Closing the Net on Sea Cage Fish Farming

Keynote paper presented by Don Staniford at "Charting the Best Course: The Future of Mariculture in Australia's Marine Environment" (27th August 2003) – a conference organised by the Queensland Conservation Council and the Australian Marine Conservation Society (http://www.qccqld.org.au/aquaconf). Conference session: Marine Aquaculture – the New Revolution or is it?

Abstract:

Aquaculture – the fastest growing sector of the world food economy - has been practised for millennia but it is only recently that intensive 'factory' fish farming has replaced traditional 'family' systems. Similarly, the transition from capture to culture economy has ushered in a new era of resource exploitation with profound economic, social and environmental consequences. A clash of cultures between finfish and shellfish farming means that fish have become a biological agent of pollution rather than a biological indicator.

'Five fundamental flaws' characterise sea cage fish farming; namely: untreated wastes; mass escapes; diseases and parasites; toxic chemicals and fish feed/food. The first four flaws can at least be mitigated by waste treatment and closed containment. Ultimately, however, the dependence upon depleted and contaminated fish feed as a fuel supply represents the fifth and fatal flaw.

Given that Australia plans to treble production by 2010 the potential to precipitate environmental impacts is significant. Already there are alarming signs that the salmon, kingfish and tuna cages littering the Australian coastline are encroaching upon pristine waters. Lessons can be learned from salmon farming in Chile, Scotland, Canada and Norway; from tuna farming in Japan, Spain and Croatia; from sea bass and bream in the Mediterranean as well as emerging species such as cod, barramundi, halibut and haddock. If Australia is to avoid a similar public and consumer backlash it ought to heed these international warnings.

To avoid environmental and food safety problems reaching crisis point, the cancerous growth of carnivorous sea cage fish farming must be stopped dead in its tracks. In practical terms that includes ripping out cages in unsuitable locations, compulsory tagging of farmed fish, closed-containment systems and the promotion of environmentally benign shellfish farming. Unless the net is closed, sea cage fish farming will be 'the one that got away'.

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Introduction:

Aquaculture increasingly represents the future for fish but sea cage finfish farming threatens both fisheries and other fish farming sectors. Far from being a panacea for the crisis in capture fisheries, the intensive farming of carnivores such as salmon, sea bass, tuna, sea bream, kingfish, red snapper, barramundi, cod and halibut serve only to compound the problem. If we continue on the present course towards the global expansion of sea cage fish farming we are heading for a disaster of Titanic proportions. The so-called 'Blue Revolution' has certainly ushered in a new era of fisheries resource exploitation that has transformed the way in which fish reaches our plates. Yet, sea cage finfish farming jeopardises both the integrity and water quality of the marine environment and also public health and food safety. The transition from a capture to a culture economy has led to profound social, environmental, economic and food safety implications. In the final analysis open sea cage fish farming is a false economy.

The Five Fundamental Flaws of Sea Cage Fish Farming:

The problems inherent in intensive sea cage fish farming are international in compass. The global reach of tuna farming in the Mediterranean, Mexico and Australia extends to markets in the Far East. And the ecological footprint of salmon farming extends way beyond the confines of Norway, Chile, Scotland, North America, Ireland, the Faroe Islands, Tasmania and New Zealand. Feed for tuna farms in Australia for example is sourced from North America. On the international stage sea cage fish farming has gotten far too big for its boots. A comparison between sea cage fish farming in the Northern hemisphere and the Southern hemisphere reveals disturbing similarities. The species farmed and the locations may be different but 'the five fundamental flaws' remain the same; namely: untreated wastes; mass escapes; diseases and parasites; toxic chemicals and fish feed/food. The first four flaws can at least be mitigated by waste treatment and closed containment. Ultimately, however, the dependence upon depleted and contaminated fish feed as a fuel supply represents the fifth and fatal flaw. This paper seeks to build on previous papers presented in Chile and the European Parliament and frame the Australian (and to a lesser extent the New Zealand) sea cage fish farming debate in a global context [1].

The Blue Revolution – Making Waves Across the World:

Aquaculture is the fastest growing sector of the world food economy. According to the latest FAO report – "The State of World Fisheries and Aquaculture 2002" - aquaculture accounted for 32% of the world's fish supply in 2000 – up from less than 5% in 1970. Between 1985 and 2000, the volume of global aquaculture production grew fourfold from 11.4 million metric tonnes to 45.7 million. Finfish production also grew four-fold from 5.2 million to 23.1 million mt. In 2000, half of the volume of aquaculture production came from marine waters, 45% from freshwater and 5% from brackish waters. Mariculture is on the march. And although carnivorous finfish species accounted for only 13% of global finfish production by weight in 2000, they comprised 34% of total production by value. Aquaculture already consumes ca. 35% of the world's fish meal and ca. 70% of the world's fish oil. If the current rate of growth in consumption continues, aquaculture will account for 56% of the world's annual production of fish meal and 98% of the fish oil by 2010. Aquaculture is quite literally eating into capture fisheries. By 2020 farmed fish are predicted to have overtaken wild caught fish. This is already the case for salmon but the shift is also taking place with other species such as cod, tuna, halibut, barramundi and kingfish [2].

Aquaculture in Australia:

Australian aquaculture in particular has witnessed unprecedented growth increasing in value by an average of 11% a year since 1991-92 and is now the fastest growing primary industry in Australia. Through its 'Aquaculture Industry Action Agenda', Australia plans to treble production by 2010 and predicts that by the end of the decade the value of farmed fish will increase from ca. A$750 million to over A$2.5 billion – 5 times the 1999 figure. This is eminently feasible (whether it is environmentally desirable is another matter entirely): in real terms the gross value of aquaculture production in Australia nearly trebled between 1991-92 and 2001-2. Aquaculture now accounts for 30% of the total gross value of Australian fisheries production and 19% of the total volume (44,300 tonnes out of 233,300 tonnes). Five species contribute the bulk of aquaculture: southern bluefin tuna ($261m), pearls ($175m), Atlantic salmon ($112m), prawns ($65m) and edible oysters ($57m). These five species made up 91% of Australian aquaculture (in value not volume) in 2001-2 [3].

The Australian government is running a five-year R & D plan and sees Australia becoming 'a major global player at the high-quality end of the market'. For example, the Australian government have just invested $28 million in a long-term project to domesticate southern bluefin tuna. The first tuna farm was only set up in Port Lincoln, South Australia, in 1991 but the tuna farming sector has grown to the point where ca. 98% of the Australian southern bluefin tuna quota is now farmed. Twelve tuna farming companies now operate on twenty-five sites concentrated around Port Lincoln requiring ca. 50,000 tonnes of baitfish including pilchards and herring. Australian tuna farming production now stands in excess of 10,000 tonnes - representing 67% of the value of world tuna farming production. Atlantic salmon and ocean trout production (ca. 15,000 tonnes valued at $111.5 million at the farm gate) is almost exclusive to Tasmania where 14 commercial operations are located in the Huon River, Port Esperance and D'Entrecasteaux Channel and Tasman Pennisula. Tasmania's production of farmed salmonids has risen eightfold since 1989-90 when only 1,750 tonnes was produced [3].

It is not just salmon and tuna that are fuelling the expansion of sea cage fish farming. The sea cage farming of barramundi ($11m) has also expanded in recent years and is predicted to grow inexorably. Yellowtail kingfish ($13m) is increasingly farmed in South Australia and is considered 'the next big thing'[4]. In New South Wales commercial production of snapper has commenced and may soon be followed by mulloway. According to the Sunday Mail (3rd March 2003), prawn farmers are interested in diversifying into gold-spot cod. A $1 million four-year project funded by the Australian Centre for International Agricultural Research is exploring the commercialisation of the gold-spot cod in Queensland and South Asia. Imported fish products now provide more than 60 per cent of seafood sold in Australia [5]. Clearly, Australia wants to be a net producer of fish.

New Zealand Aquaculture:

New Zealand does not want to miss the boat either and have embarked on an ambitious plan to promote high value species such as kingfish, salmon and are even considering bluefin tuna farming. Aquaculture contributes ca. 20% of New Zealand's export earnings but the government are sowing the seeds for future expansion. According to the New Zealand Herald (22nd June 2003), the industry aims to double its earnings by 2010 and reach $1 billion by 2020:

"With its clean waters and 17,000km coastline, New Zealand should be in the vanguard of this boom, say fish-farming proponents who aim to turn the boutique industry into a billion-dollar export earner. But if New Zealand is to swim with the big fish it needs to diversify into high-value finfish species such as kingfish, snapper and grouper which, unlike South Island salmon, can be farmed in warmer northern waters, says marine scientist Andrew Jeffs. A breeding trial at NIWA's Bream Bay hatchery has wildly exceeded expectations, producing 30,000 kingfish with the potential to fetch hundreds of dollars a kilo in sashimi restaurants in Japan" [6]

Salmon farming is still synonymous with sea cage fish farming in New Zealand. The vast majority (ca. 90%) of New Zealand's farmed salmon production originates from farms run by Malaysian-owned New Zealand King Salmon in the Marlborough Sounds and Canadian-owned Sanford Ltd off Stewart Island. However, kingfish farming is coming to New Zealand. In May this year it was announced that Island Aquafarms Ltd had converted four salmon farm cages to raise juvenile yellowtail kingfish in Crail Bay, Marlborough Sound. Aquaculture programme leader Andrew Jeffs said NIWA was focussed on increasing the value of aquaculture in New Zealand: "We are trying to develop species that are worth more than mussels. New Zealand is mostly focussed on developing low value aquaculture species". While New Zealand aquaculture was worth about $1600 per tonne, Australian aquaculture was worth $30,000 per tonne, he said [7].

