A BIG FISH IN A SMALL POND:

THE GLOBAL ENVIRONMENTAL AND PUBLIC HEALTH THREAT OF SEA CAGE FISH FARMING

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Introduction:

Aquaculture is the fastest growing sector of the world food economy but has proceeded way in advance of environmental and public health safeguards. Chile, in particular, has experienced phenomenal economic growth (Barton: 1997, 1998a) at the expense of environmental concerns (Hardy: 1994, Buschmann et al: 1996, Barton: 1998b, Hutchison: 1998, Claude: 2000, Franklin and Woods: 2001, Martinez: 2000, Langman: 2002). The threats identified in the 1970s and 1980s (Odum: 1974, Ackefors and Rosen: 1979, Beveridge: 1984, Earll et al: 1984, Luxmore: 1984) have been systematically ignored by Governments around the world intent on protecting and promoting aquacultural expansion rather than consumer and environmental protection. The lessons learned in Norway and Scotland, for example, are being ignored as the same companies make the same environmental mistakes in different areas of the world economy. So much so that aquaculture and farmed fish products now represent a global threat to both the marine environment and consumer safety (WHO: 1999). Sea cage salmon farming presents insurmountable global environmental problems in terms of mass escapes, the spread of infectious diseases, parasite infestation, the reliance upon toxic chemicals, contamination of the seabed and the discharge of untreated waste effluents (ICES: 1996, Sierra Legal Defence Fund: 1997, Weber, 1997, ICES: 1999, Black: 2001, Milewski: 2001, Philippine Daily Inquirer: 2002).

Government inquiries in Canada (Environment Assessment Office: 1998) and Scotland (Berry: 2000, Scottish Executive: 2000, Staniford: 2001b, Scottish Parliament: 2002) as well as NGO initiatives such as the 'citiziens inquiry' organised in British Columbia (Leggatt: 2001) or the 'parliament of the sea' in Chile (Ecoceanos: 2001a) have focused public attention. NGO reports in Chile (Claude: 2000, Ecoceanos: 2002), the United States (Goldburg and Tripplett: 1997, Goldburg et al: 2001), Ireland (O'Brien: 1989, O'Sullivan: 1989, Meldon: 1993), Canada (Ellis: 1996, Milewski et al: 1997, Friends of Clayoquot Sound: 1998) and Scotland (Bishop: 1987, Ross: 1997, Berry and Davison: 2001, Staniford: 2001a, Lymberry: 2002) have all raised awareness of the environmental impacts of salmon farming. All have served to open up the debate concerning the future of fish farming (Charron: 2000, Seaweb: 2002) and have led many commentators around the world to question the

very legitimacy of salmon farming (Newswatch Canada: 1994, Hide: 1996, Morton: 1996, Hutchison: 1998, Lindbergh: 1999, Ride: 2000, Wigan: 2000, Babcott: 2001, Blythman, 2001, Bristow: 2001, Franklin and Woods: 2001, Galvin: 2001, Gibb: 2001, Girling: 2001, Miller: 2001, Orr: 2001, Stanley: 2001, Tabak: 2002, The Economist: 2001, The Steelheader: 2001, Langman: 2002, Hamilton-Paterson: 2002, Hunt: 2002, Salt Spring News: 2002). Whilst there are undoubtedly many examples of responsible and sustainable aquaculture open sea cage finfish farming is surely not one of them (Folke and Kautsky: 1989, 1992, Holdgate: 1995, Reinertsen and Haaland: 1995, Wu: 1995, Naylor et al: 2000, Black: 2001, Tacon and Barg: 2001, Tidwell and Allen: 2001, Cripps: 2002, Roth et al: 2002). Any industry which is reliant upon a fast-diminishing fisheries resource to fuel its own expansion and which discharges untreated contaminated wastes directly into the sea affecting other coastal users is hardly sustainable. And the potentially fatal sting in the tail is that farmed salmon contains high levels of contaminants such as dioxins and PCBs (Jacobs: 2000, Wigan: 2001, Easton: 2002). In so many ways, the phrase 'sustainable salmon farming', like so-called 'organically farmed salmon' is an oxymoron (Staniford: 2001c).

From family to factory fish farming:
Sea cage fish farming has ushered in a new era of resource exploitation which is both irresponsible and unsustainable. Over thirty years ago the environmental economist Garrett Hardin (1968) predicted that:

"The fish populations are exploited as commons, ruin lies ahead….only the the replacement of the commons with a responsible system can save oceanic fisheries"

Far from being a panacea for the decline in wild fisheries, sea cage salmon farming has compounded the crisis. Indeed, the term 'responsible aquaculture' (Tacon and Barg: 2001) is a foreign country in today's world of salmon farming. As fish have become privatised multinational monopolisation and monocultural intensification, the last two decades has seen a fundamental shift away from 'family' towards 'factory' fish farming and a marked transition from a capture to a culture economy (Aitken and Sinclair: 1995, Williams: 1996). In 1984 aquaculture accounted for only 8% of fisheries production leaping to ca. 25% in 2001 and by 2020 aquaculture is predicted to have overtaken capture fisheries. This is already the case for salmon where farmed production was 1.1 million tonnes in 2000 compared to a wild catch of 723,000 tonnes (Berge: 2001, Berge: 2002). World salmon farming production is predicted to double to over 2 million tonnes in 2010 (in 1996 it was 600,000 tonnes and only 50,000 tonnes in 1985) (Intrafish: 1999). Global expansion has been fuelled by fewer but larger companies. Norwegian and Dutch multinationals dominate the salmon farming sector in Chile, Scotland, Ireland and Canada (Jensen: 2000). In 2000, the 30 largest salmon farming companies in the world achieved a total production of 666,300 tonnes (expected to rise to 959,000 tonnes in 2001), accounting for ca. 60% of the world's total farmed salmon production (Berge: 2001). Nutreco (Nutreco: 2001a, 2001b, Nutreco: 2002), twice as big as the next on the list, is the world number one with Cermaq, Fjord Seafood and Domstein merging in May 2002 to become the second largest (Berge: 2002). Such is the stranglehold of multinationals that four companies now control over 80% of the world's salmon feed market (Charron: 1999). Intrafish describes the situation as "almost incestuous with

so many merger talks and buyouts in the global aquaculture industry" (Berge: 2001). Nutreco, which has "vast untouched resources in Chile" estimated at 200,000 tonnes (Berge: 2001), has been heavily criticised with strikes in Chile last year (Carvajal: 2001, Ecoceanos: 2001c, Nutreco: 2001a), a 15% fall in its share price following reports of high levels of dioxins in farmed salmon (Intrafish: 2001a) and an 'Earth Alarm' investigation by Friends of the Earth Netherlands (Milieudefensie: 2001). Today, a single farm can cover many hectares of coastal area and raise up to one million fish on a site (Milewski: 20010. The ecological footprint is now so large that salmon farming is far too big for its boots (Folke et al: 1998, Martinez: 2000, Naylor et al: 2000, Thomas: 2001).

