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REPORT OF THE STUDY GROUP ON POLLUTION AFFECTING SHELLFISH IN AQUACULTURE AND NATURAL POPULATIONS

M. HERAL, R. MEIXNER, B. SPENCER, G. WALSH and J. WORMS

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* General Secretary
ICES, Palaegade 2-4
DK-1261 Copenhagen K
Denmark

I. MEMBERS OF THE STUDY GROUP

M. HERAL	Chairman and rapporteur	IFREMER B.P. 133 17390 LA TREMBLADE FRANCE
R. MEIXNER		Bundesfarshungsantalt für Fishereir HAMBURG GERMANY
I. PRICE		Fisheries and Oceans OTTAWA CANADA
B. SPENCER		Fisheries Laboratory COMWY UNITED KINGDOM
G. WALSH		Pêches et Océans MONT-JOLI CANADA
J. WORMS		Fisheries and Oceans MONCTON CANADA

II. TERMS OF REFERENCE

The Council Resolution 1990/2 : 42 decided :

A Study Group on Pollution Affecting Shellfish in Aquaculture and Natural Populations will be established under the chairmanship of M. Héral (France) and will meet in Amsterdam from 17-19 June 1991 at national expense to :

a) compile existing information from various parts of the world (especially ICES areas) on the sources and extent of pollution affecting shellfish and their marketability.

b) specify the substances and activities most commonly involved in pollution incidences affecting shellfish.

c) identify to what extent external stresses can enhance disease susceptibility in shellfish.

d) Bearing in mind the existing understanding of environmental conditions, identify situations/species where productivity, reproduction success, behaviour and marketable quality deviate from that empirically expected.

e) utilizing the information on common problems and associated factors derived from completion of task d) above, examine and identify the possible causes of the problems and propose remedial and preventive measures.

III. WORK IN THE PERIOD 1991

As the study group is very recent, only 6 members have been proposed by their countries with respectively R. Meixner (Germany), B.E. Spencer (United Kingdom) P.

Dredging activities

Dredging operations mainly comprise : Extraction of agregates and dumping of dredged spoil from estuaries, harbour, mines or sewage. Changes on the sediment chemistry and macrobenthic structure have usually been observed in non dispersive environment. In a recent review on marine dredging for sand and gravel, following the ICES working group on effects on fishes of marine sand and gravel extraction, Mitchell (1989) concluded, that the immediate consequence is the destruction of the benthic invertebrate populations with, eventually, the destruction of spawning or nurseries areas. The exposure of anoxic sediment and the turbidity associated with the extraction can modify the ecosystem with perturbation of primary production and meanwhile filtration activity of shellfish. The reintroduction of toxic contaminants have been signaled by Morton (1977) and Johnston (1981), with a number of case studies where elevated level of toxic gases, organic compounds and heavy metals have been measured. Even non contaminated sediment can damage the benthic filters by obstruction of gills causing weight loss and during long period mortality.

Dredging in estuaries, and harbour docks and in the marine environment, to maintain the navigation channel adds a new dimension to the problem previously outlined. The benthic community remains severely modified with recovery time exceeding 15 years. These dredged sediments are very often dumped elsewhere at sea, but they are very often highly contamined by heavy metals (cadmium, mercury, lead...) or salts (TBT) or organochlorine (DDT, PCB...) and hydrocarbons. Their new availability to the benthic fauna can result in severe contamination. The same problems occured with the dumping of industrial waste and sewage sludge (Maertens, 1989 and Dethlefsen, 1989) which induced a decrease in benthic biomass and the loss of a certain number of species. The same damage is brought about by the construction of trenches for pipelines or cables. Dredging in estuaries can modify riverine biocenoses due to increased mixing and salt water intrusion (Morano et al., 1985).

The destruction of the shellfish habitat can also be caused by commercial **fishing operations**. In Chesapeake Bay the use of gears such as patent tongs and dredges contributed to modify the oyster habitat by smoothing oyster reefs, reducing their height and even destroying, them inducing higher sedimentation rate and consequently less settlement of spat (Héral et al., 1990). Trawling action with sometimes thicker chains on demersal gears can cause severe damage to the benthos and make accumulated contaminants from the sediment resuspend. As the fishing effort is very intensive in some areas, some sea-beds may be fished 3 to 5 times a year (Ranck, 1985 for the Dutch fleet). Redant (1987) did a bibliography review on the effects of bottom fishing gear and harvesting techniques on benthic biota for ICES. In a recent review Fowler (1989) concluded that trawling with modern, heavy gear towed by large powerful vessels and dredging can have a very severe impact on the seabed and benthic communities. The groups of organisms most seriously affected are the epifauna, long lived infauna (molluscs and echinodems) maerl beds and sea-grasses. Communities based on fragile species such as *Sabellaria, Modiolus* and *Zostera* are severely affected by fishing practices.

