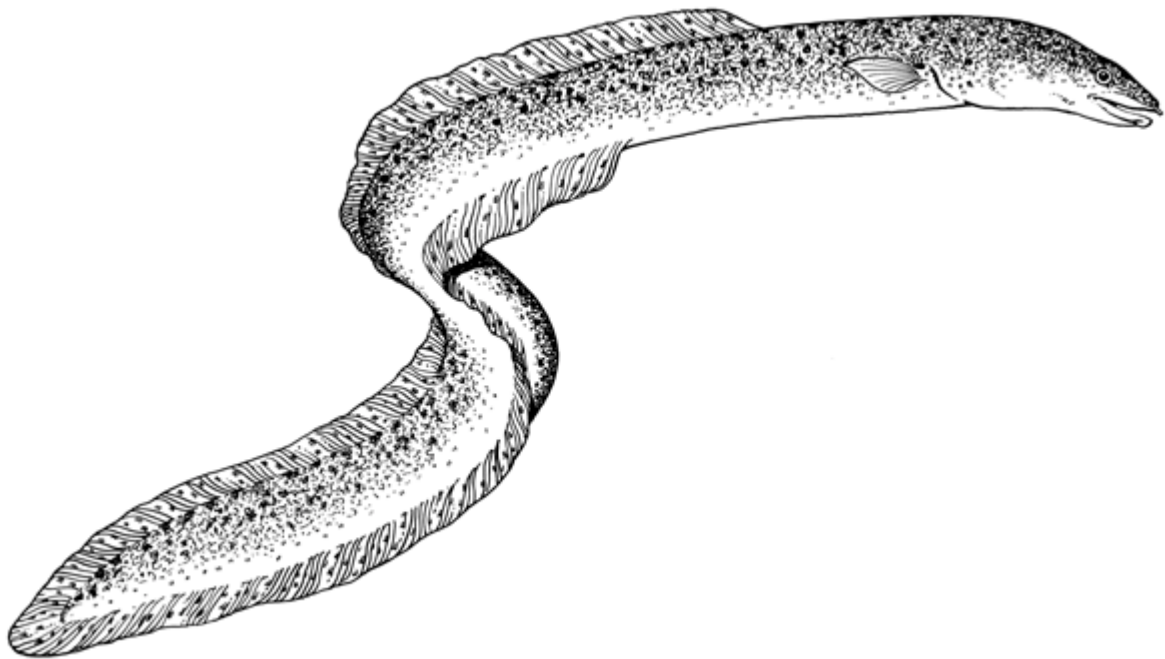


# ECOLOGICAL ASSESSMENT

## QUEENSLAND EEL FISHERY



Compiled by

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**Queensland Government**  
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## INTRODUCTION

The target species in the Queensland eel fishery are the long fin eel, *Anguilla reinhardtii* Steindachner, and the short fin eel, *Anguilla australis* Richardson. Other eel species are found in Australia but currently do not have commercial significance.

The Queensland commercial eel fishery is unusual in that the resource is harvested at two stages in the lifecycle – the adult stage and the glass eel/elver stage (juvenile). Commercial eel trappers collect adult eels from impounded waters and Culture Stock Collection Permit holders collect juvenile eels from rivers to supply seed stock for grow out in aquaculture systems. Although adult eel trappers and juvenile eel collectors harvest eels at different life stages, utilise different gear, and require different Authorities/Permits, both target the same eel population(s). Accordingly, both fishing operations are jointly managed for sustainability as a single fishery - the Queensland eel fishery.

### Distribution

Long fin females (*A. reinhardtii*) are reported to grow to a length of up to 165 centimetres (cm) and over 22 kg in weight, but commonly up to about 100 cm (McDowall 1996). Recent research in southeast Queensland shows an average length at metamorphosis and maturity of 93 cm for females and 56 cm for males (Hoyle, unpublished data). Females of most eel species, including the long fin and the short fin, attain a larger size at maturity when further from the spawning grounds (Helfman 1997, 1998; Vollestad 1992). The long fin eel makes up the majority of the adult eel catch in Queensland due to its extensive distribution along the east Queensland coastline (see Map 1). It is therefore of particular significance to the commercial adult eel fishery.

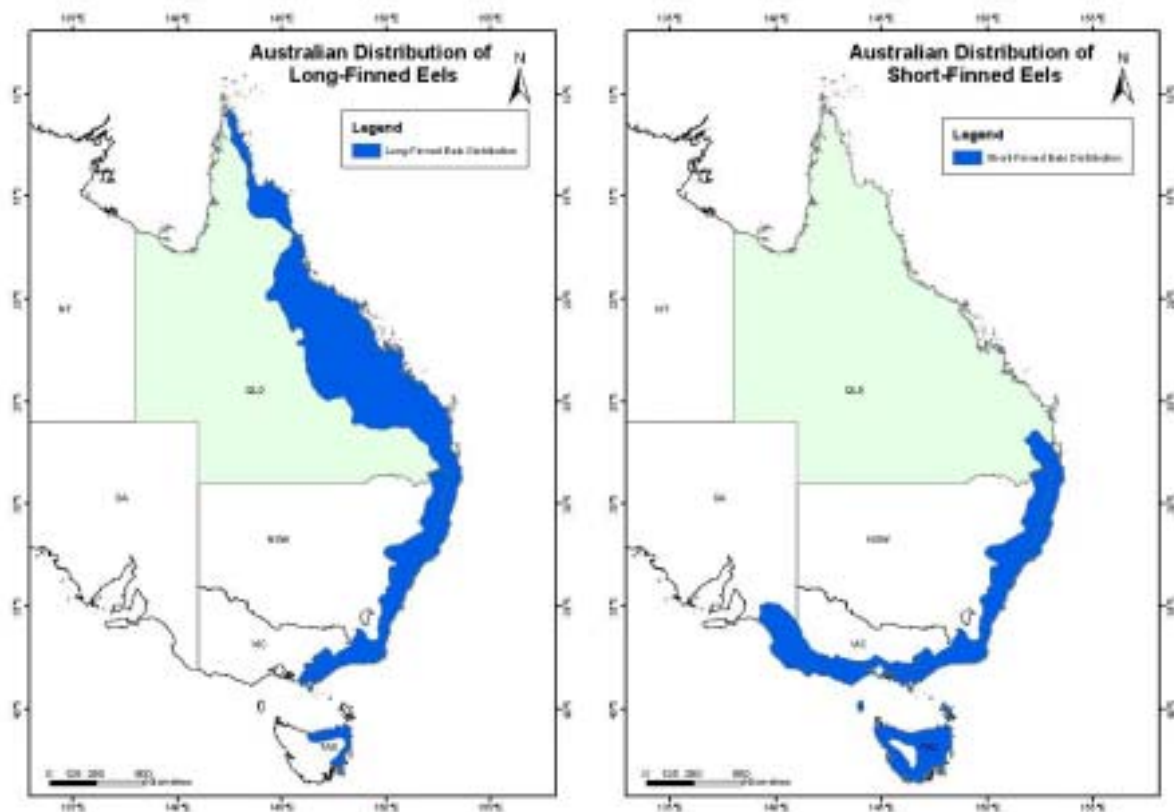
The short fin eel (*A. australis*) reaches a length of 110 cm (females) and a maximum weight of 6.8 kg. Female short fin eels are believed to mature at about 55 cm and males at below the legal size of 30cm (Todd 1980). Short fin eels make up only a minor part of the commercial adult catch as the northern limit of its distribution occurs in southern Queensland (see Map 1).

