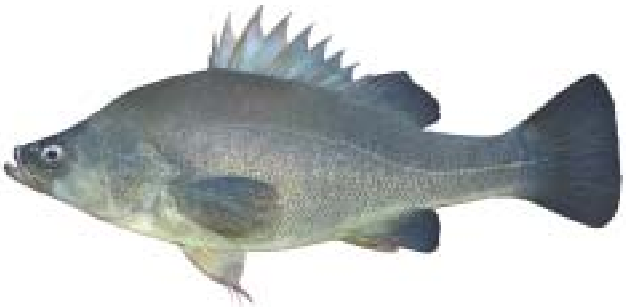
Hatchery Quality Assurance Program



Murray Cod
(Maccullochella peelii peelii)

Golden Perch
(Macquaria ambigua)

Silver Perch
(Bidyanus bidyanus)

NSW DEPARTMENT OF PRIMARY INDUSTRIES

Stuart J. Rowland & Patrick Tully

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(Bidyanus bidyanus)

Stuart J. Rowland# and Patrick Tully*

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Acknowledgements

Pond at the Grafton Aquaculture Centre with floating broodstock cages attached to walkway

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1 Summary

The Murray-Darling Basin is the natural range of these western drainage species

Fig.1.1 The Murray-Darling River System.

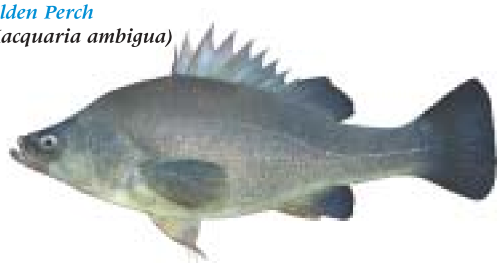
Techniques for the large-scale hatchery production of the Australian native fishes Murray cod (*Maccullochella peelii peelii*), golden perch (*Macquaria ambigua*) and silver perch (*Bidyanus bidyanus*) were developed at the Narrandera Fisheries Centre in the early 1980's, and commercial hatcheries began to produce and sell fingerlings in 1982/83. Around 30 hatcheries in NSW, Queensland and Victoria produce between 5 and 8 million fish annually. The fish are sold to stocking groups, State and Territory Governments for stock enhancement, farm dam owners, commercial fish farms, and a small number to the aquarium trade. In addition, around 2.5 million fish are produced by Government hatcheries for conservation and stock enhancement. Over the last 25 years, the regular stocking of native fish into impoundments and rivers has established large, popular recreational fisheries and contributed significantly to the conservation of these species.

In recent years, there have been concerns about some aspects of native fish hatcheries, in particular genetics, diseases and trash fish. Research has found closely related species and subspecies of Murray cod, golden perch and silver perch in other drainages and discrete populations within the Murray-Darling River System; mixing of populations through inappropriate stockings may reduce their reproductive fitness. Pathogens and diseases that are transferred on hatchery fish, may reduce survival and introduce new diseases to regions and farms. Native fish hatcheries have been implicated in the translocation of non-endemic fish. Continuation of poor practices may have serious long-term biological consequences for populations and species, and hinder the development of sustainable and economically-viable aquaculture grow-out industries.

To address these concerns, NSW Department of Primary Industries has developed a Hatchery Quality Assurance Program (HQAP) for use by Government and commercial hatcheries. The HQAP describes key features of native fish hatcheries and identifies Essential Criteria and Recommended Criteria for site selection, design and operation, and the management of broodstock, breeding programs, water quality and fish health. Breeding programs need to be closely linked to stocking programs to meet genetic goals. Essential Criteria are the basis for accreditation and auditing, and hatcheries in NSW that produce and sell Murray cod, golden perch and silver perch fingerlings for stock enhancement, conservation and commercial grow-out will be required to be accredited in accordance with this HQAP.

Murray Cod
(Maccullochella peelii peelii)

Golden Perch
(Macquaria ambigua)



Silver Perch
(Bidyanus bidyanus)

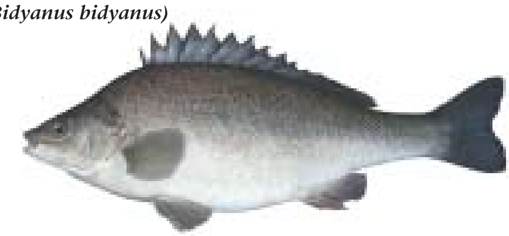


Fig.1.2 Murray cod, golden perch and silver perch.

2

Introduction

Murray cod *(Maccullochella peelii peelii)*, golden perch *(Macquaria ambigua)* and silver perch *(Bidyanus bidyanus)* are Australian native fish that are endemic to the Murray-Darling River System (Fig. 1.1, Fig. 1.2). These species play an important part in Aboriginal culture and mythology, and were caught and used as fresh food by early explorers and settlers (Rowland, 1989). Today they are highly regarded and keenly sought by anglers because of their edible and sporting qualities. The distribution and abundance of each species have declined significantly, particularly since the 1950's, and silver perch and Murray cod are now threatened species. Silver perch is listed as "Vulnerable" by the International Union for Conservation of Nature and Natural Resources (IUCN), the Australian Society for Fish Biology (Crook and Pogonoski, 2003) and NSW Department of Primary Industries, and as "Critically Endangered" in Victoria, and "Protected" in South Australia (Morris et al., 2001). Murray cod is listed as "Vulnerable" in Victoria (Morris et al., 2001) and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

During the 1960's, research into the biology of inland fishes by the late John Lake at the Inland Fisheries Research Station (now the Narrandera Fisheries Centre) resulted in limited production of juveniles of some species through manipulation of water level in ponds (Lake, 1967a, b). In 1971, a project commenced at Narrandera with the aim of developing techniques for artificial propagation, and by the early 1980's, hatchery techniques for the large-scale production of Murray cod, golden perch and silver perch had been developed (Rowland, 1983a, b; Rowland et al., 1983). Since 1984, NSW Department of Primary Industries has annually stocked up to 2 million Murray cod, golden perch and silver perch into impoundments in NSW to establish and maintain recreational fisheries.

The hatchery technology was transferred to industry, and in the summer of 1982/83, commercial hatcheries commenced producing and selling native fish fingerlings. There are currently around 25 hatcheries producing native fish in NSW and Queensland, and several small hatcheries in Victoria and Western Australia. Annual production by these hatcheries is 5-8 million (3-4 million in NSW alone and 2-4 million in other states combined). The fingerlings are sold to stocking groups, State and Territory Governments for stock enhancement, farm dam owners, fish farmers for commercial grow-out and a small number to the aquarium trade. Since 1999, a joint NSW Department of Primary Industries and community stock enhancement program, the "Dollar for Dollar Native Fish Stocking Program" has resulted in over 2 million Murray cod, golden perch and Australian bass *(Macquaria novemaculeata)* being stocked into public waters in NSW.

Up to the late 1970's, most impoundments in NSW and southern Queensland had no or limited recreational fisheries, and Murray cod, golden perch and silver perch (and other native species) had become rare or extinct in some of the impounded waters and upstream rivers (Lake, 1959, 1978; Harris and Rowland, 1996; Allen et al., 2002). Over the last 25 years, the regular stocking of hatchery-reared fish into impoundments has established large, popular recreational fisheries and contributed significantly to the conservation of Murray cod, golden perch, and silver perch (Rowland et al., 1983; Rowland, 1995a; Holloway and Hamlyn, 1998). In this period, there have also been successful stockings of Murray cod, golden perch and silver perch in rivers where these species had become extinct or declined dramatically, e.g. the MacIntyre and Gwydir rivers on the Northern Tablelands and Western Slopes of NSW (Rowland, 1995a). Techniques for the culture of silver perch and Murray cod to market-size (400 g – 2 kg) have been developed (Rowland and Bryant, 1995; Ingram, 2000), and commercial farms produced 367 tonnes of silver perch and around 110 tonnes of Murray cod in 2001/02 (Love and Langenkamp 2003; O'Sullivan and Savage, 2003). Clearly the native freshwater fish hatchery industry is well established and plays a major role in conservation and recreational fisheries, as well as commercial aquaculture in NSW and other states. The hatchery industry has the capacity to expand significantly in the future.

Hatcheries are an essential component of aquaculture industries. The supply of seedstock is fundamental to stocking programs for conservation and stock enhancement, as well as to the commercial production of market-sized fish for human consumption. The success of a hatchery is dependant on selection of a good site, substantial capital investment, construction of appropriate facilities, a high level of technical expertise, good fish husbandry, and the efficient management of water quality, fish diseases and ponds. An understanding of genetics in relation to conservation, stock enhancement and aquaculture production is also necessary. The lack of appropriate facilities and use of poor practices can lead to the production of inferior quality fingerlings.

NSW Department of Primary Industries has had concerns about some aspects of hatchery production of native fish for a number of years, in particular genetic and disease issues, and the presence of trash fish (i.e. non-target fish species) in some consignments from hatcheries. Studies by Rowland (1985, 1993), Musyl and Keenan (1992), Keenan et al. (1995), Bearlin and Tikel (2003) and Nock et al. (2003) into the genetics of Murray cod, golden perch and silver perch have found:

(i) separate species and subspecies of cod (genus *Maccullochella*) and golden perch (*Macquaria*) in drainages outside the Murray-Darling River System;
(ii) distinct populations of each species within the Murray-Darling River System;
(iii) low levels of genetic diversity in some populations and species;
(iv) low levels of genetic variation in some hatchery stocks.

Despite these studies, the population genetics of each species is still poorly understood and there is a need for further research.

Most commercial hatcheries use the minimum number of broodstock to achieve production targets, with little or no understanding or consideration of genetic factors (Moore and Baverstock, 2003; Thurstan, in press). Some hatchery operators source broodstock from other hatcheries or farm dams. Fish from farm dams are a poor basis for breeding programs because the dams are usually stocked with siblings or fingerlings from a small number of parents. An increased incidence of abnormalities and reports of poor performance (low survival, slow growth) of silver perch on some farms in the commercial grow-out industry suggest that there may already be a level of inbreeding in this species. Some native fish hatcheries in Queensland have produced and sold hybrids between silver perch and Welch's grunter (*Bidyanus welchi*) to farmers in NSW, but the performance and reproductive capacity of these hybrids are not known.

Poor genetic management in the hatchery industry could lead to loss of genetic identity, decrease in genetic diversity and lower reproduction and survival rates (i.e. reproductive fitness) in wild populations. This would contribute to an overall loss of biological diversity in the Murray-Darling River System. The maintenance of genetic diversity is a major objective in conservation programs, because genetic diversity represents evolutionary potential and is related to the level of inbreeding (Frankham et al., 2002).

The introduction of pathogens on translocated fish and subsequent diseases in endemic fish fauna is recognised as a significant problem through-out the world (Bauer, 1991; Paperna, 1991). There have been reports of diseased native fish being transported from some hatcheries and stocked onto commercial farms, and into impoundments and farm dams. Silver perch fingerlings heavily infested with ecto-parasites have been examined by the author (SJR) in consignments of silver perch from commercial hatcheries. Silver perch fingerlings, heavily infected with the fungus (*Aphanomyces invadans*) which causes the disease Epizootic Ulcerative Syndrome (EUS) or Red Spot, were transported from a commercial hatchery in the eastern drainage of NSW to a commercial farm in the western drainage. There has only been one suspected case of EUS in the western drainage, and so there is doubt about the endemicity of the fungus in the Murray-Darling River System (Dr Dick Callinan, personal communication).

Fish culture has been implicated in the production, release and subsequent population explosion of the Boolarra strain of the carp (*Cyprinus carpio*) in the Murray-Darling River System (Shearer and Mulley, 1978; Koehn et al., 2000). Native fish hatcheries have also been implicated in the translocation of non-endemic fish. The banded grunter (*Amniataba percoides*) which is endemic to north Queensland and the Northern Territory, has been translocated in contaminated hatchery stocks of silver perch and is now present in impoundments in south-eastern Queensland and as far south as the Clarence River System in northern NSW (Rowland, 2001).

Potential problems relating to the stocking of native fishes were reviewed by Harris (2003) and discussed at a workshop *"Managing Fish Translocation and Stocking in the Murray-Darling Basin"* (Phillips, 2003) held in Canberra in September, 2002. The need for a hatchery accreditation scheme across the Murray-Darling Basin was identified in the *"Native Fish Strategy for the Murray-Darling Basin 2003 – 2013"* (Murray-Darling Basin Commission, 2003). The continuation of poor practices on hatcheries may have serious long-term ecological and biological consequences for the wild populations of native fishes, as well as the sustainability and economic viability of grow-out industries. To address these concerns, this Hatchery Quality Assurance Program (HQAP) was developed by NSW Department of Primary Industries for Government and commercial hatcheries. Hatcheries in NSW that produce and sell Murray cod, golden perch or silver perch for harvest stocking, conservation stocking or commercial grow-out are required to be accredited by NSW Department of Primary Industries in accordance with this HQAP following implementation of the Freshwater Fish Stocking Fishery Management Strategy in 2004.

Carp
(Cyprinus carpio)

Banded Grunter
(Amniataba percoides)

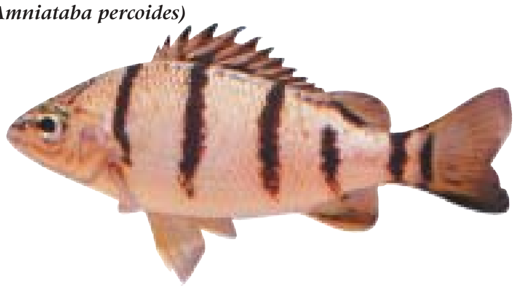


Fig. 2.1 Noxious fish that must be excluded from native fish hatcheries.

THE HQAP:

(i) *describes key features of the design and operation of hatcheries, and the management of broodstock, genetics, breeding programs, water quality and fish health;*

(ii) *identifies the* **Essential Criteria** *and* **Recommended Criteria** *for site selection, design, operation and management of native fish hatcheries;*

(iii) *provides a basis for accrediting and auditing hatcheries (the* **Essential Criteria** *located in shaded boxes in the relevant chapters of this HQAP are prerequisites for accreditation of native fish hatcheries by NSW Department of Primary Industries);*

(iv) *links with existing legislation and policies;*

(v) *can be used as a guideline for hatcheries of other species groups.*

The HQAP provides a framework for best practice and accreditation within the industry, and will provide significant benefits for the conservation of native fishes, recreational fisheries and commercial aquaculture in NSW and other states. This HQAP could also be used as a guideline for the production and stocking of the endangered species trout cod (Maccullochella macquariensis) *and eastern freshwater cod* (Maccullochella ikei) *in NSW, and the critically endangered Mary River cod* (Maccullochella peelii mariensis) *in Queensland.*

3 NSW Department of Primary Industries' native fish hatcheries

The NSW Department of Primary Industries has two native fish hatcheries, the Narrandera Fisheries Centre (NFC) and the Grafton Aquaculture Centre (GAC). Murray cod, golden perch, silver perch and trout cod are produced at NFC and silver perch at GAC. All fingerlings are stocked into impoundments for conservation and stock enhancement, except those of trout cod, which are also stocked into selected rivers within the previous distribution of the species.

Narrandera Fisheries Centre.

Apart from work on Murray cod, trout cod and Macquarie perch (*Macquaria australasica*) by Victorian fisheries scientists, research to develop the hatchery techniques for native inland species has been done at NFC and GAC. Best practices are used at these hatcheries and the breeding programs have, until now followed genetic guidelines of Rowland and Barlow (1988). Both NFC and GAC are model freshwater fish hatcheries.

3.1 - NARRANDERA FISHERIES CENTRE (ORIGINALLY THE INLAND FISHERIES RESEARCH STATION)

An inland fishing licence was introduced in NSW in 1958 to fund inland fisheries research. A 35 ha site, approximately 5km east of Narrandera, just off the Sturt Highway and 1km from the Murrumbidgee River was chosen for a research facility. The Inland Fisheries Research Station was constructed in 1960-61 and was officially opened in February 1962. The original facility included offices, a workshop, 27 ponds, 3 residences and a hatchery building. Expansion over the years has seen the addition and modification of ponds (now 46; 0.05 – 0.5 ha surface area), a larger hatchery building, an education/tourist centre, 3 effluent-settlement ponds and a broodstock shed. Water is pumped from the Murrumbidgee River to a 6 ML earthen reservoir and then gravity fed to ponds and the buildings. Bore water is also supplied to the hatchery and buildings. Effluent water drains to the effluent-settlement ponds.

During research in the 1970's and early 1980's, over 4 million Murray cod, golden perch and silver perch fry were produced. The fish survived and grew well in farm dams, and at many other stocking sites, including areas where the species had become extinct or natural reproduction and recruitment were poor. The successes of these early stockings created a demand for fish for farm dams and public stockings, and lead to the development of the commercial hatchery industry. Production of Murray cod, golden perch and silver perch for stock enhancement and conservation continued at NFC with the establishment of a stocking program in 1983. Research to develop artificial breeding techniques for Macquarie perch and trout cod began in 1984. After the successful development of techniques for trout cod (Ingram and Rimmer, 1992), but only limited success with Macquarie perch (Ingram et al., 1994), trout cod was added to the breeding and stocking program during 1990.

The name change from Inland Fisheries Research Station to Narrandera Fisheries Centre (NFC) reflected the changing roles of the station from primarily a research station to a multi-function facility. The NFC now has staff involved in research, hatchery production, education and advisory activities, aquaculture extension, conservation management and fisheries compliance.

NARRANDERA FISHERIES CENTRE
P.O. BOX 182
NARRANDERA, NSW, 2700
(02) 6959 9021 – TELEPHONE
(02) 6959 2935 – FAX

Grafton Aquaculture Centre

3.2 - GRAFTON AQUACULTURE CENTRE (ORIGINALLY EASTERN FRESHWATER FISH RESEARCH HATCHERY)

The Grafton Aquaculture Centre (GAC) was established in the mid 1980's. Since then additional ponds and buildings have been constructed and the facility currently consists of 19 earthen ponds (0.1-0.4 ha surface area), 2 reservoirs (8.5 and 9 ML capacity), an effluent/settlement dam (43ML), 3 salt-evaporative ponds, a hatchery/office/laboratory complex, and a large workshop/storage shed and associated equipment such as pumps, aerators, a tractor and other vehicles. The main water supply is the Clarence River, and most effluent water is stored, settled and either re-used for fish culture or used for irrigation by staff of NSW Agriculture. Small quantities of effluent water containing salt are held in evaporative ponds.

Between 1986 and 1989, the main function of the facility was a conservation project for the endangered eastern freshwater cod. As part of the project, hatchery techniques for the cod were developed, and around 30,000 fingerlings stocked into parts of the Clarence River and Richmond River systems where the species had become extinct.

Since 1990, there has been a major research project to develop techniques for the intensive culture of silver perch. The research has demonstrated that silver perch has great potential for commercial aquaculture, and the techniques developed at GAC provide a basis for industry development through-out Australia. Research topics have included production techniques and fish husbandry, water quality, management of broodstock, larval rearing, off-flavour, nutrition and feeding, evaluation of genetic strains (as a precursor to a genetic improvement program), disease and health management, cage culture and tank culture in a re-circulating aquaculture system (RAS). An extension service is provided by GAC staff to transfer technology to the aquaculture industry.

The life cycle of silver perch is closed (i.e. all stages in captivity), and a breeding program is undertaken each spring and summer to produce fingerlings for aquaculture research and stocking into impoundments in the western drainage for conservation and stock enhancement.