4.3. Eutrophication

The development of intensive agriculture and the discharge of poorly treated waste waters has resulted in a sharp increase in nutrient input (nitrate, ammonium, phosphorus). Similar to what has been documented in lakes and river, the nutrient balance has been modified in estuaries and coastal areas, including closed seas and whole bays function of their hydrodynamic characteristics. The main consequences of such modifications are green macroalgae proliferation and phytoplankton blooming (Menesguen, 1990). Some phytoplankton species producing toxic substances could be indirectly associated with eutrophisation (Smayda, 1990).

Gymnodinium sp. *Gyrodinium* sp., *Aureococcus* sp., *Ceratium* sp., *Cochlodinium* sp., *Hornellia* sp. (for a review see Shumway, 1989).

4.5. Pollutant actions

Organotin salts

These products used as antifouling have a deleterious effect on the environment, particularly on molluscs and especially on the Japanese oyster *Crassostrea gigas*. In a review Héral et al. (1989) list the following effects function of the dose.

- acute and chronic toxicity to the adults,
- accumulation in the flesh of the adults,
- perturbation of reproduction particularly fertility, mortality of offspring and decrease in larval growth rate,
- decrease in the growth rate of adults and thickening of the shell,
- modification of the physiology at sublethal levels.

Regulations are now in place in most of European countries and in North America, but they are not always applied for the recreative sailing boats activities.

Hydrocarbons

The chronic input of these products does not normally affect shellfish life. It is not the case when accidents occur. Groundings of oil tankers such as Torrey Canyon and Amoco-Cadiz in 1978 in French Brittany or more recently such Exon Valdez in 1990 in Alaska have destroyed all the benthic fauna directly in the vicinity of the grounding. Around the area function of the wind, wave action and the characteristic of the oil, the oil dispersed over larger areas, causing accumulation of hydrocarbons by the filter feeders. Some aromatic hydrocarbons could be carcinogen or mutagen (Alzieu et Ravoux, 1989). Furthermore an oil taste remained in the oyster and mussel during a long time which compelled local authorities to destroy the surviving oysters. The oil spill from Amoco Cadiz caused a direct loss of turnover cost evaluated at 114 million francs of 1983 (Bonnieux et al., 1980). In areas of intensive contaminated, it has taken more than 10 years to recover clean sediment. The action of the products used to precipate the fuel, to disperse it (detergents) was also one of the other factors contributing to the death of the benthos.

Other problems may occur. Meixner (comm. pers.) described that mortality and unpleasant smell of mussels was observed some miles off an oil leakage from an oil terminal near Wilhelmshaven. Though a considerable amount of mussels survived the oil spill a total economic loss resulted from the long-lasting bad taste and the ban on mussel harvest imposed by the controlling authorities.

Heavy metals

In addition to the human health impact, heavy metals and their salts can be highly toxic for shellfish. Mortality threshold have been determined for larvae and juveniles which are the most sensitive stages. The toxicity of cadmium, silver, copper, mercury, zinc, lead and their synergetical action on mollusca and on crustaceas have been studied by several authors. For a review, see Deslous-Paoli (1982) who classified the level of toxicity for shellfish larvae. By order of toxicity the authors found organotin salts, mercury, silver, copper, zinc, nickel, lead, cadmium, chromium and manganese. Mc Innes (1981) tested the synergistic effect of copper-mercury-zinc and found that cumulative toxicity was higher by 40 to 60 % to that expected.

Algal biotoxins

Several types of biotoxins affect the shellfish, mainly the Diarrhetic Shellfish Poisoning (DSP) and Paralytic Shellfish Poisoning (PSP). The marine dinoflagellate *Protogonyaulax tamarensis* has been implicated as the source of Paralytic Shellfish Poisoning (PSP) in eastern Canadian waters (Needler, 1949). More recently, it has been demonstrated that the diatomea *Nitzschia pungens* was responsible for human amnesic intoxication (ASP Amnesic Shellfish Poisoning) (Addision and Stewart, 1989). In the European countries and in North America, monitoring networks have been generalized since the last 5 years to protect good health of consumers. The different reports of the ICES working group on harmful effects of algal blooms on mariculture and marine fisheries gave the detail of national reports with the occurences of toxic plankton blooms (ICES 1989. Report of the working group on harmful effects of algal blooms on mariculture and Marine Fisheries, ICES 1990. Report of the working group on phytoplankton and the management of their effects).