The short fin eel is the species preferred for cultivation by the Australian aquaculture industry, as it is similar to the species sought after in the Japanese market and so commands a significantly greater price. However, expansion of short fin eel culture in Queensland may be limited by the low natural abundance of wild short fin eel stocks in Queensland. Southern Queensland is the northern limit of *A. australis* distribution in Australia with only small numbers found in coastal streams south of the Pine River, near Brisbane (see Map 1). The majority of *A. australis* abundance is located in the southern Australian states - New South Wales, Victoria, South Australia and Tasmania.

### Lifecycle

Until recently (Wirth and Bernatchez 2001), all anguillid eels have been considered panmictic. Panmixia is defined as random mating within a breeding population. For Australian anguillid eel populations, spawning individuals of each species migrate to a single site for reproduction and comprise a single, randomly mating population. Dijkstra and Jellyman (1999) supported panmixia for New Zealand anguillid eel populations, showing that genetic variation within the New Zealand eel population was equal to or greater than that between eel populations of adjacent regional systems. This is expected given the opportunistic nature of glass eel migrations into estuaries. By contrast, recent evidence based on highly sensitive genetic markers appears to refute the assumption of panmixia for European eels (Daemen *et al.* 2001; Wirth and Bernatchez 2001). However, the degree of possible differentiation for European eels is still unclear, and there is no evidence for genetic subdivision in other species.

We therefore retain the hypothesis that the east coast Australian *A. reinhardtii* and *A. australis* populations are single populations, while keeping other possibilities in mind. Genetic studies underway at Southern Cross University (Lismore, NSW) may clarify this matter for long fin eels (*A. reinhardtii*).



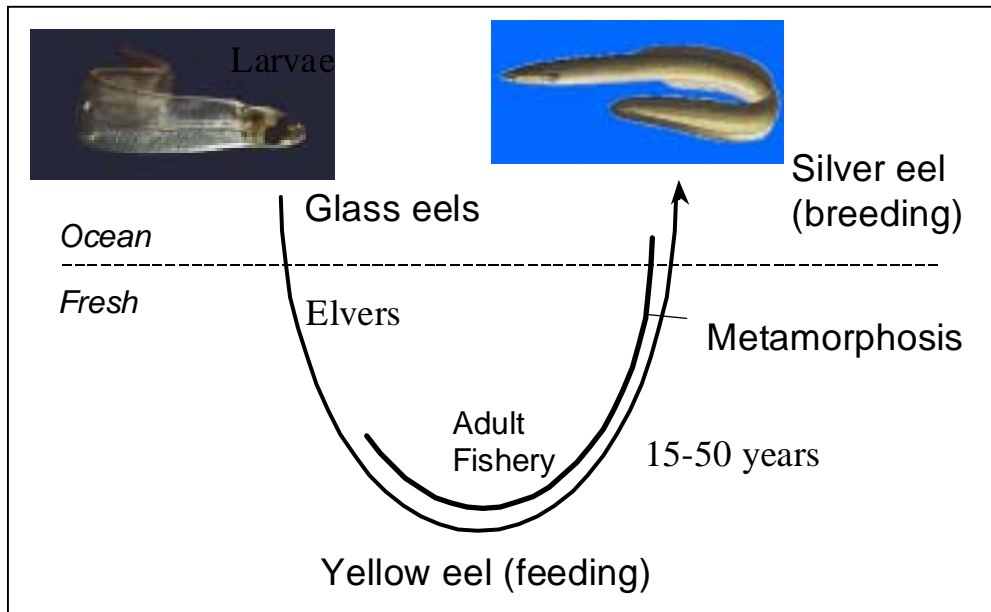
**Map 1** Distribution maps for long fin (*Anguilla reinhardtii*) and short fin (*Anguilla australis*) eels in Australia.

Adults migrate to an as yet-undefined area in the Coral Sea to spawn (Aoyama et al. 1999; Gooley et al. 1999; McDowall et al. 1998; Russell 1995; Kailola et al. 1993). Leptocephali, the larval stage, last for 12-18 months and are transported via the East Australian Current to near shore waters where they metamorphose into unpigmented 'glass eels' (Shiao et al. 2001; Beumer 1992). Glass eels move into estuaries and migrate upstream to grow and develop through a small, pigmented 'elver' stage into the larger but still immature 'adult' or 'yellow' eels. When adults reach sexual maturity they undergo marked changes in their appearance becoming silvery, hence the name 'silver eels'. Anatomy and physiology also alter at sexual maturity and eels undertake a once only downstream migration to the spawning grounds, where it is believed they spawn and subsequently die.

Figure 1 reveals that large age ranges are associated with freshwater eel life stages. Research on long fin eels in Queensland suggests that the average age at sexual maturity is 20 years for females and 10 years for males. However, the Queensland research has recorded sexually mature females ranging from 5 years to 39 years, and sexually mature males ranging from 4 years to 17 years (S. Hoyle, QDPI unpublished data).

Captive eels have not yet produced viable offspring that can be grown to marketable size. Until recently (Tanaka et al. 2001), an inability to get post-hatching larvae to feed had prevented successful metamorphosis from the post-hatch stage to the leptocephalus stage despite extensive research. This inability to complete the eel life cycle in captivity has necessitated continued harvesting of glass eels and elvers from the wild as the only viable source of stock for eel aquaculture.

Eels are potentially vulnerable to overfishing due to their unusual life history. They have a very long generation time, low natural mortality once the adult stage is reached, and all fishing occurs before breeding. Eels are thought to breed only once and die after spawning. Any fishery for adult eels therefore has the potential to affect the recruitment of juveniles into the fishery, and by association, the supply of glass eels. Since the larger spawning females are responsible for much of the recruitment into, and hence value of, the fishery, the risks are clear.



**Figure 1** Life cycle of the freshwater eel showing freshwater and marine life stages.

Sexual differentiation in eels appears to be influenced by a number of environmental factors including water temperature, salinity, and population density (Zeller and Beumer 1995; Draft Victorian Eel Fishery Management Plan 2001). Female eels generally occur further upstream (lower salinity, and lower population densities), grow larger and mature later than males. Males tend to occur more frequently in downstream brackish and estuarine areas (WBM Oceanics Australia 1995; Beumer 1992). There are no easily distinguishable visual differences between male and female eels (Moffatt and Voller 2002); however, female long fin eels comprise the majority of the commercial adult eel catch in Queensland. This is due to the fact that adult eel trapping is allowed only in artificially created freshwater impoundments and is prohibited in estuarine areas, which is the primary habitat for male eels.