Aquaculture companies are now putting pressure on the New Zealand Government to lift the moratorium on fish farming imposed in 2001. Moana Pacific, for example, is thinking of closing a kingfish farm project in Northland and moving it instead to Australia [8]. New Zealand, famous for its Greenshell mussel farming industry, would do well though to heed international warnings before committing itself to an expansion in sea cage fish farming. Whilst the Scottish environmental watchdog, Scottish Natural Heritage, was far too late in warning in 2001 that salmon farming and shellfish farming were "incompatible" [9], there is still time for Australian aquaculture to alter course.

Clash of Cultures – Finfish vs Shellfish Farming:

As in the agricultural sector there are fundamental differences between farming systems. Whilst aquaculture has been practised for millennia it is only relatively recently with the advent of intensive fish farming (mainly shrimp and salmon) in the 1970s that we have witnessed a shift away from sustainable 'family' fish farming to 'factory' farming. The intensification of sea cage finfish production in the 1980s and 1990s has ushered in a new era of resource exploitation. Subsistence shellfish farming in particular has been sacrificed for the development of finfish operations which discharge contaminated wastes directly into the sea and depend upon chemicals to control diseases and parasites. A clash of cultures between finfish and shellfish farming means that fish have now become more a biological agent of pollution than a biological indicator.

Compared to sea cage finfish farming shellfish farming is relatively environmentally benign. It requires no inputs such as fish meal and fish oil, antibiotics and other chemicals to control parasites and disease or artificial colourings and there are few outputs such as waste effluent, uneaten feed or escapes. Shellfish farming is not without its environmental impacts [10] but sea cage finfish farming is in a different league [11]. Salmon farming in particular has been targeted as a 'cancer of the coast' [12]. Environmental and food safety groups in Canada, Chile, Scotland and Ireland have exposed a catalogue of crimes against the marine environment including evidence of illegal chemical use, contamination, pollution, infectious diseases, mass mortalities and escapes [13].

Salmon farming, however, is not the only sea cage fish farming sector to have attracted criticism. Tuna farming seems set to take over salmon farming's mantle as the bete noir of environmental and fisheries groups [14]. More recently, cod farming in Norway and Scotland has been criticised for producing 50% more wastes than salmon farming [15]. And kingfish farming in Australia has come under fire for its appalling track record on escapes [16]. An international public backlash threatens to blow sea cage fish farming out of the water [17]. Nor has Australian or New Zealand aquaculture escaped the barrage of negative news articles [18] or vocal local opposition to sea cage fish farming [19].

The Privatisation of Fish:

Global protests against factory fish farming represent a potential watershed in the history of aquaculture. Whilst on land the switch from hunting and gathering to a society based upon agriculture took several thousand years, the transition from a capture to a culture fisheries economy is occurring in front of our very eyes. Clashes between fishermen and fish farmers and between sea cages and shellfish waters are symptomatic of the tensions of transition. The analogies between aquaculture and terrestrial agriculture are all too obvious. As sea cage fish farming displaces capture fisheries we are now witnessing the beginning a new era of marine exploitation - in much the same way as shifting cultivation made way for modern factory farming. The wholesale destruction of mangrove forests to make way for intensive prawn farms and the expansion of sea cage fish farms encroaching into traditional inshore fisheries area are fencing off swathes of the seaside. Marion Shoard's clarion call in her 1980 book "The Theft of the Countryside" warned of the destruction of the English countryside by modern intensive farming methods [20]. Some twenty years later the same warning signs are now visible along our coastal margins and inshore coastal waters – only this time it is the theft of the seaside. Fish are being privatised. The sea is being sold off.

A once ubiquitous common property resource is now controlled by a select few multinationals. The top seven companies, for example, control 40% of the world's farmed salmon production [21]. Multinationals such as Nutreco, Stolt and Cermaq are now diversifying their operations by adapting methods of farming salmon to other species of carnivorous fish. The global GM giant Monsanto also moved into aquaculture in Asia in 1999 and is one of the founding members of the Global Aquaculture Alliance. By 2008, Monsanto expects to earn revenues of $1.6 billion and a net income of $226 million from its aquaculture business [22]. Fish are being privatised so quickly that sea cage fish farming is not only a high risk strategy for the marine environment but also for investors be they in Japan, Europe, North America or Australia. According to ABC (27th March 2003) the Director of the South Australian museum, Dr Tim Flannery, warned investors not to go into aquaculture to make money because it is a huge leap into the unknown:

"On land we've been used to agricultural systems for at least 10,000 years….in the oceans we have maybe 50 years experience. Don't get into aquaculture for the quick buck. I personally think that the systems are so dynamic and so easily upset that you want to have every insurance that you'll still have money in ten years time" [23]

As if to prove the point salmon farming companies across the world are going bust losing millions. The world's largest salmon farming company, Nutreco, announced record losses of 186 million euros for the first half of 2003 [24]. Last year Australia's largest salmon producer, Tassal, went into receivership with debts of $30 million [25]. The boom industry of the 1990s is now going bust. Sea cage salmon farming is dead in the water.

Australian Aquaculture – Heading for the Rocks:

Australia's plans to treble production by 2010 and the focus on high value sea cage species such as tuna pose a real threat to the future. Already there are alarming signs that the salmon, kingfish and tuna cages littering the Australian coastline are encroaching upon pristine waters [26]. The New Zealand government have also recently published a damning research report on impacts of marine farming [27]. In South Australia, the hundreds farms are like a noose around Australia's neck [28]. Salmon farms in Tasmania are discharging so much untreated waste in the Huon Estuary that their expansion has been capped [29]. The increasing incidence of toxic algal blooms in New Zealand and Australian waters is becoming to hazard both to shellfish and to public health. Intensive cage finfish farming is, quite literally, suffocating marine life via the spread of contaminated wastes, mass escapes, uneaten feed, mass mortalities and the deaths of dolphins and other marine species. Damning evidence of the 'five fundamental flaws of sea cage fish farming' is now emerging. Tuna farming in particular may be making millionaires out of a small group of owners but environmental factors are not accounted for [30]. Lessons can be learned from salmon farming in Chile, Scotland, Canada and Norway; from tuna farming in Japan, Spain and Croatia; from sea bass and bream in the Mediterranean as well as emerging species such as cod, halibut and haddock. However, such international experience is not being taken on board by the Australian authorities. Unless Australian aquaculture drastically changes course it is heading for disaster.

Making the Same Mistakes:

The country and the culture species may be different but the companies involved are all too familiar. The world's largest salmon farming company, the Dutch-owned multinational Nutreco, has already secured a foothold in Australia. Nutreco is

gearing up for huge expansion in barramundi, kingfish and is interested in becoming involved in tuna farming off Port Lincoln. Norwegian company Stolt is already the second biggest tuna company in Port Lincoln. In 2001 Nutreco joined forces with Tasmanian salmon company, Tassal, to buy Pivot's aquaculture business including an aquafeed plant in Tasmania and a barramundi facility in the Northern Territory. In 2002 the Stehr Group signed a deal with Nutreco to grow out kingfish in Spencer Gulf, South Australia [31]. By the end of the end of the decade Nutreco hope to be producing 10,000 tonnes a year from their barramundi farm on Bathurst Island. The $20m farm, 100 miles north of Darwin, has capacity for 2.2 million fish and is capable of flooding the entire barramundi sector. "It has the potential to certainly displace much of the wild-caught fish on the market today," Northern Territory Minister for Primary Industries and Fisheries Mick Palmer told ABC in 2001. "That's not to say that that industry will disappear but it will provide the consumer in Australia a cheap bulk volume product that they'll be able to put very high quality fish on the home table at a price that's very competitive with other products" [32].

That's exactly what they said about salmon before the market crashed and consumer confidence led to a public backlash against cheap and nasty farmed salmon. Nutreco are still reeling from a BBC documentary – "The Price of Salmon" – which was broadcast across the world during 2001. Nutreco's share price fell 15% even before the documentary revealed that farmed salmon contained high levels of cancer-causing chemicals such as dioxins and PCBs [33]. And just this month Milieudefensie (Friends of the Earth Netherlands) revealed that Nutreco were prosecuted and fined $1,800 in December for the illegal use of the carcinogenic chemical malachite green [34]. Last year Nutreco were also accused of shoddy labour practices in Chile, bad working conditions and dozens of workers went out on hunger strike [35]. Having left a trail of pollution in their wake in Scotland, Canada, Norway and Chile, Nutreco appear to view Australia's pristine marine environment as an ideal place to import pollution.

Different Hemisphere - Same Problems:

Investigating a new research topic is rather like opening a can of worms. If the 'five fundamental flaws of sea cage fish farming' are used as template through which to examine Australian and New Zealand aquaculture parallels with sea cage fish farming operations around the world immediately become apparent. The well-documented pollution problems inherent in salmon farming in Chile, Norway, Scotland, Ireland and Canada also exist in Tasmania and New Zealand for example. It is merely a question of flushing them out. Whilst tuna farming in the Mediterranean is only just beginning to attract the close scrutiny it warrants, the experiences in the Australian tuna farming industry over the last decade are particularly revealing. Equally, yellowtail kingfish may appear a completely different kettle of fish but it is also farmed in Japan. And red snapper is another name for red bream – sea bream is farmed in the Mediterranean too. Sea cage fish farming in the Northern and Southern hemispheres are not poles apart at all. Even the briefest of trawls through the literature reveals alarming similarities between the five fundamental flaws of European sea cage fish farming and Antipodean sea cage fish farming. Over the coming months fieldwork in both Australia and New Zealand will flush out the issue yet further and will be published in the forthcoming book "Cancer of the Coast: the environmental and public health disaster of sea cage fish farming" [32]. Thus far the picture emerging is not pretty.