GRAFTON AQUACULTURE CENTRE
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GRAFTON, NSW, 2460
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FAX - (02) 6644 7879

4 Overview of hatchery techniques

4.1 - GENERAL

Hatchery techniques for Murray cod, golden perch and silver perch are well established and have been described in detail in a number of scientific and technical publications (Rowland, 1983a, b, c, d, 1984, 1988, 1992, 1996; Rowland et al., 1983; Cadwallader and Gooley, 1985; Thurstan and Rowland, 1995; Ingram, 2000, 2001).

Fig. 4.1 Silver perch broodstock are housed in cages for effective management and control. Inset: Broodstock cages are numbered to identify separate strains.

MAJOR STEPS (CHRONOLOGICALLY)

Collection and maintenance of broodstock (late summer, autumn)

Broodstock are collected from a number of sources – the wild (rivers, creeks, lagoons, canals, impoundments), farm dams or other hatcheries. Each species and each population (or strain) is held in separate earthen ponds, cages or tanks throughout the year. Murray cod and golden perch are fed live food (yabbies, fish, shrimp) and silver perch artificial diets, supplemented with live food at some hatcheries. Water quality and disease monitoring programs are required to ensure healthy broodstock.

Preparation of larval rearing ponds (winter, early spring)

The larvae of the three species are reared extensively in earthen ponds (0.1 – 0.5 ha surface area). To provide optimum conditions for larval rearing, the ponds are left dry during winter and early spring, and filled 1-2 weeks before stocking. They are fertilised with inorganic and organic fertilisers to promote blooms of phytoplankton and zooplankton.

Hormone-induced spawning and/or collection of cod eggs (spring, summer)

Hatchery production takes place within the normal breeding season of each species, and usually commences with Murray cod in spring when water temperatures are around 20ºC, i.e. late September-early October in northern NSW, and early October-November in southern NSW. Production of golden perch and silver perch is based on the induction of final oocyte maturation, ovulation and spawning using the hormone, human chorionic gonadotrophin (HCG). Injected broodstock are placed into spawning tanks (1,000 – 2,000 L) where spawning takes place within 48 hours.

Although Murray cod can be induced to ovulate using HCG and eggs stripped for fertilisation, cod spawn naturally in ponds, and production of this species at most hatcheries is based on the collection of fertilised eggs from artificial sites, e.g. cylindrical drums lined with nylon gauze, see Fig. 4.3.

Fig. 4.2
Below left: Injecting a golden perch with the hormone HCG.
Below middle: Golden perch eggs being extracted for inspection.
Below right: Eggs are then examined for quality.

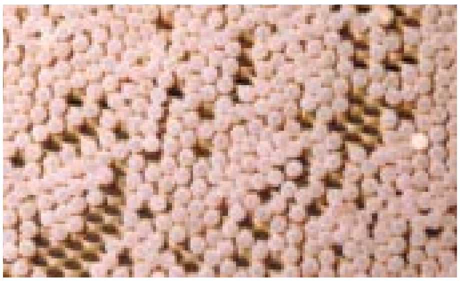

Fig. 4.3

Above, left to right: Murray cod in drum underwater; Cod drum and diver.

Far left: Cod drum opened.

Left, top: Murray cod eggs on screen.

Left, below: A batch of fertilised golden perch eggs. Note the unfertilised egg on the far right.

Quarantine and re-stocking of broodstock

After spawning, golden perch and silver perch broodstock are quarantined for up to 2 weeks in tanks containing 2.5 g/L NaCl to reduce stress and prevent fungal infection. The fish are then returned to ponds, cages or tanks where they remain until the next breeding season.

Incubation of eggs

The semi-pelagic eggs of golden perch and silver perch are removed from the spawning tanks after they have water hardened (~ 90 m after spawning) and are countered volumetrically into tanks (up to 1,000 L) or aquaria (70 – 100 L) for incubation. These tanks are aerated sufficiently to keep all eggs in suspension.

The strongly adhesive eggs of Murray cod are incubated in troughs or tanks. The incubation period for Murray cod is around 5 days at 20º - 22ºC, and 1 – 2 days for golden perch and silver perch at 23º- 25ºC. A foamy substance rises to the surface of incubation tanks as Murray cod eggs hatch, see Fig. 4.4.

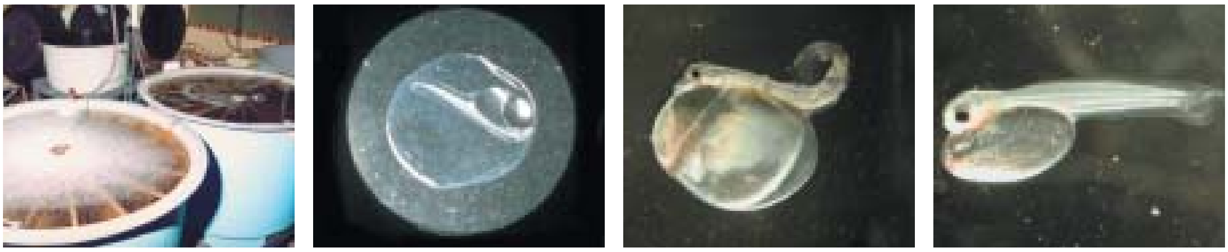

Fig. 4.4 Native fish eggs and larvae

Top left: Murray cod eggs on racks in tank.

Top right: Recently hatched Murray cod larvae.

Below left: Tanks showing foam that rises to surface after Murray cod eggs hatch.

Below second from left: Golden perch egg (embryo 4mm in length) just before hatching.

Below third from left: Deformed Murray cod larva

Below far right: Normal Murray cod post-larva (10mm in length), note the large yolk sac.

Maintenance of larvae in hatchery until feeding

Larvae are kept in the hatchery until the completion of yolk sac absorption, when exogenous feeding commences. In Murray cod this is around 10 days after the completion of hatching at 20º - 22ºC, and in golden perch and silver perch 4 – 5 days at 23º - 25ºC.

Stocking and first feeding of larvae

Golden perch and silver perch larvae are stocked directly into ponds, whereas cod larvae are usually fed *Artemia* and/or wild zooplankton collected from ponds for up to a week before stocking. Murray cod and golden perch larvae commence feeding on copepods and cladocerans, and silver perch on rotifers and copepods. High densities of small zooplankton (length < 500 µm) and good water quality at stocking are essential for survival rates of 30% or greater; survival rates of all species can be as high as 90%.

Management of larval rearing ponds

Larval rearing ponds are eutrophic, biologically-productive environments. The large blooms of phytoplankton and zooplankton, and the large number of fish fry and fingerlings cause significant fluctuations in some key water quality variables, particularly oxygen, pH and ammonia. The rearing ponds should be aerated nightly to maintain good water quality, and regular monitoring of these variables (at least 3 times/week) is an important management

Fig. 4.5 Dry larval rearing pond showing internal harvest sump.

practice. Rearing ponds are also ideal environments for some fish pathogens, particularly protozoan ecto-parasites (e.g. *Ichthyophthirius multifiliis, Chilodonella hexasticha, Trichodina sp.*), and so post-larvae and fry must be regularly sampled (at least weekly) and gill and skin tissue examined for parasites. Diseases caused by these parasites are treated by applying formalin (15 – 30 mg/L) to the ponds. Silver perch post-larvae and fry can be weaned onto artificial diets commencing around 2 weeks after stocking. Metamorphosis of all species occurs 2 – 4 weeks after stocking, at lengths of 15 – 20 mm.

The abundance of zooplankton decreases during the rearing period due to natural succession and fish predation. If it is necessary to grow fry to a larger size, they can be harvested and restocked into other ponds containing blooms of zooplankton. Alternatively, water containing zooplankton can be transferred from another pond, or zooplankton can be collected and added to the rearing pond. Care needs to be taken to manage aquatic pests such as fairy shrimp as these can significantly reduce the available feed in a larval rearing pond.

Harvesting and quarantine of fry (15 – 30 mm) and fingerlings (> 30 mm)

Fry reach lengths around 30 mm (weight, 0.5 g) in 5 to 8 weeks at which time they can be harvested by seine netting and/or draining the ponds. They are transported to the hatchery, counted (individually or by volume or weight) and quarantined for at least 1-2 days in a salt bath (2.5 – 5.0 g/L). The health of the fish and the water quality are monitored during the quarantine period.

Stocking

Fish are ready for stocking only after they are confirmed to be free of parasites and others signs of disease, and when there are no trash fish in the tanks.





Fig. 4.6

Top left: Water samples from ponds are checked for zooplankton.

Top centre: The ecto-parasite* Trichodina*, on fin tissue

Top right: Cladocerans under magnification

Above and left: Drain harvesting fingerlings from a pond at the Narrandera Fisheries Centre.

5 Site Selection

5.1 - SUMMARY

The selection of a suitable site, with an abundant supply of good quality water is the first and most important step in establishing a native fish hatchery. Poor site selection inevitably leads to failure. The farm must be located in a region with an appropriate temperature regime for the cultured species. Ideally Murray cod, golden perch and silver perch should be cultured within their natural distribution, i.e the Murray-Darling River System. Other important factors to be considered are: the suitability of soils for pond construction; topography; susceptibility of the site to flooding; availability of 3-phase electricity, labour, equipment suppliers, services, and transport for feed and fish; proximity to customers and stocking sites; ability to secure the site against poaching and theft.

5.2 - GENERAL

The success of a fish hatchery is dependent on many factors, beginning with the selection of a suitable site, and the design and construction of facilities that enable efficient and economical operation. Poor site selection and design will inevitably lead to failure.

Murray cod, golden perch and silver perch are endemic only to the Murray-Darling River System and for ecological and biosecurity reasons, hatcheries for these species should be located within the system.

The abundance and quality of water are major factors determining the success of a fish hatchery; a regular, abundant supply of good quality water is essential. The supply must be guaranteed during drought periods, which can last for several years in inland regions of Australia. Seasonal changes in quantity and quality also need to be considered during site selection. It is emphasised that no amount of understanding, monitoring and management will compensate for an inadequate water supply. Large, permanent rivers and creeks are the most commonly used sources. Surface waters are ideal for ponds because they are usually good quality and contain natural organisms such as zooplankton that play a key role in the rearing of larvae in earthen ponds (Rowland, 1992, 1996). Under-ground water has a number of features that make it particularly suitable for use in hatcheries: regular, dependable supply (usually); free of pathogens, organic, agricultural or industrial pollution, and suspended solids; relatively constant temperature; free of trash fish and other undesirable organisms (Ogburn et al., 1995; Rowland, 1998a). Under-ground water may have excessively high or low alkalinity and/or hardness, be deficient in oxygen, saturated with nitrogen, or contain relatively high concentrations of carbon dioxide, and other harmful gases such as methane and hydrogen sulphide, and minerals such as iron, lead, zinc and copper. Only some of these limitations can be over-come by storing and aerating the water before use. Consequently, it is very important to have the water thoroughly analysed and evaluated by an expert before a commitment is made to use an under-ground supply. Water quality criteria for native fishes are given in Table 5.1.

Rainfall is characteristically unreliable in much of inland Australia and so any venture that considers the use of rain run-off as the major supply (i.e. catchment and storage in a reservoir) should seriously estimate their requirements and water budget. Annual water budgets for 1 ha of grow-out ponds at different locations in NSW were estimated by Ogburn et. al (1995) and ranged from 35 ML at Grafton on the north-coast to 46.5 ML at Bourke in the drier, western part of the state. The quality of water in a large catch-ment dam will deteriorate as the level falls and aquatic organisms, suspended solids etc. become concentrated. Water from domestic supplies should be avoided as it is expensive and usually contains chemicals such as chlorine which is toxic to fish. However, domestic supplies (after de-chlorination) are suitable where large quantities are not required, e.g. for quarantine. The water entering a hatchery must be of high quality (see Table 5.1) and free of sewage, heavy metals, oils, pesticides, chlorine, methane, hydrogen sulphide and other poisonous substances. The use of eutrophic water (i.e. high in nutrients) will lead to an increased incidence of some parasitic diseases, as well as excessive algal blooms and subsequent problems with water quality. The cost of supplying water to the site may be a major factor determining the economic viability of a hatchery. Pumping costs are high and must

SITE SELECTION
ESSENTIAL CRITERIA

- ***Abundant supply of good quality water:***
  - *see Table 5.1 for water quality criteria for native fish;*
  - *for details of key variables see Rowland (1995b) and Rowland (1998);*
  - *surface waters (rivers, creeks, lakes, canals) can be used for all hatchery purposes (ponds, tanks, spawning, incubation), but are especially important for larval rearing because these waters usually contain plankton that helps "seed" the ponds;*
  - *underground waters (bores, wells) for tanks, quarantine, broodfish, spawning, incubation, and in some cases where quality allows, for larval rearing ponds.*
- ***Location within the Murray-Darling River System (for hatcheries constructed after 2004):***
  Murray cod, golden perch and silver perch are endemic only to this system.
- ***Out of reach of the Probable Maximum Flood level:***
  to prevent the escape of fish during floods.
- ***Soils that are suitable for pond construction:***
  to minimise construction costs; minimise seepage and enable efficient use of water.

be minimised. Obviously the hatchery should be as close as possible to its water supply. Gravity flow should be utilised where-ever possible because it is very efficient and cheap.

Ponds should be constructed from impervious soils to eliminate or at least minimise the loss of water by seepage; clay or clay loams are ideal. A proposed site should be surveyed for gravel or sand layers, rock strata or other soil characteristics that may interfere with water holding capacities. Dispersive or flocculative soils can lead to embankment failure or "tunneling". Advice on the suitability of soils for pond construction should be sought from appropriate experts.

SITE SELECTION
RECOMMENDED CRITERIA

- ***3-phase power.***
- ***Annual water budget of at least 40 ML/ha/year.***
- ***Annual water temperature range within 10º to 30ºC.***
- ***Combination of surface and underground water supplies:***
  for pond and hatchery supplies respectively.
- ***Close proximity to water supply (e.g. within 2 km for surface supply).***
- ***Available land:***
  large enough to accommodate the maximum number of ponds, a reservoir, an effluent/settlement dam, and buildings (hatchery, office, laboratory, tanks, storage, workshop etc.) and to allow for future expansion.
- ***Topography:***
  the land should be relatively flat and ideally slope gently away from the source of water or reservoir, to facilitate the gravity supply of water.
- ***Soils analysed for pesticide residues.***

SITE SELECTION
NOT RECOMMENDED

- ***Run-off water as the major water supply:***
  i.e. run-off, surface water captured in a large dam(s).

Other factors to consider

- ***Availability of suitable manpower to operate the farm.***
- ***Proximity to equipment suppliers and service industries.***
- ***Availability of transport for fish and feed.***
- ***Proximity to customers and stocking sites.***
- ***Ability to secure the site against poaching and sabotage.***
- ***Reliable power supply.***

TABLE 5.1 - WATER QUALITY CRITERIA FOR NATIVE FISH HATCHERIES

Values are ranges for alkalinity, hardness and conductivity, maximum levels for heavy metals, and minimum and maximum levels for other variables.

VARIABLE	VALUES	COMMENTS
Alkalinity (mg/L)	20 – 400.00	Alkalinity, hardness, conductivity and metals are relatively stable variables that "characterise" water. Waters that are very alkaline (> 500 mg/L) and/or hard (> 500 mg/L) are unsuitable for native fish and may cause slow growth, tissue damage, morbidity and mortality. Heavy metals can have sub-lethal or toxic effects on native fish at concentrations above those listed.
Hardness (mg/L)	50 – 400.00	
Conductivity (µS/cm)	0 – 5,000.00	
Heavy metals and minerals (mg/L)		
- **cadmium**	0.003	
- **calcium**	10 – 160.00	
- **copper**	0.006	
- **iron**	0.50	
- **lead**	0.03	
- **manganese**	0.01	**Variables in bold MUST be analysed during site selection.**
- **mercury**	0.002	
- **zinc**	0.05	
pH	6.5 – 8.50	
Dissolved oxygen (mg/L)	> 5.0	pH, dissolved oxygen, ammonia and nitrite are relatively unstable variables and can change rapidly from acceptable to stressful or lethal levels under certain conditions. Some underground waters can be very low in pH and oxygen, and high in nitrogen, hydrogen sulphide, carbon dioxide, ammonia and nitrite because of anoxic conditions and high pressure. Vigorous aeration of water when it reaches the surface increases oxygen and pH, and releases hydrogen sulphide, carbon dioxide, and nitrogen as gases. Consequently analyses of these variables may not accurately determine the suitability of water for fish culture.
Phosphorus	0.01 – 3.0	
Nitrogen	< 105% saturation	
Hydrogen sulphide (mg/L)	< 0.002	
Total ammonia (mg/L)	< 3.0	
Un-ionised ammonia (mg/L)	< 1.0	
Nitrite (mg/L)	< 4.0	

If the land was previously used for cropping, the soil should be tested for pesticide residues. Areas with acidic soils should be avoided because of resulting low pH and alkalinity in impounded water. Areas with high ground water cause problems because it is difficult or impossible to build ponds. If they can be built, they cannot be completely drained and dried; essential operations for efficient pond management.

The area of land selected for a hatchery should be large enough to accommodate the maximum number of ponds, a reservoir, an effluent/ settlement dam, and buildings (hatchery, office, laboratory, tanks, storage, workshop etc.). Future expansion should be considered when selecting the site. The land should be relatively flat and ideally slope gently away from the source of water or reservoir, to facilitate the gravity supply of water.

6

Design and operation of facilities

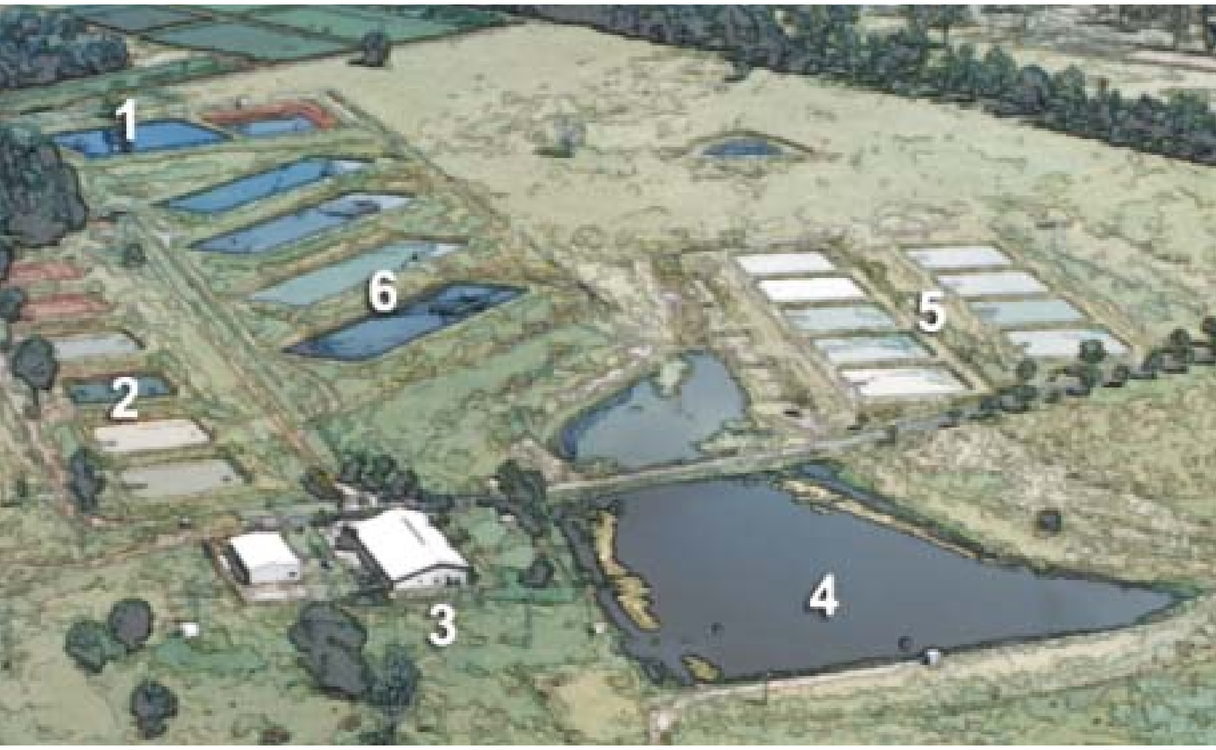

Fig. 6.1 Model farm layout - the Grafton Aquaculture Centre

1. Reservoir

2. Broodstock ponds

3. Hatchery building and machinery shed.

4. Effluent pond

5. Grow-out ponds

6. Larval rearing ponds

6.1 - SUMMARY

A native fish hatchery must be well designed to enable efficient and environmentally-sound operation and the production of high quality fingerlings. The basic components of a native fish hatchery are: water supply; reservoir; earthen ponds (0.1 – 0.5 ha surface area) for broodstock and larval rearing; an effluent-settlement dam; hatchery building with breeding facilities such as tanks for spawning and egg incubation; laboratory; tank-based quarantine facilities; office; support buildings; and associated electricity, plumbing, pumps, air blowers, filters, vehicles and other equipment. Re-circulating aquaculture systems (RAS) can be used for quarantine, broodstock or over-wintering fingerlings. A hatchery must have sufficient ponds and tanks to:

(i) accommodate the species and strains cultured;
(ii) enable breeding programs that satisfy genetic guidelines;
(iii) enable the quarantine of fish.