The management practice of closing all natural waters to adult eel trapping is to ensure there are sufficient refuge areas for eels to mature and migrate to spawn without being exposed to commercial fishing pressure. In essence, all populations of adult eels in natural waterways remain unfished and only selected rivers are open to collection of juvenile eels for aquaculture. The farm dams open to adult eel trapping have been artificially created relatively recently and have actually enhanced/increased the amount of habitat available to eels. This does not mean that fewer eels are now found in the natural systems but that additional artificial environments have been created into which more juvenile eels can disperse and reach maturity. Harvesting adult eels from the artificial dam areas will not directly alter the structure or sex ratio of the population found in the natural systems as adult eels in these systems are not exposed to any commercial fishing pressure. This is to ensure adequate recruitment into all waters including the upstream impoundments open to trapping.

The major impediment to eel recruitment is most likely large obstacles such as waterfalls, dams and weirs that can slow the progress of eel migration upstream. However, barriers are generally

passable as long as there is some water present along spillway margins (McDowall 1996). Eels are known for their ability to traverse considerable distances over land in wet conditions.

## **Overview of the development of the adult eel fishery in Queensland**

Eel trappers have commercially harvested wild adult eel populations since 1985, when seven commercial eel trapping Authorities were issued for artificially impounded freshwaters and certain rivers in south-east Queensland by the Department of Primary Industries (QDPI). However, wild stocks remained largely unexploited until commercial harvesting in freshwaters was allowed as a predator control measure as part of the Recreational Fishing Enhancement Program initiated by QDPI in 1986. Controlled trapping was seen as an important measure to improve the survival of fingerlings of other stocked fish species in impoundments by reducing the number of larger eels. Adult eels were believed at that time to be major predators of young fish, as well as native wildlife, in the artificial environments of impounded waters. Trapping was soon restricted to impounded waters due to nil or low catches in rivers, loss of gear and to reduce conflict with existing estuarine fisheries and minimise capture of non-target species.

Initially, Authorities were issued for specified private impoundments for which access had been granted by the landholder. Following this, a single trapper was allocated to individual river systems to minimise conflict between Authority holders and to allow individual assessment of eel stocks within particular systems. There was no restriction on the number of impoundments within that river system that the Authority holder could be granted provided they had access. Currently, all adult eel trappers can apply for any number of the river catchments open to eel trapping and they can trap in an unlimited number of artificially created impoundments within those catchments stated on their Authority, provided they have approval for access from the relevant property owner or water-controlling body.

A limit of 25 traps per impoundment was originally implemented to encourage daily checking of traps and the maintenance of optimum catch condition. Extended time in eel traps can lead to external damage to the eels from rubbing on the mesh, as well as the possibility of eels being exposed to increased water temperatures, decreased oxygen levels and increased stress especially when in high densities. Checking traps regularly also reduces the likelihood of any negative effects on any bycatch that may be caught (refer to later sections on bycatch: Principle 2 Objective 1). Each trap had a restriction on maximum dimensions of 2 metres in length, 0.5 metres in width and 0.5 metres in height.

By 1987 Authority numbers had increased to 28 and covered most of the important public impoundments for the first time. Through consultation with industry, trap size was increased to a maximum of 2 metres in length, 0.6 metres in width and 0.6 metres in height and the number of traps allowed in very large impoundments rose from 25 to 50.

In 1990, commercial trapping was excluded from all naturally impounded freshwaters. The closure was implemented for two reasons: specific reports of native fauna mortality associated with adult eel trapping in a number of freshwater lagoons; and to allow natural waters to remain as refuge areas for eels. The period for eel trapping Authorities was standardised to a 12-month period. In 1991, the maximum number of traps rose from 25 to 30 for all impoundments (other than very large impoundments which still had a limit of 50). Mesh size in the cod end was decreased to 25 mm to reduce the incidence of “nose burn” and “tail burn” in eels trying to escape from traps.

The number of Authorities issued in 1992 rose from the previous two years and again in 1993 due to increased interest in trapping in private dams. The number of adult eel trapping Authorities and annual catch declined slightly in 1994.

The responsibility for managing commercial eel harvesting changed from QDPI (Fisheries Division) to the Queensland Fisheries Management Authority (QFMA) in 1995 following the promulgation of the *Fisheries Act 1994*.

In 1997 the adult eel trapping fishery was managed under a Limited Entry Policy to assist in orderly and sustainable management of the fishery in accordance with the *Fisheries Act 1994*. All of Queensland's commercial fisheries at the time were thought to be at maximum effort levels in terms of resource availability and therefore it was seen as necessary to control numbers of fishers who had access to the fisheries. This meant no new Authorities could be issued until a management plan was in place for the fishery. Any applicant for a new Authority, or for endorsement of an existing Authority, was required to show that there were special circumstances applying such that the fisheries agency should depart from the provisions of this Policy in deciding the application.

In the process of producing a management plan for Queensland's freshwater fishery, a summary paper on all aspects of the Queensland eel fishery, including trap size and number, was circulated to stakeholders and responses to the survey were used to develop management proposals for a discussion paper (the first step in producing the freshwater management plan). After extensive consultation with stakeholders and the public, a management plan for freshwater was introduced in 1999. Through this process industry requested an increase in the maximum number of traps allowed; the limit was raised to 50 traps for all impoundments.

Under the provisions of the *Fisheries (Freshwater) Management Plan 1999* (the 'Plan') the adult eel trapping fishery was closed to new applicants and became managed as a closed fishery. No new Authorities could be issued and in addition, the existing Authorities were non-transferable. This management strategy was introduced to prevent the expansion of the fishery and reduce the possibility of increased fishing pressure on eel stocks.

The only current Authorities to take eels are those that were granted before the closure and have been renewed annually by the holder. Weirs and barrages were also closed to eel trapping as an element of the Plan, since allowing trapping in impounded waters above all weirs and barrages could open entire catchments to trapping. After the commencement of the Plan, Authority holders authorised to trap adult eels in weirs and barrages were allowed to continue trapping in these waters until the expiry date of their Authority. After this date, if an Authority was renewed, harvesting in the impounded waters of weirs and barrages listed as nominated waters were not authorised. Authorities which authorised the taking of eels from weirs or barrages only were not renewed.

The number of adult eel trapping authorities has been decreasing slowly since the closure of the fishery as holders fail to renew Authorities for varied reasons. In 2001 there were 43 current adult eel Authorities with 29 of those Authority holders actively fishing during the year compared to 58 Authorities in 1997.

The adult eel fishery is currently restricted to impoundments formed by dams such as Cressbrook Dam (public impoundment) or privately owned artificially created impoundments such as private farm dams. The majority of adult eel trapping occurs in privately owned farm dams as opposed to public waters. Currently, public water management agencies allow adult eel trapping in only four public impoundments in Queensland (see following section on 'Current management arrangements in the Queensland adult eel fishery').

In July 2000 QFMA merged with DPI Fisheries Division to form the Queensland Fisheries Service (QFS) within QDPI. This agency now manages the commercial eel fishery in Queensland.