1) Wastes:

By discharging untreated and contaminated toxic wastes directly into the sea, tuna, salmon, cod and kingfish farmers are using coastal waters as an open sewer. Considering all other businesses are charged waste disposal and wastewater treatment costs it is not altogether surprising that sea cage fish farmers are portrayed as unfairly freeloading on the marine environment. WWF have calculated that an average salmon discharges the waste equivalent as the sewage from a town of ca. 20,000 people – salmon farms in Scotland for example discharge almost twice the phosphorus waste as the entire human population [33]. In enclosed bays and lochs with low tidal flows and poor water exchange it is rather like flushing the toilet only once a month. No wonder coastal communities the world over do not want such a polluting presence their doorstep. When SunAqua's application to farm kingfish and red snapper in the pristine waters of Moreton Bay Marine Park, Queensland, was submitted last year Lord Mayor Jim Soorley vowed:

"It will go ahead over my dead body. This stupid and idiotic proposal would put nutrients and nitrogen back in the bay…Our waterways are too precious. We have to reduce waste and lower the nutrient and nitrogen levels" [34]

SunAqua's claim that "the likelihood of algal blooms due to increased nutrient inputs is considered to be negligible" simply does not stand close scrutiny [35]. If SunAqua wanted to eliminate risk entirely then they would adopt closed-containment technology. The solution to pollution is surely not dilution.

An increasing body of international research points to strong causal links between untreated finfish farm effluent and toxic harmful algal blooms [36]. Whilst there is a growing body of evidence detailing waste impacts from salmon farms, the threat

posed by tuna, kingfish and red snapper farm wastes has been less well publicised. Privately though the Australian Government have long known about tuna farming's capacity to produce wastes. According a 1996 Fisheries Research and Development Corporation project:

"Environmental monitoring was undertaken from the first stages of southern bluefin tuna farming development, with the early surveys suggesting localised effects on the seafloor sediments and benthic communities, as well as surrounding water column. The causes appeared to be primarily from the shading effect of the nets, accumulation of waste feed and increased sedimentation of particulate matter, as well as the release of dissolved nutrients" [37]

A 'pollute and move on' mentality has characterised the Australian Government's approach to tuna farming:

"Frid and Mercer (1989) recommended the siting of sea cages in areas of high tidal flow as this would disperse the sediment rain over a broader area and reduce the more localised environmental impact. They note, however, that nutrient enrichment of the water body for a longer period could stimulate the growth of phytoplankton. An alternative approach advocated by some resource managers and used for the farming of tuna in South Australia, is to accept that the accumulation of wastes will exceed the natural assimilative capacity of the seafloor community. In response farmers are issued with a larger lease area so as to allow the practice of cage rotation and seafloor fallowing (Bond 1993)" [38]

Such a state-sponsored policy of shifting cultivation has not been without its problems. In 1996, ca. 75% of all the farmed tuna stock in South Australia were mysteriously wiped out by a toxic algal bloom with any surviving fish towed to deep water [39]. The 1996 Boston Bay incident is still highly controversial and whilst there is some documentary evidence many facts are still to emerge from unpublished insurance and Government documents [40]. Tuna farmers claim they were the innocent victims of a natural event. However, it has all the hallmarks of man-made disaster. The link between tuna farming wastes and the algal blooms is all too obvious. One year after the 1996 tuna kill a researcher attached to Flinders University conducted tests at tuna feedlot sites near Port Lincoln and found 47 species of algal bloom. One potentially toxic bloom affected all monitored sites near Port Lincoln in May and June 1997 [41]. A subsequent TV investigation in 2000 suggested that the 1996 incident was hushed up. According to the ABC documentary 'Cells from Hells':

"In the last 30 years there have been increasing numbers of fish kills around the world. The tuna in this South Australian fish-farm died in just two days in 1996. As with so many other cases a natural cause is still the official explanation. However more and more, evidence is shifting the blame away from mother nature…. in Australia and around the world, there's a reluctance to acknowledge that it's human activity that is triggering the transformation of normally benign organisms into increasingly dangerous forms. If we continue to mismanage the way nutrients and pollutants are released into the environment we'll have to confront new incarnations of the cells from hells" [42]

It quoted Professor Gustaaf Hallegraeff from the University of Tasmania:

"The local South Australian government prefers to stick with this explanation because it somehow claims that this is a completely natural event. There is no human involvement whatsoever. The alternative claim that there is an algal bloom that caused this problem is of much more concern. But in Japan Chattonella is a prime example of an algal bloom phenomenon which is actually induced by the waste products of the aquaculture industry itself and of course that's not something that the tuna aquaculture industry want to hear"

Professor Hallegraeff told ABC that when he examined a water sample he found that it was teeming with a toxic alga never before seen in Australia called 'chattonella'. The same organism killed half a billion dollars worth of fish in Japan in 1972. Professor Hallegraeff said that in Japan chattonella is "an example of an algal bloom phenomenon which is actually induced by the waste products of the aquaculture industry". Speaking later on radio, Professor Hallegraeff stressed:

"What is important, there's a very good data set from Japan more than fifty years of data that have shown a very good relationship between increase of Chattonella marina blooms (particularly the Seto Inland Sea) and the fertilisation of water by both domestic and industrial and in particular aquaculture wastes. And this is important to take into account, that if finfish aquaculture operations develop in very sheltered areas like Boston Bay, they have to be prepared for an increasing frequency of these algal blooms" [43]

The furore prompted a parliamentary question: do toxic algal blooms represent threats to or from aquaculture? [44]. That is a question neither the industry nor the government want to answer. Others though are more public in declaring a direct link between tuna farm wastes and toxic algal blooms:

"In April 1996, organic wastes and nutrients from the faecal wastes from the 66 caged tuna farms contributed to a phytoplankton bloom in Boston Bay….respected researchers, such as Dr Anthony Cheshire (University of Adelaide) and

researchers from SARDI, have clearly identified the tuna farms as a major contributor to nutrient and organic loads within the bay. Poor flushing of waters within the bay, and a history of pollution within the bay, resulted in SARDI researchers actually predicting the eventual disaster as early as January 1993. The State government, eager to please the demands of the tuna industry, ignored all scientific warnings, and are now trying to convince the public of South Australia, that the disaster was natural, and not the result of poor environmental management and monitoring" [45]

According to the 'Australia State of the Environment Report 2001':

"Tuna farming in feedlots can generate a significant amount of pollution. Recent research suggests that pollution is causing the sudden appearance of strange micro-organisms capable of poisoning fish. It has been suggested that a toxic algae was the cause of death of the tuna in Boston Bay, Port Lincoln in 1996" [46]

And perhaps most damning of all - this from a whistleblower within the tuna farming industry:

"I have participated in a research program on the tuna cages in Port Lincoln in South Australia. It is true that food and fish waste add nutrients to the nearby water column, however some of that is absorbed by the community of sessile organisms living on the cage wall. This in itself creates a problem, the growth of these organisms slows down water exchange between the cage and outside water column. As the fish in the cage use the oxygen in the water little is replaced so the cages are routinely cleaned. This results in large piles of decomposing organic matter on the sea floor, killing any algae and seagrass underneath for some considerable distance around the cage. This can be up to 50 cm thick. The results of this research was quashed by some in South Australia but if you hunt through the court records in the Tuna Boat Owners Associations attempt to claim insurance against tuna losses in a 'storm' you should find it" [47]

This event in Australia echoes with recent incidents in Ireland where salmon farmers have also tried to blame mass mortalities due to 'acts of God' rather than look for explanations closer to home [48]. Sea cage fish farming is shooting itself in the foot by overstocking and overproduction. The Boston Bay tuna farming mass mortality incident smacks of so-called 'self-pollution' coined by scientists in the late 1980s in relation to salmon farming in Scotland [49]. Mortality rates on Scottish salmon farms have been between 10-35% over the last decade. Official figures show that between 1999 and 2002 over 4 million farmed salmon died in their cages with over 2 million being attributed on insurance claims to naturally occurring algal blooms [50]. The 1,700 tonnes of dead tuna involved in the 1996 Boston Bay incident, for example, were subject to insurance claims estimated at $45 million. Insurance claims from sea cage fish farms, be it for disease losses, algal blooms or escapes, are reaching record levels. One cannot help but wonder if sea cage fish farming is one big insurance scam [51]. Being paid compensation for a self-inflicted wound is akin to money in the back pocket and a pat on the back as a reward for polluting the marine environment. The 'polluter gets paid principle' is seemingly alive and well down on the sea cage fish farm.

Tuna farms are not the only species in Australian waters implicated in harmful algal blooms (HABs). According to the Canberra Times (17th August 2000):

"HABs often follow the establishment of fish farms due to increased nutrients in the water from waste food and fish excreta. Nutrients flowing from a trout farm upstream from Cooma were believed responsible for a blue-green algae bloom which caused the hospitalisation of Cooma residents in 1998" [52]

Nutreco's barramundi farm on Bathurst Island, Northern Territory, is also classified by consultants in a newly published Environmental Management Plan as a 'medium risk' in terms of wastes. Ignoring new developments in closed containment systems it states that:

"It is impractical to catch the waste products from marine farming operations and these need to be managed in situ. The nutrients from the faeces from a dense population of farmed fish have the potential to impact on the water column and on the bethos, causing eutrophication in the water column and benthos resulting in increase of aquatic plant growth and deficiencies in dissolved oxygen levels. In severe cases hydrogen sulphide can be generated from the sediment. Eutrophication will be exacerbated by high temperatures (as are found in Port Hurd), excess fish feed passing through the water column and by lack of water movement…..Eutrophication is not a desirable condition for the fish or for the environment. Lack of oxygen and the impact of hydrogen sulphide cause stress on the fish and potential loss of fish stocks. Increased nutrients will cause nuisance growth of algae outside the farm and will increase the potential for algal blooms" [53]

'Impractical', as used above, is merely a euphemism for unprofitable.

