inside prawn ponds

With the support of Australian prawn farmers, scientists have studied the environment of prawn ponds and the effects of pond water discharges. The knowledge is helping farmers to improve pond management and is guiding the sustainable growth of prawn-farming in Australia.

partners in research

Outcomes of a research partnership between prawn farmers, environmental regulators and scientists are helping to guide the sustainable growth of prawn farming in Australia. The partnership, within the Cooperative Research Centre for Aquaculture, has yielded a better understanding of prawn-farm discharges and recommended ways to minimise their environmental impact while improving production efficiency.

Australian prawn farm production increased from 15 tonnes to 3500 tonnes between 1984 and 2002. Some 600 hectares of ponds are now in production, supplying black tiger prawns and banana prawns to domestic and overseas markets, and exporting the high-value Kuruma prawn to Japan.

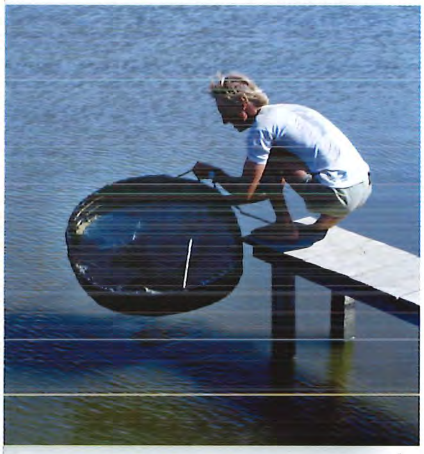
From the outset, all Australian prawn farms have operated under regulations that control the volume and quality of water discharged from prawn ponds to creeks, rivers and estuaries. These discharges allow the pond water to be replenished, preventing an over-accumulation of nutrients during the growing season.

Prawn farming uses high-protein feeds. Some of the food is converted to prawns (for example, about 20% of the nitrogen). The rest goes directly into the pond ecosystem. These nutrients, in particular nitrogen, activate rapid chemical and biological processes in the pond, and ultimately the water must be managed to maintain optimum growing conditions for the prawns.

The first comprehensive picture of these processes, and their effects on water quality, was acquired during studies at prawn farms and tidal creeks on Australia's eastern coast. The studies spanned seven years and combined the expertise of some 15 scientists, farmers and technicians. The results have provided a sound scientific basis for increasing production efficiency through improved pond management and environmental performance, and addressing regulatory issues.

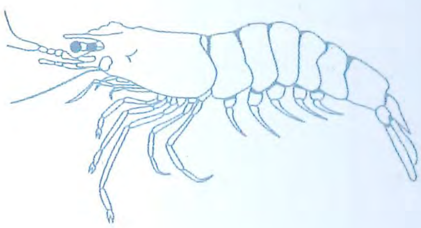
Scientists and farmers agree, however, that further integrated improvements to production efficiency and waste minimisation remain a significant challenge.

More information about prawn farming in Australia is available on the Australian Prawn Farmers Association website at www.apfa.com.au



Feeding the environment

Only a small proportion of the feed added to prawn ponds is eaten by prawns. The pond water must be diluted to maintain optimum growing conditions.



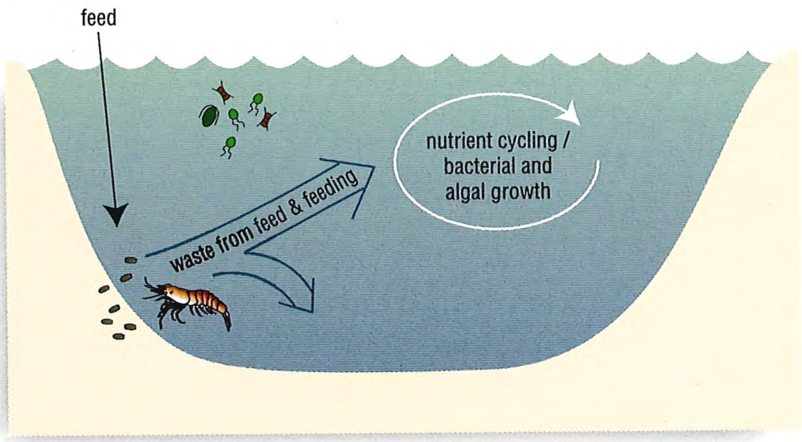
pond life

At the start of the growing season, earthen ponds are stocked with tiny prawns measuring about one centimetre. Some of the pelleted food that is added to the pond is converted into prawn flesh, but a major proportion (about 80% of the feed nitrogen) enters the pond ecosystem as inputs to nutrient cycling. These processes involve a wide variety of microorganisms including phytoplankton and common marine or estuarine bacteria. Living microorganisms take up nitrogen, in the form of ammonia, but release it when they die.