## **Overview of the development of the eel aquaculture industry in Queensland**

Glass eels and elvers are reared under culture conditions to a marketable size by aquaculturists who have an aquaculture licence endorsed for eels. Around 1995, as traditional suppliers of the Asian eel market were experiencing difficulty meeting demand due to difficulties in obtaining seed

stock, the opportunity arose for less traditional suppliers, such as Queensland, to enter the market.

Queensland has ideal conditions for eel aquaculture and has received some attention from investors. Russell (1995), in a feasibility study of eel aquaculture in Queensland, concluded that eel farming in Queensland was practicable and had the potential to be profitable. The results of initial investigations into the availability of seed stock (glass eels) were promising. Russell's (1995) report suggested that because short fin eels were entering local waters but not surviving to adults, limited and regulated removal of glass eels for intensive stocking of aquaculture ponds is unlikely to greatly effect the number of adults contributing to successive glass eel generations. Based on the findings of that report, the Queensland Government supported the development of an eel aquaculture industry. In 1995, six people were licensed to conduct eel aquaculture.

An Aquaculture Licence issued under the *Fisheries Act 1994* is required to culture eels for sale. The first License for experimental eel culture in Queensland was issued in 1988. By 1996, around 11 aquaculture farmers were licensed to grow eels, and 5 farms had eel stocks.

To source Queensland glass eels/elvers, a General Fisheries Permit for Culture Stock Collection, issued with a "quota", is required. Quota arrangements were introduced to address an unwanted trade in glass eels that was developing in the absence of quota controls and attracting opportunists profiting from exporting glass eel stocks overseas. Linking quota to facility production capabilities eliminated the ability for the Culture Stock Collection Permit to be misused for unsustainable practices. It is not an overall quota intended to limit total harvest; rather it is intended to ensure that individual farmers match their harvest with the capacity of their grow out facilities.

The quota is determined by the production capacity of the associated aquaculture facility where the eels will be grown out (further details of quota determination are provided in Appendix 1). Existing Culture Stock Collection Permits are not transferable. Furthermore, glass eels/elvers cannot be purchased from other aquaculturists or Permit holders; however, they may be sourced from Tasmania. Current management arrangements place no total allowable catch limit on juvenile eel harvest.

Initially, holders of Culture Stock Collection Permits for glass eel/elvers had exclusive rights to particular rivers for collection. This changed in 1996 in response to a need to manage fishing pressure and provide equitable access to the resource. All Permit holders were given access to 21 rivers made available for the collection of glass eels/elvers. The rivers were selected through negotiation with industry taking into account suitability of the rivers for collection. Each Permit holder's collection activities, however, are limited to only 3 of the 21 rivers at any one time. Exclusive access rights no longer apply, and there is currently no restriction on the number of Permit holders who may take glass eels/elvers from a particular river. All new applications, however, are assessed having regard for existing demands on wild stock and QFS can limit the number of fishers at a particular site in accordance with Fisheries Act 1994 management principles if the need arises.

### **Current management arrangements in the Queensland adult eel fishery**

The Queensland adult eel fishery management regime is documented and publicly available in the *Fisheries (Freshwater) Management Plan 1999* as part of the broader management framework provided by the Queensland *Fisheries Act 1994* and *Fisheries Regulation 1995*. The Plan has the legislative status of a Regulation.

The management arrangements for the adult eel fishery were developed over several years through a formal and statutory public consultative process involving the Freshwater Management Advisory Committee (FMAC), public comment on a Discussion Paper, Regulatory Impact Statements and a draft management plan.

The Freshwater Fisheries Management Advisory Committee (FMAC) provides advice and recommendations on appropriate management arrangements for the sustainable use of freshwater fisheries resources throughout Queensland. The FMAC includes representatives with a range of expertise and represents broad community interests. QFS encourages indigenous participation on all management advisory committees. Indigenous representatives have participated on the FMAC for varying periods in the past and are again currently represented. Stakeholders currently represented on FMAC include:

- aquarium fish hobbyists,
- fishing tour operators,
- commercial fishers (Queensland Seafood Industry Association),
- conservationists (including Northern Queensland Conservation Council),
- fish hatchery operators,
- fish stocking groups (Freshwater Fishing and Stocking Association of Queensland),
- indigenous interests (including Lake Eyre Basin Co-ordinating Group),
- recreational fishers (Sunfish Queensland),
- scientists,
- Department of Natural Resources and Mines,
- Department of Primary Industries, Queensland Fisheries Service
- Environmental Protection Agency, Queensland Fisheries Service
- South East Queensland Water Corporation,
- SunWater.

The *Fisheries (Freshwater) Management Plan 1999* ('the Plan') defines clear objectives for the management regime. The adult eel fishery in Queensland is managed as a closed fishery with the issue of annual Authorities. Input controls such as limited waters open to trapping and a prescribed number of traps further characterise the restricted nature of the fishery.

Under the provisions of the Plan, the Chief Executive (of the Department of Primary Industries Queensland) must commence a review of the whole plan at least five years, but no more than nine years, after the Plan commenced. The Plan commenced on 1 April 1999. The Chief Executive must also review certain sections of the Plan every two years (or at an earlier time if considered appropriate). Sections to be reviewed every two years include aspects related to the recreational fishery such as bag limits, size limits and closed waters. The first of these minor reviews of the Plan is due to be finalised in December 2002.

A review of the management arrangements for the adult eel fishery will occur as part of the review of the whole plan. A proposal exists to amend the review provisions to allow the Chief Executive to review the Plan, or an aspect of the Plan, at an earlier time (than every 5 to 9 years) if an earlier review of the Plan or an aspect is considered appropriate. This will allow for a review of management arrangements for the adult eel fishery at any time deemed necessary.

Extensive powers to respond to, and mitigate, any adverse impacts of the fishery are provided for in Queensland fisheries legislation, specifically the *Fisheries Act 1994*, Part 5, Division 2 Fisheries Declarations. These include the power to:

- (a) declare a closed season, closed waters or closed species;
- (b) declare a quota for a fishery;
- (c) make an emergency fisheries declaration where urgent action is needed to meet a significant threat to fisheries resources or habitat;
- (d) refuse to issue or renew an Authority where it is necessary or desirable for the best management or protection of fisheries resources;
- (e) impose conditions on issue or renewal of an Authority;
- (f) amend an Authority through a 28-day 'show cause notice'; and
- (g) amend an Authority by written notice - where the quota is to be changed.

### *Input from other agencies on the management arrangements for the adult eel fishery*

The taking of adult eels from nominated public waters is subject to approval from the water management agency. These include SunWater (a government-owned corporation that owns and manages most dams in Queensland), South East Queensland Water Corporation (SEQWater), Gladstone Area Water Board and local Shire Councils.

In 1999, the then Department of Natural Resources (DNR) decided to discontinue the practice of providing access to dams under its control for all commercial fishing activities. DNR implemented the 'no access' policy on the basis that commercial fishing did not fit within its strategic direction. Safety and liability issues were also cited. Existing arrangements were honoured but were not extended after the annual renewal requirement for Authority holders. In 2000, management of these dams was passed to SunWater. The 'no access' policy remains in force as of October 2002.

