# PIRSA Aquaculture: A Response to Environmental Concerns of Yellowtail Kingfish (*Seriola lalandi*) Farming in South Australia and Some General Perceptions of Aquaculture

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## Where are wild kingfish distributed?

Kingfish are distributed **globally** in cool temperate and subtropical waters of the Pacific and Indian oceans off South Africa, Japan, southern Australia and the United States of America. In Australia, kingfish have been recorded around the coast from North Reef, Queensland (23°11'S) to Trigg Island, Western Australia (31°52'S), and as far south as Tasmania.

## Why are kingfish used for aquaculture?

Kingfish are ideal for aquaculture because of their fast growth, excellent flesh quality and significant demand in international markets. Kingfish are the principal marine finfish species grown in South Australia and the sector is expanding rapidly. In 1999-2000 farm gate production was 45 tonnes valued at $500,000. By 2001-2002 production had risen to 1100 tonnes valued at $8 million. By 2003-2004, production of king fish is expected to reach 3,200 tonnes worth $24 million.

## Do kingfish have teeth?

Regardless of whether they are farmed or wild, all kingfish have tiny teeth that form broad, velvety bands (known as "villiform" teeth) in the jaws, on the front part of the roof of the mouth in the nasal region (known as the "vomer") and on each side of the palate (known as the "palatines").

## How big can wild kingfish grow?

Maximum size of 2.5 m total length and weight of 96.8 kg.

## Where do wild kingfish live?

Kingfish are a pelagic (i.e. living in the upper to middle depths of the sea), schooling fish, usually seen as adults in small to large numbers. In general they inhabit rocky reefs and adjacent sandy areas in coastal waters and occasionally entering estuaries. They are found commonly in waters down to 50 m in depth although have been recorded from over 300 m deep. Young fish up to 7 kg are known to form shoals of up to several hundred fish. They are generally found close to the coast, while larger fish are more common around deep reefs and offshore islands. Juvenile kingfish are rarely seen, as they are often found far from land associated with floating debris or weeds that provide camouflage. Juveniles are yellow with black bands. This colouration fades as the fish ages and by about 30 cm in length the fish has assumed its adult colouration.

## At what size and age can wild kingfish reproduce?

At present there is no data for South Australian kingfish, however, recent research suggests that wild kingfish in New South Wales spawn during the summer months. Males matured at smaller sizes than females. Females first matured at approximately 70 cm and 3 or more years of age, however 50% maturity was not achieved until about 83 cm. The smallest recorded mature male was 36 cm and the estimated size at which 50% of the male population were mature was 47 cm at 0 or more years of age.

## Where do wild kingfish feed?

Depending on their size, adult kingfish can feed from the seafloor, mid-water and on the surface.

## What do wild kingfish eat?

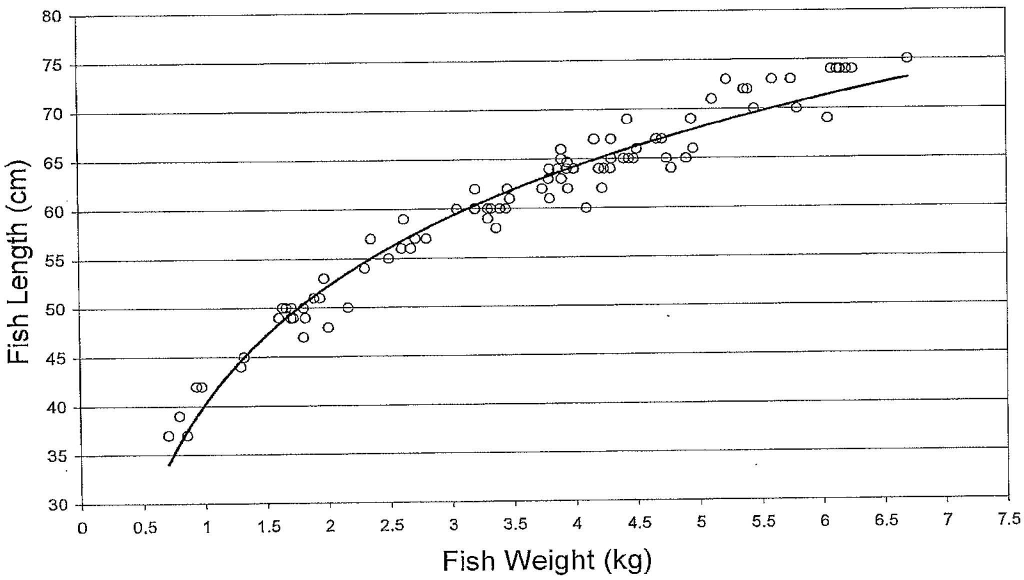
Wild kingfish feed on an assortment of fish (including Red bait, Blue mackerel and Tommy Ruff), krill, molluscs (squid and cuttlefish) and mid-water filter feeders (e.g. salps).