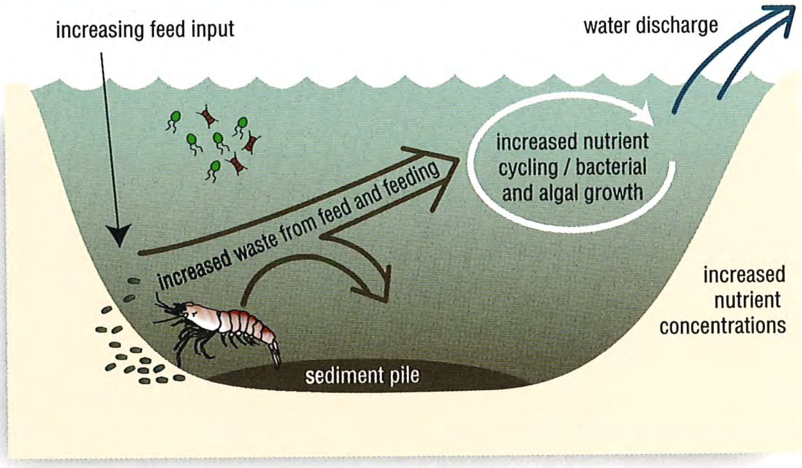
The pace of nitrogen cycling and microbial activity increases as the prawns become larger and more feed is added to the pond system. Aerators intensify the process by oxygenating the pond water. An unintended consequence of aeration is the scouring of soil particles from the pond walls, which accumulate, together with organic material, at the centre of the pond.

As the season progresses, and more nutrients are added to the pond, it becomes harder for farmers to maintain optimal water quality. One of the main problems is that phytoplankton biomass can increase too quickly and, at night time, reduce oxygen in the water to low levels. In order to avoid low oxygen levels in the ponds, and in the discharge environment, farmers periodically replenish a small percentage of the total pond volume. This practice generally occurs for the last three months of the growing season, with about 7% of pond water replenished daily from creeks, rivers or estuaries.

Early growth stage prawn pond



Advanced growth stage prawn pond



Stirring the process

Aerators inject oxygen into the ponds and create circulating water currents that scour the pond walls and allow fine-grained sediments to accumulate in the centre.

Nutrient overload

As the growing season progresses, a substantial amount of sediment can form in prawn ponds. While this is mainly inorganic matter eroded from the pond walls, it also contains organic matter such as uneaten food, dead phytoplankton and prawn moults. Bacterial processes in this sediment lead to high oxygen consumption and ammonia production.

Water discharged from prawn ponds contains higher sediment and nutrient loads than the intake water. Until recently, the most common global practice in prawn farming was to discharge this pond water directly into receiving waters.

The CRC study has helped to modify this practice by examining ways of reducing sediment and nutrient loads before releasing or recirculating pond water. These practices contribute to a range of management options now available to prawn farmers to reduce waste generation, algal growth and nutrient discharge from prawn ponds.

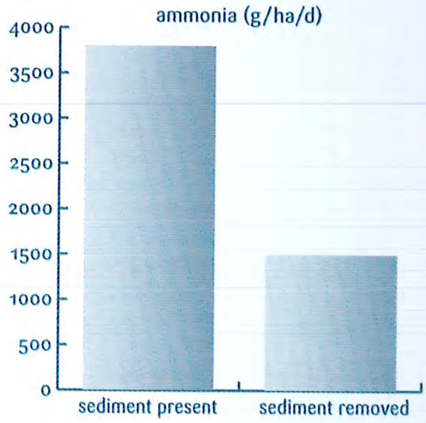
Waste-reduction strategies that integrate all of the following practices are likely to result in the greatest benefits.

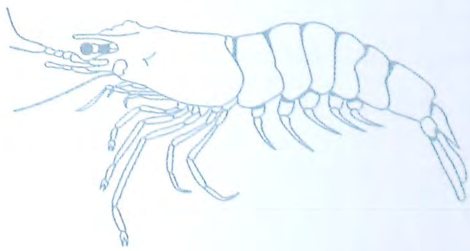
smarter feeding

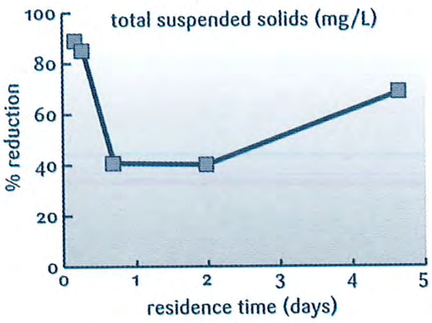
Feed wastage has the potential be reduced with improved feed formulations and processing, improved prawn biomass estimates and feeding practices.