SEQWater developed a policy in 1999 that prohibits access to their lakes for commercial harvesting of fish. SEQWater manage three large dams in South East Queensland: Wivenhoe Dam, Somerset Dam and North Pine Dam.

The above-mentioned policies, while , while independent of fisheries legislation, further restrict the waters available to adult eel trapping. Gladstone Area Water Board and some local shire councils do allow adult eel trapping in their public impoundments. There are currently four public impoundments where adult eel trapping is allowed: Lake Perseverance, Cressbrook Dam, Gordonbrook Dam and Awoonga Dam.

### **Current management arrangements in the Queensland eel aquaculture fishery**

The collection of glass eels/elvers is via the conditions stipulated on the Culture Stock Collection Permit that details Departmental requirements to ensure the sustainability of harvest. This Permit is required when seedstock (glass eels/elvers) is collected from the wild. QFS issues the Culture Stock Collection Permit in conjunction with an Aquaculture Licence. Quota is determined and allocated during the licensing process.

As at mid 2002 there were 34 Aquaculture Licenses issued for eel aquaculture. Eleven license holders also have Culture Stock Collection Permits for the harvest of juvenile eels. Only three fishers recorded catches of juvenile eels against Culture Stock Collection Permits in 2001 due to a decline in speculative interest in the eel aquaculture industry. The two underlying factors are recognition of the problems facing the eel aquaculture industry, particularly biological constraints, and changes that have occurred to management arrangements, particularly eliminating trade in glass eels.

### *Input from other agencies on the management arrangements for the eel aquaculture fishery*

Some water management bodies do not allow the collection of glass eels/elvers from structures (i.e. barrages and dams). These include SunWater and local Shire Councils. Owners who no longer provide access to their structures have cited previous damage to the structure and public liability issues in support of this decision.

### **Non-commercial harvest**

Recreational fishers take a small number of eels each year. Queensland RFISH diary surveys during 1997 and 1999 revealed that less than 1000 freshwater eels are harvested annually in Queensland.

Indigenous community fishing activity is currently being analysed for Queensland as part of the National Recreational and Indigenous Fishing Survey (NRIFS). Preliminary comparisons of raw data collected from 11 indigenous communities in the north of Queensland, sampled as part of NRIFS, suggests that eels account for 0.05% of the total number of organisms harvested by

indigenous fishers interviewed during the surveys. Once final estimates of the indigenous harvest are calculated as part of the NRIFS, these estimates will be incorporated into assessment processes and management considerations for eel harvest in Queensland.

### **By-product/Bycatch**

There are no by-product species taken in the Queensland adult eel fishery, as eels are the only freshwater fish that can be taken for trade or commerce. Any bycatch taken is required to be released.

No studies have yet been undertaken specifically to document and quantify the bycatch taken in the Queensland adult eel fishery. Reports from members of the public have suggested that the fishery has a low level of incidental capture of non-target species. However, bycatch is assumed to be low due to the small scale of the fishery, the restrictions on traps used, the restriction of fishing effort to artificially impounded areas, and the closure of waters in which eel fishing is considered a risk to other aquatic fauna.

No specific assessments or analyses have been conducted on bycatch in the juvenile eel fishery. Similar to the adult eel fishery, the amount of bycatch is considered to be minimal due to the fishing methods and gear used, and the management arrangements in force. The specific factors include the apparatus used to take juvenile eels and the use of bycatch excluding devices; Permit requirements that cod ends have an interface with the river surface, and a minimum cod end clearance time; the short set times for nets (to take advantage of tidal flows); and the 'low flow' locations fished (low flow rate enables larger, undesirable eels to swim out of nets).

### **Markets**

Almost all of Queensland's wild-caught adult eel catch is exported as live product to Asia, primarily Hong Kong and Taiwan (Debbie Brown, ABARE, personal comment, 2002; Carole Sitarz, Manchester Eels and Seafood, personal comment, 2002). The market for live, long fin eels is based on eels weighing more than 400 grams, with large eels attracting premium prices. Given that this creates an incentive to catch larger eels, the management strategy of closing natural waters to trapping ensures that the sustainability of the fishery is maintained by allowing adequate numbers of large eels to continue to migrate to the sea to spawn. A small percentage of adult eels are marketed to Europe in a frozen state and a very limited domestic market also exists in Australia for live, fresh and smoked eels. The Australian catch is less than 1% of world catch, with less than 5% of Australia's catch coming from Queensland (C. Sitarz, Manchester Eels and Seafood, personal comment, 2002).

## **PRINCIPLE 1**

**A fishery must be conducted in a manner that does not lead to over-fishing, or for those stocks that are over-fished, the fishery must be conducted such that there is a high degree of probability the stock(s) will recover.**

**Objective 1 The fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability.**

### ***Information requirements***

*1.1.1 There is a reliable information collection system in place appropriate to the scale of the fishery. The level of data collection should be based upon an appropriate mix of fishery independent and dependent research and monitoring.*

This report will address separately the adult eel trapping fishery and the juvenile culture stock collection fishery. Each criterion will contain the two sub-headings 'Adult Eel Fishery' and 'Juvenile Eel Fishery'. The separate treatment of the two fishery components reflects their separate nature. Commercial eel trappers collect adult eels from impounded waters and Culture Stock Collection Permit holders collect juvenile eels from rivers to supply seed stock for grow out in aquaculture systems. Adult eel trappers and juvenile eel collectors harvest eels at different life stages, utilise different gear types, and require different Authorities/Permits.

The separate treatment of the two fisheries in this report is for convenience and clarity only. Both target the same eel population(s) and therefore both fishing operations are jointly managed under the Plan for sustainability as a single fishery - the Queensland eel fishery.

### **Adult Eel Fishery**

Knowledge on the status of Queensland's stock of adult eels and the ability of the State's eel resources to sustain the present number of eel trappers is, at present, limited. However, with current research underway more comprehensive data will soon be available.

Both fishery dependent and fishery independent data are collected for stock assessment in the adult eel fishery.

Fishery dependent data is sourced from compulsory adult eel trapping catch returns. A Commercial Eel Trapping Catch Return Sheet for each catchment or impoundment trapped must be forwarded each month to QFS under section 118(1) of the Fisheries Act 1994 and section 109(1)(b) of the Fisheries Regulation 1995. Catch returns provide details of the:

- impoundment or catchment fished;
- total number of trap checks (whether eels have been captured or not);
- date transferred to buyer;
- weight transferred to buyer/s (kg); and
- details of buyer.

The catch return sheet system provides a paper trail from catcher to buyer to ensure information contained on the returns is correct. There is high compliance with the submission of returns, as Authorities will not be re-issued if catch returns are not up to date. If catch returns are not provided after a reminder letter is sent, an Authority holder may be asked to show cause as to why they should be allowed to remain in the fishery. If sufficient reason cannot be provided as to why the returns have not been submitted, re-issuing of the Authority may be refused.

In the past, summary reports of the catch return data have been provided to the FMAC (on request). The regular production of periodic catch return data summaries (e.g. six monthly) is currently being considered by QFS.