The false economy of sea cage fish farming:
Farming carnivores such as salmon, halibut, cod, sea bass, sea bream and tuna so high up the food chain is a case of 'robbing Peter to pay Paul'. According to Dr Daniel Pauly (Thomas: 2001), speaking at last year's American Association for the Advancement of Science conference:

"The new trend in aquaculture is to drain the seas to feed the farms. Meanwhile capture fisheries now focus on what we once considered bait. These two trends - farming up and fishing down the food web - imply massive impacts on marine ecosystems that are clearly unsustainable"

Given the net loss in fisheries resources it is no wonder fishermen feel short-changed and are increasingly questioning the impact of fish farming expansion on the fisheries sector (Butler et al: 2001, Cameron: 2001d, The Fishermen's Voice: 2001, Hunt: 2002). Since both parties are pulling in opposite directions - one farming up and one fishing down the food chain - such a clash of cultures will inevitably have global repercussions. A paper in the scientific journal Nature (Naylor et al: 2000) has calculated that over 3 tonnes of wild fish are required to produce one tonne of farmed salmon, for example (for other marine fish this rises to over 5 tonnes) [1]. Farming salmon is like farming tigers and has been described as 'biological nonsense' (Goldburg and Tripplett: 1997). On land we only farm herbivores such as cattle, pigs, sheep and chickens so why do we not apply the same principles when farming in the sea? Sadly, common sense is not a currency those bankrolling salmon farming are used to dealing in. When all the environmental, economic and social costs are internalised, sea cage fish farming makes precious little sense at all (Folke et al: 1994, Ellis: 1996, Folke et al: 1997, Naylor et al: 1998, 2000, Lindbergh: 1999, Claude: 2000, Tyedmers: 2000, The Economist: 2001, Tidwell and Allen: 2001). By not paying for waste disposal salmon farmers are effectively freeloading on the coastal marine environment. Integrated salmon farming and seaweed cultivation, for example, can partially offset some of the environmental costs (Troell et al: 1997) but it is difficult to escape the conclusion that this represents anything other than a net deficit (Barton and Staniford: 1998). Similarly, the inclusion of shellfish and seaweeds into a salmon farming system (Folke and Kautsky: 1989, Sota and Medena: 1999, Chopin et al: 2001) may ameliorate the waste problem but the industry's reliance upon toxic chemicals makes shellfish farming alongside salmon incompatible.

Salmon farming is running on empty - it is literally running out of fuel (Bishop: 1987, Naylor et al: 2000, Tacon and Forster: 2000, Jystad: 2001, Hjellestad: 2001a, 2001b). Such is aquaculture's appetite for seafood that it already consumes ca. 75% of the world's fish oil and ca. 40% of the world's fish meal (IFOMA: 1990a, 1990b, Pike and Barlow: 1999). The International Fishmeal and Oil Manufacturers Association predict that by 2010 aquaculture could consume 56% of the world's fishmeal and 90% of the world's fish oil (Charron: 1999, Pike and Barlow: 1999). According to to the Food and Agriculture Organisation, by 2010 salmon and trout alone could consume 620,000 tonnes of fish oil (Jystad: 2001). Like crude oil, fish oil - the new blue gold - has become a key commodity in the world economy with demand outstripping supply and rising prices (Hjellestad: 2001b, 2001c, Staniford: 2001b). Fisheries resources are becoming so scarce and so expensive that salmon companies are stockpiling fish feed and investing in fishing fleets to catch fish themselves. In June last year the Research Council of Norway, where a staggering 80% of all fish caught by Norwegian trawlers is used to provide feed for the fish farming industry, predicted that "within three to eight years the lack of marine oil raw materials could hinder the growth of Norwegian salmon farming" (Hjellestad: 2001a). Not only is this fuel supply fast running out but also the remaining fish is contaminated with dioxins, poly-chlorinated bi-phenyls (PCBs) and organochlorine pesticides (Jacobs et al: 1997, 1998, 2000, 2002). Hence the increasingly desperate search for alternatives such as soya, seaweeds, krill and plankton (Jystad: 2001, Sinnott: 2002). The Institute of Marine Research in Norway explains how PCB contamination in fish meal has led them to seek substitutes further afield in the Arctic and further down the food chain in the shape of krill:

"PCB accumulates in fish, so there is more PCB higher in the food chain. That means that there is less PCB in krill, which is lower in the food chain" (Hjellestad: 2002)

Fish diets, especially those high in fish oils and fish meal, have also been linked to eutrophication (Talbot and Hole: 1994) and pollution (Johnsen and Wandsvik: 1991, Johnsen et al: 1993, Tacon: 2002). The substitution of fish feed with vegetable diets has been shown to have less of a waste impact on phytoplankton and hence on pollution (AQUATOXSAL: 2002) but salmon fed on vegetables is not to everyone's taste. For example, after a consignment of Norwegian farmed salmon was sent back by Japan, the managing director of the Nutreco fish feed company Skretting said that 'the increased use of vegetable oil as an ingredient in fishfeed is suspected as a potential reason for the funny taste of the product' (FIS: 1999). Similar problems with taste have been encountered with farmed cod (Fossbakk: 2001) and there really is no substitute for wild fish. Any amount of technical tinkering (Sinnott: 2002, Smith: 2002) will not alter the fact that turning a carnivore into a herbivore is doomed to failure (Naysmith: 2001a). Salmon farming is like an oil tanker, leaving a trail of toxic waste in its wake, heading for the rocks. Unless it changes course immediately it will sink as quickly as it first reared its ugly head.

Cancer of the coast:

Salmon farming's capacity to foul its own nest is no more so apparent than in the lochs, bays, loughs, fjords and inlets around the coasts of Norway, Scotland, Ireland, British Columbia, New Brunswick, Maine, the Faroes, Tasmania, New Zealand and Chile. Norway is the world leader (ca: 450,000 tonnes) but Chile (ca: 400,000

tonnes) is fast closing the gap with Scotland (ca. 160,000 tonnes) ranked in third place. The rapid rise of Chilean farmed salmon in export markets has been described as the "Chilean invasion" (Berge: 2002) yet it has been fuelled predominantly by Norwegian companies (Jensen: 2000). Production in Chile, for example, is expanding so fast that exports of salmon and trout between January and March this year were 116,256 tonnes (Arias: 2002). The waters off China, Argentina, South Africa and France are next the multinational's shopping list but these countries should think twice before allowing salmon farms to pollute pristine coastal waters. In Canada (Hellou: 2002a, 2000b) and Scotland (Pirie: 2001, SEPA: 2001a) research has shown high levels of PCBs, DDT and alkylated polycyclic aromatic hydrocarbons (PAHs) in the sediments under salmon cages. The build-up of bacteria under cages (at up to 10 times the background environment) can also affect the health of the salmon themselves (Brown et al: 2000). The cocktail of toxic chemicals used on salmon farms jeopardises not only the marine environment but also the safety of workers (Douglas: 1995, GESAMP: 1997, Kelleher et al: 1998, Connolly: 2002). Chemicals used on salmon farms include carcinogens, mutagens and a myriad of 'marine pollutants'. The decision to licence them is based more on economic expediency than consumer safety and is tantamount to state-sponsored pollution (Merritt: 2002).