Reservoirs, ponds and tanks must be screened (with appropriate-sized mesh – see *Essential Criteria*) to prevent the entry of "trash" fish to the hatchery and the escape of fish from individual facilities. It is very important that redfin (*Perca fluviatilis*), mosquito fish (*Gambusia holbrooki*), goldfish (*Carassius auratus*), noxious species such as carp (*Cyprinus carpio*) and banded grunter (*Amniataba percoides*), as well as non-target fish such as eels and gudgeons that may be present in the water supply, are excluded from the reservoir and ponds. If present these fish can:

(i) prey on larvae, fry and fingerlings;
(ii) stress broodstock, fry and fingerlings;
(iii) cause disease;
(iv) compete for food;
(v) contaminate batches of fingerlings dispatched from the hatchery.

Fish in the reservoir (and the effluent-settlement dam) act as a source of pathogens and sub-sequently increase the incidence of disease on a hatchery.

The success of a hatchery depends on staff that are trained and experienced in the technical and practical aspects of fish culture.

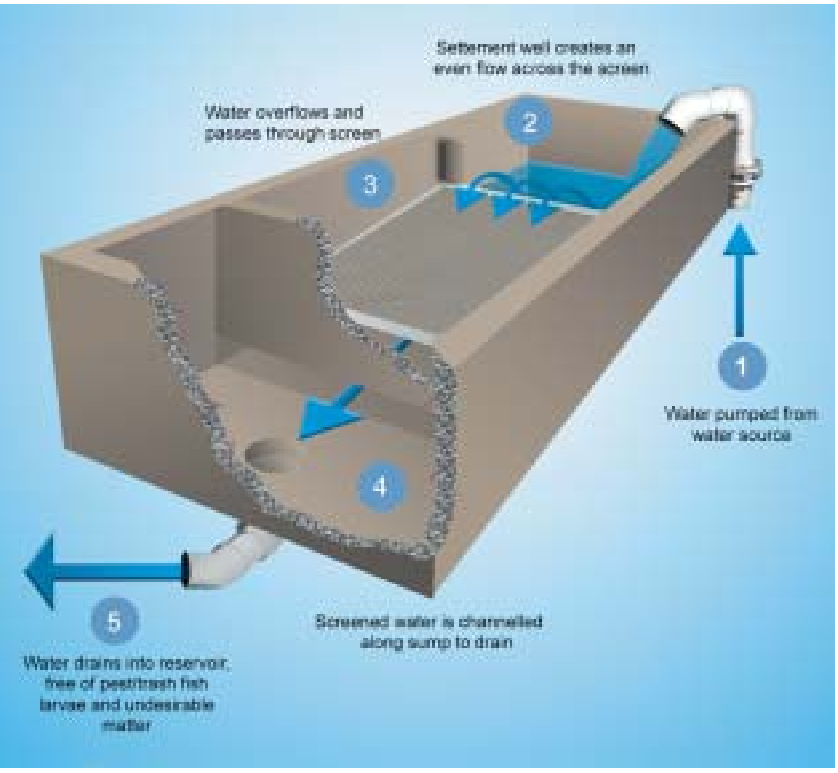

Fig. 6.2 Diagram of the water supply inlet at the Grafton Aquaculture Centre showing the horizontal screen used to exclude aquatic organisms.

RESERVOIR
ESSENTIAL CRITERIA

- ***Screened inlet for surface waters:***
  500 µm screen to prevent the entry of trash fish (all life cycle stages, including larvae) and other aquatic organisms into the reservoir; robust screen, e.g. 2m x 2m stainless steel (see Fig. 6.2).
- ***Screened outlet for all waters:***
  5 mm to prevent the escape of trash fish from the reservoir.
- ***Capacity to drain and dry reservoir:***
  for the following reasons:
  (i) to remove all fish, especially trash fish;
  (ii) to desiccate pathogens;
  (iii) to enable disinfection, e.g. application of lime to the substrate;
  (iv) to enable silt to be removed and/or the substrate to be tilled or scraped;
  (v) to enable repairs and general maintenance.

6.2 - RESERVOIR

The reservoir receives and stores water from the major source. It enables control of supply and quality, exclusion of trash fish and other unwanted aquatic organisms, and efficient delivery of water to ponds and the hatchery. The reservoir provides a reserve of water at critical times, e.g. during power failure, pump break-down and flood. Reservoirs are normally earthen, with separate and screened inlets and outlets (Fig. 6.3). Water from under-ground supplies can be stored in earthen, fibreglass, plastic or concrete reservoirs. Reservoirs should be aerated to prevent stratification and to maintain good water quality.

RESERVOIR
RECOMMENDED CRITERIA

- ***Located and constructed to enable gravity flow:***
  efficient, reliable and economical delivery of water to all facilities.
- ***Capacity should exceed twice volume of largest ponds:***
  e.g. if largest pond holds 5 ML, reservoir should be at least 10 ML.
- ***Aeration:***
  e.g. paddlewheel or diffused aerator, to maintain good water quality and prevent or reduce stratification.
- ***Back-up water supply for hatchery building:***
  an elevated reservoir to ensure water is available under gravity during power failure.

Fig. 6.3 Reservoir at Grafton Aquaculture Centre showing inlet, aerator and outlet tower.

Fig. 6.4 Dry earthen pond showing the outlet tower and internal harvest sump.

6.3 - EARTHEN PONDS

Earthen ponds are the basic production unit at native fish hatcheries, and are principally used to hold broodstock and to rear larvae.

Ponds must have appropriate plumbing to enable efficient management of water, and screened outlets to prevent the escape of fish.

EARTHEN PONDS
ESSENTIAL CRITERIA

- ***Drainable by gravity:***
  drainage line from deepest section of pond.
- ***Separate inlet and outlet.***
- ***Screened (500 - 1,000 µm) inlet if water directly from surface supply:***
  to prevent the entry of trash fish.
- ***Screened outlet structure:***
  1 mm² when larvae stocked, 6 mm for fry and fingerlings and 6 – 25 mm for broodstock; to enable the draining of ponds and to prevent the escape of all fish during harvest, water exchange and over-flow.
- ***Harvest sump, supplied with fresh water:***
  for all ponds, to reduce stress and physical damage to fish, and to provide good quality water during harvest.
- ***Records:***
  for each pond to include the following – date, species, number of fish, size of fish, activity (stocking, feeding, harvest, sampling), information on disease, chemical treatments, general comments.
- ***Larval rearing ponds must be dry before use:***
  (i) to enhance the production of plankton, particularly the zooplankton on which larvae feed;
  (ii) to desiccate pathogens;
  (iii) to treat with lime if necessary;
  (iv) to provide conditions for good water quality through the oxidation of sediments;
  (v) to reduce or eliminate predators such as large aquatic insects and dragon fly larvae;
  (vi) to ensure there are no trash fish in the ponds when larvae are stocked;
  (vii) to reduce or prevent growth of macrophytes.
- ***Sufficient broodstock ponds (or tanks and cages) to satisfy breeding program:***
  e.g. if ponds are the main broodstock-holding facility and Murray cod and golden perch are to be stocked into 3 separate rivers a minimum of 6 broodfish ponds (3 x Murray cod, 3 x golden perch) would be required; although tagged broodstock of different strains can be mixed, it is recommended they are kept separate.
- ***Sufficient larval rearing ponds to satisfy breeding program:***
  e.g. production of Murray cod and golden perch to be stocked into 3 separate rivers would require 6 larval rearing ponds if used concurrently, 3 x Murray cod and 3 x golden perch; 3 ponds would suffice if used initially for Murray cod, and then drained, dried and re-used for golden perch.

Fig. 6.5 Broodstock pond (0.1–ha surface area) with aerator.

EARTHEN PONDS
RECOMMENDED CRITERIA

- ***Shape:***
  square (0.1 ha surface area) or rectangular (0.2 – 0.5 ha).
- ***Size:***
  broodstock 0.05 – 0.1 ha; larval rearing 0.1 – 0.5 ha.
- ***Outlet tower - concrete:***
  also called a monk or penstock; contains boards to control water level and screens to prevent escape of fish; vertical PVC pipes are acceptable as outlets, but are not recommended.
- ***Inlet pipe:***
  150 mm (6") diameter, with valve.
- ***Outlet pipe:***
  at least 150 – 200 mm (6" – 8") diameter; a diameter of 500 mm (20") enables rapid water exchange and facilitates external drain harvest of fish.
- ***Internal sump:***
  e.g. 50 cm deep, 50 cm wide, 20 m long for 0.1 – 0.2 ha ponds (Fig. 6.4); for collection of broodfish and fingerlings after the pond is drained.
- ***External sump:***
  for collection of fish outside the pond.
- ***Aeration (3-phase power):***
  to maintain optimum water quality. These should be fitted with automatic timers and manual overides.
- ***Overhead netting of larval rearing ponds:***
  to prevent bird predation.
- ***Broodstock ponds to be drained and dried annually or at least each 2-3 years:***
  for the following reasons;
  (i) to remove all fish, especially trash fish;
  (ii) to desiccate pathogens;
  (iii) to treat with lime if necessary;
  (iv) to enable silt to be removed and/or the substrate to be tilled or scraped;
  (iv) to enable repairs and general maintenance;
  (v) to provide conditions for good water quality;
  (vi) to reduce or prevent growth of macrophytes;
  (vii) to facilitate the rotation of Murray cod broodstock (see Chapters 10 and 11).
- ***Larval rearing ponds dry over winter and early spring:***
  to facilitate plankton blooms and good water quality.
- ***Plant a crop (wheat, oats, rye grass) every 2 years in larval rearing ponds during late autumn and winter:***
  to use phosphorus bound-up in the soil and to promote rotifer blooms.
- ***Lime bottom of larval rearing ponds:***
  especially if alkalinity is low (< 20 mg/L); may promote rotifer blooms and reduce problems with fairy shrimp; 500 – 1,000 kg/ha agricultural limestone ($CaCO_3$).
- ***Vehicular access to all banks.***

Fig. 6.6 Cultivating a larval rearing pond before filling and fertilising.

6.4 - EFFLUENT-SETTLEMENT DAM

The effluent-settlement dam receives all effluent water from the ponds and hatchery, except water containing salt – there should be a separate dam for any water with salt. The settled water can be re-used for fish culture or used for irrigation.

EFFLUENT-SETTLEMENT DAM
ESSENTIAL CRITERIA

- ***All hatcheries must have an effluent-settlement dam.***
- ***Twice volume of largest pond:***
  if the largest pond contains 5 ML, the effluent-settlement dam should be 10 ML or larger.
- ***Ability to screen overflow/outlet to prevent escape of fish.***

EFFLUENT-SETTLEMENT DAM
RECOMMENDED CRITERIA

- ***Earthen dam.***
- ***Does not receive run-off.***
- ***Pump that can return water to reservoir and/or ponds.***
- ***Ability to drain and dry:***
  (i) to remove all fish, especially trash fish;
  (ii) to desiccate pathogens;
  (iii) to enable silt to be removed and/or the substrate to be tilled, scraped or limed;
  (iv) to prevent excessive growths of macrophytes such as milfoil (Myriophyllum spp.)*;*
  (v) to enable repairs and general maintenance.
- ***Aeration:***
  to maintain optimum water quality.
- ***Effluent to enter over wide area:***
  to facilitate the settlement of solids.
- ***Salt-evaporative pond(s):***
  separate to effluent-settlement dam; to receive water containing salt from hatchery.

6.5 - HATCHERY BUILDINGS, INFRASTRUCTURE AND EQUIPMENT

Hatchery building(s) contains breeding facilities, quarantine facilities and associated power and plumbing systems, plus laboratory, office(s), stores and records.

Fig. 6.7 Tanks (500L) used for incubation of eggs, holding fingerlings or quarantine; external standpipe controls water level and internal pipe screens the water.

HATCHERY BUILDINGS, INFRASTRUCTURE, EQUIPMENT
ESSENTIAL CRITERIA

- ***Filtration/screening of all surface waters and water from earthen reservoirs that enter the hatchery building:*** *sand filtration and/or cartridge filters of 100 µm; under-ground water directly from bore may not need to be filtered, but may need to be stored and aerated.*
- ***Spawning tanks:*** *1,000 – 5,000 L; recommended with temperature control.*
- ***Quarantine tanks:*** *500 – 10,000 L; separate from spawning tanks.*
- ***Each tank with own water supply.***
- ***Drainage system to remove all over-flow or drained water from tanks and other facilities:*** *water to effluent-settlement dam or salt-evaporative pond.*
- ***Aeration of all tanks:*** *high-volume, low-pressure blower(s); diffused air through airstones.*
- ***Screened outlets in all tanks:*** *screen size depends on fish, e.g. maximum of 25 mm for broodfish, 6 mm for fry/fingerlings.*
- ***Incubation facilities:*** *may be tanks or aquaria for the pelagic eggs of golden perch and silver perch, or tanks or troughs for Murray cod eggs; screens 500 µm for golden perch and silver perch, 1,000 µm for Murray cod.*
- ***Laboratory facilities:*** *specific area containing bench, sink, water, microscope(s), balances, reference material, records; ideally a separate, closed room.*
- ***Refrigeration:*** *for chemicals such as hormones.*
- ***Office.***
- ***Support buildings and workshop:*** *for maintenance and to house vehicles, feed, and general equipment.*
- ***Storage areas for chemicals and inflammable liquids:*** *to satisfy OH&S requirements.*

HATCHERY BUILDINGS, INFRASTRUCTURE, EQUIPMENT
RECOMMENDED CRITERIA

- ***Circular tanks:*** *fibreglass or plastic; with central drain for self-cleaning; internal or external standpipe.*
- ***Re-circulating aquaculture system (RAS):*** *for quarantine, holding broodstock or over-wintering fingerlings.*
- ***3-phase electrical system:*** *power for heaters, aerators, welding equipment.*
- ***Generator*** *for emergency power supply.*
- ***Emergency oxygen supply:*** *bottled oxygen.*
- ***Computer system:*** *for data management and record keeping, general office use and access to e-mail and Internet.*
- ***Telephone and fax.***

6.6 - GENERATOR FOR EMERGENCY POWER SUPPLY

Electricity is essential for the operation of a fish hatchery, especially during the breeding season. It is strongly recommended that each hatchery have a generator to provide electricity during failure of mains power. The generator should be large enough to power all essential equipment (e.g. blowers, pumps, aerators, heaters), and with the capacity to cover any future expansion of the hatchery. GAC has a 110 KVA generator as an emergency power supply.

6.7 - STAFF

Aquaculture is an intensive animal industry, and the success of native fish hatcheries is dependant on high quality staff that have a good understanding of the biology of each species, and the technical and practical aspects of aquaculture. On smaller hatcheries, staff need to be "all-rounders" with a combination of technical and practical skills, while on large farms there may be scope for specialisation, with trained personnel concentrating on the more technical aspects such as hormone-induced breeding, water quality and diseases. There are a number of courses available at Technical and Further Education (TAFE) facilities and universities – see Aquaculture Trade Directories for information.

6.8 - DUTY OF ANIMAL CARE

Fish hatchery operators have a duty to provide appropriate facilities and care for native fish. Directions for animal care on research institutions in Australia such as the NSW Department of Primary Industries R&D facilities, are provided by the National Health and Medical Research Council (NHMRC) and appropriate Animal Care and Ethics Committees. The NHMRC directs that "the overall condition and management of facilities must permit effective maintenance and servicing and be compatible with maintaining the animals in good health". The NSW Department of Primary Industries Animal Care and Ethics Committee (ACEC) has provided written guidelines for fish care (see Barker et al., 2002). The ACEC and the NSW Department of Primary Industries institutions are responsible for ensuring that facilities are appropriately staffed, designed, constructed, equipped, operated and maintained to achieve a high standard of animal care. In relation to monitoring requirements, Barker et al. (2002) states "All fish holding facilities and support systems must be inspected every 24 hours".

7 Water quality

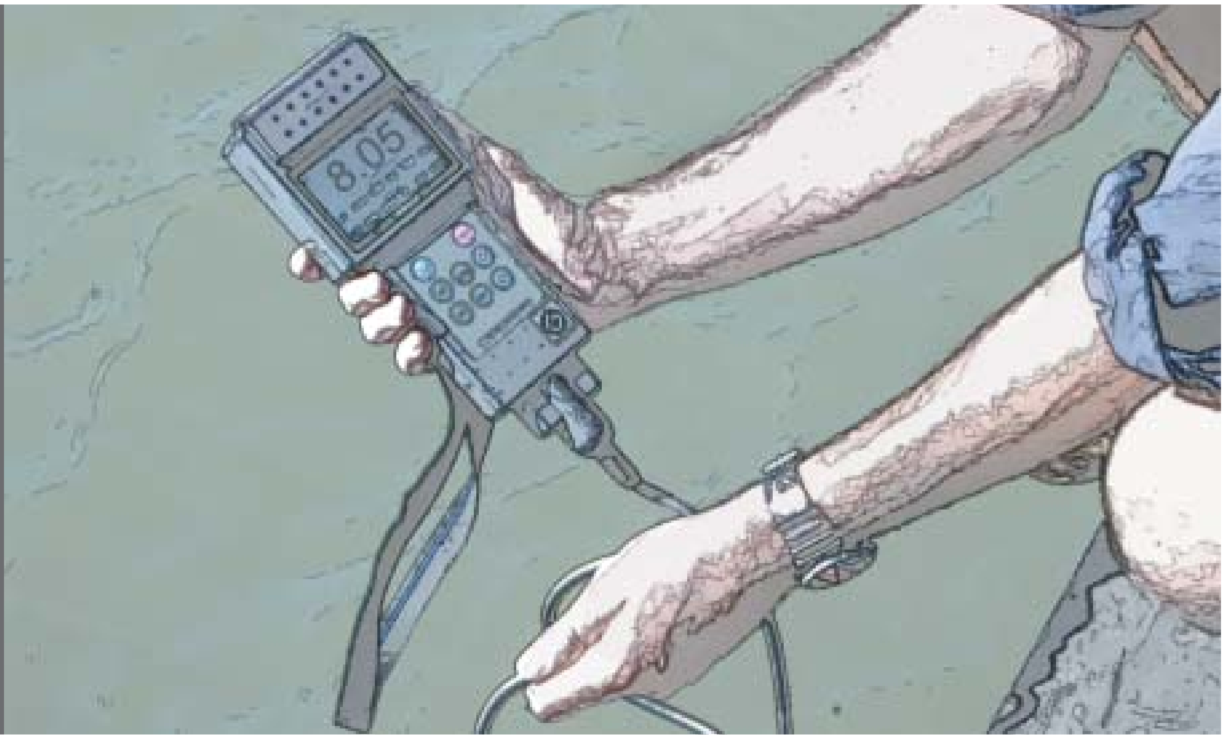

Fig. 7.1 Meter used to measure water quality variables.