The second source of data on adult eels is independent of the fishery itself and comes from three sources:

1. A research project on adult eels;
2. QFS Long-Term Monitoring Program; and
3. Recreational fishing surveys such as the Queensland RFISH survey and the National Recreational and Indigenous Fishing Survey (NRIFS).

1. QDPI Agency for Food and Fibre Sciences, Fisheries and Aquaculture Division, in conjunction with the Fisheries Research and Development Corporation (FRDC) have a three year Adult Eel Project (hereafter referred to as QDPI-FRDC Adult Eel Project) currently underway. This project is due to be completed in 2002. The research project, along with a collaborative project in New South Wales, aims to determine demographic factors important for management modelling of the long fin eel fishery in Queensland and throughout Australia. The project also aims to develop the methodology and a database for collecting, analysing and sharing information on adult eel status and resource sustainability. It will develop the database structures, sampling techniques and statistical models to be used in ongoing monitoring by QDPI.

Successful management of sustainable adult eel fisheries requires first, a management system supported by demographic and fishery-based data, and second, a feedback mechanism in the form of an index of abundance. The current research project will provide the first and develop a methodology for the second.

Objectives of the project include:

- Estimate population parameters required for a management model - these include survival, density, age structure, growth, age and size at maturity and at recruitment to the adult fishery;
- Estimate the variability of the parameters among individuals in a range of habitats;
- Develop a management population dynamics model and use it to investigate management options;
- Establish baseline data and sustainability indicators for long-term monitoring;
- Assess the applicability of the above techniques to other eel fisheries in Australia, in collaboration with NSW; and
- Provide recommendations to Victoria.

Preliminary results from the QDPI-FRDC Adult Eel Project indicate that fishing of adult eels can substantially reduce the number of female spawners, since they are vulnerable to harvest for so long before reaching a size where they mature and migrate to spawn. Adult eel catchability also appears to be high in the artificial habitats of impoundments, based on anecdotal evidence of the rate of depletion. Trapping catch rates are also highly variable, with little apparent relationship to temperature or other environmental factors (QDPI-FRDC Adult Eel Project, unpublished data). Refuge areas with good access to the sea, where fishing is permanently prohibited, appear an effective way to maintain spawner numbers, and therefore both the supply of glass eels and the regeneration of adult stocks (Hoyle and Jellyman, in press). The panmictic nature of eel populations (random breeding and free interchange of genes within a population) gives closures particular power since recruitment sourced from the reserve is distributed throughout the species range (Hoyle and Jellyman, in press).

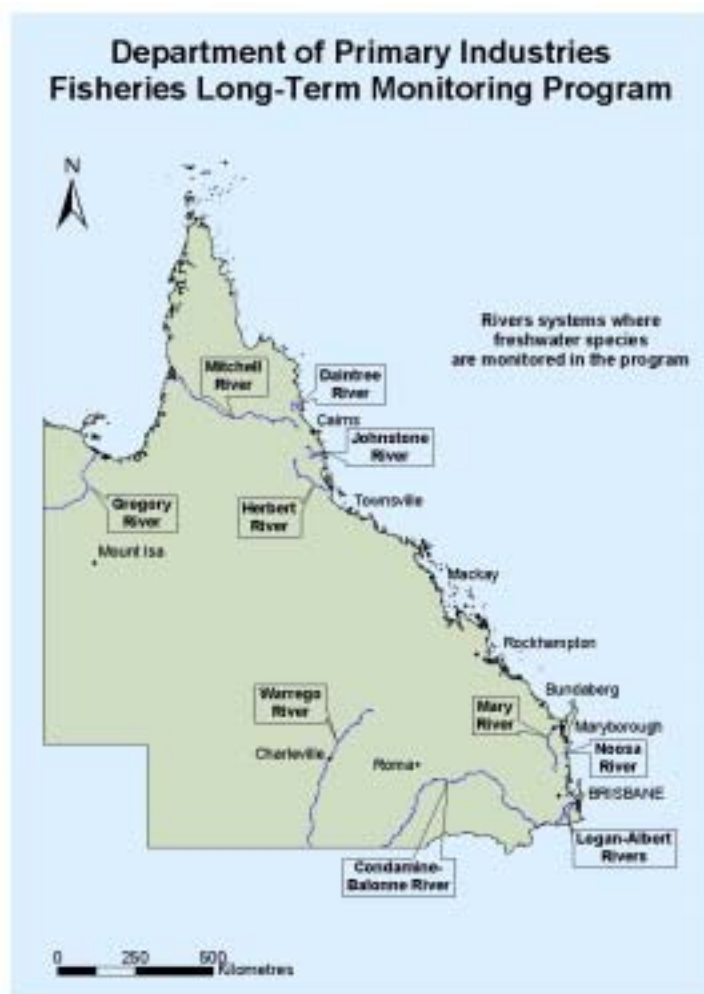
In Queensland, the network of such refuge areas is extensive, as all rivers, streams and other wetlands are closed to adult eel trapping. The only waters open to adult eel trapping are farm dams on private property (and a few public impoundments). Therefore, effectively all waters in the

natural distribution of eels, including rivers, creeks, lakes and swamps are set aside as refuge areas (closed to commercial trapping) for adult eels.

The long-term effect of closures to trapping is estimated by considering the effect of returning a proportion of the fishery's production to an unfished state (Hoyle and Jellyman, in press). The only waters open to adult eel trapping are the man-made storage facilities that are additional to the natural waters originally available to eels. These waters were not available to eels before agricultural activities commenced. This highlights the limited amount of water actually open to adult eel trapping and that waters covering the entire natural distribution of eels are set aside to ensure sufficient migration, spawning and recruitment of east coast eel stocks.

2. Fishery independent monitoring of freshwater fish (including eels), using boat-based electrofishing, is carried out annually as part of the QFS Long-Term Monitoring Program (LTMP). This program has on-going funding to enable the collection and development of long-term data sets. All fish caught during the surveys are identified and measured. The objectives of the LTMP are to

- monitor population changes of key recreational and commercial species by monitoring:
  - catch per unit effort (CPUE);
  - age structure;
  - size structure;
- monitor changes in species diversity; and
- monitor water quality and habitat conditions.



**Map 2** Rivers sampled in the Long Term Monitoring Program.

There are ten freshwater river systems throughout Queensland that are surveyed on an annual basis under this program (Map 2). Six of those are in the east coast drainage division where eels are found: the Herbert, Johnstone, and Daintree rivers in northern Queensland; and the Noosa, Mary, and Albert-Logan rivers in southern Queensland. Surveys are not undertaken in impoundments. This data is being used to develop the sustainability indicator in Objective 3 of the QDPI-FRDC Adult Eel Project above.

3. RFISH recreational fishing surveys are conducted by QFS every two years and provide ongoing estimates of recreational catch. The National Recreational and Indigenous Fishing Survey (NRIFS) undertaken in 2000/01 will also provide information on the impact of indigenous fishing on eel stocks.