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VII. RECOMMENDATIONS

a) The study group must be really constituted, the different countries have to nominate their members. The absence of pollution specialists, at the present time, will make it difficult for the study group to achieve the different tasks fixed by the council.

b) The tasks of the study group must be better defined by the parents committee as some other working group exist with somewhat overlaping mandates and/or concerns :

- Working group on environmental assessment and monitoring strategies,
- Working group on marine sediments in relation to pollution,
- Working group on the effects of extraction of marine sediments on fisheries,
- Benthos Ecology working group,
- Working group on phytoplankton and the management of their effects,
- Working group on biological effects of contaminants,
- Working group on environmental impacts of mariculture.

These 7 groups are already working more or less on pollution and shellfish.

c) The proposed study group (with new members) should meet for three days in April 1992 in Nantes (France) to start fulfilling the terms of reference and particularly :

- to complete the present text to answer terms of reference a b and d,
- to identify relationships between pollutants and disease susceptibility in shellfish,
- to propose remedial and preventive measures.

viral hepatitis and the consumption of raw oysters or other bivalves taken from seawater grossly contaminated by sewage.

3. Health risk by algal biotoxins

3.1. Diarrhetic Shellfish Poisoning (DSP)

The filter-feeding mussels, which are taken for food, may absorb e.g. DSP-biotoxins derived from planktonic dinoflagellates of the genus Dinophysis. Populations of such dinoflagellates develop in the North Sea annually. Due to the somewhat sheltered position of mussel beds seems to be a sporadic event, which may depend on a special combination of hydrographic factors.

After a DSP-incident of gastrointestinal sickness affecting about 75 mussel consumers a biological monitoring of plankton blooms was started. The monitoring work is done by state authorities of Niedersachsen and Schleswig-Holstein. If cell numbers of potentially toxic dinoflagellates surpass certain limits a special warning is given to the mussel fishery. This plankton monitoring and bioassay and HPLC-investigations of the mussels was effective during the last 5 years in protecting the mussel consumer against DSP.

4. Mussel consumers and international contacts

4.1. Increasing consumption

The growing international travel, e.g. by commerce and tourism, and modern food trands foster the consumption of various sorts of sea food in Germany and other countries. German consumers seem to be convinced, that this kind of food is healthy and it is still in its natural state.

4.2. Consumer awareness and media

People realize that there are hazards regarding pollution, food-borne microbial infections and intoxications because of the present day media. New tendencies are observed. People give up, at least for a while, their habits of buying certain types of food items, if warnings are given by the various media. Mussel consumption in Germany went down sharply when people heard over cases of Cholera in a southern European country some years ago. It took some months before the consumption reached normality again.

5. Prevention of pollution

German mussels culture takes place in various parts of the Waddensea. This dislocated pattern of distribution has been sussessful in reducing the risk of contamination of all mussel beds on one occasion by accidental pollution up to the present time. The same holds regarding the cases of localized appearance of toxic algae or oil leakages.

Prevention of pollution at its source is crucial for the fisherman, because mussels in Germany are at a low prize. Therefore losses by pollution or any expensive techniques of purification or depuration would endanger mussel farms because of uneconomic production costs. The main aim of the German musselfarmer is a product at a reasonable cost, which is acceptable for human consumption without further treatment.

Although the current signs are that concentrations of TBT in water and animal tissues are decreasing and a general lowering of concentrations in surface sediment is occurring, it is likely to be many years before the most sensitive species fully recover.

Some areas naturally contain high levels of heavy metals (eg copper and zinc) washed out from dissused mine workings and geological strata. These metals may accumulate in the flesh without harming the bivalves but may render them unpalatable due to their unpleasant flavour. Copper tainting, for example, has been reported from some areas of the Fal, Tamar and Lynther (Cornwall) but this type of contamination and others, such as oil taint (Southampton Water (Hampshire)) can be removed by relaying stock in unpolluted waters for several months.