## What do farmed kingfish eat?

Farmed kingfish feed on a dry extruded pellet that has been adapted for marine fish. Pellets that have greater than 20% fat content are used most efficiently and should be fed to the fish between one and four times a week depending on water temperature and fish age and size. The food conversion ration (FCR) for a one-year-old farmed kingfish can be as low as 2:1 (i.e. for every 2 kg of pellets fed, the fish gains 1 kg of weight).

## What is the relationship between size and weight of farmed kingfish?

The length versus weight relationship for farmed kingfish in South Australia is summarised in the following figure.




## How far can wild kingfish move?

Results from a study conducted in New South Wales from 1974 to 1995 during which 17,000 kingfish were tagged showed that the majority of the 1376 fish recaptured (with length less than 600 mm) were found to be within 50 km of their tagging point. Small fish showed less movement than large fish, but few large fish were tagged. The maximum distance moved was 3000 km (fish tagged in New South Wales were recaptured in New Zealand) and the maximum time at liberty was 1742 days.

### What is the state of wild kingfish populations?

A significant commercial fishery existed in South Australia for kingfish until closures prohibited netting in the Northern Sector of Spencer Gulf in 1990, largely in response to pressure from anglers who prize kingfish for their fighting qualities. Since then there has been little formal investigation of wild kingfish populations. Information from New South Wales (a state without kingfish aquaculture) indicates increasing catches of wild kingfish, with 2002/2003 likely to see further increases in wild fish numbers. The same pattern is seen in the Sydney Fish Market with wild caught kingfish increasing from 91,531 kg in 1999 to 217,164 kg in 2002. This suggests a natural increase in the wild populations. It is not known whether the New South Wales populations are dependent or independent of South Australia kingfish stocks.

### In the past, how have farmed kingfish escaped in South Australia?

Kingfish have escaped through holes bitten in cages by sharks, during net changeovers, if netting fails due to manufacturing defects or if the net is damaged as a result of impingement from vessels (wayward or otherwise).

### Don't net changes allow fish to escape?

In the earlier years of the industry a couple of small escape events were associated with net changing. In these cases limited numbers of fish, approximating a few hundred, were accidentally released. Since then industry has become more experienced in its procedures, they have worked hard to eliminate procedural errors for example by introducing quality management systems such as ISO 140001. As a result there have been no escapes for a long time that could be attributed to net changes. Predator interactions with nets then became the predominant factor in escapes, and again the industry has had to work hard to try and overcome this problem. The last escape was not due to procedural error, or predators but due to net failure, and again industry is addressing this factor so that ultimately there will be a very much reduced risk of escapes.

### What is the reported size and number of escaped farmed kingfish to date?

There has been speculation amongst some community groups that escapes have numbered in the hundreds of thousands, however the public register on the PIRSA Aquaculture website details the reports of 18,809 escaped fish. This figure is consistent with the numbers of fish entering the farms and those going to market. PIRSA has endeavoured throughout to be entirely open and honest in reporting of escapes.

Date and numbers of escapees are publicly available using the following link (http://www.pir.sa.gov.au/pages/aquaculture/public_reg/ytk_escapes.pdf) and summarised in the following table:

| Date | Number | Average weight per fish (kg) | Length (cm)[c] | Biomass (kg) |
|---|---|---|---|---|
| 01/06/01 | 896 | 1.02 | 41 | 914 |
| 2nd ¼, 01 | 450 | 0.10 | - | 45 |
| 23/07/01 | 536 | 0.72 | 35 | 386 |
| 09/05/02 | 5500 | 0.50 | 28 | 2750 |
| 16/09/02 | 569 | 3.30 | 61 | 1878 |
| 31/01/03 | 1438 | 0.019 | - | 27 |
| 31/01/03 | 5000[a] | 1.70 | 49 | 0[a] |
| 06/04/03 | 11949[b] | 2.50 | 56 | 16373[b] |
| 18/06/03 | 448 | 0.15 | 7 | 67 |
| 31/07/03 | 2423 | 2.00 | 52 | 4846 |

[a]All recovered; [b]5400 recovered; [c]lengths based on farmed kingfish length vs. weight relationship.