7.1 - SUMMARY

Successful hatchery production of native fish depends on the maintenance of good water quality. Poor water quality will either kill eggs, larvae or fish directly, or cause stress leading to reduced feeding, slow growth, inhibition of gonadal development and reproduction, and increased susceptibility to disease. The water quality variables temperature, dissolved oxygen, pH, and ammonia should be regularly monitored using meters and appropriate equipment, and accurate records should be kept. All facilities must be aerated and have a capacity for exchange of water.

7.2 - GENERAL

Water quality in freshwater aquaculture is discussed in detail by Boyd (1982, 1990) and in relation to Australian fish by Rowland (1995b, 1998a). Key variables and relevant values are listed in Table 5.1. Eggs and larvae usually have more stringent requirements than juveniles and adults, and so the quality of water for fish hatcheries must be high.

The relatively stable variables of alkalinity, hardness, conductivity and metals need to be analysed during site selection; however, they are not greatly influenced by fish culture activities and so do not need to be regularly monitored (other than alkalinity in RAS). Temperature influences all chemical and biological processes, and has direct effects on dissolved oxygen concentration (DO), pH and ammonia. These variables are unstable and are significantly influenced by fish culture activities; DO, pH and ammonia can change from acceptable levels to stressful or lethal levels within several days, particularly in summer (and within a few minutes in RAS).

There is a strong link between water quality and fish health – the susceptibility of fish to disease is greatly increased by poor water quality. Water quality can deteriorate rapidly in larval rearing ponds where there are often large blooms of phytoplankton and zooplankton, and a large biomass of fish. Consequently, these four variables must be monitored regularly. DO is lowest near dawn, whereas maximum levels of pH and ammonia usually occur in mid-afternoon.

The water quality monitoring program used at GAC is given in Table 7.1.

WATER QUALITY
ESSENTIAL CRITERIA

- ***Water quality meter(s) and equipment:*** *with the capacity to monitor temperature, DO, pH, total ammonia-nitrogen (TAN), conductivity/salinity; un-ionised ammonia (NH_3) is calculated using TAN, temperature and pH.*
- ***Regular monitoring of water quality:*** *data sheets and records showing regular collection of water quality data from all ponds, tanks and other facilities (see Appendix I for an example of a data sheet).*
- ***Aeration:*** *of all tanks, incubation facilities.*
- ***Capacity to exchange water rapidly (in all facilities):*** *flows to tanks (1,000 – 10,000 L) holding broodstock and fingerlings should be around 15 L/min, with a capacity up to 250 L/min to enable tanks to be filled quickly.*

WATER QUALITY
RECOMMENDED CRITERIA

- ***Trained technical staff with a good understanding of water quality in aquaculture.***
- ***Regular calibration and maintenance of water quality meter(s) and equipment:*** *according to manufacturer's guidelines.*
- ***Aeration systems with timers:*** *in all ponds.*
- ***Use of appropriate pond fertilisation regimes:*** *for recommendations see Rowland (1983, a, b), Boyd (1990), Thurstan and Rowland (1995).*
- ***Equipment to monitor alkalinity and hardness:*** *especially where RAS is used.*
- ***Use Good Aquaculture Practices to assist in managing water quality:***
  - *daily inspection of ponds;*
  - *observation of broodstock and post-larvae at feeding;*
  - *use recommended feeds and feeding regimes;*
  - *spell and dry broodstock ponds every 2 – 3 years;*
  - *dry larval rearing ponds during winter and early spring;*
  - *appropriate use of chemicals.*

TABLE 7.1 - MONITORING PROGRAM FOR WATER QUALITY IN BROODSTOCK AND LARVAL REARING PONDS AT GRAFTON AQUACULTURE CENTRE

SEASON, MONTHS, TEMPERATURES	DAYS	TIME OF DAY (h)	VARIABLES
Spring – Summer – early Autumn **September – April** **> 20º**	Monday, Wednesday, Friday	06.00 – 08.00 15.00 – 16.00	DO, temperature, pH DO, temperature, pH, ammonia*
Late Autumn – Winter **May – August** **< 20º**	Monday, Thursday	06.00 – 08.00 14.00 – 15.00	DO, temperature DO, temperature, pH, ammonia*

** Ammonia once weekly if at acceptable levels.*

Fig. 7.2 Aeration of broodstock pond maintains good quality water.

8

Disease and health management

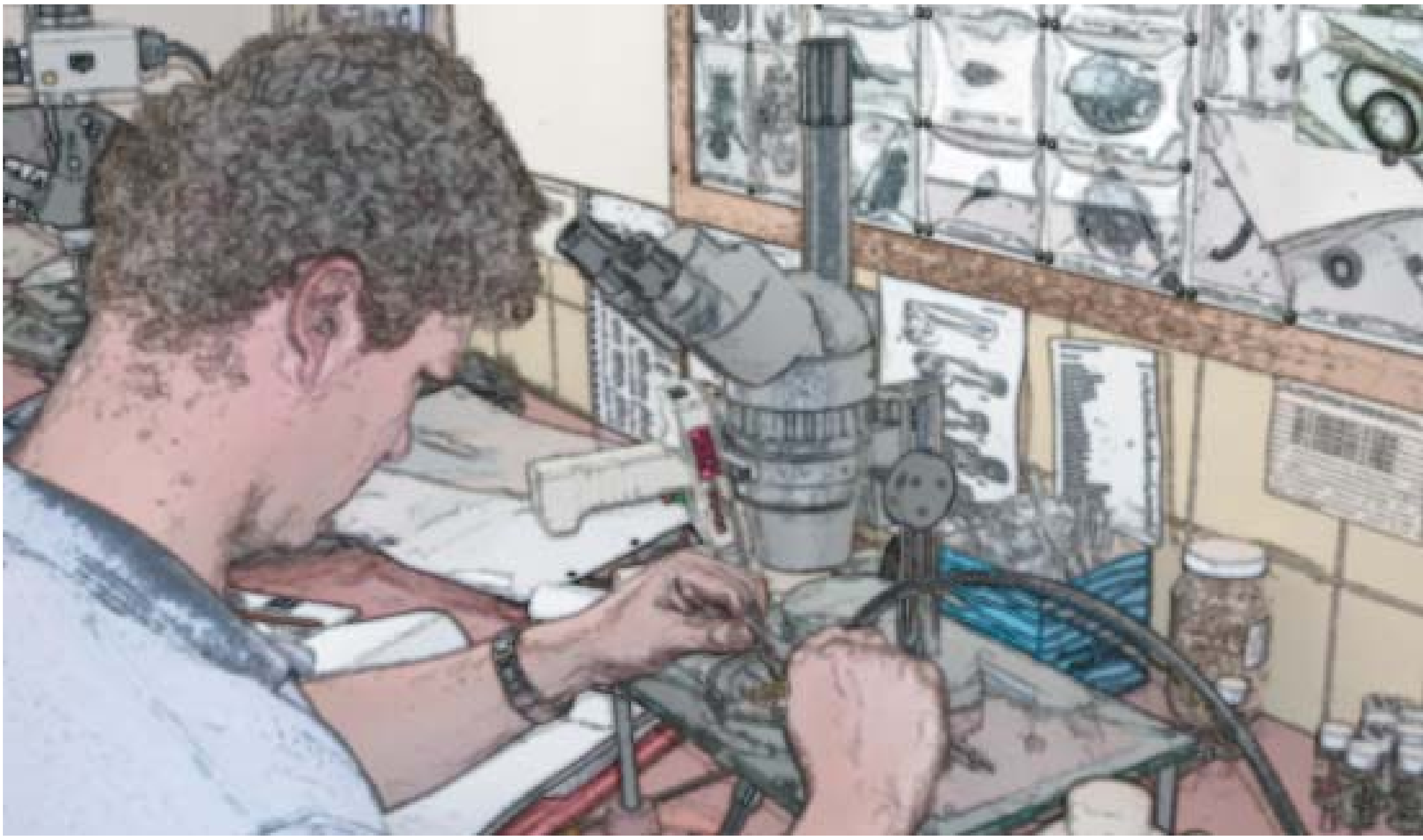

Fig. 8.1 Using a microscope to examine gill and skin tissue for parasites and signs of disease.

8.1 - SUMMARY

Diseases cause significant losses of fish on hatcheries and farms throughout the world. The important diseases of Murray cod, golden perch and silver perch are known and this HQAP gives Essential Criteria for their prevention, diagnosis and treatment.

Under culture conditions, Murray cod and silver perch are particularly susceptible to diseases caused by ecto-parasitic protozoans, especially white spot or ichthyophthiriosis (caused by the pathogen, *Ichthyophthirius multifiliis*) and chilodonelliosis (*Chilodonella hexasticha*). Numbers of these parasites can increase rapidly during an infestation, causing acute disease and high mortalities. Early diagnosis and treatment are imperative to maintain healthy stocks and to ensure high survival. Native fish are also susceptible to three fungal diseases, "fungus" (sap, caused by *Saprolegnia* sp.), Epizootic Ulcerative Syndrome (EUS or red spot disease caused by *Aphanomyces invadans*) and Winter Disease (mainly silver perch; caused by *Saprolegnia parasitica*). Fungal diseases can be difficult to treat, and the use of good fish husbandry and pond management is required to minimise the incidence of fungal infections and losses. Bacterial diseases are uncommon in native fish hatcheries, and are usually only seen when fish are subjected to very poor water quality (particularly low DO and high temperatures), severe crowding and rough handling, e.g. drain harvest of larval rearing ponds. Few incidences of viral diseases have been recorded on native fish in the wild or on farms. However, under laboratory conditions Epizootic Haematopoietic Necrosis Virus (EHNV) is known to kill silver perch, and Murray cod can carry the virus. EHNV is endemic in wild populations of redfin, and so EHN is a threat to native fish and their culture.

A Health Management Plan and the use of Good Aquaculture Practices are necessary to minimise losses on hatcheries.

After harvest, a quarantine period of at least 24 h, and examination of gill and skin tissue for signs of disease and parasites are essential to ensure the good health of fingerlings for stocking.

8.2 - HEALTH MANAGEMENT PLAN

All native fish hatcheries should have a Health Management Plan that includes the following components:

(i) farm design;
(ii) pond management techniques;
(iii) use of quarantine procedures;
(iv) nutrition of broodstock, larvae, fry and fingerlings;
(v) routine water quality monitoring;
(vi) prophylactic treatment of broodstock ponds;
(vii) regular sampling and examination of gill and skin tissues for parasites of post-larvae, fry and fingerlings from larval rearing ponds and in hatchery tanks;
(viii) disease diagnosis, on-farm and at laboratory when required;
(ix) disease treatment;
(x) training of farm staff in disease diagnosis and treatment;
(xi) disinfection of ponds, tanks and equipment:
(xii) procedures for the dispatch of disease-free fish;
(xiii) chemicals and their appropriate use and storage.

8.3 - PREVENTION OF DISEASES

The incidence of diseases is relatively low on well designed hatcheries that have a Health Management Plan and use Good Aquaculture Practices. A major aim of any aquaculture facility is to prevent the entry and spread of pathogens. Pathogens can be introduced in the water (particularly if the main supply is surface water from a river, creek, canal etc.), on fish that enter with the water, on fish brought onto the hatchery from the wild or other hatcheries and farms, and on some aquatic birds, including ducks, pelicans and cormorants. Pathogens can be transferred in the water from the reservoir to ponds and tanks, from pond to pond on fish, birds and equipment such as nets, and from ponds and tanks to the effluent-settlement dam. All attempts should be made to keep the reservoir and the effluent-settlement dam free of fish, especially the species being cultured and species such as redfin, carp, goldfish and eels that are known to carry organisms pathogenic to native fish. Many apparently "clean" fish may carry low numbers of pathogens – these may proliferate and cause disease if fish are stressed by factors such as poor water quality, handling and poor nutrition.

The use of quarantine procedures is an integral part of a Health Management Plan, and will greatly reduce the chance of introducing or spreading pathogens. Quarantine is particularly important for new fish arriving at the hatchery, e.g. new broodfish from the wild, or broodfish or fingerlings from another farm. However, fish harvested from any pond should also be quarantined for a period (e.g. minimum 3 days), that is sufficient to reduce stress and ensure they are free of disease. Quarantine tanks should be aerated and subjected to relatively low light intensity and normal photo-period. A partial cover over the tanks (e.g. 50%) helps to reduce stress. A salt (NaCl) concentration of 2.5 g/L reduces stress in freshwater fish and inhibits fungal infection and infestation by some parasites, including *I. multifiliis.*

PREVENTION OF DISEASES
ESSENTIAL CRITERIA

- **Health Management Plan:**
  a written document for the hatchery.
- **Quarantine all batches of fish:**
  new broodstock from the wild, fish from other hatcheries and farms, fish harvested from ponds on the hatchery, fish to be stocked into ponds, fish to be dispatched for stocking.
- **Tanks for quarantine:**
  500 – 10,000 L circular tanks; aeration; water supply; ideally physically separated from other hatchery tanks and water supplies.
- **Examination of all batches of fish in quarantine:**
  for parasites and signs of disease.
- **Sterilisation bath for hand nets, buckets and other equipment used in sampling and disease diagnosis:**
  chlorine (200 mg/L for nets, buckets, boots and 1,000 mg/L for tanks and transport equipment), formalin (1,000 mg/L; short-term, e.g. < 1 day) or salt (10 g/L).

PREVENTION OF DISEASES
RECOMMENDED CRITERIA

- ***Quarantine tanks should be isolated from other parts of the hatchery:***
  e.g. in a separate room and/or on a separate water supply, with containment of waste-water.
- ***Chemical treatment in quarantine to prevent disease:***
  permanent bath of 2.5 g/L NaCl; daily, short-term (1 h) bath of 10 g/L NaCl and/or 50 mg/L formalin.

8.4 - DIAGNOSIS OF DISEASES

Diagnosis of diseases involves regular observation and sampling of fish, microscopic examination of gill and skin tissues, identification of pathogens, and the application of appropriate treatments and management decisions. Hatchery operators must be able to identify the common pathogens (protozoans, monogeneans, fungi) using a microscope, because early diagnosis is essential to prevent or minimise losses. In the case of unknown pathogens and bacterial diseases, moribund or chilled specimens should be sent to a laboratory for examination by fish pathologists; if this in not possible in the short-term (1 – 2 days), specimens should be preserved in 10% formalin for later submission.

Broodstock are stocked at low densities in earthen ponds, tanks and cages and the incidence of diseases under these conditions is relatively low. Stress associated with handling broodstock, particularly Murray cod, within 4 months of the breeding season can cause resorption of eggs in some females (Rowland, 1988). Consequently, it is not advisable to sample broodstock during this period to monitor diseases. Several prophylactic treatments of formalin (25 – 30 mg/L) 4 weeks apart are recommended to prevent white spot and chilodonelliosis during winter and early spring. On the other hand, larval rearing ponds are eutrophic, biologically-productive environments that are conducive to some pathogens, particularly protozoans. Larvae and fry must be sampled at least weekly, and gill and skin tissues examined for parasites.

DIAGNOSIS OF DISEASES
ESSENTIAL CRITERIA

- ***Specific laboratory area:***
  closed room, bench, sink, water supply, lighting.
- ***Binocular microscope:***
  high power, internal light source, mobile stage, three objectives able to view at a magnifications of X 40, X 100, X 200, X 400.
- ***Appropriate level of knowledge to correctly identify the causative agent(s) of a disease.***
- ***References to assist in diagnosis:***
  e.g. Rowland and Ingram (1991), Callinan and Rowland (1995), Noga (2000).
- ***Data sheets:***
  detailing rearing facility, date, species, number and size of fish sampled, type and number of pathogens etc.; data sheets showing regular monitoring of fish health (see Appendix II for an example of data sheet).
- ***Sampling equipment:***
  seine net, cast net, lift net, plankton net, traps, sled with net; sterilising chemicals (chlorine or formalin) for use on equipment between batches.
- ***Dissecting and laboratory equipment:***
  scalpels, scissors, probes, forceps, microscope slides, distilled water, petri dishes, vernier callipers, cover slips, knives, cutting board, scales, ruler, gloves (see Fig. 8.2).
- ***Formalin (10% buffered) and plastic containers:***
  to preserve tissues and/or specimens for dispatch to laboratories for pathology.
- ***Plastic bags (heavy duty), oxygen and boxes or bins:***
  for dispatch of live and moribund specimens to laboratories for pathology and histology to aid in diagnosis of bacterial and other diseases.
- ***Esky for the transport of chilled specimens:***
  to laboratories for pathology and histology to aid in diagnosis of bacterial and other diseases.

DIAGNOSIS OF DISEASES
RECOMMENDED CRITERION

- ***2 microscopes:***
  1 high power (essential) and 1 low power (to X 40) dissecting microscope.

Fig. 8.2 Equipment for dissecting and examining fish for diseases.

8.5 - TREATMENT OF DISEASES

Once a disease has been diagnosed, appropriate action must be taken. In many instances this is the application of a chemical to a pond or tank (see Table 8.1).

TREATMENT OF DISEASES
ESSENTIAL CRITERIA

- ***Appropriate chemicals on farm:*** *have chemicals on-hand for use when required; see Chapter 9 for information on permitted chemicals.*
- ***Known volumes of ponds and tanks:*** *at different depths of water so that correct dosage of chemicals can be applied.*
- ***Known quantities of chemicals to be applied to each pond and tank at certain volumes and dosages.***
- ***Microscopic examination of fish tissues post-treatment to ensure chemical has controlled the disease.***
- ***Records of chemicals applied to ponds and tanks.***
- ***Knowledge of OH&S issues in relation to chemicals.***

TREATMENT OF DISEASES
RECOMMENDED CRITERION

- ***All staff trained in chemical usage and OH&S issues associated with on-farm chemical use.***

8.6 - DISPATCH OF DISEASE-FREE FISH

It is essential that all fish leaving a hatchery are free of disease to:

(i) ensure that healthy fish are stocked into the wild, into farm dams or onto other fish farms;
(ii) prevent the spread of pathogens to regions and farms where they are not currently found.

DISPATCH OF FISH
ESSENTIAL CRITERIA

- ***Quarantine all fish for at least 24 hrs after harvest.***
- ***Chemical treatment in quarantine to prevent disease:*** *permanent bath of 2.5 g/L NaCl; or daily, short-term (1 h) bath of 10 g/L NaCl and/or 50 mg/L formalin.*
- ***Examination of 5 fish, 24 hours prior to the dispatch, from within each batch for signs of disease and the presence/absence of parasites on gill and skin tissues:***

  see Appendix III, Hatchery Dispatch and Health Statement.