Salmon farms in Tasmania have also been placed under the microscope. An ongoing project - "The effect of fin-fish aquaculture on phytoplankton populations" - at the University of Tasmania for example is investigating the link between salmon farming wastes and toxic algal blooms. The project outline states that:

"Marine-farming of finfish releases particulate and nitrogenous waste that impacts the immediate and surrounding coastal environment. This project is examining how this waste (particularly nitrogen) is entering the pelagic environment and whether it influences phytoplankton biomass and species composition, leading to harmful algal blooms (HABs)" [54]

A government report on the Huon Estuary in Tasmania published in 2000 also tackled the question of salmon farming wastes and the link with algal blooms [55]. This followed a 1996 FRDC project which conceded that:

"Key environmental issues in the Huon Estuary are associated with effects and fate of nutrient and organic matter loads from the catchment, from coastal waters, and from activities in the estuary, especially salmon farming….Salmon farms may affect water quality nearby their sites. Our field observations yielded evidence of higher ammonia concentrations in surface and mid-depth waters close to the marine farm zones" [56]

Evidence of salmon farming's capacity to foul its own nest has been slowly seeping out since the 1980s. Back in 1989 New Zealand scientists investigating the impact of salmon farming wastes on Big Glory Bay, Stewart Island, warned of potential effects on the water column [57]. As a report published last year for the Ministry of Fisheries explains:

"The best documented impacts of finfish farming within New Zealand were gathered during a phytoplankton bloom at Stewart Island. Chang et al (1990) identified the phytoplankton species responsible for the mortality of 600 tonnes of salmon in January 1989; Mackenzie (1991) provided background information regarding phytoplankters and the nature of the toxicity from the bloom, whereas Pridmore and Rutherford (1992) estimated that salmon farming increased the nitrogen concentration of the bay by about 30%" [58]

The incidence of toxic algal blooms, coincident with the rapid expansion of salmon farming, has certainly increased over the last decade in New Zealand waters [59]. An international conference on HABs - Harmful Algal Blooms 2003 - will take place later this year in New Zealand in November [60]. We will have to wait and see what, if anything, comes out of the wash. Sea cage fish farmers though do not like to air their dirty linen in public. The Ministry of Fisheries report concludes by recommending a lid be kept on any problems in order to preserve New Zealand's lucrative export market in farmed shellfish and salmon:

"Phytoplankton blooms were linked to mass mortalities of salmon at Stewart Island and have been discussed in the benthic impacts effects section. Their effects on wild populations are unknown; it is possible that dense blooms could have localised effects on wild fish, but mobile species would generally be expected to avoid such areas. HABs are a recurrent feature of New Zealand aquaculture in recent years. It is possible that their recurrence is merely due to improved surveillance, but their presence requires increased vigilance in order to maintain domestic and export markets. Aquaculture activities have the potential to accelerate the spread of blooms, but they also provide increased surveillance"

Farmed salmon are romantically portrayed by some farmers as 'canaries in the cage' acting as barometers of the health of our blue planet and monitors of pristine water quality. If farmed salmon really are canaries then with the millions of dead salmon littering the bottom of sea cages we are already in deep trouble.

2) Escapes:

The very nature of sea cage fish farming predetermines a high level of risk in relation to escapes. Moving further offshore to cleaner waters will only serve to exacerbate that risk. Whilst escapes of farmed salmon have dominated the international headlines there have also been escapes of farmed cod in Norway and from sea bass cages in the Mediterranean [61]. Mass escapes of kingfish into Australian waters are also reaching crisis levels – so much so that SARFAC have set up "Kingfish Watch" to monitor the increasing number of escapes in South Australian waters [62]. Local fishermen are concerned at the expansion of kingfish farms at the gateway to the Great Australian Bight. A campaign to stop further developments is being headed by the recreational fishing council and local professional fishermen who have heard reports from the Spencer Gulf about escaped kingfish threatening other fish stock. According to The Australian (9th April 2003): "A year ago, an unusually high number were reported at the top of Spencer Gulf, leading to reports the aggressive predatory fish had escaped, devouring their way through schools of whiting and garfish, even through squid 'leaving only ink and tentacles' behind" [63]. The current situation in Australia with kingfish escapes resonates loudly with the disastrous history of farmed salmon escapes in Canada, Scotland, Norway and Chile [64].

Escapes of potentially diseased and infected farmed kingfish have steadily increased over the past three years, with 1882 escaping in 2001, 6069 in 2002 and 21,258 so far in 2003. Official government figures reveal that 29,209 farmed kingfish have escaped in 10 separate incidents since June 2001 [65]. A $2 million three-year research project to address key issues including the interaction between wild and farmed kingfish and aquaculture and marine mammal populations was announced in February 2003. "This study will increase research we have already been doing following the initial escapes," said Fisheries Minister Paul Holloway. "We need more research and the industry does have to improve its performance". However, Trevor Watts of the South Australian Recreational Fishing Advisory Council wants a moratorium as a matter of precaution:

"We still believe there should be a moratorium on kingfish farming until a range of issues are resolved, particularly the fish escaping. We would also like to know the measurements of the chemicals and antibiotics that are used and is the industry taking note of overseas experience?" [66]

In April, following the eighth kingfish escape in less than two years, Fisheries Minister Paul Holloway was forced to admit once again the need for "further tightening of the industry's operating procedures and farming practices". Anecdotal evidence suggests the escapees are swimming up to 50km from their pens, and locals are reporting declines in fish stocks in the area [67]. In South Australia escapes from kingfish farms have reached such level that the Government (PIRSA) are developing a code of practice and operating standards, which will be incorporated into license conditions. The Government is currently conducting tests on kingfish aimed at distinguishing escapee farmed fish from wild kingfish [68]. Nor are escapes from kingfish farms the only problem.

Escapes from salmon farms have long been a feature of salmon farming in Tasmania but have increased dramatically in the last few years [69]. To such an extent that in July the Tasmanian Minister for Primary Industries, Water and Environment, Bryan Green responded to the persistent problem of escapes by urging salmon farmers to adopt a formalised code of practice [70]. The Tasmanian authorities admitted last week that:

"Until recently large escapes were relatively rare and were rather eagerly greeted by the recreational fishing fraternity. Two large escapes (thousands of fish) recently took place in Macquarie Harbour on the West coast, where a group of operators new to the locality underestimated the operating conditions. The area does not have a large population of recreational fishers, and commercial licensed netters (who are not permitted to sell salmonids) complained that their large catches of salmon were interfering with their flounder catching activities and creating a disposal problem" (Darby Ross, Department of Primary Industries, Water and Environment, pers.comm.)

Escapes from barramundi farms have been reported in Lake Argyle [71] and there is anecdotal evidence that recreational fishermen have caught escaped farmed snapper around Port Stephens [72]. Each escapee is a potential vector for the spread of infectious diseases and parasites. Escaped farmed fish are highly mobile pollutants.

3) Diseases and parasites:

The diseases may be different but the problems are exactly the same. Whether it is Infectious Salmon Anaemia in North America (Maine and New Brunswick), the Faroes and Norway, Infectious Pancreatic Necrosis (Scotland and Norway), Rickettsia (Chile) or Kudoa (Canada), diseases and parasites are simply a function of intensification and overproduction [73]. Cramming migratory fish into cages at stocking densities equivalent to battery farmed chickens is a recipe for disaster. A report by Compassion in World Farming calculated that each farmed salmon has the equivalent space to swim around in as a bathtub of water [74]. The explosion in diseases endemic in salmon farming will inevitably manifest themselves in emerging new species such as tuna, cod, halibut, barramundi and kingfish.

In Tasmania the biggest killer is Amoebic Gill Disease (AGD). According to the Fisheries Research and Development Corporation, "prevalence of the disease and costs associated with the freshwater treatment are increasing". AGD is "associated with extensive mortality and reduced production of Atlantic salmon in Tasmania" and accounts for 10-20% of production costs [75]. Overproduction has also led to welfare problems with jaws deformities in farmed Tasmanian salmon [76]. In New Zealand, whirling disease has been reported in salmonids [77]. Other problems on salmon farms include cataracts, deformities such as 'hunchback' syndrome and so-called 'death crowns' due to sea lice infestation [74]. Mass mortalities on salmon farms are so commonplace that the Department of Agriculture, Fisheries and Forestry Australia have published a handy 'Disposal Manual' that covers 'the safe transport and disposal of carcases, animal products, materials and wastes'. The 'Destruction Manual' 'guides the decision to destroy stock, and the choice of appropriate techniques' [78].

Diseases and parasites are also problems in other sectors; be it nodavirus or barramundi encephalitis virus (BEV) in barramundi, 'Beko' disease, gill fluke and black spot in kingfish or blood fluke in tuna [79]. A potentially huge problem also

exists in Kudoa contamination of farmed tuna. According to a 1991 Fisheries Research and Development Corporation project: "The only fish health issue identified during the project was the presence of the parasite Kudoa in 0.5% of the marketed southern bluefin tuna" [80]. It is not known whether these studies have been published or if Kudoa has taken a hold in Australian tuna farmed. What is certain however is the capacity of Kudoa – a flesh eating parasite – to shatter market confidence. In Canada, Kudoa (also known as "soft-flesh syndrome") has devastated the farmed salmon market costing the Canadian industry CA$30-40 million and affecting 20-50% of salmon farmers. The problem with Kudoa is that the parasite does not manifest itself until several days after the fish has been slaughtered, when it 'liquefies' the salmon's flesh [81]. Kudoa would not be good news for Australian tuna farmers dependent upon exports to the Japanese sashimi sector. Kudoa is not the only parasite affecting farmed tuna – instead of eating the flesh of the fish this one burrows through the brain:

"A syndrome characterized by atypical swimming behaviour followed by rapid death was first reported in captive southern bluefin tuna Thunnus maccoyii (Castelnau) in the winter of 1993. The cause of this behaviour was found to be a parasitic encephalitis due to the scuticociliate Uronemanigricans (Mueller). Based on parasitological and histological findings, it is proposed that the parasites initially colonise the olfactory rosettes and then ascend the olfactory nerves to eventually invade the brain" [81]

New diseases in farmed tuna are emerging all the time as tuna farming expands and problems manifest themselves. A recent review of disease in tuna stated that: "it has become clear that much more research needs to be undertaken on the physiology of the species (southern, northern and Pacific bluefin tuna) currently used in aquaculture in order for the pathogenesis of some conditions to be properly understood" [82].