Other threats include the interbreeding of wild salmon and farmed escapees (Clifford et al: 1998, Youngson et al: 1998, Hansen et al: 1999, Fleming et al: 2000, Galvin: 2001, Volpe: 2001), impacts on cetaceans (Morton and Symonds: 2001), sea lice infestation (Edwards: 1998, Butler: 2001, Watershed Watch: 2001, Bjorn and Finstad: 2002, Butler: 2002) and the spread of infectious diseases such as Infectious Pancreatic Necrosis (IPN) and Infectious Salmon Anaemia (ISA) to wild fisheries (McAllister and Bebak: 1997, FoCS: 1998, Murray: 1999, McCarthy: 2000, Paone: 2000b, Cameron: 2001c, Royal Society of Edinburgh: 2001). ISA outbreaks have been recorded since 1998 in Scotland, Maine, the Faroes and Norway where the situation is described as "worse than ever" (Solsletten: 2001). In Canada this year an outbreak of Infectious Hematopoietic Necrosis (IHN) led to over one million fish being slaughtered (4 million salmon were slaughtered during the ISA outbreak in Scotland). In May a deadly new parasite was discovered at a salmon farm in Northern Norway threatening one of the best Atlantic salmon rivers in Europe (Intrafish, 2002b). An obvious way of spreading diseases, parasites and genetic pollution is via escapes. There have been over 1 million reported escapes from fish farms in Scotland alone since 1997 with an estimated 5 million in Norway over the last decade. In the Faroes in February this year 600,000 salmon escaped (Intrafish: 2002a) in what is believed to be the largest escape anywhere in the world and escapes are such a problem that in British Columbia Atlantic salmon are now breeding in the Pacific (Needham, T: 1995, Volpe et al: 2000, Volpe et al: 2001) and have been caught in Alaskan waters. Any Atlantic salmon caught in Chile will also be escapees. Nor does the introduction of GM technology (GM salmon trials have already taken place in New Zealand, Scotland, Canada and Chile) augur well for the future (Van Acken: 2001, Solar: 2002). And the replacement of contaminated fish meal and fish oil in the diets of farmed salmon with GM soya will inevitably meet with consumer resistance, especially in Europe (Jystad: 2001). Welcome to the brave new world of 21st century fish.

Chemical culture:

Flooding coastal waters with a cocktail of toxic chemicals is the antithesis of the precautionary principle (Ross: 1989) and highly questionable under international environmental law (OSPAR: 1994, GESAMP: 1997). For example, despite a background of increasing environmental and public health concerns (PAN: 1997, DETR: 1998, Rodger: 1999, Davies et al: 2001, Zitko: 2001), the Scottish Environment Protection Agency (SEPA) has opened the floodgates to chemical use on salmon farms (Redshaw: 1995, SEPA: 1997, SEPA: 1998a, Carrell: 2000, Rae: 2000). Since 1998 the UK Government have approved over 700 chemical licences for cypermethrin (trade name Excis), azamethiphos (Salmosan), teflubenzuron (Calicide) and emamectin benzoate (Slice) (Merritt: 2002). Even before 1998 the UK aquaculture industry was hooked on a wide range of toxic chemicals including dichlorvos, ivermectin and antibiotics (Rae: 1979, Ross: 1990, Davies: 1991, SWCL: 1992, SWCL: 1993). A typical discharge consent issued by SEPA to salmon farmers permits the use of over 50 different chemical formulations including antiparasitics, antibiotics, antifoulants and disinfectants and the number of 'medicines' licensed for use on salmon farms by the Veterinary Medicines Directorate increased from 3 in 1989 to ca. 40 in 2002 (Henderson and Davies: 2001). Since Scotland is acknowledged as the most difficult country to secure approvals (Cameron and Charron: 2001), chemical consumption in other salmon farming countries such as Norway, Canada and Chile may be even higher. In the Scottish Parliament questions concerning the exact quantities of chemicals used remain unanswered (Cameron: 2002a). Other requests for chemical data have been denied by either the Government or the chemical companies concerned but figures that are available are alarming. According to the Scottish Government (Scottish Office: 1992) the annual use of chemicals in 1989 was as follows: Chloramine-T (1.5-2 tonnes), formaldehyde (14 tonnes), vaccines (2,400 litres), iodophors (5 tonnes), furazolidone (0.2 tonnes), ethoxyquin (4-5 tonnes), dichlorvos (20-50 tonnes), sulphadiazine and trimethroprim (0.2 - 0.3 tonnes), oxolinic acid (8-10 tonnes), oxytetracycline (8-10 tonnes), malachite green (1.5 tonnes), canthaxanthin (1.5-2 tonnes), astaxanthin (1.5-2 tonnes), copper oxide (small) and methyltestosterone (0.1 gram). Since 1989 the Scottish salmon farming industry has increased five-fold.

Elsewhere in Canada (Burridge and Haya: 1995, DFO: 1996, Ellis: 1996, CCNB: 1998, Environmental Assessment Office: 1998, Ernst et al: 2001) and Norway (Grave et al: 1991, DNM: 1999, Grave et al: 1999, Horsberg: 2000, ICES: 1999, FIS: 2001) a global picture of drug abuse in salmon farming is becoming clearer. In Chile, certainly in the mid-1990s, diseases were controlled "mainly by an increasing and often indiscriminate use of antibiotics" (Hide: 1996). Moreover:

"An international survey revealed that eleven compounds representing five pesticide types are currently being used on commercial salmon farms for sea lice control. These include two organophosphates (dichlorvos and azamethiphos); three pyrethrin/pyrethroid compounds (pyrethrum, cypermethrin, deltamethrin); one oxidizing agent (hydrogen peroxide); three avermectins (ivermectin, emamectin and doramectin) and two benzoylphenyl ureas (teflubenzuron and diflubenzuron). The number of compounds available in any one country is highly variable, ranging from 9 (Norway) to 6 (Chile, United Kingdom) to 4 (Ireland, Faeroes, Canada) to 2 (US). Dichlorvos, azamethiphos and cypermethrin were the most widely used compounds (5 countries) followed by, hydrogen peroxide, ivermectin and emamectin (4 countries

each), teflubenzuron (3 countries), diflubenzuron (2 countries), and deltamethrin, pyrethrum and doramectin (1 country each), although, like trichlorfon, dichlorvos use is being discontinued in several countries notably Norway and the Faeroes" (Roth: 2000)