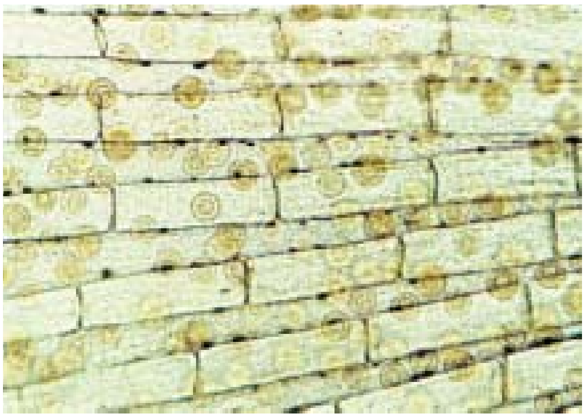

Fig. 8.3 Numerous **Trichodina**, *a common protozoan parasite on the fin tissue of a fingerling (X 200 magnification).*

8.7 - NOTIFIABLE DISEASES

Authorities at state, national and international levels must be notified of the occurrence of certain diseases on fish farms. Two of the diseases have been recorded in silver perch – epizootic ulcerative syndrome (EUS or red spot) and goldfish ulcer disease (*Aeromonas salmonicida* infection). It is currently thought that EUS is not found naturally in the Murray-Darling River System (Dr Dick Callinan, personal communication).

The notifiable diseases of freshwater fishes are: epizootic haematopoietic necrosis; infectious haematopoietic necrosis; *Oncorhynchus masou* virus disease; spring viraemia of carp; viral haemorrhagic septicaemia; channel catfish virus disease; viral encephalopathy and retinopathy; infectious pancreatic necrosis; infectious salmon anaemia; epizootic ulcerative syndrome (*Aphanomyces invadans*); bacterial kidney disease (*Renibacterium salmoninarum*); enteric septicaemia of catfish (*Edwardsiella ictaluri*); piscirickettsiosis (*Piscirickettsia salmonis*); gyrodactyliosis (*Gyrodactylus salaris*); furunculosis (*Aeromonas salmonicida* subsp. *Salmonicida*); goldfish ulcer disease (*Aeromonas salmonicida* – atypical strains); whirling disease (*Myxobolus cerebralis*); enteric redmouth disease (*Yersinia ruckeri* – Hagerman strain).

8.8 - AQUAVETPLAN

AQUAVETPLAN is the nationally accepted aquatic disease emergency response plan that describes the proposed approach to an aquatic animal disease emergency event. The plan was prepared by the Commonwealth Department of Agriculture, Forestry and Fisheries Australia (DAFF) and other agencies including the NSW Department of Primary Industries, and comprises of a series of manuals outlining national emergency preparedness, and response and control strategies for disease emergencies in Australia. The manuals provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

Timely and appropriate response to national disease issues is a requirement of any hatchery and as such all hatchery operators should become familiar with these national documents. NSW Department of Primary Industries strongly recommends that all fish farms and fish hatcheries obtain a copy of the AQUAVETPLAN. For further information contact:
The Department Agriculture Forestry and Fisheries (Aquatic Animal Health Unit) on (02) 6272 4328.

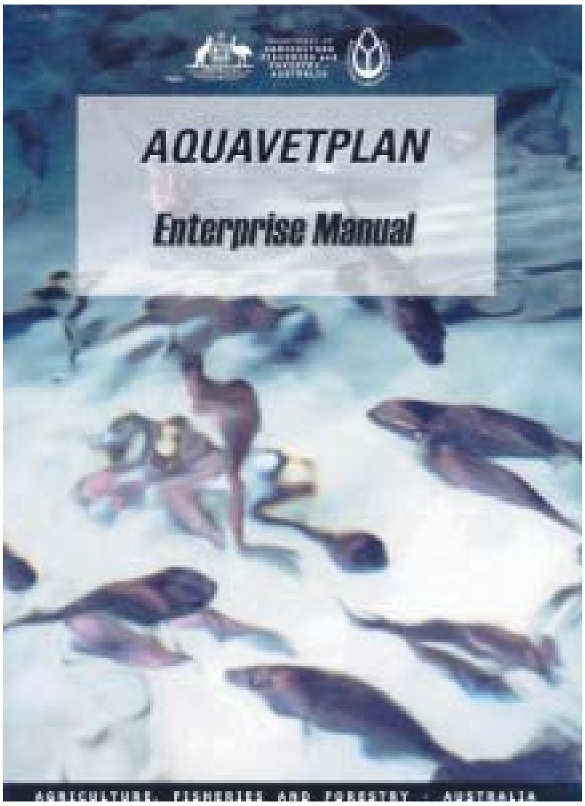

Fig. 8.4 AQUAVETPLAN Operational Procedures Manuals – also available on line from Agriculture, Fisheries and Forestry, www.daff.gov.au

TABLE 8.1 - IMPORTANT PATHOGENS AND DISEASES OF MURRAY COD, GOLDEN PERCH AND SILVER PERCH*

TYPE OF ORGANISM	PATHOGEN – DISEASE OR COMMON NAME	TREATMENT
Protozoan	*Ichthyophthirius multifiliis* – white spot *Trichodina* sp. – trichodiniosis *Chilodonella hexasticha* – chilodonelliosis *Ichthyobodo* sp. – ichthyobodiosis *Tetrahymena* sp. – tetrahymena *Coccidia* sp. – coccidiosis	15 – 30 mg/L formalin (ponds and tanks) 2.5-5.0 g/L NaCl (tanks) for white spot and trichodiniosis. 10 g/L NaCl (tanks) for chilodonelliosis 13 g/L NaCl (tanks) for ichthyobodiosis
Monogenean	*Lepidotrema bidyana* – gill fluke *Gyrodactylus* sp. – gill fluke	30 mg/L formalin or 0.5 mg/L trichlorfon
Copepod	*Ergasilus* sp. – ergasilus *Lernaea* sp. – anchor worm	10 g/L NaCl for 3 days (tanks) for ergasilus
Fungus (mold)	*Saprolegnia* sp. – fungus, sap *Saprolegnia parasitica* – winter disease *Aphanomyces invadans* – EUS, red spot	2.5 g/L NaCl prevention (tanks) 30 mg/L formalin (ponds) no known chemical treatment; maintain good water quality.
Bacteria	*Flavobacterium columnare* – columnaris *Aeromonas salmonicida* (atypical stain) – gold fish ulcer disease (GUD) *Aeromonas* – tail rot, fin rot *Mycobacterium* sp. *Streptococcus* sp.	Antibiotics as recommended by fish pathologist e.g. 20 mg/L oxytetracycline for 7 – 10 days for columnaris and finrot
Virus	*Epizootic Haematopoietic Necrosis Virus* – (EHN)	Endemic in redfin in the wild; no known treatment; under laboratory conditions kills silver perch and Murray cod a carrier.

* *for detailed description of diseases and treatments see Rowland and Ingram (1991), Callinan and Rowland (1995) and Noga (2000).*

9 Chemicals

9.1 - SUMMARY

Chemicals of various types play an important role in aquaculture industries. The status of chemicals in aquaculture as determined by the Australian Pesticides and Veterinary Medicines Authority (APVMA) are presented. Only these and chemicals that are registered for food-producing animals, can be prescribed by veterinarians for use in aquaculture. Some chemicals previously used in the industry, such as malachite green and the antibiotics chloramphenicol and quinolones, cannot be prescribed and used.

9.2 - GENERAL

Chemicals of various types play an important role in aquaculture industries. On native fish hatcheries, they are used to facilitate handling fish, control reproduction, improve water quality, promote plankton blooms, sterilise pond bottoms and equipment, and to prevent and control both diseases and aquatic plants.

Under the Chemical and Veterinary Chemicals Code Act 1994, all chemicals which fit the definition of agricultural and veterinary chemicals in the Act, must be registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA, formerly the National Registration Authority, NRA) before they can be sold, supplied and used in Australia. Many chemicals used in aquaculture fit this definition, yet to date few are registered. Chemicals are registered on the basis of the purpose to which they are to be used. Percival (2001) identified essential chemicals in Australian aquaculture, and in conjunction with the NRA, established a legal basis for usage involving registration, minor use permits (MUP) and exemptions (Table 9.1). In addition, formalin can be used under an off-label permit. Some of the MUPs have lapsed (Table 9.2). There are other chemicals registered for other food-producing animals that may be used off-label under veterinary prescription; examples are given in Table 9.3.

There are a number of chemicals that should not be used in aquaculture under any circumstances because of concerns linked to human health. Quinolones (e.g. Enrofloxacin, Oxolinic acid) are antibiotics used in human health management, and their use in food-producing animal industries, including aquaculture, has been linked to the development of antibiotic resistance in humans. Chloramphenicol is another antibiotic which has historically been used in human and animal medicine. It is now banned due to links with bone marrow suppression and anaemia in humans. Although nitrofurans are very effective against some pathogenic organisms, they are carcinogenic and mutagenic and their use is now is prohibited (Noga, 2000). Similarly, malachite green was commonly used to treat fungal and ecto-parasitic diseases in fish culture in the 1900's; however, it is a suspected human carcinogen and its use is now prohibited in most countries in the world. These chemicals are not registered for use in any food-producing species and are not able to be prescribed for off-label use by Registered Veterinarians in NSW.

Australian aquaculture promotes itself as a "clean, green" industry. The use, or detection of illegal residues of chemicals will jeopardise the future of an individual farm, a species, an industry and Australian aquaculture in general. Although the issue of chemical residues in fish tissues is more applicable to grow-out industries directly producing fish for human consumption, fish hatcheries are also subject to the same standards of chemical usage in Australia. Some chemicals, such as malachite green, have extremely persistent residues, and this is part of the reason their use is not permitted. Detection techniques for chemical residues are becoming more sensitive and it is likely that in the future, residues of some chemicals used in the hatchery phase will be detectable in market-size fish.

Adherence to the use of chemicals as directed by the APVMA is a legal requirement of fish farmers.

TABLE 9.1 - STATUS OF CHEMICALS IN THE AQUACULTURE INDUSTRY AS DETERMINED BY THE AUSTRALIAN PESTICIDES AND VETERINARY MEDICINES AUTHORITY

CATEGORY	CHEMICAL	USE/COMMENT
Registered	Aqui-S	anaesthetic
	Human chorionic gonadotrophin (HCG)	spawning induction
	Anguillvac - Vibriosis C vaccine	vaccine
Off-label Permit	Formalin	external parasites, fungal infections
Minor Use Permit	Benzocaine	anaesthetic
	Ovaprim	spawning induction
	SGnRH, LHRHa	spawning induction
Exempt	Calcium carbonate, calcium hydroxide, calcium oxide, calcium sulphate, magnesium carbonate	increase pH, increase alkalinity, improve buffering, calcium source, sterilise pond bottom
	Astaxanthin Beta carotene Canthaxanthin	flesh colourants
	Ethoxyquin	anti-oxidant
	Zeolite	absorption of ammonia
	Aluminium sulphate, ferric chloride	flocculation of suspended clay colloids
	Fertilisers – organic and inorganic	promotion of plankton blooms

TABLE 9.2 - CHEMICALS FOR WHICH MINOR USE PERMITS HAVE LAPSED

CHEMICAL	USE IN AQUACULTURE
Sodium chloride	flavour enhancer
Propionic acid	preservative, mold inhibitor
Oxytetracycline **Amoxycillin** **Trimethoprim/sulfadiazine**	antibacterials
Trifluralin	antifungal
Simazine	algacide
Methyltestosterone	hormone

-

	USE / COMMENT
Oxytetracycline	bacterial infections; tagging (chemical marking on the bones of fish)
Trimethoprim **Sulphonamide** **Erythromycin**	antibiotics
Praziquantel **Trichlorfon**	external parasites (e.g. gill flukes)
Copper sulphate	external parasites, algacide

10 Broodstock & population genetics

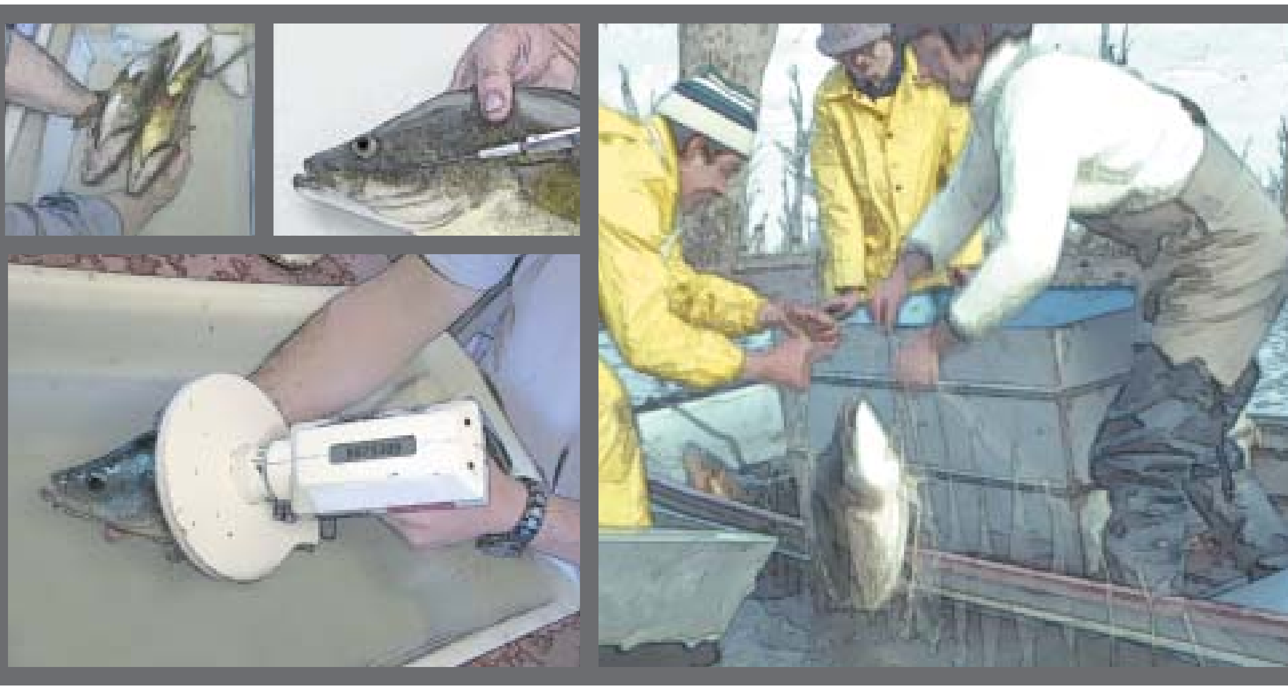

Fig. 10.1 Collecton and management of broodstock.

Top left: Checking sex and condition of silver perch broodstock.

Top right: A syringe is used to insert the tag just forward of the preoperculum flap.

Right: Using a tag reader to check tag number.

Far right: Capturing Murray cod broodstock using a gill net.

10.1 - SUMMARY

Broodstock are the most important component of a fish hatchery and significant resources and effort must be committed to their collection and management. The quality and quantity of broodstock directly influence the production and success of breeding programs, as well as the suitability of fingerlings for conservation stocking, harvest stocking and commercial aquaculture.

Murray cod, golden perch and silver perch each consists of separate populations (or strains) within the Murray-Darling River System. These populations are genetically distinct, but the number of populations of each species, and the distribution of each population are not known. Genetic variation is the raw material for evolution, and so the maintenance of both genetic identity and genetic variation is essential for the reproductive fitness of wild populations and the conservation of threatened species.

To satisfy the requirements of breeding programs (see Chapter 11), a minimum of 10 pairs (♂:♀ = 1:1) of Murray cod and golden perch, and 20 pairs of silver perch should be collected from each river (i.e. each population or strain) that is to be stocked. Individual broodstock must be tagged and fish of each strain held in separate ponds, cages or tanks. The reproductive performance (fecundity, hatch rate) of native fish decreases within 5 years in captivity, and so to maximise performance and production, and to facilitate the maintenance of genetic variation, broodstock should be replaced with mature fish from the wild after 5 years.

Silver perch broodstock can be bred and reared in captivity (i.e. domesticated), and the reproductive performance of these fish remains high, at least until 10 years of age. Domesticated broodstock of each species can be used in hatcheries to produce fingerlings for commercial grow-out. However, they must not be used in conservation and harvest stocking programs because domestication results in a loss of genetic variation through selection for traits that are favourable under culture conditions, but may be detrimental in the wild.

Methods for the capture and transportation of broodstock are described.

10.2 - POPULATION GENETICS OF NATIVE FISH

Species are groups of populations that are reproductively isolated from other such groups; there is no gene flow between species. In the wild, species usually consist of distinct, isolated populations that can potentially interbreed but have characteristics (appearance, aspects of biology and genetics) that distinguish them from other populations. It is considered that at least some of these differences reflect natural selection and adaptation to local environmental conditions. Consequently, mixing of fish from different populations may have serious, adverse biological affects.

Studies of the population genetics of Murray cod, golden perch and silver perch have been done by Rowland (1985, 1993), Musyl and Keenan (1992), Keenan et al. (1995), Bearlin and Tikel (2003) and Nock et al. (2003). There are separate species to Murray cod in two eastern drainage systems [eastern freshwater cod in the Clarence and Richmond river systems, and the Mary River cod in the Mary River System] and distinct populations of Murray cod in the Murray-Darling River System. The populations of golden perch in other drainages (Bulloo-Bancannia, Lake Eyre, Dawson-Fitzroy) are either sub-species or separate species to *M. ambigua*. Within the Murray-Darling River System there are separate populations of golden perch in the Paroo River, Ambathala Creek, the Lachlan River/Lake Cowal, and a central population in the Murray, Darling and Murrumbidgee rivers. There are populations of silver perch in the Murray, Lachlan, MacIntyre, Condamine and Warrego rivers within the system, as well as a translocated population in Cataract Dam in the eastern drainage near Sydney. Other important findings of these studies were:

(i) genetic variation in some species in the wild, particularly silver perch is low;
(ii) genetic variation in fish on hatcheries and in stocked populations in impoundments was lower than in natural populations.

Despite these studies, the population genetics of Murray cod, golden perch and silver perch remains relatively unclear because of limited sampling of the wild and hatchery stocks, and the restricted number of genes (genetic loci and haplotypes) examined in all studies.

Guidelines for broodstock collection, management and breeding programs must be conservative because of the importance of genetic identity and genetic variation in wild populations, and the potential for irreversible biological damage through inappropriate stockings.

10.3 - BROODSTOCK

General

Significant resources and effort must be committed to the collection and management of broodstock. Broodstock should be captured in late summer and autumn when the likelihood of catching native fish is high. Stress associated with capture, handling and transportation in winter and early spring may induce resorption in females or result in severe damage, stress and poor reproductive performance. Subsequently, these fish are of no value to the hatchery that season and cannot contribute to the natural reproduction in the wild. It is usually inefficient and unreliable to attempt to collect broodstock during the breeding season.

All fish must be quarantined after capture. Each genetic strain of each species must be stocked into a separate pond, cage or tank. All broodstock must be tagged so that records of matings and the performance of each individual can be monitored. Reproductive performance of broodstock can be evaluated using the following criteria:

(i) incidence of spawning;
(ii) fecundity (i.e. the number of eggs spawned, best expressed as relative fecundity which is the no./kg total body weight);
(iii) fertilisation rate (% fertilised eggs);
(iv) hatch rate (% eggs that hatch);
(v) quality of the larvae (appearance, activity, survival pre-stocking).