Specific instances of oil spillages which affect molluscan shellfisheries are rare. However, in 1989 a small spillage of diesel fuel oil (estimated to be about 0.25 t) occurred near to be mussel beds in the R. Conwy, Gwynedd, Wales, causing a temporary closure of the fishery as a precautionary measure.

Predicting consumer detection of tainting, taint depuration in mussels exposed to diesel and standardizing sensory procedures supporting EC Directives is seen by some European institutes as an important research need. An initiative proposed by the University of Birmingham (School of Psychology) and MAFF Torry Research Station together with institutes in the Netherlands and Spain is seeking funds (FAR) to support this research.

Radioactivity in surface and coastal waters of the British Isles

The DFR monitoring programme is set up to verify the satisfactory control of liquid radioactive waste discharges to the aquatic environment, and to ensure that the resulting public radiation exposure is within nationally-accepted limits. The most recent report describes the results of the environmental monitoring programme carried out during 1989 (MAFF 1990b). Table 5 (Table 46 in MAFF 1990b) summarises the estimates of public radiation exposure from discharges of liquid radioactive waste in the UK, 1989. Committed effective dose equivalents were all within the International Commission on Radiobiological Protection (ICRP) - recommended principal dose limit of 1mSv year-1 for members of the public.

Sewage contamination

The per capitata consumption of molluscan shellfish in the UK is low and cases of shellfish poisoning are comparatively few. As with other foods, contamination and subsequent illness may occur as a result of poor handling and post-harvesting hygiene. Particular problems can occur from the consumption of bivalve molluscs where these are taken from waters contaminated with sewage and have not expelled bacteria and viruses prior to harvesting for consumption. The species of most concern are oysters, clams, mussels and cockles which predominately come from estuarine and coastal waters and therefore are more prone to sewage contamination, particularly in the waters of the more densely populated areas of England and Wales. Production of these species amounted to 24,600 tonnes in 1990. Few problems are associated with scallops because they come from deeper and therefore less polluted waters and only the muscle meat is consumed.

The shellfish waters around the coast of England and Wales, which are sufficiently contaminated with domestic and/or industrial discharges so that shellfish grown in them may not meet the standards for safeguarding public health may be subject to "closure orders". Figure 2 shows the distribution of waters subject to "closure orders" in England and Wales. Depending on the level of pollution within a "closure order", bivalve shellfish may or may not be allowed to be sold for consumption. The terms of the "closure order" specify whether the bivalve molluscs may be sold subject to cooking, or cleansing free of

Table 1 (from MAFF 1991)

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Table 2 (from MAFF 1991)

Mean summer (May to September) concentrations (ng l^{-1}) of tributyltin in the water of UK estuaries, marinas and harbours, 1986-1989

Estuary/location	Shellfish site	1986	1987	1988	1989
Crouch	Fambridge	15 ± 8	33 ± 27	21 ± 8	13
	Bridgemarsh	22 ± 12	17 ± 12	13	8
	Creeksea	35 ± 17	17 ± 9	22 ± 14	8 ± 2
	Burnham	15 ± 17	21 ± 18	23 ± 18	11 ± 4
	Bush Shore	26 ± 9	22 ± 15	13 ± 5	8
	Roach mouth	26 ± 12	18 ± 13	15 ± 12	8 ± 7
	Holliwell Buoy	11	26 ± 23	10 ± 4	3 ± 2
	Holliwell Point	16	6 ± 5	6 ± 5	2
Blackwater	West Mersea	38 ± 21	36 ± 29	76 ± 43	25
Dart	Blackness Point	38 ± 33	13 ± 4	13 ± 5	8 ± 3
Kingsbridge	Frogmore	15 ± 6	11 ± 6	51 ± 95^{b}	5 ± 2
Teign	Arch Brook	12 ± 10	7 ± 6	6 ± 2	6 ± 4
	Marinas/harbours				
Plymouth	Sutton marina	1160 ± 84	882 ± 323	274 ± 79	266 ± 134
Dart	Dart marina	95 ± 66	85 ± 32	21 ± 4	16 ± 6
Kingsbridge	Salcombe	117 ± 84	62 ± 71	30 ± 18	21 ± 15
Teign	Teignmouth	22 ± 24	23 ± 25	19 ± 12	25 ± 15
Beaulieu River	Bucklers Hard*	93 ± 45	1090 ± 1850^{a}	82 ± 9	25 ± 7
Southampton Water	Hythe marina			1960 ± 2470^{c}	93 ± 62