## What is being done to prevent farmed kingfish escapes?

The industry has undertaken a number of key measures to prevent escapees including:

1. Inspections of the pens by divers have increased so that holes made by sharks are identified and fixed.
2. Dead fish in the pens are removed quickly to reduce the numbers of wild predators.
3. The industry is also investigating shark repellent pods to decrease attacks on the nets.
4. All licence holders have procedures in place to attempt the recapture of any escaped fish.

## Will escaped farmed kingfish damage the genetic integrity of wild kingfish populations in South Australia?

For farmed kingfish to damage the genetic integrity of wild kingfish the following circumstances must occur:

1. Farmed kingfish must be reproductively mature.
2. Farmed kingfish must spawn i.e. release viable eggs and sperm.
3. The spawn from farmed kingfish must mix successfully with wild kingfish spawn – the resultant progeny must then survive to reproduce successfully themselves with existing wild kingfish stocks.
4. Wild kingfish must be genetically distinct enough from farmed kingfish to produce either a genetic in- or out-breeding depression.

The largest kingfish to escape averaged 3.3 kg. Using the length versus weight relationship this equates to fish approximately 61 cm in length. It is very probable that all the females from this escape were **not** reproductively mature. Males that escaped at that size may have been reproductively mature. For fish to become reproductively mature there must be a readily available, high quality varied diet and the appropriate series of environmental cues eg temperature, light intensity, lunar cycle. Given the gut contents of escaped farmed fish, it is unlikely that males would feed well enough to support gonad development. Finally, all of the kingfish raised in aquaculture facilities in South Australia are first generation offspring of captured wild broodstock. Any escaped fish, therefore carry the same genetic makeup as the wild fish. Cross breeding therefore, in the highly unlikely event that it would occur with wild kingfish, would have **no** effect on the population gene pool of wild kingfish.

## Are the fish farms increasing the number of sharks in the area?

Firstly, scientists from SARDI Aquatic Sciences have analysed the catch and effort data from the commercial shark fishery in Spencer Gulf on both an annual and monthly basis. There appears to be a seasonal (i.e. natural) trend in movement of whaler sharks into the gulf and west coast waters during the warmer months of the year. Secondly, the biomass of kingfish in the gulf, compared with that of the other species is very low, actually, and it is unlikely that it would represent significant extra incentive for sharks to enter the gulf. Sharks, if present naturally, may well visit aquaculture facilities in the area, but farms routinely remove their mortalities and so no reward is presented to the sharks. It is unlikely, therefore, that aquaculture attracts extra sharks into the area.

## What causes deformities in farmed kingfish and do they pose a risk to wild kingfish?

It is true that skeletal deformities have been detected in farmed kingfish at various levels of prevalence. The deformities identified are more likely to be related to the management of the stocks whilst in the larval stages, specifically water temperatures and nutrition (eg incompletely formulated juvenile rations). The effects of handling, nutrition and water temperature on the incidence of deformities in cultured fish species are well documented in scientific literature. They therefore do not represent an infectious or genetic issue, and cannot be passed on to wild fish.

## How does the behaviour of escaped kingfish differ from wild fish?

Although farmed kingfish are bred from wild-caught brood stock, farmed fish incur considerable behavioural changes during grow out that impedes their ability to survive in a natural marine environment. The behaviours learned in a farm environment are very strong. Farmed fish are more risk prone as they have not learnt to avoid predators and other dangerous situations and display decreased foraging behaviours. Evidence from a variety of sources suggests that escapees prefer pellets to 'real' food items such as fish, crustaceans and molluscs. Escapees tend to remain close to a farm for an extended period of time enabling recapture to be attempted.