In Norway, as dichlorvos use slowed down a new suite of chemicals such as azamethiphos, praziquantel, fenbendazole, diflubenzuron, deltamethrin, emamectin and teflubenzuron took its place (Horsberg: 2000). Salmon farming is locked into a chemicals arms race (Sommerville: 1995), be it legally via state-sponsored pollution or via salmon farmers using toxic chemicals such as ivermectin and cypermethrin (both often referred to as "jungle juice" or "horsey stuff") illegally. In Shetland the problem is so visible that chemical containers have been washed up on the beach (SEPA: 2001b). Nor are Scottish salmon farmers the only ones guilty of using toxic chemicals illegally (SEPA: 1998b, Barnett: 2000, BBC: 2000, FoE: 2000, SEPA: 2002, VMD: 2002). Salmon farmers in Norway (Jensen: 2001), the United States (Ernst et al: 2001) and Chile (Franklin and Woods: 2001) have all been caught out. As SEPA stated:

"There is some illegal use of cypermethrin in Canada, often at night using high concentrations and no tarpaulin. There has been some alleged illegal use of cypermethrin products in Shetland using compounds which contain persistent aromatic hydrocarbons" (SEPA: 1997)

Most of the chemicals used on salmon farms to kill sea lice also kill other sea life (Edwards: 1996) and some are so toxic that they can cause cataracts in farmed salmon (Fraser et al: 1989, Fraser et al: 1990). Shellfish farmers have expressed concern over the use of chemicals (MacLeod: 2000, Ross and Holme: 2001) and some even have disruptive effects on the reproduction of wild Atlantic salmon (Moore and Waring: 2001). Azamethiphos, cypermethrin, teflubenzuron and emamectin are all labelled as "marine pollutants" on the chemicals manufacturers Safety Data Sheets. Unsurprisingly they do exactly what they say on the tin. It hardly takes a rocket scientist to work out that "marine pollutants" pollute the marine environment (Staniford: 2002). The European Medicines Evaluation Agency, for example, openly conceded that "the proposed use of Azamethiphos in fish farming means that deliberate contamination of the environment will occur" (EMEA: 1999). SEPA have also admitted that azamethiphos is ten times more toxic than another organophosphate, dichlorvos (SEPA: 1997) and Canadian research has also shown toxic effects of azamethiphos and cypermethrin on lobsters (Burridge et al: 2000). Cypermethrin has recently been shown to have "area-wide effects" on sensitive species such as shellfish (Ernst et al: 2001) and significant impacts on salmon's sense of smell (Moore and Waring: 2001). An ongoing Government-sponsored study by the Scottish Association of Marine Science also highlights the potential risks of the sea lice chemicals such as teflubenzuron and emamectin (Natural History Museum: 1997, Scottish Association of Marine Science: 2002a, 2002b, Edwards: 2002b). Early indications are that "teflubenzuron and emamectin causes mortality and deformity at very low concentrations" and "that sea lice chemicals may exert significant ecological effects at concentrations well below indicative LC50 values and after only brief exposures" (SAMS: 2002b). The project, part of which has been plagued by

problems including logistical difficulties between scientists and salmon farmers (Edwards: 2002b), states that:

"The chemicals used to control sea lice are highly toxic to crustaceans, and are used by the salmon farming industry because of their efficacy at killing certain life stages of the parasitic copepods. The little data available on the toxicity of sea lice chemicals to planktonic copepods is confined to less ecologically relevant species. Because planktonic copepods have a similar life cycle to parasitic copepods they are also likely to be adversely affected. Copepods are of prime importance in marine ecosystems and numerically dominate in the zooplankton. They form the base of virtually all pelagic food chains and provide the link between phytoplankton and fish. The toxicity of three sea lice treatment chemicals, cypermethrin, emamectin benzoate and teflubenzuron, to common planktonic copepods is being investigated using laboratory bioassays and in situ exposures" (SAMS: 2002b)

In the meantime, however, there is a dearth of environmental information in the public domain on the more recent chemicals such as emamectin benzoate (Stone et al: 2000) and teflubenzuron (Anon: 2000, Trouw Aquaculture: 2000). Nutreco have undertaken a project in conjunction with the Scottish Association of Marine Science, for example, on the impact of Calicide (teflubenzuron) on sea urchins but this remains unpublished (SAMS: 2001) and requests for further information have been refused on grounds of 'commercial confidentiality'. Figures produced by Nutreco, the manufacturers of Calicide, help explain why such documents are not yet in the public domain: 90% of the parent compound (teflubenzuron) is excreted via faeces with high levels still detected some 18 months after chemical treatment (Nutreco: 1998). Other scientific papers on the environmental impact of Calicide remain 'private and confidential' (Institute of Aquaculture, McHenery: 1999, Ritchie: 1999). The Association of Scottish Shellfish Growers, who voted in 2001 for a moratorium on the expansion of salmon farming (Ross and Holme: 2001), said that "Calicide is one chemical too far for the marine environment in general and shellfish interests in particular" (MacLeod: 2000). Instead SEPA have approved over 100 licences for the use of Calicide.

Judging by the time lag between the use of chemicals such as ivermectin (Duffus: 1996a, Davies et al: 1998, Grant and Briggs: 1998a. 1998b, Cannavan et al: 2000), TBT (Balls:1987, Davies et al: 1998), azamethiphos (Gillibrand and Turrell: 1999, Abgrall et al: 2000, Ernst et al: 2001), cypermethrin (Ernst et al: 2001, Moore and Waring: 2001) and dichlorvos (Dobson and Tack: 1990, Wells et al: 1990, Murison et al: 1997, McKeown and Hay: 1998) and scientific publication it may be a decade until these risk assessments enter the peer-reviewed public domain. Since 'commercial confidentiality' often precludes publication, for the time being at least, any environmental risk assessments of the latest chemicals remain unpublished or 'private and confidential' (e.g Natural History Museum: 1997, Nutreco: 1998). Even reports dating back over ten years are still not in the public domain as the chemical companies concerned have either refused to publish them (Ciba-Giegy: 1987a, 1987b, 1988a, 1988b, 1988c, Duffus: 1996a, McHenery: 1999, Ritchie: 1999) or the UK Government, for example, have deemed them 'Security Level 1' documents out of reach of the general public (e.g Davies: 1991, Seafish Industry Authority: 2001). Other UK Government reports are so confidential the name of the chemical is given a

security code instead of a name (Madden et al: 1992a, 1992b, McHenery: 1991a, 1991b, Callahan et al: 1992) or the documents are "not to be quoted without prior reference to the authors" (e.g Murison et al: 1990, Wells et al: 1990, Robertson et al: 1991, Scottish Office: 1992, McKeown and Hay: 1998, Gillibrand and Turrell: 1999). Such is the pervasive culture of secrecy in Scotland (Bristow: 2001, Edwards: 2001a, 2001b).