Biology and sexual maturity

The biology of each species impacts on hatchery performance and production. For example, Murray cod are large and aggressive, and fecundity is relatively low; up to 7,600 eggs/kg (Rowland, 1998b). To minimise aggression, and to ensure all fish are in good condition and undergo their complete reproductive cycle, only a relatively small number of Murray cod broodstock should be stocked in a pond (e.g. 200 fish/ha). Golden perch and silver perch can be stocked at densities up to 1,000 fish/ha in ponds. They are both fecund species (up to 250,000 eggs/kg) and so a large number of eggs, larvae, fry and fingerlings can be produced from a relatively small number of adults, e.g. one female of 2 kg and one male can spawn around 500,000 high quality eggs (i.e. where fertilisation rate is high ~ 90%); a high hatch rate (90%) will produce a total of 405,000 larvae; 50% survival in larval rearing ponds will produce 202,500 fry. Note: all these fry are full siblings, i.e. brothers and sisters.

A batch of fingerlings consisting of siblings is acceptable for commercial grow-out culture and stocking into farm dams for recreational fishing purposes, but is totally unsuitable for stocking into natural waters for conservation stocking and harvest stocking, where the stocked fish may become part of the local breeding population.

The generation period for native species is considered to be 5 years for the purposes of breeding programs. Murray cod reach sexual maturity in the wild at 4 or 5 years of age; in rivers, all cod larger than 590 mm and 3.9 kg are mature, but in impoundments such as Lake Mulwala, cod do not mature until they are larger than 610 mm and 5.0 kg (Rowland, 1998b). In rivers, male and female silver perch mature at 3 and 5 years, and golden perch at 2 and 4 years, respectively (Mallen-Cooper and Stuart, 2003). However, domesticated male and female silver perch mature at 2 and 3 years respectively (Rowland, 2004), showing how domestication can affect the biology of a species.

Source of broodstock

Murray cod and golden perch broodstock must be sourced from the river to be stocked so that the genetic identity of that population is maintained. The capture of silver perch from rivers and creeks is prohibited because of its threatened status; broodstock may be sourced from the NSW Department of Primary Industries. Many commercial hatchery operators obtain broodstock from other hatcheries or use fish from farm dams (stock-watering dams on sheep and cattle farms or on-farm irrigation dams) that have been stocked with hatchery-reared fish. Although fish can be plentiful and readily available in these dams, their origin and age are usually unknown. Fish in dams usually have an inferior genetic basis for breeding programs because most dams are stocked with full-siblings, or fingerlings from only a few pairs of parents. Breeding programs based on these fish will result in rapid inbreeding, leading to high levels of abnormalities, and "weak" fish which grow slowly, are highly susceptible to disease and poor water quality, and are themselves poor breeders.

Performance of broodstock over time

The performance of native fish broodstock may deteriorate over time. In Murray cod, the incidence of "blue-sac" syndrome in cultured larvae was linked to a deficiency of essential amino acids and the age of broodstock (Gunasekera et al., 1998). However, the performance of broodstock on several commercial hatcheries that use natural spawning techniques has not changed significantly over a 15 – 20 year period (Bruce Malcolm and Ray Mepham, personal communication). The reproductive performance of golden perch and silver perch originally captured from the wild, decreases significantly after 3 or 4 years in captivity. For example, the performance of the Cataract strain of silver perch held at GAC decreased over 4 years; relative fecundity declined from 150,000 to 72,000 eggs/kg and hatch rates 73% to 23% (Rowland et al., 2003).

Feeding of broodstock

There is usually a direct relationship between the quality and quantity of feed supplied to broodstock and their reproductive performance. Poorly conditioned fish are usually poor breeders, i.e. they either don't spawn, or spawn a relatively low number of eggs, and/or produce poor quality eggs and larvae. Hatchery operators must provide adequate feed to broodstock. Murray cod and golden perch are fed live feed such as yabbies, shrimp and native fish (e.g. bony bream, *Nematalosa erebi*). Silver perch can be fed on pellets (commercial, species-specific diets are available from feed mills) or a combination of live and artificial feed; recommended feeding regime for silver perch broodstock is given by Rowland et al. (2002).

Domestication of silver perch for commercial aquaculture

Domesticated broodstock are those that have been bred and reared in captivity. A study at GAC demonstrated that silver perch broodstock can be domesticated and the life cycle of silver perch can be closed (Rowland, 2004). Domesticated broodstock mature at a younger age (males 2 years and females 3 years) than silver perch in the Murray River, and their breeding performance in terms of fecundity and hatch rate is as good or better than wild fish. The performance of the domesticated strain GAC, remained relatively constant up to 10 years of age, after which time both fecundity and hatch rate declined (Rowland et al., 2003). The use of domesticated silver perch broodstock will eliminate reliance on wild populations and provide a basis for future hatchery production for commercial aquaculture and genetic improvement programs for this species. However, domestication leads to a loss of genetic variation and to changes in behaviour and performance (Tave, 2001; Miller and Kapuscinski, 2003) and so domesticated broodstock should not be used in conservation and harvest stocking programs.

Domestication of broodstock results in:
(i) a loss of genetic variation;
(ii) selection for traits that are favourable in aquaculture, but may be detrimental in the wild.
Consequently, domesticated broodstock should not be used in conservation and harvest stocking programs.

BROODSTOCK FOR CONSERVATION AND HARVEST STOCKING
ESSENTIAL CRITERIA

- ***Use only broodstock from the wild.***
- ***Collect a minimum of 10 pairs (♂:♀ = 1:1) of sexually mature Murray cod broodstock and golden perch broodstock from each river (i.e. each population or genetic strain):*** *to ensure there are sufficient fish to maintain genetic identity and maximise genetic variation.*
- ***Collect a minimum of 20 pairs (♂:♀ = 1:1) of sexually mature silver perch broodstock from each river (i.e. each population or genetic strain):*** *to ensure there are sufficient fish to maintain genetic identity and maximise genetic variation.*
- ***Keep records of broodstock collected and fingerlings stocked in each population/river.***
- ***Do not use broodstock from farm dams:*** *unless details of origin, genetic base, parentage and age are known and satisfy guidelines in this HQAP.*
- ***Do not use broodstock with deformities or abnormalities.***
- ***Tag all broodstock:*** *the use of Passive Integrated Transponder (PIT) tags is recommended and this will become mandatory under the Hatchery Accreditation Scheme.*
- ***Stock broodstock of each species from each river in separate ponds, cages or tanks.***
- ***Keep records of all individual fish:*** *origin, tag no., date captured, weight, pond/cage/tank, performance each breeding season, matings.*
- ***Replace broodstock after 4 – 5 years:*** *ideally around 20% of broodstock should be replaced each year.*
- ***Return broodstock to the river and location where originally captured:*** *ensure they are disease-free.*

Fig. 10.2 PIT tag that is inserted under the skin of fish, actual size is 11mm x 2mm.

BROODSTOCK FOR CONSERVATION AND HARVEST STOCKING
RECOMMENDED CRITERIA

- ***Collect broodstock from the wild in late summer and early autumn:*** *high catchability; limited stress on fish; least effect on breeding cycle.*
- ***NSW Department of Primary Industries is developing a comprehensive broodstock collection and management policy.***

BROODSTOCK FOR COMMERCIAL AQUACULTURE
ESSENTIAL CRITERIA

- ***Establish Murray cod and golden perch broodstock with fish from the wild, using as many pairs of parents as possible.***
- ***Use strains known to be suitable for intensive culture:***
  e.g. Cataract strain of silver perch for cage culture.
- ***Use silver perch broodstock from the NSW Department of Primary Industries.***
- ***Do not use broodstock from farm dams:***
  unless details of origin, genetic base, parentage and age are known and satisfy guidelines in this HQAP.
- ***Do not use broodstock with deformities or abnormalities:***
  where possible report location, species, size and deformities/abnormalities to the NSW Department of Primary Industries.
- ***Tag all broodstock:***
  the use of PIT tags is recommended for commercial hatcheries.
- ***Domesticate broodstock.***
- ***Keep records of all individual fish:***
  origin, tag no., date captured, weight, pond/cage/tank, performance each breeding season, matings.

BROODSTOCK FOR COMMERCIAL AQUACULTURE
RECOMMENDED CRITERIA

- ***Use inter-strain crosses as recommended by the NSW Department of Primary Industries.***

Advice on breeding programs for commercial aquaculture is available from the NSW Department of Primary Industries.

10.4 - BROODSTOCK COLLECTION AND TRANSPORTATION

Permit

The collection of Murray cod and golden perch broodstock using commercial fishing gear, such as gill nets or drum nets, requires a permit issued by the NSW Department of Primary Industries. Angling for broodstock does not require a permit, providing that angling for the target species is permitted in the area. However, where the number of fish collected is expected to exceed the recreational bag limit for a species (i.e. more than 2 Murray cod on a single day) a collection permit is required. The taking of fish using commercial fishing gear without a permit, or where any part of the operation results in a breach of the *Fisheries Management Act 1994*, may result in the offender facing serious charges and substantial fines. Hence, the broodstock collection permit should be an integral part of any hatchery operation.

Broodstock collection permits may be obtained from the NSW Department of Primary Industries by contacting:
The Permits Clerk,
Port Stephens Fisheries Centre,
Locked Bag 1, Nelson Bay, 2315.
Telephone 02 4916 3822.

Allow several weeks for the broodstock permit to be processed.

Broodstock collection permits will not be issued for silver perch, eastern freshwater cod and trout cod due to their threatened status unless the activity relates to a program authorised by the NSW Department of Primary Industries.

Silver perch broodstock are available from the NSW Department of Primary Industries, Grafton Aquaculture Centre, Telephone 02 6644 7588

The NSW Department of Primary Industries may apply special conditions to the permit to avert any impact on threatened species or for any other matter. Purchasing fish from anglers or other persons not licensed to sell fish in NSW is an offence. Any non-target native fish taken in the broodstock collection operation must be returned to the water with the least possible harm. The permit only authorises the taking of the species described in the permit and does not include any fish for personal consumption or sale.

Methods of collection and gear

A major objective of broodstock collection is to minimise injury and stress to the fish during capture and transportation. Most established hatchery operators use techniques refined over many years; however, the following points may help guide inexperienced personnel.

The use of commercial fishing gear such as drum nets or gill nets is very efficient, and enables the effective collection of fish. Drum nets are generally used to capture Murray cod and golden perch in flowing waters, and gill nets are used in slow-flowing or still waters. Drum nets and gill nets can damage fish by removing the fish's protective mucus and scales, thereby exposing the skin. Such damage can lead to disease, particularly bacterial and fungal infections. Consequently, to minimise stress and damage, drum nets should be checked at least twice daily and gill nets should be checked each 2 – 6 hours, and not be left unattended for longer periods. Set lines are also effective in most waters and there is usually minimal injury and stress of fish if the lines are checked every few hours. Murray cod and golden perch taken on set lines often relax and lay still after being hooked.

Fishing locations, assistance and public relations

Broodstock collection permits are only issued for natural waters (not dams or impoundments) where the progeny of the broodstock are to be stocked. Local knowledge of appropriate locations, fishing methods, bait etc. for collection may be obtained from local anglers and the local NSW Department of Primary Industries' office. The use of commercial fishers to assist in broodstock collection has been authorised in the past, but all commercial inland native finfish fisheries are now closed. Former commercial fishers or persons with local knowledge may be used to assist in broodstock collection, providing their details are included on the collection permit; any person(s) assisting in the collection must be nominated and named on the collection permit.

Members of the public are quick to report illegal fishing activity and so public perceptions should be considered when collecting broodstock. Where signs are required to be displayed by the permit they must be used and be clearly visible. Always carry the collection permit and contact the local NSW Department of Primary Industries office (as required by the permit) to inform the Fisheries Officer of your intended movements and activities in the area. Failure to contact the local fisheries office can result in unnecessary call-outs to a site when the broodstock collection has been mistaken for an illegal fishing operation. Talk to anglers and other people in the vicinity to explain your activities.

Transportation of broodstock

After capture, fish should be immediately placed into a large tank (> 1,000 L) containing good quality water; the water may be from the collection site or the hatchery. The water should be oxygenated using bottled oxygen, and salt (NaCl) should be added at a concentration of 2.5 g/L to reduce stress, prevent fungal infection and to kill some species of ectoparasites. Fish transportation techniques are described in detail by Rimmer and Franklin (1997) and Simpson et al. (2002). Once the target number of fish is captured, they should be returned to the hatchery as soon as possible and placed in quarantine for a period of at least 2 weeks; in a bath of 2.5 g/L NaCl. Water from the collection site, used to transport fish to the farm should be sterilised with chlorine (at 200 mg/L) and disposed of in the effluent-settlement dam. Several fish should be checked for parasites and disease to ensure no pathogens are introduced to the hatchery. The fish can be stocked into ponds, cages or tanks after quarantine.

COLLECTION AND TRANSPORTATION OF BROODSTOCK
ESSENTIAL CRITERIA

- ***Obtain permit from the NSW Department of Primary Industries prior to collection.***
- ***The application for collection permit under section 37 of the* Fisheries Management Act 1994 *must contain the following details;***
  - *Name(s) of the person(s) applying for the permit*
  - *Name(s) of any person(s) assisting in the collection of the fish*
  - *Species proposed to be taken*
  - *Number of fish (maximum) proposed to be taken*
  - *Exact location of site(s) from where the fish are proposed to be taken*
  - *Description of the gear to be used*
  - *Collection period - generally not longer than 3 months from date of issue but may be extended*
  - *Permit fee - increases each year in-line with the Consumer Price Index.*
- ***Contact the local NSW Department of Primary Industries office:***
  advise of the impending collection, within 48 hours (or other time as specified).
- ***Display any signs required under the permit.***
- ***Ensure appropriate gear is used for the waters fished.***
- ***Release any non-target native species:***
  euthanase noxious species such as carp and other trash fish.
- ***Use appropriate transport tanks:***
  with good quality water and oxygen;
  use 2.5 g/L salt in transport tank to reduce stress and prevent fungal infection.
- ***Quarantine broodstock for at least 2 weeks;***
  - immediately upon arrival at hatchery;
  - before stocking into ponds, cages or tanks.

COLLECTION AND TRANSPORTATION OF BROODSTOCK
RECOMMENDED CRITERIA

- ***Return fish to hatchery as soon as possible following capture.***
- ***Do not collect fish from farm dams unless the history of the fish is known.***
- ***Chlorinate and dispose of water from collecting site. Do not introduce to farm.***

11

Breeding programs

11.1 - SUMMARY

Breeding programs for conservation and aquaculture have different goals. Conservation requires the maintenance of genetic identity and genetic variation in wild populations, and so programs must endeavour to maximise variation in broodstock and progeny, and minimise effects of domestication. Effective population size (N_e) (calculated from the number of broodstock used to produce fingerlings) should be at least 50 per generation for non-threatened species (e.g. golden perch) and 100 for threatened species (e.g. silver perch). An N_e of 50 can be achieved by using at least 5 different pairs of broodstock each year to produce each batch of fingerlings for stocking in a river over a 5-year period. Progeny from 10 pairs must be used to achieve a N_e of 100. Because some fish don't spawn or spawn poor quality eggs, at least 8 pairs of Murray cod and golden perch, and 16 pairs of silver perch should be injected with hormones. One female must be mated with only one male, and females must be mated with a different male each year. Where natural spawning of Murray cod is used, broodstock must be rotated between ponds at least every 2 years to reduce the chance of same-pair matings in consecutive years. Similar numbers of larvae from at least 5 pairs of Murray cod and golden perch broodstock and 10 pairs of silver perch must be stocked into each larval rearing pond. There should be no grading or selection of fingerlings after harvest. The broodstock must be replaced with fish from the wild after the generation period of 5 years.

Ideally, the breeding program for each species should be linked to a stocking program for each river/population to maximise genetic variation and to achieve N_e. Stocking programs will be managed in future under the Fish Stocking Fishery Management Strategy.

The major aim of breeding programs for the commercial production of market-size fish is to produce fish with favourable traits such as fast growth and disease resistance. This is achieved through domestication; however, the maintenance of genetic variation is also an important factor. Breeding programs should commence with, and maintain the maximum amount of genetic variation available to ensure reproductive fitness, reduce the chances of inbreeding and maximise the potential for improvement. To date, there have been no official genetic improvement programs for Murray cod, golden perch and silver perch. It is recommended that breeding programs on commercial hatcheries commence by following guidelines for conservation and harvest stocking programs to establish domesticated lines.

11.2 - GOALS FOR CONSERVATION AND HARVEST STOCKING PROGRAMS

Breeding programs for conservation and harvest stocking have similar goals, but they differ to those of commercial aquaculture programs. Fish stocked to establish and maintain populations for recreational fisheries, either in impoundments or rivers, may mix with existing populations and subsequently contribute to natural reproduction in the wild. Although the size of the endemic populations is an important factor influencing a breeding and stock enhancement program (Frankham et al., 2002; Miller and Kapuscinski, 2003) because there is no data on the size of native fish populations, it is recommended that the same guidelines be used in breeding programs for both conservation and stock enhancement of native fishes.

Inbreeding and loss of genetic diversity are major concerns in conservation programs. Inbreeding has deleterious effects on reproduction and survival, and loss of genetic diversity reduces the ability of populations to adapt in response to environmental change (Frankham et al., 2002). The hatchery production of fish can cause the genetic hazards of extinction, loss of within-population variation, loss of between-population variation and domestication (Miller and Kapuscinski, 2003). Consequently, conservation and harvest stocking programs must endeavour to maximise variation in broodstock and progeny, and minimise effects of domestication. Captive breeding and restocking programs must ensure that the wild, endemic populations are not "swamped" by large numbers of fingerlings that are siblings or closely related, providing the opportunity for inbreeding and a rapid decrease in the reproductive fitness of the wild population.

Inappropriate management of breeding programs for conservation and stock enhancement can lead to serious, long-term, deleterious consequences for wild populations. The results of poor practices are often insidious and may not be evident for many years or decades.

11.3 - BREEDING PROGRAMS FOR CONSERVATION AND HARVEST STOCKING

Genetic guidelines for native fish hatcheries, based on Brown (1983) and Rowland and Barlow (1988) have been used since the mid-1980's in breeding programs at NFC and GAC, and for Murray cod and trout cod at the Marine and Freshwater Research Institute, Snobs Creek, Victoria (Douglas et al., 1994). However, the practices may need to be altered because results of a recent study by Bearlin and Tikel (2003) suggest that collection of silver perch from Cataract Dam for use as broodstock at GAC captured only a limited amount of the genetic variation present in the wild population.

Management procedures for fish breeding programs for conservation and stock enhancement were recently reviewed by Miller and Kapuscinski (2003), Gilligan (in press) and Moore (in press) and their recommendations are aimed at maximising effective population size (N_e), minimising inbreeding depression and loss of genetic variation, reducing adaptation to captivity, preventing the swamping of the wild gene pool, and maintaining the genetic identity of the wild populations. Procedures included in this HQAP to implement the recommendations are:

(i) allocation of N_e for non-threatened species and threatened species;
(ii) using only wild broodstock;
(iii) the random collection of sufficient numbers of broodstock;
(iv) the use of equal numbers of males and females;
(v) minimising mortalities in the hatchery;
(vi) ensuring captive conditions are as similar as possible to the wild;
(vii) releasing fish as early as possible;
(viii) stocking of equal numbers of offspring from each breeding pair;
(ix) releasing fingerlings at appropriate size and locality, and using methods that will maximise survival.