## Will the escaped kingfish feed on other fish and invertebrates, including cuttlefish?

Fish reared in aquaculture facilities are recognised as having poorer survival skills than wild fish, having become conditioned to human presence and a supply of high quality palatable feed. Escaped fish are not expected to feed strongly, and may in fact have difficulty recognising or catching prey.

## What are the wastes produced from farming kingfish in sea-cages?

Kingfish farming produces particulate organic and dissolved organic and non-organic material. These are in the form of excess feed, faeces and ammonia excreted by the fish.

## What effects can the wastes from farmed kingfish have on the environment?

The environmental effects of these wastes can vary from unmeasurable to significant and will be dependent upon a number of factors, principally; the actual amount released to the environment, the degree of water movement around kingfish farms and the ability of flora and fauna present in the water column (phytoplankton, zooplankton) on the seafloor (algae, seagrasses, filter feeders, crustaceans and fish) and in the sediments (bacteria, worms and other infauna) to assimilate the excess carbon and nitrogen produced. Typically, effects are noted directly underneath sea-cages and decrease with increasing distance away.

## How are the environmental effects of farmed kingfish monitored?

Kingfish farmers are required by law (under the Aquaculture Act 2001) as part of their license to culture fish to conduct an annual environmental monitoring program that assesses the impacts on the seafloor and the water column.

## South Australian kingfish farms are in their infancy, however gill fluke and black spot problems have already been reported, why is this so?

Fluke infection has been reported. Regular health monitoring, fluke counts and occasional treatments with hydrogen peroxide keep numbers low on the farms. Fluke infections originate from passing wild kingfish that have a natural level of infection.

## Do farmed fish spread disease to wild fish?

Infection of farmed stock with diseases found in wild stocks may well occur in areas where native wild stocks and farmed stocks are in close association. The presence of the disease is more likely to be noted in a farm due to health monitoring programs. It is important to remember that stocks are healthy and free of parasites and disease when transferred into the sea farms. Transfer of disease is more likely therefore to occur from wild to farmed fish. Whilst it is also true that any disease entering the farm from the wild is likely to have a faster spread within the farm, they are also more likely to be noticed and managed appropriately. The licence conditions require that farmers report notifiable diseases, and any mortality issues of an unusual nature.

### Once problems are found with parasites and disease in farmed kingfish, are these treated with chemicals and pesticides?

Not necessarily so, the mainstay of farm control is management practices including: fallowing, separation of age classes of fish, regular monitoring for parasite numbers, farm layout and husbandry practices. Only when there is no alternative are veterinary medicines used. Hydrogen peroxide may be used – this breaks down to water and oxygen. Pesticides as such are not used on farms, only veterinary medicines that have been tested in animals and used in many production species without problems. The use of medicines on the farm requires prior approval from PIRSA. Again, PIRSA has conducted research into environmental effects of some of the common veterinary medicines to better be able to apply approval conditions.

### Is it true that pellets fed to farmed kingfish contain hormones, antibiotics and growth promoters?

This is a common misconception. There are no growth promoters (apart from good quality well formulated feed containing vitamins, minerals and beneficial micronutrients) used in South Australia. No hormones are fed to fish in South Australia to make them grow faster. Antibiotics are used sparingly (they are expensive), only under a veterinary prescription to treat sick fish, and only after approval has been granted by PIRSA Aquaculture.

### Why doesn't the Government do some of these...?

1. *The sterilization of all fish put into sea cages - to avoid breeding with wild fish stocks.*
   In South Australia the fish put into sea pens are first generation offspring of wild broodstock. They therefore are genetically the same as the wild fish.
2. *Branding or tagging of all fish put into sea cages - to enable ready identification of escaped fish and who lost them.*
   Tagging would be difficult as the fish are small (approximately 5 grams and about 2.5 cm) when first introduced to sea pens. Research into the possibility of marking fish in the hatcheries has been supported by PIRSA.
3. *Locating all fish farms in land-based facilities - to avoid escapes.*
   This is economically not viable; to legislate this would shut down most of the industry.
4. *A ban on the use of prophylactic antibiotics together with testing for antibiotic residues - To stop the use of these.*
   All farms must apply to PIRSA for permission to use any medication. It is not PIRSA policy to approve prophylactic (preventative) use, but restrict medicine use to therapeutic (treatment) reasons only. The approval process already includes safeguards such as compulsory residue testing.