**Also a shellfish site*
^{a}263 ± 130 without June value, ^{b} 8 ± 2 without August value, ^{c} mean = 728 without May value
SD only given where n > 4

Table 3 (from MAFF 1991)

Mean summer (June to August) concentrations (µg g^{-1} wet weight) of tributyltin in Crassostrea gigas, 1986-1989

Estuary	Site	1986	1987	1988	1989
Crouch	Fambridge	1.61	1.64	0.62	0.36
	Bridgemarsh	1.20	1.46	0.44	0.33
	Creeksea	1.49	1.73	0.61	0.38
	Burnham	1.24	1.57	0.50	0.45
	Bush Shore	0.74	1.26	0.34	0.31
	Roach mouth	0.80	0.98	0.24	0.27
	Holliwell Buoy	0.37	0.56	0.17	0.11
	Holliwell Point	0.18	0.28	0.08	0.08
Blackwater	West Mersea	2.26	2.18	1.34	0.65
Dart	Blackness Point	0.88	1.35	0.50	0.26
Kingsbridge	Frogmore	1.39	1.44	0.48	0.21
Teign	Arch Brook	0.30	0.49	0.25	0.13
Beaulieu	Bucklers Hard	6.35	3.65	5.60	1.28

Summarised estimates of public radiation exposure from discharges of liquid radioactive waste in the UK, 1989.

Establishment	Radiation exposure pathway	Critical group	Exposure[*], mSv
British Nuclear Fuels plc			
Sellafield	Fish and shellfish consumption	Local fishing community	0.19
	External	Houseboat dwellers (River Ribble)	0.17
	Handling of fishing gear	Local fishing community	< 0.1[#]
	Porphyra/laverbread consumption	Consumers in South Wales	< 0.01
Springfields	External	Houseboat dwellers (River Ribble)	0.17[a]
Capenhurst	Shellfish consumption	Local fishing community	< 0.1[a]
Chapelcross	Fish and shellfish consumption) External)	Local fishermen	< 0.1[a]
United Kingdom Atomic Energy Authority			
Harwell	Fish consumption) External)	Anglers[•]	< 0.01
Winfrith	Fish and shellfish consumption	Local fishing community	0.03
Dounreay	Handling of fishing gear	Local fishermen	< 0.1[#b]
	External	Local community	< 0.01[b]
	Fish and shellfish consumption	Local fishing community	< 0.01[b]
Nuclear Power Stations Operated by the Electricity Companies			
Berkeley and Oldbury	Fish and shellfish consumption) External)	Local fishing community	< 0.01[b]
Bradwell	External	Houseboat dwellers	< 0.02[b]
Dungeness	External) Fish and shellfish consumption)	Bait diggers	0.01
Hartlepool	Fish and shellfish consumption	Local fishing community	< 0.01[a]
	External	Coal collectors	< 0.001[a]
Heysham	Fish and shellfish consumption) External)	Local fishing community	0.15[a] < 0.1[a]
Hinkley Point	Fish and shellfish consumption) External)	Local fishing community	< 0.01[b]
Hunterston	Fish and shellfish consumption) External)	Local fishing community	< 0.02[a]
Sizewell	Fish and shellfish consumption) External)	Local fishing community	< 0.003[b]
Torness	Fish and shellfish consumption) External)	Local fishing community	< 0.001[a]
Trawsfynydd	Fish consumption) External)	Local fishing community	0.09
Wylfa	Fish and shellfish consumption) External)	Local fishing community	0.01[a]
Defence Establishments			
Aldermaston	Fish consumption) External)	Anglers[•]	< 0.002
Chatham	External	Houseboat dwellers	< 0.01
Devonport	External	Bait diggers	< 0.01
Faslane	Fish and shellfish consumption) External)	Anglers	< 0.01[a]
Rosyth	External	Dredgermen	< 0.01[a]
Holy Loch	External	Local community	< 0.01[a]
Amersham International plc			
Amersham	Fish consumption) External)	Anglers[•]	< 0.01
Cardiff	Fish and shellfish consumption) External)	Local fishing community	< 0.1

[*] Unless otherwise stated represents the committed effective dose equivalent, to be compared with the ICRP recommended principal dose limit of 1 mSv year^{-1} or with the subsidiary limit of 5 mSv year^{-1} provided the lifetime average does not exceed 1 mSv year^{-1} (see sub section 3.4)