Kingfish are also emerging as carriers of infectious diseases and parasites. In their environmental statement for a kingfish and red snapper farmed in Moreton Bay Marine Park, Queensland, SunAqua concede that "wild snapper in Western Australia are known to have several parasites including the didymozoid trematode" and that "the pathogens Vibrio spp and Cryptocaryon irritans are also recorded in cage culture in Japan and New Zealand" [84]. In Japan, species of marine flatworm, such as hadamushi, are already significant problems in farmed yellowtail kingfish. Hadamushi has also been found in wild yellowtail kingfish in Australia and it is predicted that more parasite outbreaks are likely to occur in Australia in the future [85]. Research by fish biologist Tim Dempster at the University of Sydney on a sea-cage kingfish farm at Port Stephens in New South Wales (and on Mediterranean farms) also shows has sea cages attract vast numbers of wild fish which can either infect farmed fish or be infected themselves [86].

Imported fish meal also has the potential to devastate wild fish populations and spread diseases. Feeding large tonnages of imported fish such as pilchards to farmed tuna is an activity that presents a high quarantine risk. Such a high risk strategy has not prevented tuna farmers in South Australia, unable to source fish feed from local stocks, importing ca. 50,000 tonnes of pilchards from North American waters. In 1995 and 1998 the local pilchard populations started dying off. As the Fisheries Research and Development Corporation explains:

"The pilchard mass mortalities of 1995 and 1998/9 were unprecedented in their rate and geographical scale of spread. Waves of mortality spread from South Australia to Western Australia and to Queensland at a rate of 10-40 km d^{-1}. In many cases, stocks were reduced by over 60%. The cause of this mortality was certainly a herpesvirus" [87]

As with the link between toxic algal blooms and fish farm wastes, the causal relationship between imported farmed fish meal and wild fish mortalities is all too obvious. Again, however, the government seem more interested in protecting the tuna farming industry than wild fish. A report to CSIRO in 1997 stated that pilchards imported as feed may have been implicated in the herpes-like virus infected affecting wild populations of pilchards but indicated that there was "administrative difficulties and debate regarding the independence of scientific advice". According to a government scientist "there is strong circumstantial evidence for a connection between the locations of the pilchard mortalities in 1995 and 1998 and their proximities to caged aquaculture ventures in South Australia" [88]. Coincidence or causal link – we may never know for certain [89]. In 1999 the Environment, Resources and Development Committee of the Parliament of South Australia recommended:

"The rapid phasing out of the importation of pilchards in conjunction with the phasing in of manufactured diets for farmed tuna. The Committee would like to see commercial trials of the use of manufactured diets in the next tuna season, in partnership with the industry. These trials should occur as a matter of urgency" [90]

Losses from diseases and parasites are not the only mortality problems on sea cage fish farms. In South Australia, at least 13% of all dolphin carcasses studied are believed to have died as result of entanglement, including many in the tuna feedlots near Port Lincoln. A study by the South Australian Natural History Museum recommended minimising wastage when feeding tuna, since overfeeding attracts other fish species to the vicinity of the feedlots. Evidence strongly suggested that dolphins and sea-lions were eating these other species in the vicinity of the feedlots, and then becoming entangled [91]. Seal

predation is also a big problem in the Marborough Sounds of New Zealand [92]. The threat from predators is altogether more hazardous though in Australian waters. As well as Leopard seals and sealions, predators include whale sharks, tiger sharks and crocodiles [93]. As one barramundi farmer in Northern Territory explained to ABC in 2001:

"They've got a whole different range of predators, if we haven't got seals coming up and nipping you on the gumboot we've got crocodiles potentially tearing you off and eating you, so sometimes it's hard to see the feed loss and that sort of thing" [94]

4) Chemicals:

The illegal and state-sponsored use of toxic chemicals has received considerable attention in Scottish salmon farming [95] and more recently in Chile with the illegal use of the carcinogen malachite green [96]. The use of artificial colourings has also been under the spotlight with a lawsuit in the United States taking legal action against supermarkets for not labelling farmed salmon [97]. European salmon farmers have until the end of the year to drastically reduce the levels of Canthaxanthin (E161g) after the European Commission's Commissioner on Health and Consumer Protection declared the artificial dye unsafe [98]. Where this leaves New Zealand and Tasmanian salmon farmers using artificial chemicals to colour their farmed salmon is unclear but it is known the artificial dye astaxanthin is used in both New Zealand and Australia. The current status of chemical use in Australia is thus far unclear.

Chemicals used on kingfish farms are understood to include hydrogen peroxide as a bath to control skin and gill fluke infections and Praziquantel for more intense infections. Sunaqua's environmental statement for their proposed kingfish and red snapper farm in Moreton Bay, Queensland, alludes to the use of 'therapeutants and chemicals' but does not list them [99]. When asked to list all the chemicals to be used, Sunaqua's MD merely states that "no chemicals or agents would be allowed to be administered without QFS (Queensland Fisheries Service) consent" and that "we will not be using antibiotics as a matter of course" (Dr Julian Amos, pers.comm). Requests to Government officials for further information on chemical use in Australia and New Zealand have either been refused or are taking time to process. According to the Department of Primary Industries, Water and Environment in Tasmania, "chemical use in salmon farming in Tasmania has generally been very low" but they do not specify which or in what quantities. They do admit that anti-fouling copper-based paints are being widely used:

"The industry has in the past avoided the use of conventional anti-foulants on net cages, but has recently obtained a limited permit from the National Registration Authority to use copper-based anti-foulants on predator nets in an attempt to combat seal attacks during frequent net changes of unprotected nets. A condition of the permit is a study to determine the impact of this use. Work is still continuing on potential alternatives anti-foulants" (Darby Ross, pers.comm)

Last year the Scottish Executive expressed "reason for concern because of the accumulation of copper in sediments below fish farms, and its potential toxicity to benthic organisms". A survey carried out in 1996-7 by the Scottish Environment Protection Agency found that sediments directly beneath the cages and within 30 metres of the farms were severely contaminated by copper and zinc at 7 of the 10 farms surveyed. The report pointed out that elevated copper and zinc concentrations, in combination with high levels of other potentially toxic substances such as sulphides and ammonia, could represent a significant barrier to the recolonisation of benthic sediments when fish farm sites are fallowed [100]. New Zealand scientists have also found concentrations of zinc that exceeded the criteria for adverse ecological effects and suggested that recovery of benthic assemblages might be delayed because of heavy metal contamination in the polluted sediments under salmon cages [101].

In Tasmania, "effective treatments" being investigated by the Fisheries Research and Development Corporation include "the use of multiple freshwater baths to remove and kill the parasitic amoeba". The chemicals referred to are chlorine dioxide (Anthium dioxide^{TM}), chloramine-T (Halamid^{TM}) and hydrogen peroxide (Ecoshield^{TM}). According to FRDC, "Further development of these treatments is planned through the health program of the CRC for sustainable aquaculture of finfish (Aquafin) to provide a cost effective and efficacious treatment for AGD" [102]. As the industry trebles production over the next decade there will inevitably be an explosion in diseases, parasites and the consequent use of chemicals. Nutreco's barramundi farm in Northern Territory has only been in operation for a few years but it has already experienced disease outbreaks requiring chemical controls:

"Treatment for gill fluke and the copepod is relatively benign with hydrogen peroxide bathing being used….The hydrogen peroxide is transported as a 50% solution to Barrabase in 200 litre drums and moved to pens when required. The fish to be treated are crowded into an area approximately one quarter of the size of the pen. The hydrogen peroxide is diluted with water to a concentration of 400ppm and pumped through the pens using a soaker hose" [103]

If Nutreco are already experiencing significant disease problems with production levels at only ca. 500 tonnes per year what chemicals will they have to resort to if production reaches the 10,000 tonnes predicted by 2010?