The most blatant example of the failure to control chemical discharges from salmon farms is the organophosphate pesticide dichlorvos (Ross and Horsman: 1988, Ross: 1990, Edwards: 2002a) which is also known as 'Nuvan', 'Aquagard' or 'Neguvon' (in fly spray killers it goes by the catchy trade name 'Doom'). In Scotland, trials of dichlorvos, which involved dangling dichlorvos fly-strips into the salmon cages, were conducted by Unilever in Loch Ailort in 1976 (Rae: 1979, Saward et al: 1982) and despite an increasing body of research showing both environmental and public health concerns (Stanislawska-Swiatkowska and Ranke-rybicka: 1976, Ross and Horsman: 1988, Murison et al: 1990, Murison et al: 1997, EPA: 2000) dichlorvos use on salmon farms in Scotland continued throughout the 1980s and 1990s (Novartis - formerly Ciba-Giegy withdrew the licence in November 1999). In Norway and the Faroes, the use of dichlorvos (and trichlorfon which degrades into dichlorvos) was discontinued in the mid-1990s (Roth: 2000) but ca. 7 tonnes were used in 1989 (ICES: 1999, Horsberg: 2000). The UK's Department of the Environment estimated in 1991 that "10-20 tonnes" of dichlorvos (up to 5 times all other household, pest control and agricultural uses combined) was used annually on Scottish salmon farms (DoE: 1991) and the Scottish Office calculated that "20-50 tonnes" were used in 1989 (Scottish Office: 1992). SEPA admitted this year that many licences to use dichlorvos are still active (Edwards: 2002a, Cameron: 2002b). So many litres of dichlorvos were poured into Scottish lochs that by the 1990s sea lice developed resistance (Jones et al: 1992).

Dichlorvos was also used extensively in Ireland (Tully and Morrissey: 1989) where a former worker with testicular cancer is now taking legal action (Connolly: 2002), Chile (SEPA: 1999a, Kent: 2000) and Norway (Samuelsen: 1987, Grave et al: 1991, Horsberg: 1999) with trials taking place in Canada (Cusack and Johnson: 1989, Castledine and Armstrong: 1990). In Norway, the quantities of dichlorvos used were so high that fatal organophosphate poisoning of the farmed salmon took place (Salte et al: 1987, Horsberg et al: 1989) and residues were detected in the flesh of the salmon (Horsberg and Hoy: 1990). In Canada, it was discovered that the dichlorvos pesticide formulation Aquagard (manufactured by Ciba Giegy), which consists of the solvent di-n-butyphthalate is more toxic to juvenile Atlantic salmon that the active ingredient dichlorvos alone (Burridge and Haya: 1995). Following on from evidence gathered by the US Environmental Protection Agency (EPA: 20000), in July 2001 the Department of Health's Committee on Mutagenicty in the UK finally published evidence that dichlorvos was carcinogenic (DoH: 2001) and in April 2002 the UK Government eventually banned the use of dichlorvos (DEFRA: 2002). As late as 1998 human trials of dichlorvos were being conducted in England on behalf of the American chemical company AMVAC (EWG: 1998, Walth and Pulaski: 1999). A study on the leukemia, lymphoma and testicular tumours in Western Ireland "found a significant increase in testicular tumours in agricultural workers other than farmers, albeit with very small numbers; this group comprised predominantly those engaged in

fish farming" (Kelleher et al: 1998). Further studies are urgently required in other salmon farming coutries where dichlorvos use has been widespread. As yet:

"There is no evidence to date of an increase in this category of testicular malignancies in fish farm workers in other countries that retain adequate occupational surveillance data and have a significant fish farm industry such as Scotland and Scandinavia and there are no confimatory studies of tumours among the fish themselves, though potential toxicity to Nuvan, the principal agent used to control sea lice infestation has been studied at varying concentrations" (Kelleher et al: 1998, 656)

In Scotland, Norway, Ireland and Chile it seems salmon farmers have been blindly participating in a 25 year trial. Successful legal action in Ireland (Connolly: 2002) could open the floodgates to similar compensation claims.

The UK's Committee on Mutagenicity also published evidence showing malachite green was mutagenic in 1999 (Department of Health: 1999, Worldcatch: 2000, Carrell: 2001a). Malachite green has been used extensively, be it legally or illegally, in the UK (Alderman: 1985, Alderman: 1997), Norway (Jensen: 2001) and Chile (Franklin and Woods: 2001) for over 15 years and just last year was detected by the Veterinary Medicines Directorate in farmed salmon on sale in UK supermarkets (VMD: 2002). The same body also found PCBs in farmed salmon imported from Chile and Norway and in farmed trout from Denmark (Cameron: 2002c, VMD: 2002). Residues of chlordane, toxaphene, cadmium, DDT, dieldrin, oxytetracycline and dioxins have all been found in the flesh of farmed salmon. Copper and zinc from the excessive use of antifoulants have also been detected in sediments at over 20 times the safety limits (SEPA: 1998d) and the abuse of antibiotics has also left its mark (Capone et al: 1996). So extensive is the use of the artificial pigment canthaxanthin (Prodanou: 2001) that escaped salmon and fish feeding near salmon cages have been found containing pink dye (Fisheries Management and Ecology: 2000). And, rather vividly, "so persistent are these dyes that they tone the excrement to match" (Girling: 2001). The industry's purely cosmetic response has been to call such toxic chemicals 'vitamins', 'medicines', or 'chemotherapeutants'.

Ultimately, the policy of 'chemotherapy' is doomed to failure and it is certainly not sustainable (Alderman: 1999). Governments around the globe have colluded to allow salmon farmers free reign to pollute with impunity with soaring chemical use in aquaculture (Alderman: 1988, Meyer and Schnick: 1989, Michel and Alderman: 1992, Costello: 1993, Roth et al: 1993, Schnick et al: 1997, Schnick: 1998, Long: 2000, Rae: 2000, Roth: 2000, Costello et al: 2001, Henderson and Davies: 2001). Scientists have focused on the efficacy of killing sea lice to the exclusion of other marine impacts (Raverty: 1987, Buchanan: 1992, Stone et al: 2000, Toovey and Lyndon: 2000). Lest it be forgotten that sea lice are crustacea and so too are crabs, lobsters, prawns and shrimps and therefore chemicals designed to kill sea lice also have significant effects on other crustacea (Egidius and Moster: 1987, Murison et al: 1990, Berry: 1992, Burridge et al: 2000, Ernst et al: 2001). 'Harmonisation' of chemicals regulations is merely a euphemism for global approvals of yet more chemicals (Schnick: 1992, Armstrong: 1994, Schnick and Smith: 1999) with unknown synergistic effects of such a cocktail of chemicals. The only safe way of getting off the chemical treadmill is to start ripping out the salmon cages which have

spread like a cancer around our coasts. A moratorium on salmon farming expansion (Berry and Davison: 2001, Ecoceanos: 2001b) at the very least is urgently required. Last year Friends of the Earth Scotland called for a 'back to basics' approach advocating "The 3Rs": relocation, revocation and removal (FoE: 2001b). With a legacy of badly located farms and contaminated sites complete removal may be a bitter pill to swallow but it is the only sensible and sustainable solution. Moving cages around a single area (Goudey et al: 2001) is merely storing up problems for a later date (Pohle et al: 2001). Many farms in Scotland, for example in Loch Fyne and Loch Sunart, have been forced to move out of enclosed lochs due to overproduction (Staniford: 2001). The 'pollute and move on' mentality of shifting cultivation in the sea is surely not acceptable.