Although an N_e of 50 is insufficient to prevent inbreeding depression over time unless there is gene flow into the population, it is commonly recommended in the literature as the minimum value to prevent detrimental effects of inbreeding depression (Frankham et al., 2002; Miller and Kapuscinski, 2003; Gilligan, in press). Most stockings of Murray cod, golden perch and silver perch are at locations where there are remnant populations of each species. Consequently, it is recommended that N_e should be 50 for non-threatened native species (Murray cod and golden perch) and 100 for threatened species (silver perch, trout cod and eastern freshwater cod) (see Table 11.1). An N_e of 50 can be achieved by using the following numbers of different pairs of broodstock each year to produce fingerlings in 1 – 5 year breeding/stocking programs: 1 year – 25 pairs; 2 years – 13; 3 years – 9; 4 years – 7; 5 years – 5. The numbers of broodstock must be doubled to achieve an N_e of 100 (see Table 11.2).

TABLE 11.1

Effective population size (N_e), minimum number of pairs of broodstock injected and contributing fingerlings each breeding season for conservation and stock enhancement of native fish. Generation period for each species is 5 years.

SPECIES	CONSERVATION STATUS IN NSW	N_e (♂:♀ = 1:1)	MINIMUM PAIRS OF BROODSTOCK INJECTED	MINIMUM PAIRS CONTRIBUTING FINGERLINGS
Murray cod	Not threatened	50	8	5
Golden perch	Not threatened	50	8	5
Silver perch	Vulnerable	100	16	10
Trout cod	Endangered	100	16	10
Eastern cod	Endangered	100	16	10

Thurstan (in press) identified the major problems facing commercial hatcheries as:

(i) difficulties in acquiring good quality broodstock;
(ii) the unsuitability of fish in farm dams;
(iii) insufficient facilities (ponds, tanks) to enable genetic guidelines to be met;
(iv) use of poor hatchery techniques; and
(v) the lack of understanding of the population genetics of each species.

The management options for commercial hatcheries recommended by Thurstan (in press) were considered in the preparation of this HQAP. Where a hatchery is unable to meet the requirements of this HQAP, consideration should be given to limiting the number of species and/or populations/rivers to be stocked. Hatcheries could concentrate on local rivers or rivers in specific areas of the state. There is also potential for co-operation between hatcheries.

11.4 - LINK BETWEEN BREEDING PROGRAMS AND STOCKING PROGRAMS

The breeding program for each species must be linked to a stocking program for each river/population to satisfy genetic guidelines. Fingerlings from a minimum of 5 pairs of broodstock must be stocked into each river over 5 consecutive years to maintain genetic variation and to achieve an N_e of 50. Fingerlings from 25 pairs of broodstock will achieve an N_e of 50 in 1 year (see Table 11.2).

BREEDING PROGRAMS FOR CONSERVATION & HARVEST STOCKING
ESSENTIAL CRITERIA

- ***Use at least 5 different pairs of Murray cod and golden perch broodstock each year to produce each batch (i.e. destined for a particular river) of larvae:***
  to maintain genetic identity, maximise genetic variation and achieve an Ne of 50.
- ***Use at least 10 different pairs of silver perch broodstock each year to produce each batch (i.e. destined for a particular river) of larvae:***
  to maintain genetic identity, maximise genetic variation and achieve an N_e *of 100.*
- ***Inject at least 8 pairs of Murray cod and golden perch broodstock for spawning to produce each batch of larvae:***
  to ensure that at least 5 pairs spawn, because in each group of broodstock there are often fish that don't undergo normal gonadal development, or don't spawn, or spawn poor quality eggs.
- ***Inject at least 16 pairs of silver perch broodstock for spawning to produce each batch of larvae:***
  to ensure that at least 10 pairs spawn.
- ***Place each pair (1 female and 1 male) of golden perch and silver perch broodstock in a separate tank:***
  i.e. at least 8 spawning tanks for golden perch and 16 tanks for silver perch.
- ***Randomise matings with respect to fish size and appearance:***
  to maintain genetic variation and achieve N_e*; broodstock with abnormalities should not be used.*
- ***Mate golden perch and silver perch females with different males each season:***
  to maximise genetic variation and achieve N_e*.*
- ***Rotate Murray cod broodstock in ponds every year or at least every 2 years:***
  to reduce the chance of same-pair matings over consecutive years; to achieve N_e*.*
- ***Stock eggs from each successful spawning in a separate incubator:***
  i.e. up to 8 incubators for Murray cod and golden perch and 16 for silver perch.
- ***Discard excess eggs/larvae:***
  to maintain equal contribution from each pair of broodstock and to achieve N_e*.*
- ***Collect data and keep records on number of eggs, fertilisation rate, hatch rate and number of larvae from each spawning.***
- ***Stock similar number of larvae from each of the 5 or more spawnings of Murray cod and golden perch, and 10 or more spawnings of silver perch into each larval rearing pond:***
  fingerlings harvested from this pond can then be stocked directly into the river from where the broodstock were collected.
- ***Do not grade or select fish in any way after harvest, prior to stocking:***
  to maintain genetic variation.
- ***Link breeding program with stocking program for each population over a 5 year period:***
  to maintain genetic variation and achieve N_e*.*

BREEDING PROGRAMS FOR CONSERVATION & HARVEST STOCKING
RECOMMENDED CRITERIA

- ***Use hatchery techniques recommended by NSW Fisheries:***
  see Rowland (1983 a, b, 1996), Thurstan and Rowland (1995).
- ***"Successful" spawnings and good quality eggs:***
  > 80% fertilisation and > 50% hatch rate.
- ***Do not wean post-larvae, fry or fingerlings:***
  to ensure culture conditions are as similar to the wild as possible.

Other hatchery practices include: pooling broodstock and allowing mass spawning; mixing eggs from all spawnings in incubation tanks; and mixing fingerlings post-harvest. However, the number of broodstock that actually spawn, the number of eggs from each spawning and the differential mortality of eggs, larvae or fingerlings between individual matings and parents cannot be determined using these practices and so they are not recommended.

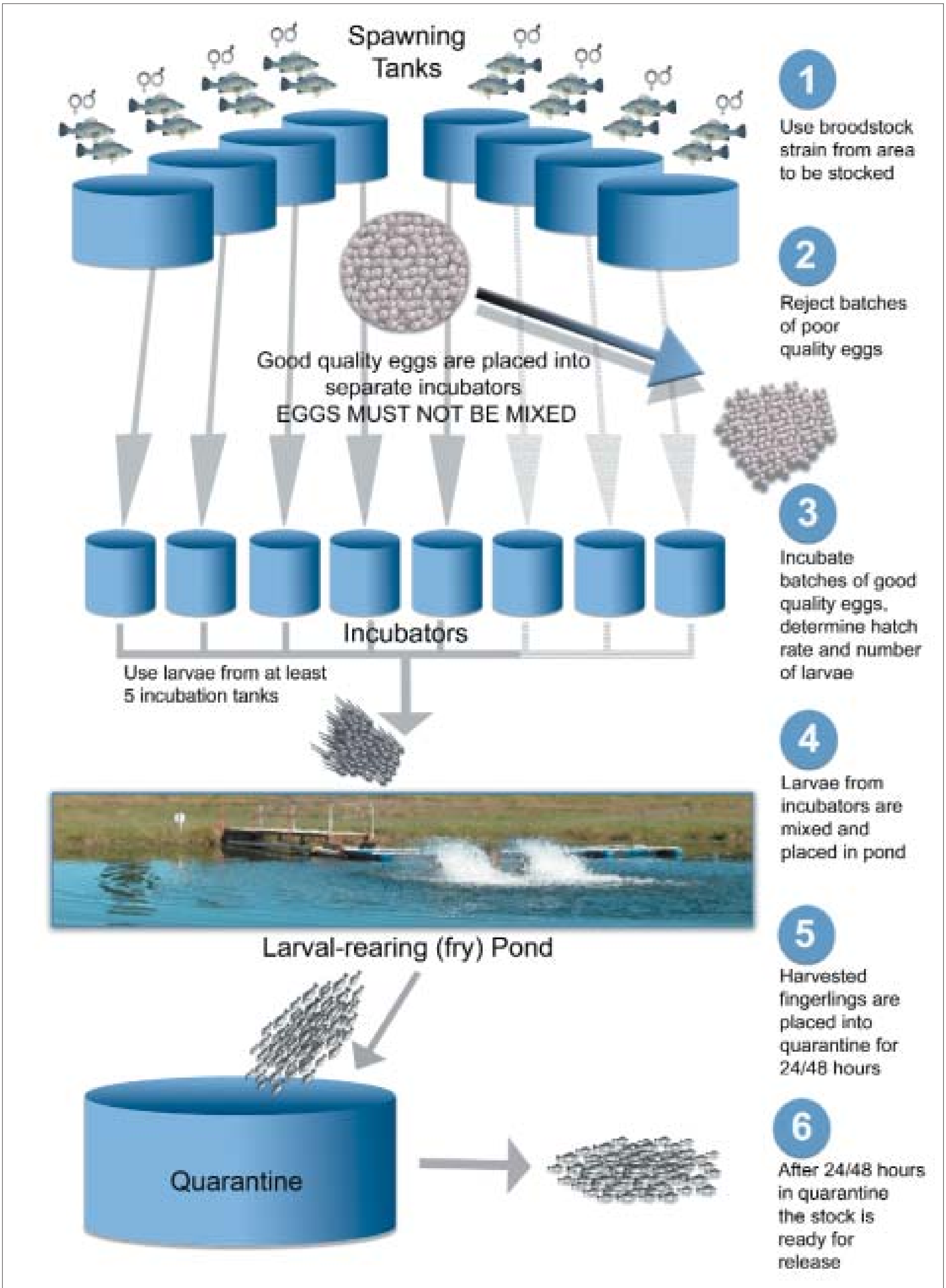

Fig. 11.1 Diagram of breeding program where effective population size (N_e) is 50

11.5 - BREEDING PROGRAMS FOR COMMERCIAL AQUACULTURE

The major aim of breeding programs for the commercial production of market-size fish is to produce fish with favourable traits such as fast growth and disease resistance; however, the maintenance of genetic variation is also an important factor. Breeding programs should commence with, and maintain the maximum amount of genetic variation available to maintain reproductive fitness, reduce the chances of inbreeding and maximise the potential for improvement.

BREEDING PROGRAMS FOR COMMERCIAL AQUACULTURE
ESSENTIAL CRITERIA

- *Use broodstock of known origin, age and genetics.*
- *Use genetic strains or crosses known to be superior for intensive aquaculture.*
- *Establish domesticated lines using as many founder broodstock as possible.*
- *Seek advice on breeding programs from NSW Department of Primary Industries and other relevant authorities.*

11.6 - GENETIC IMPROVEMENT PROGRAM FOR FARMED SILVER PERCH

Research to evaluate the performance of two wild strains (Murray, Cataract) and a domesticated strain of silver perch (GAC) has been conducted at GAC. A genetic improvement program involving cross-breeding, mass selection and heritability studies commenced in January 2004. Improved genetic strains and crosses may be available to industry in the future.

Silver perch broodstock can be readily domesticated; however, the performance of domesticated Murray cod and golden perch broodstock is not known. It is recommended that hatcheries initially follow the guidelines for breeding programs for conservation and stock enhancement to establish domesticated lines. For further information, see Tave (2001) who reviewed the management of broodstock in relation to quantitative genetics and improvement programs for fish hatcheries.

TABLE 11.2 - NUMBER OF BROODSTOCK REQUIRED TO ACHIEVE AN N_e OF 50 OR 100 IN BREEDING/STOCKING PROGRAMS OVER 1 TO 5 YEARS.

NUMBER OF YEARS OF PROGRAM	TOTAL NUMBER OF BROODSTOCK EACH YEAR		NUMBER OF DIFFERENT PAIRS EACH YEAR	
	N_e = 50	N_e = 100	N_e = 50	N_e = 100
5	10	20	5	10
4	14	28	7	14
3	18	36	9	18
2	26	52	13	26
1	50	100	25	50

12 Translocation and stocking

12.1 - SUMMARY

The stocking of hatchery-reared fish has been a major management tool for freshwater fisheries, and has contributed significantly to the conservation, as well as stock enhancement of Murray cod, golden perch and silver perch. However, stocking and in particular translocation, has the potential to create ecological problems. The ecological, genetic and disease-related problems associated with fish stocking and translocation have been considered in the preparation of this HQAP. Implementation of the *Essential Criteria* for site selection, design and operation, water quality, disease and health management, broodstock collection, breeding programs and stocking will significantly improve hatchery practices, prevent the translocation of inappropriate species and strains of Murray cod, golden perch, silver perch, prevent the release of trash fish and pathogens from native fish hatcheries, and ensure the stocking of healthy fingerlings.

12.2 - TRANSLOCATION

Translocation is the movement by humans of live aquatic organisms (including all stages of an organism's life cycle and any derived, viable genetic material) beyond their natural distribution, to areas that contain genetically-distinct populations, or to areas with superior pest and disease status. Translocation involves not only the target species (i.e. the fish being consigned and stocked), but organisms contained within the transport water (e.g. trash fish, plankton, insects, amphibians, aquatic plants), organisms attached to the fish (e.g. ectoparasites), or organisms within the fish (e.g. endoparasites). Some translocated aquatic organisms can create ecological problems that are extremely difficult to manage. These may involve competition for food and space, predation, habitat alteration, introduction of pathogens and diseases, and genetic interactions (loss of genetic integrity, decrease in genetic variation, "swamping" of local stocks by large numbers of siblings, and hybridisation).

Translocation of fish may occur through numerous sources, but those specifically associated with native fish hatcheries are:

(i) stocking of inappropriate species or strains for conservation and stock enhancement;

(ii) the escape from hatcheries, fish farms or farm dams of a species or strain being cultured outside its natural range;

(iii) the transportation of non-target species from one area to another resulting in an unintentional stocking (e.g. trash fish in a consignment).

These mechanisms for translocation are addressed by the conditions set in this HQAP.

The 'NSW Fisheries' Introduction and Translocation Policy Paper (1994)' is currently under review to ensure it meets the standards recommended by the 'National Policy for the Translocation of Live Aquatic Organisms (1999)'. Translocation issues associated with the aquarium trade are beyond the scope of this document and will be managed through pest-species management initiatives to be conducted by the NSW Department of Primary Industries and other agencies.

12.3 - STOCKING

Permits

Every stocking event that involves the release of fish into natural waters of NSW requires authorisation under a stocking permit (section 216 of the *Fisheries Management Act 1994*). The release of fish into these waters, other than under the authority of a permit is an offence. This permit system enables NSW Department of Primary Industries to ensure that appropriate species and strains are stocked into NSW waters.

Stocking permits are issued for all non-departmental stockings such as the Dollar for Dollar Native Fish Stocking Program or one-off stocking events arranged by fishing clubs, acclimatisation societies or individuals. Stocking permits are issued to the person or group organising the event, and although the hatchery operator is generally not involved in the stocking permit process, hatchery operators who provide stock for any stocking program should familiarise themselves with the permit authorising the event to ensure that any conditions of the permit are met. Where an individual or stocking group approaches a hatchery operator to supply fish for a stocking event and they do not have a permit, the hatchery operator should refer them to the NSW Department of Primary Industries.

Stocking permits are issued from the NSW Department of Primary Industries' Port Stephens Fisheries Office upon written application (or completed Dollar for Dollar application) and must be submitted to:
The Permits Clerk,
Port Stephens Fisheries Centre,
Locked Bag 1, Nelson Bay, 2315.

STOCKING PERMIT
UNDER SECTION 216 OF THE FISHERIES MANAGEMENT ACT 1994
ESSENTIAL CRITERIA

- ***A stocking permit from the NSW Department of Primary Industries to release fish into natural waters.***
- ***Application must detail:***
  - *the name(s) of the person(s) applying for the permit*
  - *the name(s) of any person(s) assisting in the stocking of the fish*
  - *the species proposed to be stocked*
  - *the number of fish (maximum) proposed to be stocked*
  - *the exact location of the site(s) where the fish are proposed to be stocked*
  - *the name of the hatchery from which the stock are to be procured*
  - *the time span during which the stocking is to be undertaken (generally not longer than three months from date of issue)*
  - *if a Dollar for Dollar stocking, a completed dollar for dollar stocking application form available from any office of the NSW Department of Primary Industries.*

Note: Allow several weeks for a stocking permit to be processed. Currently, there is no administrative fee for a stocking permit.

Fig. 12.1 External drain harvest of silver perch fingerlings at the Grafton Aquaculture Centre.

Harvesting, counting and quarantine
Fry and fingerlings are harvested from ponds by seine net (usually for small batches, <10,000) and by draining the pond (drain harvest). The fish are placed directly into oxygenated bins or tanks on a vehicle and transported to the quarantine tanks as soon as possible. Fish can be counted into these tanks, either individually for small batches (up to several 1,000) or by the following methods:

(i) by weight in water:
(ii) volumetrically by displacement of water in a measured container;
(iii) volumetrically in a solid, fine mesh container;
(iv) by weight out of water.

Fish in at least 5 sub-samples of 500 fish, taken periodically through-out the harvest, should be anaesthetised and counted to determine the number of fish per unit weight or volume, and to enable the total number to be calculated.

Fry and fingerlings should be quarantined for at least 24 hrs before transportation and stocking (see Chapter 8 for comments on quarantine). Some hatchery operators prefer to quarantine for 12 – 24 hours and then count the fish.

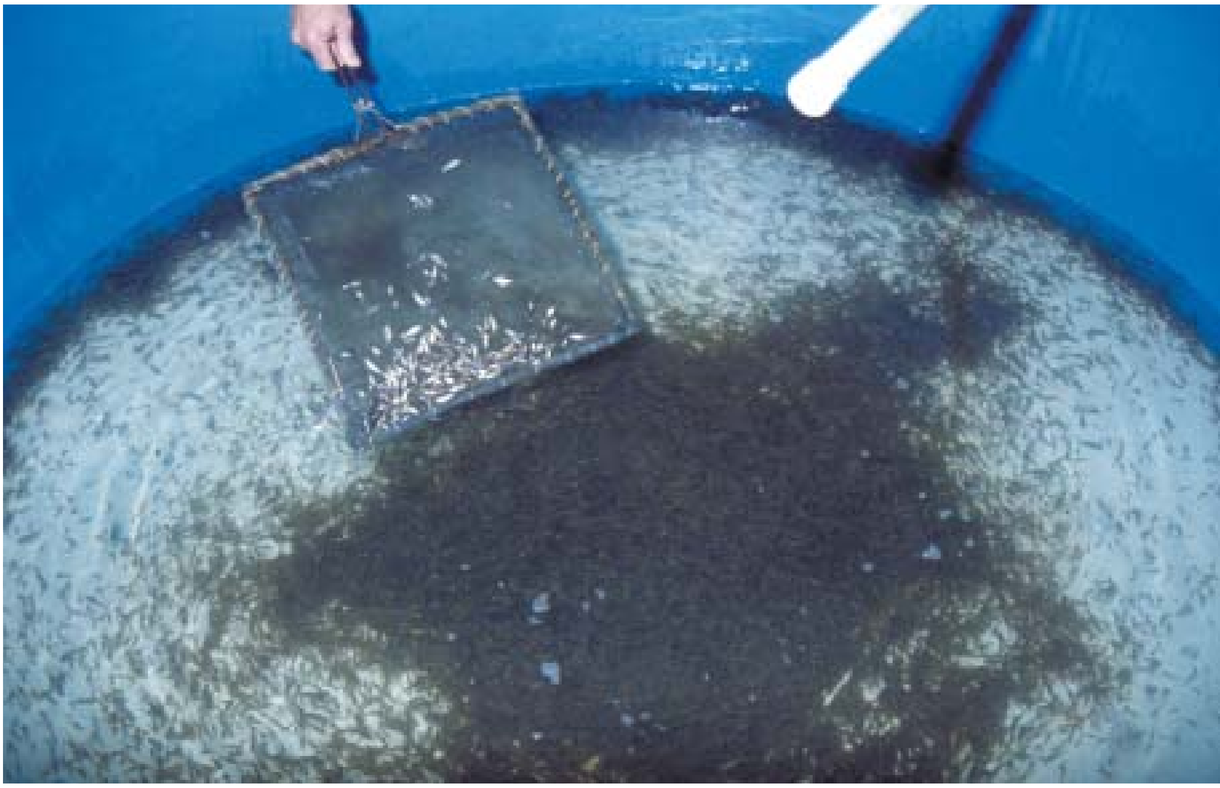

Fig. 12.2 Sampling fingerlings from a tank to check for signs of disease, abnormal or damaged fish, and trash fish prior to transportation and stocking. Gill and skin tissue from five fish must also be examined for parasites (see Chapter 8).