5) Feed:

The fifth and fatal flaw of sea cage fish farming relates to its dependence upon a wild fish fuel supply that is both depleted and contaminated. Sea cage fish farming is like an oil tanker running on empty [104]. Vast quantities of fish meal and fish oil are imported from Chile and Peru countries to supply salmon, cod, halibut, turbot and tuna farms all over the world [105] Marine fish and salmonids together account for 85% of all fish oil consumed by the aquafeed sector [106]. Such are sea cage aquaculture's demands that krill from the Antarctic and Arctic are now being targeted by the capture sector as raw material. Krill are a precious commodity to salmon farmers in particular as they as relatively PCB-free and also naturally contain pink pigment [107]. The crux of the current problem is that we are scraping the bottom of the barrel when it comes to exploiting fisheries – we are 'fishing down marine food webs' but at the same time we are also 'farming up marine food webs'. As Dr Daniel Pauly said at the American Association for the Advancement of Science meeting in 2001: "the new trend in aquaculture is to drain the seas to feed the farms" [108]. The Australian Fisheries Research and Development Corporation recognised this problem back in 1993:

"If aquaculture is to continue to expand in Australia cost-effective diets based on Australian agricultural ingredients urgently need to be developed. The replacement of fish meal as the protein source of choice is a global research priority driven by a declining supply of fish meal and rapidly expanding aquaculture and aquaculture feed industries" [108]

Research has been ongoing in Australia over the last decade to investigate the potential of soybean meal, pea protein concentrate and lupin protein concentrate to replace fish meal protein [110]. The substitution of fish meal with vegetable protein is a significant trend within the global sea cage fish farming industry. For example, the proportion of vegetable oils used in Nutreco Aquaculture's total fish feed production doubled from 5.5% in 2001 to 11.4% in 2002. Scottish Quality Salmon (SQS) recently revised its standards to allow members to substitute up to 25% of the fish oil in salmon diets with plant oil whereas Norway salmon farmers use up to a third vegetable oils [111]. A new European Union-sponsored initiative - "Fish Oil and Meal Replacement" (FORM) – is also underway across Europe to find alternative fuel supplies for carnivorous fish [112]. Tuna farmers in Australia have also looked at switching from the use of fish such as pilchards to dry feed pellets with a significant vegetable component. Results from the studies show that food conversion ratios improves significantly from 15 to 1 with pilchards to 5 to 1 for pellets (five tonnes of pellets turns into one tonne of tuna flesh) [113].

Despite the savings in feed costs (and in terms of environmental impact) tuna farmers are reluctant to switch to pellets as the final product tastes different to wild fish. Similarly, the substitution of fish meal with vegetable protein fundamentally alters the 'meaty' taste of carnivorous fish. It seems carnivorous fish fed on soybeans, maize, peas and other vegetables are just not fishy enough. You are what you eat after all. For example, the Japanese - the largest buyers of farmed salmon and tuna for sushi and sashimi – have in the past sent back consignments of Norwegian salmon complaining that it tasted too 'earthy'. In taste tests farmed cod also fared badly against wild caught cod [114]. Ultimately, trying to turn a carnivore into an herbivore is doomed to failure and rather like force-feeding a tiger on lentils and rice [115].

So if there are no wild fish left in the sea and vegetables are not palatable to either the fish themselves or the end consumer what options are left open to sea cage fish farmers? Australian scientists think the answer may lie on land not out to sea. Just as BSE was rearing its ugly head in Europe, scientists at CSIRO's Queensland research facility and at the University of Tasmania started working on the substitution of fish meal with terrestrial protein from chickens and other meat- producing animals. A 1993 FRDC project outlined the problem:

"Australia is particularly vulnerable to any world shortage of fish meal because of our reliance on imported fish meal. However, Australia has an abundant supply of terrestrial animal and vegetable protein feeds which have the potential to at least partly if not fully replace the fish meal presently used in compounded aquaculture diets. Successful and cost-effective replacement of fish meal by terrestrial proteins in aquaculture diets may provide export opportunities for Australian feed manufacturers to supply the large Asian aquafeed market" [116]

Trials were conducted on barramundi using "three terrestrial abattoir meals (poultry offal meal and two meat meals) and blood meal". Diets based on meat meal or poultry offal meal performed as well as diets based on Tasmanian fish meal. Another 1995 project by the FRDC stated that:

"Australia has an abundant supply of terrestrial animal and vegetable protein feeds which has the potential to at least partly if not fully replace the fishmeal presently used in compounded aquaculture diets. Fish reared on diets containing high inclusions of meat meal, with or without some fishmeal but supplemented with fish oil, was found by trained taste panel

assessment to be liked as well or better than fish reared on a diet formulated with a high fishmeal content…..These results demonstrate unequivocally the suitability of meat meal as a partial or complete replacement of fishmeal protein in grow-out diets for barramundi" [117]

When asked for further details on meat substitution in fish feeds, the author of a paper on meat meal in farmed barramundi published earlier this year [118] replied that:

"The reported meat meal work in barramundi feeds was done before the BSE issue made headlines around the world. Although Australia has been fortunate in not having had any BSE problems, our feed manufacturers have taken a firm position of excluding any terrestrial animal protein from aquaculture feeds where harvested fish is exported to Europe or other countries (e.g. Japan) where certification of freedom from land animal products in feeds is required. In reality, this means that meat meal is excluded from all Atlantic salmon feeds (only one feed manufacturer in Australia) and usage in barramundi feeds would be minimal. I am not privy to the feed formulations used by the Feed Companies. The BSE issue is a concern but it is also a shame that meat meal is banned because it a very good source of protein for fish. I am unaware of any reports implicating transmission of BSE to humans through consumption of fish" (Kevin Williams CSIRO, pers.comm)

Australian researchers advocating the use of meat meal in fish diets should perhaps read a report - "Prions get fishy" – published earlier this year in Nature. It states that:

"Fish, like sheep, elk and humans, could suffer a version of 'mad cow disease', or BSE, preliminary evidence suggests. The results might help to reveal how the disease jumps from species to species. Infectious prions are thought to cause BSE and human variant Creutzfeldt-Jakob disease (vCJD). They probably crossed from sheep to cows, and then to humans in infected meat" [119]

Such is the concern for cross-contamination in Europe that the UK Government are investigating farmed fish for BSE type diseases and the European Union banned fishmeal in animal feeds [120]. Nor are barramundi the only aquaculture species in Australia weaned on meat. According to the Department of Primary Industries "farmed crocodiles are generally fed chicken heads and/or kangaroo meat and sometimes beef and horse offal" [121]. More seriously, farmed salmon have been fed on potentially infected meat meal. A 1998 FRDC project, in collaboration between Nutreco's fish feed company Skretting Australia (the major manufacturer of salmonid feeds in Australia) and the Nutrition Group at the Tasmanian Aquaculture and Fisheries Institute stated that:

"Atlantic salmon parr were used to assess the apparent digestibility of crude protein (nitrogen), indispensable amino acids and energy of 19 protein sources with potential for use in Atlantic salmon feeds. Protein sources included marine (fish meal), animal (meat, meat and bone, blood, feather, poultry meals) and plant (canola, corn, lupin, soybean, wheat) products" [122].

Since Australia already imports over 60% of its fish products and is committed to trebling aquacultural production by 2010 it is clearly under pressure to increase its supplies of fish meal and find alternative feed sources. Whether that involves importing contaminated fish such as herring from Europe, disease-ridden pilchards from South America or feeding fish on potentially contaminated meat, meat and bone, blood, feather and poultry meals the risks are all too real. The painfully obvious conclusion is that we must stop farming carnivores such as salmon, tuna, barramundi and kingfish and start supporting sustainable forms of aquaculture such as shellfish farming.

Food for Thought:

Fish is an important food source – in fact it is the primary source of animal protein for one billion people. However, it is a myth peddled by apologists for expansion of carnivorous fish farming that all aquaculture "feeds the poor" and must therefore be supported at all costs. The bulk (93%) of total finfish production within developing countries in 2000 was contributed by omnivorous/herbivorous and filter-feeding fish species. In contrast, 73% of the total finfish production within developed countries in 2000 was due to the culture of carnivorous fish [122]. The so-called 'Friends of Aquaculture' [123] and Global Aquaculture Alliance's "Feeding the world through responsible aquaculture" programme [124], for example, are clearly designed to group the whole spectrum of farmed fish sectors in the same boat and present a united front. Yet, as in the agriculture sector, aquaculture has many different facets and affects the marine environment in many different ways. Sea cage fish farming is as similar to shellfish farming, for example, as intensive factory farming is to small scale subsistence or organic farming. Genetically engineered fish, for example, are portrayed as a panacea for the world food problem [125] but are nothing to do with alleviating poverty and everything to do with making money.

The developing world is clearly dependent upon family fish farming to support itself but factory fish farming in the developed world is altogether different. The business of carnivorous sea cage fish farming essentially turns a cheap low

quality wild fish product into a luxury cash crop. Australian and Mediterranean farmed tuna, for example, is sold almost exclusively to the Japanese sashimi markets whilst farmed salmon from Chile, Norway, Canada and Scotland also find their way into sushi bars. Farmed yellowtail kingfish is being marketed under the Japanese name for the fish, hirmasa. Potential markets for Australian hirmasa are certainly not the starving millions in Africa but high class restaurants and gourmet shops in Japan and North America. Barramundi from Nutreco's farm in Northern Territory is not sent to Africa but exported to restaurants in New York and Europe where it is sold for $30 a plate [126]. Sea cage fish farming is as far away from 'feeding the world' as it gets.

The notion that farmed fish is a healthy substitute for wild fish is a fallacy. There are fundamental food safety differences between wild caught fish and factory farmed fish. Back in 1999 the World Health Organisation published a report on "Food Safety Issues Associated with Products from Aquaculture" concluding that there were considerable gaps in our knowledge which hindered the process of food safety risk assessment [127]. Australian and New Zealand scientists all contributed to a report concerned with the contamination of aquaculture products published in 2000. They too concluded that "information is still lacking on the effects of toxicants and water quality parameters on Australian and New Zealand aquaculture species" [128].