Toxic salmon wastes:
The global advance of intensive salmon farming has meant that farmed fish have become agents of pollution rather than biological indicators of pollution (Ruokolahti: 1988, Frid and Mercer: 1989, Ross: 1989, Alvial: 1991, Tsutsumi et al 1991, Wu: 1995, Grant and Briggs: 1998a, 1998b, Ernst et al: 2001). The capacity of fish farms to pollute the freshwater and inshore coastal environment is well documented (Hinshaw: 1973, Odum: 1974, Solbe: 1982, Gowen and Bradbury: 1987, Pearson and Gowen: 1990, Kelly: 1993) but the scale of salmon farming expansion is such that the wider marine environment is now at risk (GESAMP: 1996). The carrying capacity of coastal areas to support sea cage salmon farming (Beveridge: 1984, Barg: 1992) was surely breached years ago (Folke et al: 1994, 1997, 1998). Salmon farms have been shown to pollute the area directly under the cages (Earll et al: 1984, Brown et al: 1987, Braaten et al: 1988, Lumb: 1989, Lewis and Metaxas: 1991, Hargrave et al: 1993, Black et al: 1994a, Black et al: 1996, Provost et al: 1997, Intrafish: 2001c, Piker et al: 2002) but this 'self-pollution' can also extend out much further into coastal waters (BBC: 2002) and over much longer periods (Nickell et al: 1995, Pohle et al: 2000, Pohle et al: 2001) than predicted by models (Silvert: 1992, Silvert: 1994, Gillibrand and Turrell: 1997, Silvert and Cromey: 2001, Gillibrand and Cromey: 2002).

The release of nutrients to the sea from salmon farms has been increasingly linked to hypernutrification and eutrophication (Ackefors and Enell: 1990, Aure and Stigebrant: 1990, Handy and Poxton: 1993, Gowen: 1994, Folke et al: 1997, Chen et al: 1999, ICES: 1999, Arzul et al: 1999, Edwards: 2000, MacGarvin: 2000, Martin: 2000, Navarro: 2000, Arzul et al: 2001, Girling: 2001, Arzul: 2002, Dosdat: 2002, SAMS: 2002c, Tett and Edwards: 2002). Chemical wastes from salmon farms have also been linked to wider toxic effects and phytoplankton changes (Raine et al: 1990, McKeown and Hay: 1998, Lutzhoft et al: 1999, Haya et al: 2001, SAMS: 2002a) as well as impacts on fish health (Horsberg and Hoy: 1990, Black et al: 1994b, Moore and Waring: 2001) and the build up of bacteria (Brown et al: 2000). Sea cage farms littering the coast are in effect using the marine environment as an open sewer. In enclosed areas with low flushing rates this equates to flushing your toilet only once a month. The untreated effluent, including toxic waste containing chemicals such as dioxins and PCBs, generated by salmon farms is hardly a drop in the ocean (Bergheim and Asgaard: 1996, Hennessey: 1996, SEPA: 1998c, Davies: 2000). A major source of the nitrogen and phosphorus contamination (and of PCBs and dioxins) is the fish

feed itself (Johnsen and Wandsvik: 1991, Johnsen et al: 1993, Phillips et al: 1993, Talbot and Hole: 1994, Gavine et al: 1995, Arzul et al: 2002, Tacon: 2002).

At the European level, salmon farm wastes are receiving increasing scrutiny (Alabaster: 1982, Rosenthal et al: 1993, EC: 1995, HELCOM: 2001). The effluent from Norwegian salmon farms, for example, represents a significant and increasing part of Norway's coastal discharges of nitrogen and phosphorus (Braaten et al: 1983, Enell: 1995, Ervik: 1997, ENDS: 2000, Hansen et al: 2001). According to the Directorate for Nature Management phosphorus and nitrogen wastes from salmon farms increased from 2,500 to 3,500 tons and 13,000 to 16,000 tons respectively (DNM: 1999). It also stated that "in many countries, the aquaculture industry is the greatest source of human-created emissions of phosphorus and nitrogen". WWF have estimated that the 115,000 tonnes of Scottish salmon produced in 1999 equated with the phosphorus and nitrogen sewage waste equivalent of 9.4 million and 3.2 million people respectively (Scotland's population is only 5.1 million). Globally, salmon farms discharge the sewage waste equivalent of tens of millions of people. In the OSPAR Convention Area alone (including Scotland, Denmark, Norway and Ireland) nutrient discharges from aquaculture were estimated in 2000 at 36,000 tonnes of nitrogen and 6,000 tonnes of phosphorus (OSPAR: 2001). In the absence of discharges of human sewage, agricultural runoff or industrial effluent, aquaculture's contribution can be even more significant in isolated areas of the global economy.

Salmon farm wastes may tip the ecological balance to such an extent that toxic algal blooms are triggered (Black: 1993, Berry: 1999, Martin: 2000, Arzul: 2002). During the past decade, there has been a 'global epidemic' in marine microalgae that are harmful to finfish, shellfish and humans (Smayda: 1990, Hallengraef: 1993, Cookson: 2001). Mass mortalities of farmed salmon have been recorded recently in the Chiloe area of Chile (Carvajal: 2002), Shetland in Scotland (Cameron: 2001a) and in Norway (Tangen: 2002) where millions have died in their cages leading to severe financial losses (Cookson: 2001) and huge compensation claims. Mass mortalities are not new (e.g. Bruno et al: 1989) but their frequency is increasing. The crux of this simmering debate (Folke et al: 1994, Berry: 1996, Black et al: 1997, Folke et al: 1997, G3 Consulting: 2000, Berry: 2000, Scottish Executive: 2000) lies in the question of culpability and, ultimately, insurance liability. For example, are salmon mortalities always 'natural' phenomena or are some harmful algal blooms self-induced by the excess generation of toxic salmon farm wastes (Martin: 2000, AQUATOXSAL: 2002)? Instead of salmon farmers receiving financial compensation for mass mortalities due to algal blooms ('the polluter gets paid principle' in practice) should not shellfish farmers and fishermen be paid compensation by salmon farmers responsible for the spread of toxic algal blooms affecting their rural livelihood?