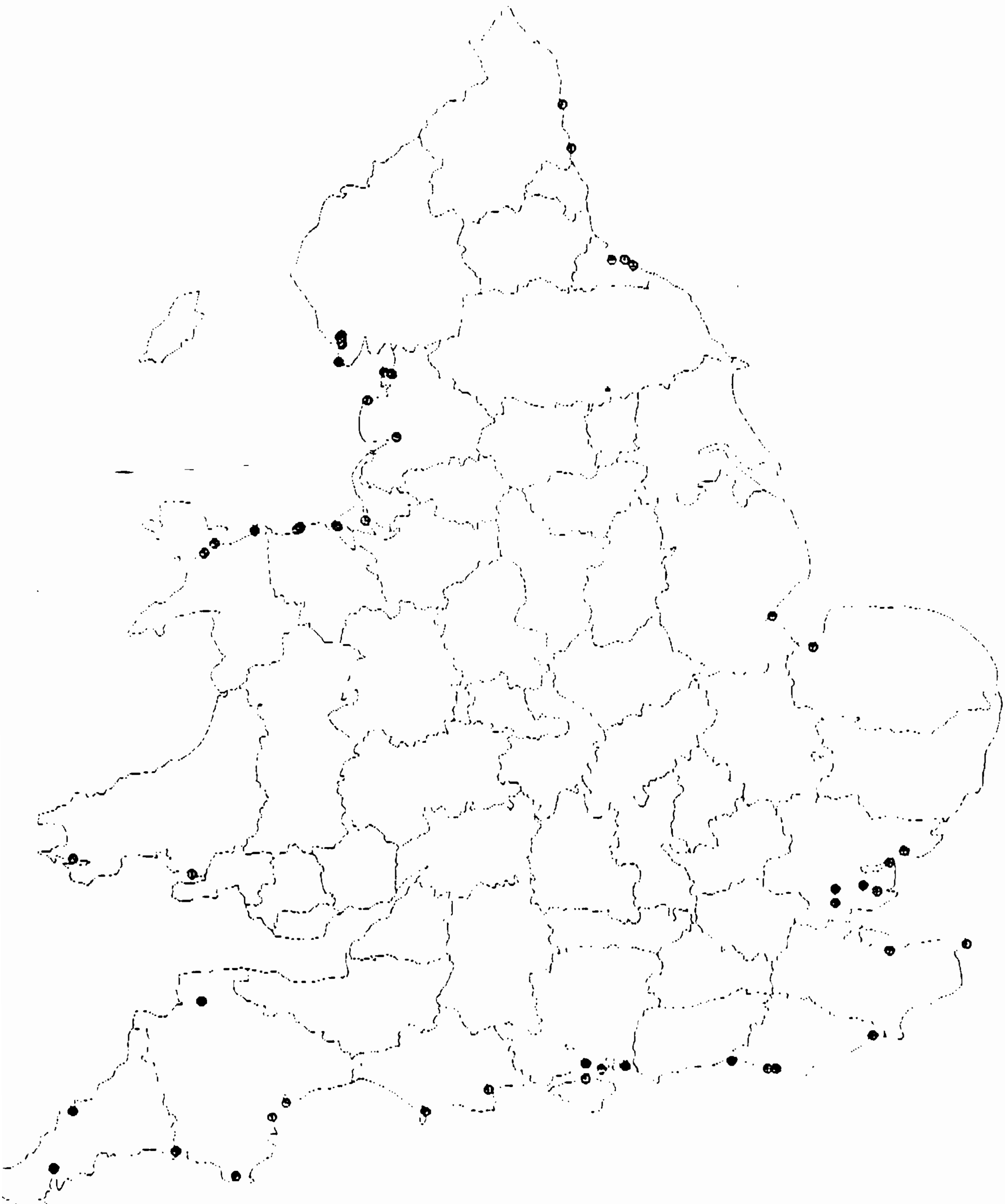
[•] A notional group with maximising consumption and occupancy rates has been assumed (see text)

[#] Exposure to skin, to be compared with the ICRP recommended dose limit of 50 mSv year^{-1} (see sub section 3.4)

[a] Mainly due to discharges from Sellafield

[b] Partly due to discharges from Sellafield.

Shellfish Closure Orders 1989



Produced by Cartographic Unit (HQ), FCS, ADAS, Gloucester, September 1989
Reference 209241MG71

* Due to limitations of the base map data this MAFF Divisional boundary has to be included

Figure 2