#### *Existing enforcement / compliance arrangements for the collection of adult eels*

The Queensland Boating and Fisheries Patrol (QBFP) has the role of surveillance and enforcement of commercial eel harvesting, subject to the conditions, terms and restrictions of Authorities issued for these purposes.

As a condition of the Authority to Take for Trade or Commerce (issued to adult eel collectors) an Authority holder is required to notify the nearest office of the QBFP at least 24 hours before the commencement of, and within 24 hours of completion of trapping activities. This condition does not apply to any waters that are privately owned (eg farm dam) or to any water to which the public does not have access.

QBFP conducts field inspections of Authority holders' activities. Since the introduction, in 1999, by SunWater (owner of the majority of Queensland's public impoundments), of the policy to discontinue the practice of providing access to public impoundments for eel trapping, inspections by QBFP have declined. This decline has resulted from the lack of activity by adult eel trappers within public impoundments and the lack of public complaints.

Few public complaints are received by QBFP about the few adult eel trappers that still have access to public impoundments. Trappers that currently work in public impoundments regularly report their activities to the local QFS QBFP office before and after fishing activities.

Any person who fails to comply with Authority conditions or who is found committing an offence in relation to their Authority may be asked to show cause as to why the Authority should not be cancelled, revoked or suspended in accordance with Section 80 of the *Fisheries Act 1994*.

QFS QBFP also has a Fishwatch Hotline for members of the public to report illegal fishing activities.

#### *Juvenile Eel Fishery*

The holder of a Culture Stock Collection Permit and approved collection supervisors must each keep a Register book that records all movements of glass eels and must be made available for inspection by QBFP upon request. The register book must include, for each collection activity:

- date the arrangement was made with the Permit holder;
- permit holders name, address and Permit number;
- date of each collection;
- location of each collection;
- number of glass eels/elvers requested;
- number of glass eels/elvers taken during each collection;
- name of the person in charge of the collection;
- names of people who assisted during collection; and
- transport details to the approved area on the Aquaculture Licence.

The holder must provide a catch return for each day they fish, regardless of whether or not they catch any glass eels or elvers. The catch returns must be forwarded monthly to QFS and if fishing is not undertaken, a nil return must be lodged for that month. Catch returns must include:

- date of each collection trip;
- person who supervised the collection activities;
- collection location;
- number of kilograms of glass eels/elvers caught each night at each location;
- estimated number of glass eels/elvers per kilogram taken during each collection activity;
- type of collection apparatus/gear used for each collection activity;
- description of the collection site; and/or
- details of any eels purchased from Tasmania; and
- signed by the Permit holder.

The maintenance of accurate harvest information is required and is a condition of all Authorities, Permits, and Licenses to conduct eel trapping, collection, and culture.

#### *Existing enforcement / compliance arrangements for juvenile eel harvesting*

QBFP has the role of surveillance and enforcement of commercial eel harvesting, including glass eel collection for aquaculture, subject to the conditions, terms and restrictions of Permits issued for these purposes. QBFP also undertakes random inspections of aquaculture facilities to determine compliance with eel Aquaculture Licence conditions. The number of inspections conducted is determined by resource availability.

Holders of Culture Stock Collection Permits for glass eels and elvers must contact their nearest QBFP office prior to each trip and inform them of:

- date, time and place of each collection activity; and
- name of each person authorised to supervise and assist with each collection activity.

Additionally, a sign must be displayed when collection activities are being undertaken.

### **Assessment**

*1.1.2 There is a robust assessment of the dynamics and status of the species/fishery and periodic review of the process and the data collected. Assessment should include a process to identify any reduction in biological diversity and/or reproductive capacity. Review should take place at regular intervals but at least every three years.*

#### Adult Eel Fishery

Eel population dynamics are very different in most aspects from those of all other commercially fished species in Australia. The fishery is also highly dispersed, targeting many small populations with no interchange of pre-sexually mature adults between them. The unusual features of eel population dynamics include catadromy (migration from freshwater to the sea to spawn), presumed panmixis, environmental sex determination, low natural mortality, late maturation for females and death after spawning. These idiosyncrasies require tailored strategies for both assessment and fishery management.

Effective eel fishery management, as in all fisheries, requires a management system that is robust to the uncertainties about the species population dynamics and current status, and about the current and future effect of the fishery on the population. Eel population models developed using *A. dieffenbachii* (the New Zealand long fin) and *A. australis* (short fin eel) data from New Zealand have been used to demonstrate that for the New Zealand long fin eel a management system involving substantial areas closed to fishing is robust to the existing uncertainties. These

uncertainties include spatial and temporal variation in recruitment rate and population density, natural mortality and density dependence at various life history stages, and fishing mortality (Hoyle and Jellyman in press).

Such a management system appears suitable for maintaining both adult and glass eel supplies in *A. dieffenbachii* and *A. australis* (Hoyle and Jellyman in press). The model takes into account the high proportion of females taken, since the lack of migration between fished and unfished areas means that females in unfished areas are unaffected by adult eel trapping. The modelling indicates that the key issue is to ensure that sufficient unfished areas are maintained to supply viable levels of egg production. This model produced similar results in preliminary modelling for the Australian long fin eel *A. reinhardtii*.

Only artificially impounded waters are open to adult eel trapping in Queensland, and the decreased level of two-way migration over impoundment walls already reduces the contribution of these areas to egg production (McCleave 2001; Knights and White 1998; White and Knights 1997). Closing unimpounded areas to fishing ensures that fishing itself is likely to have limited further effects on sustainability of eel populations. The objective of management therefore is to maintain sufficient unfished areas to maintain egg production without any contribution from fished areas.

Given this management system, the activities of the fishery can only have a limited effect on the species' reproductive capacity, since adult eels outside artificial impoundments remain available to supply recruits. The main limitation on Queensland eel populations is therefore the proportion of Queensland's stream and riverine eel habitat that remains downstream of artificial impoundments. Such a robust management system reduces the need for comprehensive population assessments, which would in any case be impractical.

The highly fragmented nature of the eel resource makes it impossible to undertake detailed assessment throughout the fishery, or to estimate spawning stock biomass. No broad-scale eel fishery in the world has a robust estimate of spawning stock biomass, despite such fisheries having a far higher value in Europe, New Zealand and the United States than in Australia. Density estimation on a local scale has been attempted with some success, though local estimates of absolute numbers are often unreliable due to large variation in catchability at small spatial and temporal scales. The difficulty of assessing eel stocks in fished areas, of managing adult eel trapping effort effectively, and of preventing overfishing of long-lived, late-maturing females, are the reasons for developing a management system that relies on egg production from unfished areas.

Mark-recapture experiments have been recommended as one of the best ways to estimate eel population size in some environments (Niasmith and Knights 1990). The QDPI-FRDC Adult Eel Project has used mark-recapture in sections of impoundments, streams and rivers to attempt to estimate eel population density. Parallel electrofishing sampling experiments were run on random transects in impoundments, stream and rivers. Analysis of these experiments is not yet complete. Data obtained in the QDPI-FRDC Adult Eel Project will be used to develop a methodology for measuring indices of abundance. The mark-recapture experiments will also be used to determine if such procedures give meaningful estimates of absolute abundance.