Harmful algal blooms, hypernutrification and eutrophication associated with intensive aquaculture operations have been recorded in Scotland (Jones et al: 1982, Austin: 1983, Gowen et al: 1983, Gowen et al: 1988, Stirling and Dey: 1990, Gowen and Ezzi: 1992, Handy and Poxton: 1993, Berry: 1999, Navarro: 2000), Ireland (Gowen: 1990, Massik and Costello: 1995), Norway (Persson: 1991, Wallin and Hakanson: 1991, Kaartvedt et al: 1991), Japan (Nishimura: 1982, Parsons et al: 1990), Finland and Sweden (Ruokolahti: 1988, Ronnberg et al: 1992), Hong Kong (Wong and Wu: 1987, Wu: 1994, 1999), New Zealand (Pridmore and Rutherford: 1992, Rhodes et al:

2001), Tasmania (Crawford et al: 2001), Canada (Wildish et al: 1993, Smith et al: 2001) and Chile (Arzul et al: 1999). Amnesic, Paralytic and Diarrhetic Shellfish Poisoning events have plagued the Scottish (Gowen: 1987, Berry: 1997, Gallacher et al: 2000, MacLeod: 2000), Canadian (Whyte et al: 2000), Irish (Gowen and Bloomfield: 1996, O'Boyle et al: 2000), Chilean (Clement, A and Lembeye: 1993, Arzul et al: 1999), New Zealand (Mackenzie: 2000) and Norwegian (Dahl: 1989, Tangen: 2002) coasts. Suffice to say that the evidence pointing to a causal link, in certain areas, between toxic algal blooms and salmon farming is surely now beyond reasonable doubt. For example, a recent study by the Scottish Association of Marine Science funded by the EC (Navaroo: 2000) found significant planktonic ecosystem impacts of salmon cage aquaculture in Loch Fyne, Scotland:

"Results to date reveal higher concentrations of ammonia, organic phosphorus and nitrogen at the stations near the fish farm during most months. They also show higher abundance of bacteria, nanoflagellates and ciliates. This suggests that fish farm effluents are enhancing local concentrations of organic and inorganic nutrient. The associated higher abundances of heterotrophic micro-organisms near the fish farm suggest that these nutrients may in turn be directly or indirectly enhancing microbial activity"

The international community have finally begun to tackle the issue with the International Council for the Exploration of the Sea (ICES) asking in 1999: "Are the excreta produced by mariculture (finfish and shellfish farming) capable of causing significant changes in the growth of coastal phytoplankton species, particularly of toxin producers?" AQUATOXSAL, for example, is an EC-funded research project involving Chile, Argentina, France and Germany investigating the links between salmon farm wastes and toxic algal blooms (Arzul et al: 1999, Arzul: 2002, AQUATOXSAL: 2002). As part of AQUATOXSAL, conferences took place in Puerto Montt, Chile in 1999 and Brest, France in 2001 with publication of a final report expected later this year (Arzul, pers.comm). Although the final proceedings are not yet available the AQUATOXSAL web-site (http://www.aquatoxsal.de) does provide some details and the AQUATOXSAL forum (http://www.aquatoxsal.de/forum/index.html) asks if there is "evidence for blooms due to salmonid aquaculture?" (AQUATOXSAL: 2002). It raises a number of issues:

"We can extrapolate from our data that the input of inorganic nitrogen coming from all fish farms in the X. Region in Chile is very high (approx. 17.000 t N). The influence on the benthos is well documented and we have a clear relation to aquaculture activities. My question to you: Do we have evidences (sic) that there is an increase of primary productivity (phytoplankton, seaweed) in the last years in this region?"

Certainly, in the last year toxic algal blooms have devastated farmed salmon and shellfish along the Chilean coast and have even caused human fatalities (Intrafish: 2002c). Another EC project - MERAMED - is investigating environmental impacts of sea cage fish farming such as sea bass, sea bream and tuna in the Mediterranean (MERAMED: 2001). In Scotland, in response to a petition (PE 96) by marine toxicologist Allan Berry (Berry: 2000), the Scottish Executive have hired Professor Ted Smayda of the University of Rhode Island to assess "the impact of nutrient inputs

from fish farms on the algal communities of the Scottish coastal zone". Another ongoing five-year project began in 1999 to investigate the impact of sea lice chemicals including impacts on zooplankton and phytoplankton (SAMS: 2002a, 2002c, Edwards: 2002). Previously, the Scottish Executive published a critique of PE 96 (Scottish Executive: 2000) and the Scottish Parliament concluded in November 1999 that "further research into the alleged link between fish farming and outbreaks of shellfish toxicity take place as a matter of urgency" (Scottish Parliament: 1999). Dissatisfied with the response from the Scottish Parliament Mr Berry has now petitioned the European Parliament asking for an investigation into the link between toxic algal blooms and salmon farming (Ross: 2001).

In British Columbia the Pollution and Prevention and Remediation Branch of the Ministry of Environment hired consultants to "document emerging research with respect to plankton blooms and netcages" (G3 Consulting: 2000). Particular problem areas in Canada include Broughton Archipelago (Sutherland et al: 2001) and the Bay of Fundy (Wildish et al: 1993, Pohle et al: 2000). In the L'Etang Inlet, Bay of Fundy, "aquaculture operations are the largest anthropogenic source of nutrient inputs" (Milewski: 2001). In Scotland, an ongoing project by the Marine Laboratory Aberdeen and the Scottish Environment Protection Agency (to be completed in August 2002) is focusing on ten lochs which have been identified as 'hot spots' (Cameron: 2001b, Scottish Executive: 2002). If excess nutrient enrichment or eutrophication is discovered (Tett and Edwards: 2002) there is a real risk that curbs will be made on Scotland's 350 salmon farms. In Scandinavia, where in addition to Norwegian salmon farming there is a significant trout farming industry in Denmark and Finland, HELCOM has recently adopted stricter "measures aimed at the reduction of discharges from marine fish farms" (HELCOM: 2001).

In an attempt to deal with the increasing waste problem, scientific research has focused on the use of seaweeds to remove salmon farm waste (Chopin et al: 1999, Troell et al: 1999, Buschmann et al: 2001, Chopin et al: 2001, Watanbe: 2001), the addition of chemicals or clays to 'neutralise' toxic wastes (Rensel: 2000) and the use of 'nappies' to collect wastes (SEPA: 1998c). In the final analysis, completely closed systems for the containment of contaminated wastes can be the only sustainable solution and that necessarily rules out open sea cage salmon farming (Cripps: 1994, Cripps and Kelly: 1996, Costa-Pierce: 1996). If salmon farming is to have any kind of future, closed sea cage salmon systems may offer an alternative (G3 Consulting: 2000). Even integrated systems of seaweed and salmon, for example (Troell et al: 1997), only deal with a fraction of the waste and such a system will have difficulties resolving the issue of contamination of PCBs, dioxins and the suite of toxic chemicals used on salmon farms. The fact that some of the chemicals used on salmon farms actually kill seaweeds might be somewhat of a stumbling block (Robertson et al: 1991). The solution to pollution is not dilution.