The high level of risk associated with farmed fish products can be graphically illustrated in the "Rapid Food Alerts" issued by member states in the European Union. Fish products (farmed and wild) were responsible for over a quarter (26%) of all food alerts issued during 2002 – the riskiest of all food categories and ranked higher than meat, dairy and other food products [129]. The harsh truth is that fish are the most contaminated of all foodstuffs and farmed fish fed on a cocktail of toxic chemicals and on contaminated fish meal are the worst of the worst [130]. For example, the European Commission's Scientific Committee on Food concluded in November 2000 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. The European Commission's Scientific Committee on Animal Nutrition concluded in November 2000 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" [131]

Given that carnivorous farmed fish such as salmon are fed a diet containing 30% fish oil and 45% fish meal (for tuna this rises to ca. 100%) it is not surprising that these same contaminants bio-accumulate in the flesh of the fish. Farmed salmon, for example, have been shown in tests carried out by the UK's Pesticides Residues Committee to be contaminated with DDT, chlordane, dieldrin and lindane [132]. The Irish Food Safety Authority has found levels of PCB contamination four times higher in farmed salmon than wild salmon [133]. And a recent report published in North America comes to similar conclusions and calls farmed salmon a cancer risk [134]. Nor is the problem restricted to salmon farms in Europe and North America. Earlier this year, for example, Japanese farmed blowfish were found to be contaminated with the carcinogenic chemical formalin [135]. Contaminated fish such as herring from the Northern hemisphere have also been exported to feed tuna farms in Australia [136]. When questioned about the potential for dioxin contamination in imported fish meal, Food Standards Australia New Zealand stated that: "FSANZ does not consider that current scientific evidence in relation to dioxins warrants the testing of fish imported into Australia" (Mark Salter, pers.comm).

Given the problem of dioxin and PCB contamination in European fish (eight times more contaminated than fish caught in the Southern hemisphere), the FSANZ's stance is alarming and represents the antithesis of the precautionary principle. According to a report published by the European Parliament in 2001, 90% of Swedish and Finnish fish is classed as "high risk" and there are hot spots of PCB/dioxin pollution in areas such as the Mediterranean and Baltic Sea [137]. Nor is this only a public health issue – testing of sediments by the Scottish Environment Protection Agency has shown high levels of PCBs under salmon cages (caused by contaminated fish feed).

Residues testing by the Australian authorities have revealed high levels of contamination in wild fish as well as farmed fish. The 'Australian National Residue Survey Results' for 2001-2002 for example detected copper contamination in 100% of farmed salmon tested (60 out of 60 samples), mercury in 87% (52 out of 60 samples), selenium in 100% (60 out of 60 samples) and zinc in 100% of farmed salmon tested (60 out of 60 samples). Farmed tuna fared even worse with copper detected in 100% of samples tested (18 out of 18), lead in 89% (16 out 18), mercury in 100% (18 out of 18), selenium in 100% (18 out of 18) and zinc in 100% (18 out of 18). Heavy metal contamination was also found in farmed barramundi with 100% (8 out 8) of samples contaminated with copper, 50% (4 out of 8) with lead, 100% with mercury (8 out of 8), 100% with selenium (8 out of 8) and 100% (8 out of 8) with zinc. Fish were responsible for 43% of samples with residues over the maximum levels permitted [138].

The dangers of eating too much fish are all too real. Another survey – "Metal Contamination of Major NSW Fish Species available for human consumption" – by New South Wales Health Department showed that 13.6% of fish sampled exceeded

one or more of the metal contaminant standards. Excessive selenium accounted for 74% of the fin fish failures and mercury 22%. Under 'Risks to Public Health' the report stated that:

"While fish is not a staple food in the Australian diet it can provide a significant proportion of dietary metal contaminants. Fin fish is the major source of dietary exposure to mercury, crustaceans are the major sources of dietary exposure to cadmium, and fish in general is a major source of dietary exposure to arsenic" [139]

Globally, we have polluted our marine and freshwater environments to such an extent that we are now reaping the consequences with the bio-accumulation of contaminants up through the food chain and into our fish. The farming of carnivorous fish simply (and very efficiently) bio-magnifies these contaminants and concentrates them in the flesh of the farmed fish. Instead of eating the end product however we should label it as 'hazardous goods' and dispose of safely rather than serve it up as a supposedly 'healthy and nutritious' meal. There are simply too many question marks about the safety about farmed fish to inspire any kind of consumer confidence. For example, mercury contamination in wild tuna is well known [140] but it is unclear whether tuna farming increases or decreases levels of mercury in the flesh of the fish. When questioned whether farmed tuna is tested prior to export to Japan, for example, Government agencies in Australia and in the Mediterranean remain strangely silent on the sensitive subject. The outstanding question is whether farmed tuna have even higher levels of mercury contamination than wild tuna. I guess it depends on how old the tuna are when they are caught and what they are fed on. Just as the farming of salmon bio-accumulates cancer-causing chemicals such as dioxins and PCBs, tuna farming is a potential public health disaster. In food safety terms the farming of tuna, salmon and other carnivorous species reliant upon a depleted and contaminated food source leaves a nasty taste in the mouth.

Slipping through the Worldwide Net:

Despite the burgeoning body of evidence exposing the fundamental flaws inherent in sea cage fish farming, government agencies around the world have sponsored and bankrolled rapid expansion in advance of environmental and public health safeguards. Effectively this is state-sponsored pollution. Farmers have been given carte blanche to do as they please and have essentially been handed a blank cheque. Governments have protected sea cage fish farmers from public scrutiny and permitted them to pollute with impunity. Farmers seemingly have given diplomatic immunity from prosecution. Any fines that are handed out are merely a drop in the ocean to multi-million dollar businesses such as Nutreco. The process of Environmental Impact Assessment, for example, has either been circumnavigated altogether or environmental assessments have been carried out after farms have already been established. Nutreco's barramundi farm in Northern Territory, for example, proceeded without a proper Environmental Impact Assessment. According to Kirsten Blair of the Environment Centre for Northern Territory:

"Considering the impacts sea cages have had elsewhere, Environment Minister Tim Baldwin will be neglecting his responsibilities if he allows this operation to commence without a full public and transparent Environmental Impact Assessment…. The pristine marine environment of the Northern Territory is one of our major assets and it will be a tragedy if the NT starts repeating the mistakes already made with aquaculture elsewhere in Australia" [141]

Nutreco have subsequently published an 'Environmental Management Plan' but this is rather like shutting the cage door after the barramundi have bolted [142]. Sea cage fish farming continues to slip through the legislative net worldwide. The lax regulatory regimes in Australia and New Zealand are no different than in Scotland, Norway or Canada who all claim to have the 'most tightly regulated industry in the world'. As Dr Otto Langer, a former Canadian government official now working for the David Suzuki Foundation in Vancouver, states:

"Throughout the development of the industry there has been an obvious lack of meaningful government control and regulation. The Provincial and Federal Governments have promoted the industry at a cost to the environment….From its very onset the industry was prone to countless violations of the Fisheries Act. This has included the escape of hundreds of thousands of fish including Atlantic salmon, harmful alteration of habitat including the smothering of the benthos under the net pens with fish wastes, unapproved facilities that interfere with navigation, and the illegal deposit of deleterious substances. Despite this, the agencies did not put this industry on an even playing field with other industries that would be held responsible for similar actions" [143]

The above quotation refers to salmon farming in Canada but it could equally apply to sea bass farming in the Mediterranean or tuna farming in Australia. The Australian Marine Conservation Society (AMCS), for example, points to the 'poacher-gamekeeper' role of the state as both protector of the environment and promoter of the industry:

"AMCS considers that there is a conflict of interest in the fact that PIRSA, a primary industry promotion and development agency, also licences, regulates and monitors aquaculture operations in South Australia. Responsibility for industry support,

development and promotion should be clearly separated from industry regulation, particularly regulation of aquaculture impacts on the environment. DEH and EPA should have formal responsibility for approving or prohibiting aquaculture developments on environmental grounds, and sufficient staffing and resources should be provided for this task" [144]

Sadly, such is the incestuous nature between multinational industries and global governance that the above acronyms translate easily to Norway, Scotland, Canada and Chile. Government environmental agencies around the world, starved of funding, have had to sit idly by as farmers display a healthy disregard for the law. Earlier this month for example, Tassal, the largest salmon farming company in Tasmania, was found guilty of price fixing [145]. Salmon farming companies in Chile were also caught using chemicals illegally [146]. In May, salmon farmers in Maine were found in violation of the Clean Water Act [147]. In the same month, Irish salmon farmers were exposed as flouting European law in at least half a dozen cases in relation to aquacultural expansion [148]. Salmon farmers it seems view themselves as above the law.

Tuna farmers have been caught out too. A report published in 2000 by the Environment, Resources and Development Committee of the Parliament of South Australia stated that:

"Its [tuna farming's] long-term environmental impacts are unknown and its development is preceding legislative and policy control. This case of tuna feedlots in Louth Bay demonstrates the deficiencies in the management of this form of aquaculture….As well as revealing the inadequacy of the legislation regulating aquaculture, this inquiry has also highlighted either the lack of will or the lack of sufficient compliance officers to successfully enforce the existing legislation. The Committee finds that the current regulations for aquaculture do not adequately address planning issues surrounding this industry" [149]

Two years previously another inquiry by the Environment, Resources and Development Committee of the Parliament of South Australia exposed gaping holes in the assessment process:

"Development plans currently lack sufficient detail, partly due to a lack of biological data, to give developers any level of certainty on lease approvals. This lack of biological data also hampers adequate assessment of development applications for marine aquaculture. As a consequence the approval process is largely application driven with currently 300 applications pending and insufficient resources to properly assess them. In the majority of applications, a site inspection, including transects by divers, does not occur despite the inadequate biological data available….Current processes for assessing aquaculture development applications are not viewed by some interested parties as sufficiently independent, transparent or scientifically rigorous" [150]

In handing out production licences, often without public consultation and without environmental impact assessments, countries such as Scotland, Canada, Norway, Chile and Australia have served sea cage fish farmers with what amounts to 'compulsory pollution orders'. Dr Langer continues his Canadian critique:

"Most jurisdictions other than Chile boast that they have the most stringent salmon farm regulations in the world. British Columbia is no exception. Despite the mandates of MWLA, MAFF, DOE and DFO the promotion of the industry far outstrips the necessary research, regulations, and enforcement necessary to allow salmon farmers to adopt techniques and operating procedures that are environmentally sustainable. There has been little objective assessment of the environmental impacts caused by the salmon farm industry or how the government does its job to manage this industry. Day to day decision by government agencies has been unbalanced in that they insist that fish farms cause no or little risk to the environment. The information available simply does not support that politically motivated agenda"

Once again, the above acronyms of government agencies in Canada could easily be substituted for SNH, SEPA and SERAD in Scotland [151] or SARDI, PIRSA and EPA in South Australia . Such is the universal state support for sea cage fish farming that the Canadian critique outlined above would have similar resonance across the globe. The lawless nature of Chilean salmon farming was recently described by Ecoceanos's Juan Carl Cardenas in a Norwegian newspaper as like the "wild West without a sheriff" [152]. If Australia continues on its present course it could be entering the realms of cowboy country itself.