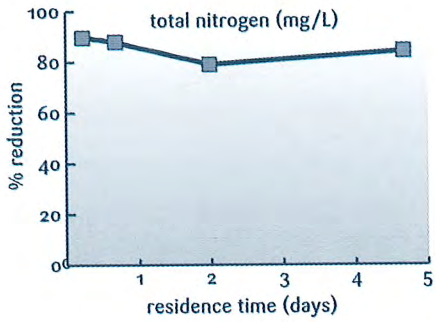
lining ponds

Ammonia production can be halved by lining ponds with plastic and other materials to reduce erosion and sediment accumulation.









settling time

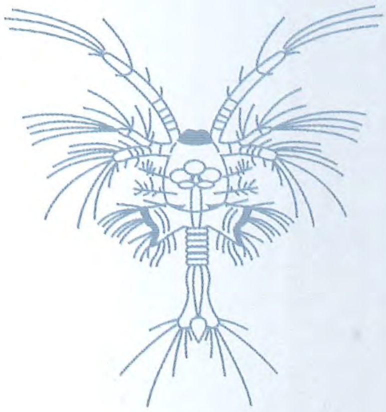
Pond water can be retained for one to three days in sedimentation ponds that have no aeration. This allows soil particles and organic matter to settle to the bottom.

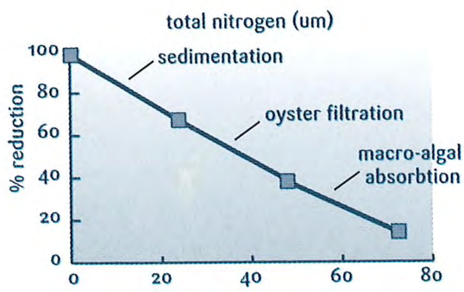
Total suspended solids can be reduced substantially (about 60% reduction) by passing farm effluent through sedimentation ponds for a period of less than one day. After two to three days in the sedimentation pond, however, total nitrogen levels are only reduced by about 20% by passive sedimentation.

A recent industry survey has demonstrated a high level of industry adoption of settlement ponds. More than 17% of total production area is now dedicated to water treatment and more farms are moving toward partial recirculation.

wastewater reuse

After sedimentation and biofiltration, there is potential to recirculate pond water within the farm, further reducing the volume of wastewater discharge. To improve the cost-effectiveness of wastewater reuse, these processes, and their potential integration with engineered waste treatments, are being adopted. Further research and refinement are needed to improve the reliability and cost-effectiveness of integrated waste minimisation technology.





active treatment

Further reductions in nitrogen levels can be achieved by stocking settlement ponds with marine plants, bivalves such as oysters, fish and prawns, or other crustaceans. This process is called biofiltering or bioremediation. Laboratory studies have shown that nitrogen can be reduced by 70% using a combination of sedimentation, filter-feeders such as oysters, and macroalgae as a final nutrient absorption step.

going downstream

Two mangrove-lined tidal creeks were studied to determine the effects of prawn-farm discharges on water quality and ecosystem health. The discharge water typically contains elevated concentrations of particulate and dissolved organic matter, ammonia and soil particles, compared with the intake water.

The research found that prawn farm discharges influenced some key processes in the creek, the magnitude of change decreasing with distance from the discharge point. Most of the changes were evident in the water column, rather than the creek sediments.

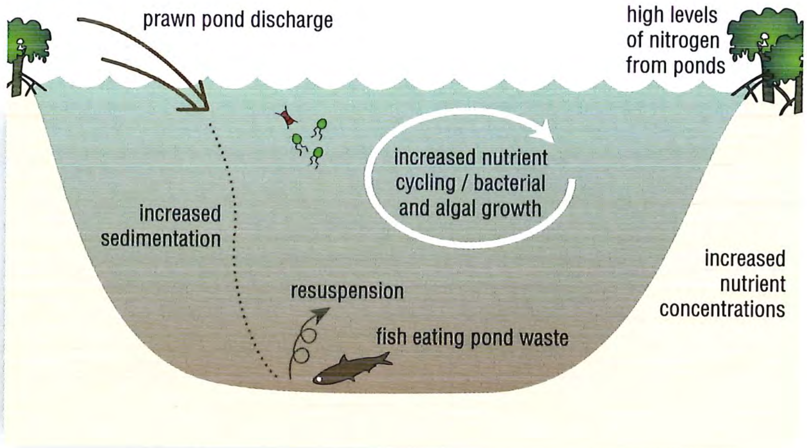
more nutrients

Elevated nitrogen concentrations and algal loads occurred near the prawn farm in the small mangrove discharge creek examined in the study. Phosphorus was also elevated and was present mostly bound to particles.