Food for thought:
Salmon farming is dead in the water (Miller: 2001b). Nor can the sea cage farming of other marine species such as tuna, sea bass, cod, halibut, sea bream and haddock necessarily avoid the same fatal mistakes (Philippine Daily Inquirer: 2002). The farming of finfish represents a health hazard (Staniford: 1999, WHO: 1999, Paone: 2000a, Sandison, B: 2001, Bonham-Carter: 2001, Brouwer: 2001, Dowden: 2001,

Edwards: 2001b, Grigson and Black: 2001, Healthwell: 2001, Humphrys: 2001, Lazaroff: 2001, New Straits Times: 2001). Cage aquaculture (Beveridge: 1996) in the sea is one of the major new polluters of the new millennium. In the Northern hemisphere especially (Allsop et al: 1999, Lundebye et al: 2000), we have polluted our marine environment to such an extent that we are now reaping the consequences in the biomagnification of contaminants up through our food chain (Allsop et al: 2000). The consumption of fish from areas such as the Baltic (Kiviranta et al: 2002) and by extension the use of fishmeal and fish oil in salmon farming diets from contaminated areas (Lundebye et al: 2000) carries with it a public health warning. Seafood products are a real cause of Government concern in the UK (MAFF: 1999, Seafish Industry Authority: 2001) and elsewhere. In particular, the farming of fish high up the food chain is an extremely efficient way of concentrating contaminants. In November 2000 the EC's Scientific Committee on Animal Nutrition stated that "fish meal and fish oil are the most heavily contaminated feed materials with products of European fish stocks more heavily contaminated than those from South Pacific stock by a factor of ca. eight" (EC: 2000a) whilst the EC's Scientific Committee on Food stated that fish can contain ten times higher levels of dioxins than some other foodstuffs and can represent up to 63% of the average daily exposure to dioxins (EC: 2000b).

Since 'you are what you eat' it comes as no surprise to discover that farmed salmon contains high levels of PCBs and dioxins (Mac et al: 1979, Jacobs et al: 2000, Edwards: 2001b, Wigan: 2001, Easton et al: 2002, FSAI: 2002). Fish oil is now so contaminated (Jacobs et al: 1997, Jacobs et al: 1998, Lundebye et al: 2000) it should carry a 'hazardous goods' label. Fatty fish such as farmed salmon, which has up to 4-5 times the fat content of wild salmon (Fracassini: 2001, Leake: 2001), presents an even higher risk. That the salmon industry increased the fish oil (and hence the fat) content of fish feed from 8% in 1979 to up to 40% in current diets (Davies: 2000, Jystad: 2001) when knowledge of health risks of contaminated fish feed existed over 20 years ago (Mac et al: 1979) shows their utter contempt for consumer protection. Given the level of prior knowledge apparent within the industry it is therefore difficult to describe salmon farming's use of organic contaminants as "unintentional" (Hellou et al: 2002b). In fact, when the European Commission gathered data on PCBs and dioxins in fish feed they found that there was a lack of Government studies but that "possibly more have been carried out within the industries but have not been published" (EC: 2002a). How many more industry-sponsored studies exist in 'private and confidential' Government reports (e.g Seafish Industry Authority: 2001)?

Farmed fish feed is so fatty and contaminated that it even stains the seabed (Henderson et al: 1997, Pirie: 2001, SEPA: 2001a, Hellou et al: 2002a, Hellou et al: 2002b). That the world's largest salmon feed company, Nutreco, recently appointed a Corporate Director of Food Safety and are desperately trying to substitute fish oils with vegetable oils shows how difficult a task the industry now faces (Hole: 2002, Sinnott: 2002, Smith: 2002). Nor will it make the task any easier to hear that rendered animal by-products are judged as a "necessity in the new millennium" (Tacon: 2000), especially when the BSE food scare is still fresh in the minds of the public (Bonham-Carter: 2001, Meikle: 2002). According to Marine Harvest (a subsidiary of Nutreco) the dioxin issue has "not yet reached the pinnacle" with

ongoing challenges including listeria, antibiotics, salmonella, PCBs and GM ingredients (Fagan: 2001). Nutreco (Nutreco: 2001b) also claimed that:

"Nutreco has in place a system for monitoring dioxins and PCBs in all raw materials used. Since this scheme came into place during 1999 Nutreco Aquaculture has stayed beneath proposed EU levels for dioxins. Nutreco Aquaculture fish feed companies have increased the proportion of fish meal and fish oil coming from the Pacific sources…Nutreco Aquaculture is actively eliminating fish meal and fish oil from suspect sources and the process will be complete in 2001"

With consumers losing trust in 'suspect' farmed salmon there are serious question marks over the safety of Nutreco's product (Stanley: 2001). Next week's Nutreco-sponsored Aquavision conference (Nutreco: 2002) will search for answers concerning food safety and salmon farming. In answer to their own question - "if farmed salmon contains dioxins, is it safe to eat?" (Nutreco: 2001c) - the only safe answer is surely 'no'.

Such is the concern that in the UK, for example, the Food Standards Agency is currently advising consumers only to eat one portion of oily fish per week (FSA: 2001) and are launching a new testing programme for dioxins in farmed salmon. In Norway and Finland there are health concerns over eating too much fish (Horsberg: 1999, ENDS: 2001, Kiviranta et al: 2002) and over the contamination of fish meal (Lundebye et al: 2000). The EC are also engaged in a programme to test for PCBs and dioxins in a range of fish including Chilean, Norwegian, Canadian and Scottish farmed salmon. Once collated, this information will ideally allow comparisons to be made between Northern and Southern hemisphere, freshwater and marine, finfish and shellfish and between farmed and wild. Consumers, for the first time, will therefore be able to make an informed decision about the fish they are buying. Little wonder salmon farming companies and supermarkets are reluctant to even label their fish as 'farmed' (Fracassini: 2001, Blythman: 2002). Whether they will ever label artificial colourings (Forristal: 2000), chemicals used on salmon farms (Fracassini: 2001) or the disease history of farms (Edwards: 1999) is another matter entirely. Some supermarkets are pressurising salmon farmers to use less pesticides (Naysmith: 2001b) but there is a long way to go before they clean up their act (Cook: 2001, Hendersen and Davies: 2001, SEPA: 2002, VMD: 2002). Given the 'hidden extras', customers are clearly getting more than they bargained for when opting for cheap BOGOF (Buy One Get One Free) farmed salmon. In the meantime consumers are being asked to "Go Wild" and steer clear of factory farmed fish (Zuckerman: 1999, FoE: 2001a, Morton: 2001, New Straits Times: 2001, David Suzuki: 2002, Ecotrust: 2002, Grace Factory Farm Project: 2002, Miller: 2002).

Notes:

[1] A response to the paper by Naylor et al in Nature (2000) has been submitted to Marine Pollution Bulletin:

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Chamberlain, Konrad Dabrowski, Ian Davies, Antoine Dosdat, Anastasio Eleftheriou, Arne Ervik, Hillel Gordin, Christopher S. Heinig, Volker Hilge, Ioannis Karakassis, Holmer Kuhlmann, Thomas Landry, Mathias von Lukowicz, Jaqueline McGlade, Andrew Price, Robertt B. Rheault, Harald Rosenthal, Ulrich Saint-Paul, Paul A. Sandifer, Marco Saroglia, William Silvert, Werner Steffens, Doris Soto, Laszlo Varadi, Johan Verreth, Marc Verdegem, Uwe Waller. 2001? An intellectual injustice to aquaculture development: a response to the review article on "Effect of aquaculture on world fish supplies". Marine Pollution Bull. (submitted).
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As yet, the paper remains unpublished except on the internet:
http://response.home.sapo.pt/index.html
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