5. Lists of any pesticides or chemicals approved by Environmental Agencies to be publicly available - To avoid all possible misuse.
   This information is available on the website of the Australian Pesticide and Veterinary Medicines Authority
6. Public notification of escapes together with heavy penalties - To give growers an incentive to stop escapes.
   PIRSA releases information of escapes as received by placing details on the public register in the PIRSA website. Prevention of escapes and the immediate reporting of them are licence conditions and breaches may be punishable by revocation of the licence and/or a $35,000 fine.
7. Setting maximum stocking rates to avoid overcrowding which promotes parasites and diseases.
   Maximum stocking rates are included in current licence conditions. The factors that influence disease susceptibility and spread on a farm are more complex than this simple statement implies. Licence conditions and operating standards exist that deal with a number of these eventualities. Farming practice has developed to provide best practice in husbandry to reduce factors that influence disease susceptibility.
8. Implement compliance monitoring and enforcement to ensure that fish farms actually observe the rules imposed on them.
   Fish farms may be inspected at any time by Fisheries Compliance officers, and PIRSA officers visit the farms to observe practices and review stocking records.

## Perceptions and Facts Regarding Aquaculture In General

PERCEPTION: It takes about 5 kg of wild fish to produce 2 kg of farmed fish. This is because the pellets that are fed to them include wild fish products.

FACTS: Fish feed includes fish meal and fish oil, both of which are derived from wild caught fish. The fish that are caught to use for fish meal/oil production are species not caught for human consumption either because of the size of the fish or for aesthetic reasons. The feed conversion efficiency of wild carnivorous fish have been given as a range from 2.5kg to 5 kg prey fish to produce 1kg wild fish.

The paper loosely referred to, in many of the objections to aquaculture as an industry, specifies an average figure of 1.9kg wild fish to produce 1 kg of farmed fish (rather than the 2.5kg quoted above). In addition the calculations are based on 1997 figures, and relatively inefficient farming systems e.g. feed conversion ratios of 1.5 – 2.2 are quoted, whereas modern farming practice can achieve values 50% better than this, altering respectively the 1.9kg value downwards. Calculations taking into account water content of diet, protein level of diets and actual amount of fish meal in diet as compared to other protein sources have even arrived at a figure of 0.5kg wild fish to produce 1kg aquaculture product.

The issue is not as cut and dried as some might like to suggest. The latest SOFIA (State of Fisheries and Aquaculture) report from the Food and Agriculture Organisation (FAO) of the United Nations (UN) indicates that 93 million tonnes of wild fish were caught and 32 million tonnes of aquaculture product produced. Of this 125 million tonnes human consumption accounted for 93 million tonnes and roughly 30 million tonnes were used for fish meal and fish oil production. Of this 30% of fish meal and 40% fish oil were used for aquaculture feed. The remainder was used in terrestrial animal feed; where it can take up to 7kg feed to produce 1kg of edible meat.

Comparison of the systems:

| System | Weight of wild prey fish to produce 1 kg of edible fish |
|---|---|
| Aquaculture | 1.9 kg (may be as low as 0.5 kg for some species) |
| Wild caught fish | 2.5 to 5 kg |

The comparative efficiencies of aquaculture, wild fish and terrestrial production systems can be compared, and you can draw your own conclusions. Of note is the commentary from FAO indicating that world fishery capture is fairly steady, and that instead of more fish being caught for an expanding aquaculture industry, it is expected that a greater proportion of the fish meal and fish oil will be diverted to aquaculture feed use. Currently the use of vegetable oil and protein as a major constituent of fish feeds is being investigated, potentially reducing pressure on use of fish meal and fish oil.

*PERCEPTION: In Scotland escaped salmon are 3 to 4 times more prolific than wild fish (www.qccqld.org.au/save <http://www.qccqld.org.au/save>thebays) causing the Scottish Parliament to implement an enquiry. Some reports have even suggested they outnumber wild salmon by many times this number.*

FACTS: The committee established to look at fish farming in Scotland was set up following requests from both environmental groups and the aquaculture industry, to try and bring out truths and dispel myths. It was not started, as this suggests because of escapes of cultured fish. The Scottish Executive reported that, in 2002, there had been 191 escaped salmon caught by any means anywhere in Scotland out of the total of 57,920 caught by anglers. This does not suggest that escaped fish are taking over the population.