Preparation and transportation to stocking site

Before each consignment leaves the hatchery, fish must be sampled to ensure:

(i) there are no signs of disease;

(ii) there are no emaciated, abnormal or damaged fish;

(iii) there are no trash fish.

If there are diseased fish, the whole consignment must remain in quarantine and be treated for the disease. All trash fish must be removed before the consignment leaves the hatchery.

If the consignment is free of disease and trash fish, the Hatchery Dispatch and Health Statement (Appendix III) can be signed; a copy is given to the receiving person(s), one sent to NSW Department of Fisheries (Permits Clerk, Port Stephens Fisheries Centre, Private Bag 1, Nelson Bay, NSW, 2315), and one retained at the hatchery. Trash fish should be euthanased and disposed of in an appropriate manner (see Barker et al., 2002).

Water must be oxygenated if fish are being transported for any distance taking more than a few minutes. In the case of tankers, this is achieved through the use of bottled oxygen, plastic air-line and a diffusing device such as an air-stone. Concentrations of oxygen in the transport tank should be maintained at 8 mg/L or higher. Water quality meters should be used to monitor the water periodically, e.g. each 2 – 4 hours depending on number of fish, temperature and distance transported. Salt (NaCl; 2.5 g/L) should be added to the water to reduce stress and inhibit fungal infection.

Small batches of fish are placed in bags, these should be made of durable plastic, filled with water to approximately one quarter of the bag's volume, inflated with oxygen and sealed with a strong rubber band. The bag can be placed in a strong cardboard box or garbage bin for protection during transportation.

Advice on the transportation of fish can be obtained from Aquaculture Extension Officer, Grafton Aquaculture Centre, PMB 3, NSW, 2460 Telephone - (02) 6644 7588.

PREPARATION AND TRANSPORTATION TO A STOCKING SITE
ESSENTIAL CRITERIA

- ***Quarantine for at least 24 hours post-harvest:***
  to evacuate all stomach contents; reduce stress; may need to be a longer period if there are problems with diseases or trash fish; do not feed in quarantine.
- ***Ensure fish are free of disease:***
  see Chapter 8 and Appendix III.
- ***Ensure fish are in good condition:***
  not emaciated; no damaged fins or tails; normal colour and appearance; no haemorrhagic (red or bleeding) areas.
- ***Ensure free of trash fish:***
  observe; collect random sample of ~ 1,000 fish from each tank. Anaesthetise and examine; remove all trash fish; see Appendix III.
- ***High quality water in the transport tank:***
  filtered hatchery water with no solids or undesirable material such as larvae and trash fish; bore water is recommended as a suitable, pathogen-free source.
- ***Oxygenate water for the entire journey:***
  use bottled oxygen; carry sufficient bottles for un-scheduled delays during transportation or the stocking process; minimum DO of 8 mg/L is recommended.
- ***Salt (NaCl) at 2.5 g/L:***
  to reduce stress; prevent fungal infection.
- ***DO, pH meters and thermometer:***
  to monitor DO, pH and temperature during transportation and water at stocking site.

Fig. 12.3 Anglers assisting with the "broadcast" or "scatter" method of stocking fingerlings from a NSW Fisheries truck.

PREPARATION AND TRANSPORTATION TO A STOCKING SITE
RECOMMENDED CRITERIA

- ***Transport tanker:***
  > 1,000L.
- ***Insulated tank.***
- ***Pump and hose:***
  for acclimatisation of fish in tank and emergency exchange of water.
- ***Vent for air to escape:***
  to prevent build-up of carbon dioxide and subsequent low pH.

Release

Unless fish are collected from the hatchery, release at the stocking site is the final involvement of the hatchery operator. In either case, the quantity and quality of the fish is the responsibility of the hatchery operator. Immediately prior to release, the consignment should be checked to ensure fish are:

(i) alive (< 0.1% mortality);
(ii) active;
(iii) normal colour;
(iv) not damaged (fins, tail, eyes).

In most situations, fish need to be acclimatised to the "new" water. Sudden changes in water quality, particularly temperature and pH can be very stressful, and in extreme cases, lethal to fish. Firstly the quality of the receiving water should be monitored to ensure it is acceptable (e.g. DO >5 mg/L, pH 7.0 – 9.0); if the quality is poor, consideration should be given to moving to another site. If the difference between water in the tank and the site is >2°C temperature or >1 unit pH, the transport and receiving waters should be mixed over a period of 10 – 30 minutes depending on the difference. Water from the release site can be mixed with water in the tank using a pump. If fish are consigned in plastic bags, these can be immersed in the receiving waters to equilibrate temperature and/or water at the site added periodically to the bag. Meters (temperature, DO, pH) are used to monitor the water quality.

To maximise survival, small fish are generally released in or adjacent to structural habitat such as amongst reeds or snags close to shore. Current stocking practices vary from single site release or "spot" method, to the "broadcast" or "scatter" method where small batches of fish are taken from the tanker in containers or plastic bags and released at many locations throughout the general area to ensure a wide distribution of fish. "Trickle" stocking involves releasing fish at a site over a period of time, e.g. several weeks. Releasing an entire consignment in a single location may result in severe predation by other fish species or birds due to the concentration of the stocked fish. Local anglers generally provide local knowledge and advice, and often assist with the stockings by hatchery operators and the NSW Department of Primary Industries. Persons assisting in the release should be made familiar with stocking procedures and the authorising permit. Various aspects of stocking native fish in impoundments are discussed by Simpson et al., (2002).

STOCKING OF FISH
ESSENTIAL CRITERIA

- ***Stock fish into river where broodstock were collected:***
  to maintain genetic identity and genetic variation of population; to maintain biodiversity of the Murray-Darling River System.
- ***The stocking of each river should be part of a 5 year program:***
  to maximise genetic variation and achieve N_e.
- ***Fish health:***
  sample of at least 1,000 specimens from all levels of the water column (if in a tanker); check the consignment for diseased, dead or moribund fish, activity and condition of fish; reject any batch with > 0.1% mortality.
- ***Monitor water quality at stocking site:***
  DO >5.0 mg/L, pH 7.0 – 9.0.
- ***Acclimatise fish immediately before release:***
  routinely at each site; particularly where temperature varies by >2° and pH by > 1 unit; take 10 – 30 min.
- ***Stocking permit:***
  Ensure the release is performed in accordance with the provisions of the authorising permit.

STOCKING OF FISH
RECOMMENDED CRITERIA

- ***Release fish near obvious structures or cover (snags, rocks, submerged vegetation).***
- ***Ensure water in small containers is well oxygenated when fish transported to multiple sites.***
- ***Ensure all persons are familiar with stocking procedures and permit conditions.***

13 Occupational Health & Safety (OH&S)

13.1 - GENERAL

Fish hatcheries, like other small businesses, play a vital role in NSW, employing people and generating wealth for local and state economies. Fish hatcheries by their very nature can be extremely hazardous environments (wet areas, electrical hazards, dangerous machinery, chemicals, empty ponds, deep water, heavy weights etc.) and the need for close attention to OH&S issues cannot be over-emphasised.

WorkCover, the state's OH&S management authority, is responsible for setting standards for workplace safety issues through the Occupational Health and Safety Act 2000, and the Occupational Health and Safety Regulation 2001. Under this legislation, fish hatchery operators are responsible for:

(i) keeping a safe and healthy workplace;
(ii) making sure they have the right workers compensation insurance policy for their business;
(iii) ensuring there is prompt treatment and support for an employee who has a work-related injury.

Changes to the OH&S legislation took effect in September 2001 and several new areas of concern must be addressed by every small business in NSW (employing 20 or less staff). A significant change resulting from the OH&S Act 2000 is the 'duty to consult' with employees on any matters affecting their health and safety. This means employers must talk to their workers and get their input on how to best make the workplaces safe. The duty to consult applies to all employers regardless of the number of people they employ. From September 2003, all small businesses were required to fully comply with these changed laws. These changes require that small businesses have to implement a risk management plan. Risk management means:

(i) identifying all foreseeable workplace hazards;
(ii) assessing the risks arising from those hazards;
(iii) implementing measures to eliminate or control those risks.

To help with understanding these new responsibilities, WorkCover provides advice and education services, making it easier for hatchery operators to comply with the laws.

The NSW Department of Primary Industries strongly supports appropriate OH&S management of all hatcheries. As these issues are mandatory under the OH&S legislation, it is not necessary to repeat the all the requirements in this document. Further information regarding OH&S and the WorkCover Authority may be obtained from:

WorkCover Information Centre:
Telephone: 13 10 50
Fax: 02 9287 5491
Web: www.workcover.nsw.gov.au

13.2 - ZOONOSES

Zoonoses are diseases of animals that can be transmitted to humans. Fish farmers, as well as fishers and fish hobbyists, need to be aware that they can contract diseases from fish. Immuno-suppressed people are at most risk. The fish pathogens can be acquired topically from fish spine punctures or open wounds, or through ingestion of raw or under-cooked fish.

Bacteria are the most common pathogens, in particular *Mycobacterium marinum, Aeromonas hydrophila, Streptococcus iniae, Edwardsiella tarda*, and various *Vibrios* (Lehane and Rawlin, 2000). Symptoms in humans are typically skin inflammation and infections, lesions, ulcers, nodules, swelling, stiffness, muscle necrosis, septicaemia and arthritis. Diseased fish are more likely to transmit infection because of increased bacterial loads.

Fish farmers should:

(i) maintain healthy fish:
(ii) wear gloves and take care handling fish, particularly fish with bacterial diseases;
(iii) seek medical attention for symptoms.

Accreditation, auditing, compliance & reporting

14.1 - HATCHERY ACCREDITATION SCHEME (HAS)

The HAS is a feature of the Fish Stocking Fishery Management Strategy (FMS). From around 2007, this scheme will apply to both Government and privately-owned hatcheries that produce fish for stocking programs. Elements of the HAS will include the principles outlined in this HQAP and other factors considered necessary for accreditation that result in the production of high quality stock in line with the requirements of the FMS.

14.2 - AUDITING AND COMPLIANCE

Any hatchery may be inspected by a Fisheries Officer who can conduct an audit of the facility to ensure it is in compliance with the provisions of the authorising aquaculture permit or any other statutory requirement. By virtue of section 253 of the *Fisheries Management Act,1994*, a Fisheries Officer may enter any aquaculture facility without prior notice to conduct an inspection at any time during the day or when activity is normally being conducted on the site. The inspection may involve scrutiny of the operation with regard to the following:

(i) species under cultivation;
(ii) water surface production area;
(iii) screens, outlets and other stock security issues;
(iv) use and presence of chemicals;
(v) compliance with standard and special aquaculture conditions;
(vi) disease and fish health issues;
(vii) effluent release or disposal.

If the hatchery is subject to hatchery accreditation under the Fish Stocking FMS, the inspection may involve Essential Criteria in this HQAP.

From 2004, compliance management of the NSW aquaculture industry will be conducted under the Aquaculture Compliance Strategy (a statewide compliance program to replace random inspections). Under the strategy, Fisheries Officers will be trained to conduct thorough inspections; however, where a farm is found to be fully compliant it may not require further inspection for up to three years. Farms will be required to submit an annual self-reporting compliance statement. The aquaculture permit holder will be sent an audit form (checklist) of compliance issues specific to the hatchery or farm and they conduct their own inspection. The audit form must be returned to the NSW Department of Primary Industries and signed-off by the permit holder stating that the farm is compliant. Where a farm does not reach compliance in accordance with self-reporting system, the permit holder must identify the relevant issues and state what action, and time required to bring the farm into compliance.

For further information on this topic contact the Aquaculture Compliance Section at the Port Stephens Fisheries Centre on (02) 4916 3919.

14.3 - REPORTING

It is a condition of every aquaculture permit that the permit holder reports annually on the level of production relating to the farm or any other information legally requested. Production information is pooled to assess the value of each industry sector and is used to help develop policy and assist in management decisions.

During 2003, the NSW Fisheries' native fish and trout hatcheries underwent a process to develop a standard hatchery reporting system to ensure consistency of data and use of electronic means for analysis. The information can also be used in other applications such as spatial mapping in Geographic Information Systems (GIS) allowing the activity to be depicted in relation to the origin and distribution of stock. The development of standard hatchery reporting will be extended to industry as part of the Fish Stocking FMS.

15 NSW Department of Primary Industries policies & management

15.1 - MANAGEMENT AND ADMINISTRATION OF HATCHERIES

The aquaculture industry in NSW is regulated under the *Fisheries Management Act 1994* (the Act). The NSW Department of Primary Industries manages aquaculture through a permit system established under Part 6 of the Act (Aquaculture Management) designed to ensure the industry develops in an environmentally-sustainable and economically-viable manner. Each industry sector is categorised by a class of permit.

PERMIT CLASS	AQUACULTURE
Class A	Extensive aquaculture (Public Water Land)
Class B	Intensive aquaculture (Public Water Land)
Class C	Extensive aquaculture on private land
Class D	Intensive aquaculture on private land
Class E	Extensive aquaculture on two or more privately owned locations
Class F	Fish-out pond, tank or structure
Class G	Experimental aquaculture
Class H	Fish hatchery
Class I	Charity (fish-out events)

To operate a fish hatchery in NSW, where the hatchery stock is produced for sale (a commercial hatchery), the facility needs to be licensed with a class H permit. Any new entrant to the aquaculture industry, or an existing fish farmer (holding a class C, D, E or F permit) wishing to obtain a class H permit, must first submit an application to the NSW Department of Primary Industries' Aquaculture Administration Section.

Application forms are available on line at www.fisheries.nsw.gov.au/aquaculture or from any office of the NSW Department of Primary Industries. An application for a class H aquaculture permit must be submitted on the approved application form and must be accompanied by the processing fee and a commercial farm development plan (a business plan supporting the application). If an application for a class H permit is to be made for an area of the state where an Aquaculture Industry Development Plan (AIDP) applies, then the application must be lodged in accordance with the AIDP.

15.2 - AQUACULTURE INDUSTRY DEVELOPMENT PLANS

Aquaculture Industry Development Plans provide best practice and environmental management components of the NSW Sustainable Aquaculture Strategy; a state planning policy designed to identify and categorise aquaculture developments on the basis of potential environmental risk. The AIDP includes the following sections: business planning; species selection; site selection; planning and design; operating the farm. The AIDP process incorporates a whole-of-government approach for the assessment and licensing of aquaculture ventures, and the process should take less time to determine than under the previous application process. Most of the potential impacts of the type of proposal have already been assessed, and the application process guides applicants into making sound proposals.

AIDPs relate specifically to land-based aquaculture and only apply where the operation is proposed for development on private land. Applicants need to be aware of whether an AIDP applies to the area in which they wish to develop a hatchery, as this will guide the application process. Information about AIDP's may be obtained by contacting NSW Department of Primary Industries Aquaculture Management Branch at the Port Stephens Fisheries Centre on 02 4982 1232.

15.3 - FISH STOCKING FISHERY MANAGEMENT STRATEGY

From the end of 2004, all fish stocking events in NSW will be managed under a Fishery Management Strategy (FMS). The Fish Stocking FMS is a state-wide management framework to guide the activity of fish stocking into the future including the appropriate management of relevant hatcheries, both Government and private. The FMS sets out policy, management and administrative procedures designed to ensure that the activity of fish stocking in NSW is conducted in an ecologically-sustainable manner. The vision for the FMS is to provide effective enhancement of freshwater recreational fishing, while supporting conservation outcomes for fish in the inland waters of NSW. These programs are to be undertaken within a clear management framework, consistent with the principles of ecologically-sustainable development.

Over recent years there has been an opportunity for private, commercial hatcheries to produce fish for stocking programs (such as the Dollar for Dollar Native Fish Stocking Program and some conservation stockings) and these programs are set to continue in the future.

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Appendix 1

WATER QUALITY - GRAFTON AQUACULTURE CENTRE **POND/TANK NO.**

COND = conductivity, TURB = turbidity, DO = dissolved oxygen, TEMP = temperature, TAN = total ammonia nitrogen, NH_3 = unionised ammonia, mg/L = ppm

Appendix 11

DISEASE MONITORING - PARASITES

POND NO.	STOCKING DENSITY	DATE STOCKED

PRODUCTION PHASE (TICK) ☐ I - HATCHERY; ☐ II - FINGERLING; ☐ III - GROW-OUT

DATE	FISH NO.	LENGTH mm	WEIGHT g	TOTAL NUMBER OF PARASITES (in 5 fields of view) (gill/skin)						
				WHITE SPOT GILLS ther troph	SKIN ther troph	CHILO	I'BODO	TRICH	DACT/ GYRO	OTHERS OR COMMENTS
	1									
	2									
	3									
	4									
	5									
	MEAN									
COMMENTS										
	1									
	2									
	3									
	4									
	5									
	MEAN									
	1									
	2									
	3									
	4									
	5									
	MEAN									
COMMENTS										
	1									
	2									
	3									
	4									
	5									
	MEAN									
COMMENTS										

Appendix 111

Hatchery Dispatch and Health Statement

Hatchery: Aussie Fish Hatchery
Batch no. (Year/number, e.g. 04/01)**:** 05/04

Species: Murray cod
No.: 5,000 **; Mean length** (mm)**:** 35 mm **; Mean weight (g):** 0.8
Date harvested: 12/3/04 **; Date dispatched:** 16/3/04
Quarantine period: 3 days
Destination: Lachlan River, Condobolin

Are there any other species present? **Yes** **(No)**
If Yes, what species?:
Were they removed?:

General observations (tick)

Observation	Yes	No
Moribund fish		✓
Signs of disease e.g. flashing, abnormal colour		✓
Fungal lesions		✓
Lesions or ulcers e.g. pale or red areas		✓
Visible external parasites		✓
Abnormalities		✓

If abnormalities, describe:
Prevalence (%):

SAMPLE

Microscopic examination of gill and skin tissue (tick)
No. fish examined: 5

Parasite	Absent	Present
Ichthyophthirius multifiliis (white spot or Ich)	✓	
Chilodonella spp.	✓	
Trichodina sp.	✓	
Ichthyobodo necator	✓	
Gill flukes	✓	
Others	✓	

Signature: J. Smith **Date:** 16th March 2004
Print name: John Smith
Position: Owner/Manager