The Final Frontier:

Developments in off-shore engineering technology are taking aquaculture into unchartered waters [153]. Moves by Japan and the United States in particular towards offshore aquaculture raise the prospect of a frontier economy. Ocean scientists from Hubbs-SeaWorld Research Institute, for example, are investigating the use of oil rigs off the Californian coast for fish farming. The marriage of oil rigs and farmed fish may not be a perfect partnership though. A vital issue that must be tackled relates to the growing threat of mercury pollution – wild fish such as tuna, swordfish and marlin are already contaminated

with mercury. Since oil rigs have been fingered as a source of mercury pollution in fish are they really a safe haven for raising farmed fish for human consumption? [154]

Food safety fears aside, the US National Marine Fisheries is busy promoting the development of aquaculture in the Exclusive Economic Zone (3-200 miles offshore) and have already published an 'Operational Framework for Offshore Aquaculture'. Experimental pens of halibut and haddock are already being grown in the Exclusive Economic Zone off the coast of New Hampshire and white seabass off California. One farm 33 miles off the coast of Florida wants to farm cobia, mahi mahi, Florida pompano, greater amberjack and red snapper [155]. Other US projects are underway in waters off Puerto Rico, Hawaii and Washington State [156].

In South Australia, environmental groups have voiced concern that moving tuna farms further out into Spencer Gulf will mean more interaction with wildlife, particularly near the Sir Joseph Banks Group and Dangerous Reef. Flocks of scavenging silver gulls could displace terns and other birds on the islands, while sea lions, sharks and dolphins could have negative interactions with fish cages, according to groups such as the Australian Marine Conservation Society and the Conservation Council of South Australia [157]. Sea cage companies though see big advantages in moving into deeper water.

"By residing in an environment that boasts strong tidal flushing, open ocean aquaculture does not have to contend with the kind of waste build-up that occurs at near shore operations. The constant flushing also means that diseases may not have as strong a chance of flourishing" [158]

According to Intrafish (21st August 2003):

"It seems, then, that the question is not if open ocean aquaculture is feasible but rather how quickly fish farmers will be able to achieve the economies of scale and the automation required to make it a profitable enterprise. Hawaii, for one, expects to have ten open ocean farms within a decade. Who will be next?"

Orders for off-shore cages have been received from Spain, China, the Bahamas, the Caribbean, the United States, Korea and Australia. Welcome to the brave new world of 21st century fish.

Twenty First Century Fish - a Leap in the Dark:

Developments in offshore technology coupled with advances in genetic engineering are now science fact not science fiction. Fish though are the riskiest of all species currently being genetically engineered [159]. Unlike Dolly the Sheep who sits quietly in an enclosed field munching grass, farmed salmon are genetically programmed to swim thousands of miles across the open ocean. A new report published in June by the Korea Maritime Institute warns of the dangers of GE seafood [160]. In Australia there does not appear to be any clear policy direction with regards to the current or future use of transgenic or GE seafood and aquaculture. However, behind closed doors it is obvious that Australia is preparing to take the plunge. The Australian Institute of Marine Science hosted 'Genetics in Aquaculture 2000' [161] and scientists such as Dr Peter Grewe at CSIRO Australia are "reducing the risk of transgenic fish or shellfish by using sterility techniques" [162]. At a seminar in Australia in 2001, Dr Grewe explained that:

"The CSIRO's Sterile Feral program has developed an alternative technique that uses a genetic construct to render aquaculture species (both fish and invertebrates) reproductively unviable unless they are dosed with a repressor compound at a critical life history stage to permit survival….This genetic construct consists of a temporality active promoter linked to a repressible element that drives a blocker gene sequence and function to cause early mortality of offspring produced by escapees unless they a given a specific repressor molecule" [163]

CSIRO's quest for sterility is driven by the concern that "fish genetically improved via selective breeding or transgenic modification can contaminate wild populations". According to Dr Grewe:

"Work at CSIRO has focused on oysters, zebra fish and mice. The objective is to achieve aquaculture production of non-native species with zero risk of uncontrolled reproduction in the wild" [164]

Australian waters are certainly being coveted by GE fish companies. In May this year AquaBounty's Elliot Entis spoke at a conference in Australia [165]. ABC News reported (28th May) his visit claiming that "The world's first transgenic Atlantic salmon could be dished up on dinner tables in as little as 12 months" [166]. AquaBounty has already conducted field trials of GE salmon in New Zealand. The trials at New Zealand King Salmon are thought to have started in 1994 and are somewhat shrouded in secrecy. Papers have been presented at a conference in Australia in 2000 and to Aquaculture Canada 2002 [167] but information is still not freely available. Despite abandoning their trials in 2000 King Salmon said it would retain frozen

GE salmon sperm "at a secure location" so it was available to continue the program in the future [168]. If the political and public climate warms to GE seafood, GE salmon in New Zealand may yet come in from the cold. It may already be too late. Jeanette Fitzsimons, Green Party MP, revealed in June 2001 that: "The evidence shows it is highly likely that eggs from genetically engineered salmon escaped into the wild during the NZ King Salmon experiment at Kaituna" [169].

Closing the Net:

To avoid environmental and food safety problems reaching crisis point, the cancerous growth of carnivorous sea cage fish farming must be stopped dead in its tracks. In practical terms this includes ripping out cages in unsuitable locations, compulsory tagging of farmed fish, closed-containment systems and the promotion of environmentally benign shellfish and herbivorous finfish farming. A 'back to basics' approach is required which returns the industry back to first principles and back onto a sustainable course. For existing sea cage fish farms this may entail the '3Rs'; namely relocation, reduction and removal [170]. For new farms the process of Environmental Impact Assessment and Strategic Environmental Assessment must be taken into account at all stages in the pre-application, public consultation and planning process. Unless the net is closed, sea cage fish farming will be 'the one that got away'.

One of the easiest ways to mitigate the environmental effects of sea cage fish farming would be through the introduction of closed-containment systems. Such systems already exist but are dismissed out of hand by salmon and tuna farmers as too expensive. Cost savings from closed containment systems have been demonstrated however. The Future SEA Farms system, for example, out-performed conventional open netcages in tests in British Columbia reducing sea lice infestation 12-fold and decreasing mortality rates almost three-fold. Mariculture System's in-water system called SARGO is fitted with a filter that screens out bacteria and sea lice – it too increased farmed fish growth, decreased disease and decreased the use of feed [171]. Research in Canada clearly shows that waste treatment and closed containment systems are the sensible and sustainable way forward [172].

Nor do Australian tuna, barramundi or kingfish farmers have any excuse through lack of available technology. Efficient closed containment systems are already being used on land-based fish farms. Fish Protech, for example, have operated closed containment systems in Australia since 1990. According to Fish Protech:

"The Fish Protech system is designed to produce no waste into the environment. All water and output flows are recycled and reused in an environmental accepted way. Fish Protech fish farms have received EPA approval to locate in watershed (drinking water collection) areas. Other Fish Protech farms have received approval to sell the recycled water to local farmers or to recharge aquifers. Over 12 years of operation there have been no fish escapes or damage to the environment. This is impossible to achieve with ponds, cages or any other farming method….All waste is treated and never reaches the farm facility making the technology Australia's most environmentally friendly aquaculture system" [173]

If this closed-containment technology does what Fish Protech claims then why do sea cage fish farmers not treat their waste and eliminate escapes in the same way? Fish Protech says it already has 52 systems in operation across Australia with many more under construction. Meanwhile, sea cage fish farmers seem content to discharge contaminated wastes untreated directly into the sea. The Port Lincoln Times reported in May that 'tuna barons', Sam Sarin, with an estimated worth of $350 million, Tony Santic, $200 million and Hagen Stehr $160 million have all made it onto the elite list of Australia's richest people [174]. Pollution pays. By not paying for the pollution they cause, sea cage fish farms are treating the marine environment and other coastal users with contempt. As marine scientist Allan Berry explains:

"Cage farms are licensed to discharge untreated trade wastes directly to the sea, avoiding and externalizing the expense of waste treatment. This enables fish to be produced for less than a third of the cost, inclusive of waste treatment. This anomalous defect in environmental regulation (most other intensive livestock producers have to internalize such costs) has enabled an industry dominated by multinationals to become one of the world's largest, wealthiest and most influential sources of licensed pollution. Those who introduced, promoted and defended the industry, adopted the slogan: 'Jobs come first, nothing must be allowed to come in the way of such a benefit to fragile rural economies. Any environmental damage is a small price to pay'. Unfortunately for all of us, most politicians do not understand that the economy is only a part of the environment" [175]

Closed-containment systems would go a long way to solving four out of the 'five fundamental flaws of sea cage fish farming' – they would offer waste-treatment, prevent escapees, minimise the spread of parasites and disease and would consequently reduce the reliance on chemicals. It will be a bitter pill for sea cage fish farmers to swallow but the message is simple: closed-containment or close down.

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