dry weight	0.16	-	1.26	0.82	-	-	-	1.89	0.30	1.69	-
µg/g lipid	-	-	-	8.0	3.5	1.6	20	-	4.9	-	-
TOTAL											
µg/g wet weight	-	0.23	3.2	0.08	0.22	0.10	27	1.04	0.21	0.48	0.16
µg/g dry weight	0.40	-	58	0.82	-	-	-	5.2	0.71	1.81	-
µg/g lipid	-	-	-	8.0	27	8.0	798	-	8.1	-	-

TABLE 20: PRISTANE, SQUALENE AND TOTAL HYDROCARBON LEVEL IN LIVER AND MUSCLE OF FISH

	COD		GREENLAND COD		GREENLAND HALIBUT		AMERICAN PLAICE		WOLF-FISH		REDFISH		CAPELIN WHOLE FISH	HAGFISH
	LIVER	MUSCLE	LIVER	MUSCLE	LIVER	MUSCLE	LIVER	MUSCLE	LIVER	MUSCLE	LIVER	MUSCLE		
PRISTANE														
µg/g wet weight	27	0.08	2.8	-	51	4.7	7.1	0.15	1.86	0.07	99	21	8.9	0.38
µg/g dry weight	-	-	-	-	-	-	-	0.77	-	-	-	-	-	-
µg/g lipid	-	-	-	-	-	56	52	1.83	29	9.1	494	488	-	11.7
SQUALENE														
µg/g wet weight	216	1.20	39	3.3	503	13.5	21	0.89	49	1.60	30	1.23	5.2	9.75
µg/g dry weight	-	-	-	-	-	-	-	5.0	-	-	-	-	-	-
µg/g lipid	-	-	-	800	-	151	168	218	622	146	150	31	-	313
TOTAL														
µg/g wet weight	248	1.3	42	3.3	556	18.3	29	1.1	52	1.8	132	22	16.9	10.1
µg/g dry weight	-	-	-	-	-	-	-	5.9	-	-	-	-	-	-
µg/g lipid	-	-	-	800	-	207	228	239	663	158	660	522	-	324