*PERCEPTION: In Maine (USA) the Department of Environment has declared Atlantic salmon an endangered species and won a legal action against Heritage Salmon resulting in agreed processes to avoid further damage. These include not growing genetically modified salmon, not using prophylactic antibiotics and branding all farm fish.*

FACTS: The Maine DoE did not take Heritage Salmon to court. The "Public Interest Research Group (PIRG)" a Non Government Organisation, did attempt to sue Heritage Salmon for perceived breaches of water regulations. The case was settled out of court by Consent Decree (i.e. a negotiated agreement developed by both parties). The agreement covers:

- Heritage will not grow European salmon. Escaping European fish can cross-breed with wild North American salmon; their less fit offspring could hasten the demise of the wild salmon (*they can continue to farm fish including other salmonid species, this issue concerned introduced species not relevant to kingfish culture in South Australia as they are native fish*).
- Heritage will not grow genetically modified salmon (*South Australia aquaculture does not use genetically modified fish*).
- Heritage will take strong measures to prevent fish escapes. Heritage must employ fully functional marine containment systems designed, constructed and operated so that fish do not escape to open water from any of its farms (*this is in line with the regulations and Code of Practice produced in South Australia*).
- Heritage will also mark its fish as specified by the federal wildlife services, so that any escapees can be traced (*research is being carried out in South Australia, funded through PIRSA and FRDC into recognition of escapees*).
- Heritage will fallow its farm sites (*South Australia farms also fallow*).
- Heritage will limit the number of fish it grows by capping the "stocking density" of its cages at the time when fish are most susceptible to disease (*South Australia farms have stocking density limits*).
- Heritage will not discharge toxic substances in concentrations identified by the state as toxic to aquatic organisms, and sediments may not contain toxic substances originating from Heritage's farms at levels likely to have an adverse impact on marine life. This provision addresses longstanding concerns about pesticides and other chemicals used at salmon farms (*South Australia requires approval for all use of medicines or chemicals – a tightly regulated area, incorporating maximum discharge levels specified by the EPA where required*).
- Prophylactic antibiotic use is prohibited, and Heritage must test for antibiotic residues in local fish and shellfish. Also, detailed information about any antibiotic use will be made publicly available (*again, South Australia farms must apply for approval to use antibiotics, prophylactic use is not acceptable to PIRSA*)

PERCEPTION: November 25th 2002, Vancouver, Canada. The Pacific Fisheries Resource Conservation Council identified sea lice escaping from open net salmon farming pens as the probable cause of a collapse last summer of wild pink salmon stocks in the Broughton Archipelago on northern Vancouver Island (www.ens-news.com).

FACTS: Reading the actual report indicates that the study involved a comparison of lice numbers on wild fish at varying distances from fish farms. This does not prove any causal link. In the authors own words "surveys that compare sea lice infestation on hosts in areas near and distant from fish farms, such as this one, cannot provide causal linkage between farmed and wild hosts, or vice versa". The report serves to highlight increased sea lice numbers during the study and indicates that the reasons and effects of this need to be studied more closely. PIRSA has committed funds to a scientific research project designed to address concerns in this area.

In addition a study published recently in the Bulletin of the European Association of Fish Pathologists showed that simple statements indicating parasites from farmed fish cause declines in wild fish cannot be made and that the whole picture is much more complicated.

The work, carried out over a 4-year period by West Sutherland Fisheries Trust biologist, Shona Marshall, shows that "there appears to be a weak relationship between lice abundance on the wild salmonids within Laxford Bay [close to the fish farm sites sampled] and the stage of production on the neighbouring fish farm."

Dr Marshall also concluded that: "While this is as expected from other studies within the west coast of Scotland, the lack of conclusive statistically significant correlations between the lice abundance on the wild and farmed fish, indicates that other factors have a greater importance to lice abundance. In particular there is a seasonality apparent in the data, both in terms of lice abundance and the stages present."