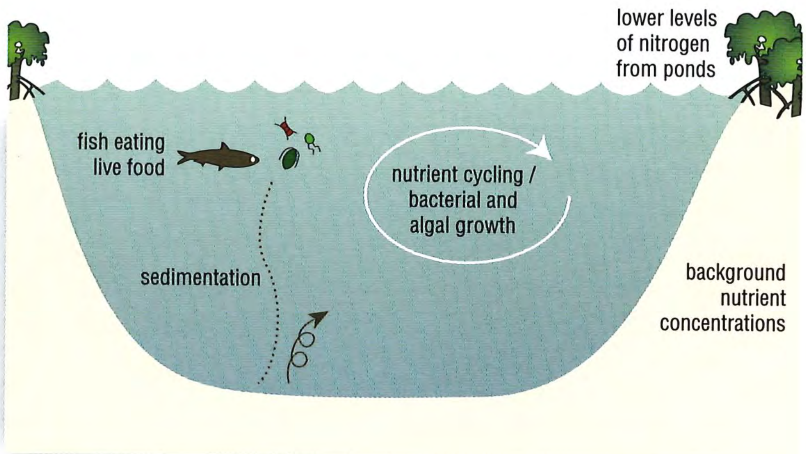
high algal production

Algae production is the process most affected by the prawn farm discharge. Algal growth rates near the farm discharge points were even higher than in the prawn farms, probably due to more favorable light conditions. Marine bacterial and algal production was high near the farm and gradually declined in response to the dilution of nutrient concentrations.

Creek near farm discharge

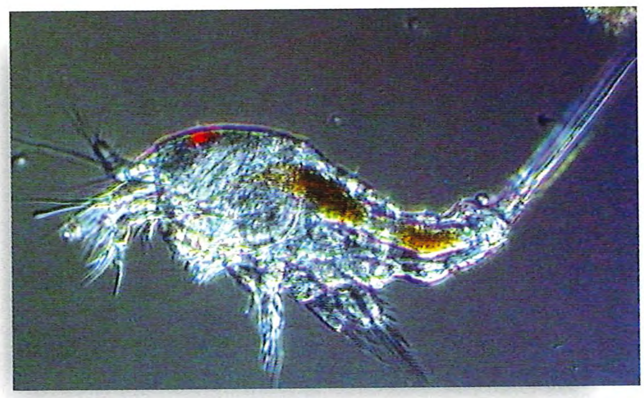


Creek further downstream from farm discharge



The area of influence

Scientists now understand the processes responsible for dispersal and biological uptake of prawn farm effluent downstream of the discharge point.



Zooplankton: agents of uptake

Smaller zooplankton, such as this copepod, actively consume farm-derived phytoplankton and incorporate these materials in the food web.

zooplankton changes

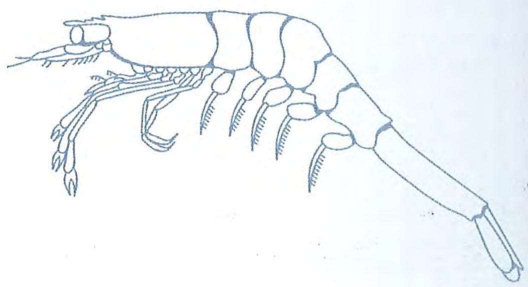
Near to the discharge point, zooplankton communities are dominated by smaller species. These small animals graze phytoplankton and bacteria from the prawn farm discharge, and incorporate these into the marine food chain. Further downstream, larger zooplankton species are a food source for larger consumers, such as fish.

resuspended sediments

No obvious differences in sediment processes were detected in the creek. This is probably because sediment particles settle on the creek bed soon after discharge, but are quickly resuspended due to tidal action.

mangroves reveal more

Mangrove and macroalgae nitrogen isotope signatures provide sensitive measures of the range of influence of prawn farm discharges. Using this technique, the uptake of nutrients derived from pond discharge by mangrove trees and macroalgae was found to extend further downstream than might be expected, given the gradient of nutrient concentrations in the creek water.



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