PERCEPTION: *Sweden's Environmental Protection Agency declared salmon farming an "environmentally dangerous industry".*

FACTS: A workshop in May 2002 addressing environmental hot spots concluded, "the Finnish fish farms in the Archipelago and the Åland Sea might be ready for deletion from the List of Hot Spots, possibly later this year." The fish farming Hot Spot meets the requirements of the HELCOM Recommendation (measures undertaken to reduce discharge – forming part of an Environmental Management System such as those being developed in South Australia aquaculture. The Finnish farms are concentrated in certain areas within the Åland Sea and the Finnish Archipelago and give rise to local eutrophication (i.e. excessive enrichment of waters by nutrients) problems. These nutrient emissions constitute the major part of the load in those areas. It is apparent that concern stemmed from inefficient farming practices resulting in greater than appropriate nutrient discharge, however this problem tends to arise in enclosed areas with little water exchange, generally not an issue in South Australia. The workshop also concluded that the majority of nutrient loading originated from terrestrial sources and that "solving this problem will take a long time."

PERCEPTION: *In a questionnaire for fish farms 92% of fish farms had experienced harmful algal blooms in their country. 64% of farms had been affected by this bloom and 33% had experienced fish mortality (www.icbm.de/mathmod.com). This shows that fish farms cause algal blooms!*

FACTS: Fish farmers, with due regard to maintaining high water quality for their fish will routinely monitor the water for algal species. It is therefore more likely that any algal bloom will be detected in the proximity of fish farms than if they occurred in isolated water bodies. Many algal blooms arise in areas where no aquaculture is carried out. The effect of algal blooms on fish (whether farmed or wild) is a separate issue from the cause of the bloom in the first place. A recent study performed for the Scottish Environmental Protection Agency (The Scottish government regulatory authority for protecting terrestrial and aquatic environments in Scotland) and released on 28 January 2003 has concluded that:

- "data...do not show conclusively that there has been a wide scale increase in the abundance of organisms responsible for harmful algal blooms".
- "models have shown that the algal production attributable to fish farm nutrients in Scottish coastal areas is small relative to that generated by marine and terrestrial nutrient inputs".
- "enrichment by fish farm nutrients is too little, relative to natural levels, to have the alleged effects."
- "no convincing evidence to suggest that changes in nutrients as a result of fish farm inputs ratios are likely to stress potentially toxic species to cause them to increase their toxicity."

The report indicated that in extremely enclosed lochs with minimal water exchange there was an increased probability of fish farm inputs having a more significant effect on algal development.

*Specific provisions are in place in South Australia to minimise the risk of algal blooms associated with fish farms. These include conservative limits on total production and stocking density limits on individual farms. Fish farmers are required to undertake an environmental monitoring program addressing impacts on water quality including algal blooms. Existing water quality data indicate that finfish farming in South Australia is not significantly affecting water quality in comparison with control sites located in pristine coastal environments including Thorny Passage. Similar results have been reported for salmon farms in Tasmania and Scotland.*

PERCEPTION: But what about this case... in January 1989, a bloom of the raphidophyte flagellate Heterasigma akashiwo in Big Glory Bay, Stuart Island, New Zealand, killed NZ$ 12 million worth of cage - reared chinook salmon (Chang, Anderson & Boustead 1990 ). This is because fish farms increase the nutrient levels in the water and cause the blooms!

FACTS: This bloom of Heterosigma occurred in 1989. Fish farms were first established in New Zealand in 1981. Major algal blooms were reported in 1976 and 1978, prior to fish farming, as well as after the introduction of fish farming. The report referenced above, when studied closely, indicates that the cause of the bloom was probably raised nitrate levels in the bay, the water in the bay was measured and found to be identical in nitrate load to the flowing water in the main Foveaux Strait beyond. The conclusion reached by the authors was that the nutrient input to the bay probably resulted from water exchange from the Foveaux Strait and was not attributable to the fish farms.

In fact in New Zealand the majority of plankton blooms recorded have occurred in the vicinity of Auckland, not in association with any aquaculture establishments. (Personal communication, NZ shellfish monitoring program).

Currently published studies do not indicate that nutrient input from fish farms cause algal blooms, as we have already seen from the SEPA study. Nutrient inputs from fish farms in all but very enclosed water bodies with minimal water exchange have been recognised to be very small compared with ocean and terrestrial inputs that they do not represent a sufficiently large imbalance to trigger blooms.