In addition, the LTMP carries out annual freshwater electrofishing surveys at fixed sites in the six river systems previously mentioned (see Map 2, Section 1.1.1), estimating catch rates of freshwater fish species including eels. The electrofishing surveys as part of the LTMP began in 2000. The QDPI-FRDC Adult Eel Project is combining the LTMP survey results with project data to develop, by the end of 2002, a model-based index of abundance incorporating several size classes, which may reflect the status of eel stocks. It is important to note that the LTMP surveys are fishery independent, use electrofishing rather than eel trapping apparatus, and do not focus on impoundments (where all adult eel trapping occurs).

The presumed panmictic nature of eel populations means that localised depletion can be replaced with glass eels produced by spawners from other locations. That is, larvae do not appear to be capable of homing to the water bodies from which either or both of their parents came. It is assumed that adult eels from many areas come together at the spawning sites and that larvae intermix in the ocean and are transported back to rivers dependent on ocean currents. Recruitment into any river or lake is not dependent on where other eels are present or where the spawning eels came from (Arai et al. 2001). The overall level of recruitment may reflect spawning stock biomass, though other factors, such as access of adults to the sea, environmental effects on larval survival and oceanic transport, have substantial effects on local and overall glass eel supply. Glass eel supply at the freshwater/saltwater interface is highly variable in space and time in all eel species where it has been studied.

The model being developed as part of the QDPI-FRDC Adult Eel Project was also used to estimate demographic parameters for long fin eel *A. reinhardtii*. Parameters include fishing pressure, growth rate and growth variation, mortality rate, and length at maturity for both sexes. Data on sex ratio, size and age distribution of sampled eels are included in the model.

### Juvenile Eel Fishery

See adult section.

#### *1.1.3 The distribution and spatial structure of the stock(s) has been established and factored into stock assessment responses.*

### Adult Eel Fishery

Long fin eels inhabit coastal rivers from the Jardine River (Cape York, Queensland) to Wilson's Promontory (Victoria) as well as Tasmania. They also occur in New Caledonia and Lord Howe Island. Short fin eels are present in coastal rivers from the Pine River (South-East Queensland) to the Murray River (South Australia) and in Tasmania (see Map 2 Section 1.1.1). They are also widespread and common in New Zealand. The abundance of long fin eels is greatest in Queensland and New South Wales, while short fin eels are more abundant in Victoria and Tasmania (Kailola et al. 1993; Beumer and Sloane 1990).

East coast Australian and south west Pacific *A. reinhardtii* populations are believed to comprise a single interbreeding stock, with recruitment into Australian rivers determined by the East Australian Current system distributing eel larvae along the entire coast (Allen et al. 2002; McDowall 1996; WBM Oceanics Australia 1995; Beumer 1986). Therefore trapping of adult eels in impoundments will not directly influence recruitment to a particular river catchment. The degree to which removing adult females will decrease spawner numbers, and therefore reduce glass eel abundance, is managed by closing the majority of eel habitat areas to trapping.

Natural freshwaters such as rivers, streams, creeks, lagoons and natural swamps are not open to adult eel trapping and serve as natural refuge areas for eel stock regeneration and to allow mature adults to return to the sea to spawn. All waters that would have been available to eels before farm dams were built are closed to trapping of adult eels. These closed, unimpounded waters, include estuarine areas where male eels are predominantly found and upstream freshwaters, inhabited more frequently by female eels. This ensures adequate mature eels of both sexes remain to reproduce. Therefore the closed systems represent the entire original distribution of freshwater eels. The major factor influencing viable stock levels in these natural systems (migration of juveniles upstream and mature adults downstream) then becomes the presence of barriers such as weirs and dams as opposed to fishery operations. Eels do have the ability to negotiate extremely steep barriers and can traverse land in wet conditions so the barriers are generally not impassable but can slow eel movement. The provision of fishways on barriers provides additional access to some impoundments. To illustrate, juvenile eels have been

recorded using a vertical slot fishway on the Burnett River (Stuart and Berghius 2002). There are increasing requirements to incorporate fishways in Queensland impoundments.

Only very limited information is available about the extent of changes to eel habitat due to development. Development can both increase and reduce the productivity of eel populations. For example, in New Zealand, streams draining pasture support higher densities of eels than do streams draining forest (Rowe et al. 1999) and eels also grow considerably faster in pastoral habitats (Chisnall and Hicks 1993). The QDPI-FRDC Adult Eel Project consistently obtained very high catch rates of long fin eels *A. reinhardtii* at multiple electrofishing sites on the highly modified suburban stream of Kedron Brook. Moderately increased nutrient loads therefore appear to benefit eel populations.

The negative impacts that development can have on eel populations can take several forms. Acidity (Turnpenny et al. 1987) and chemical pollutants (Couillard et al. 1997; Brusle 1991) have both been found to reduce the productivity of eel populations. Productivity in unimpounded waters upstream of weirs or dams can also be reduced by the downstream barriers to migration that such structures can provide (White and Knights 1997). Glass eels are capable of climbing even high concrete dam walls given a trail of water to follow, but nevertheless barriers can increase mortality, discourage upstream migration, and reduce the supply of recruits. There are many such barriers, of numerous types, in Queensland's and eastern Australia's rivers and streams. There is, however, no database available on the distribution of these barriers or the quantity of habitat to which they affect access. It is also difficult to estimate how much such barriers affect eel recruitment to freshwater. Eel growth and mortality are density dependent (De Leo and Gatto 1996; Berg and Jorgensen 1994; Vollestad and Jonsson 1988), and eels tend to become female at lower densities (Krueger and Oliveira 1999), which would alleviate to some degree the effects of barriers to upstream movement.



**Map 3 Area open to adult eel trapping:** The East Coast Drainage Division is open to trapping of adult eels, with the exception of all coastal island catchments. Within this area, trapping is only allowed in artificially created impoundments in those catchments listed on an eel Authority, for which a trapper has gained access from the landholder or water-controlling agency. (See Appendix 2 for numbers of trappers with access to each catchment.)

All Queensland East Coast Drainage Division catchments are open to adult eel trapping with the exception of the Island catchments (see Map 3). However, adult eel trappers may only collect

eels from impoundments in catchments listed on their Authority (Appendix 2 lists how many trappers have access to each catchment). The five coastal island catchments in Queensland (Hinchinbrook, Whitsunday, Curtis, Fraser and Stradbroke Islands) were closed to adult eel trapping in 2000/2001. The catchments were closed to trapping on the basis that they either fall within national parks and/or World Heritage Areas, or they do not contain waters that meet the criteria to be included in the fishery area.

The fishery area is further restricted as commercial adult eel trapping is only allowed in public and private freshwaters which are impounded by an artificial/human-made structure, that is, a dam or weir. The fishery area is specifically provided for in the Plan as follows:

A person may only take eels from waters in –

- (a) an impoundment formed by a dam stated on an eel Authority; or
- (b) a privately owned, artificially created impoundment within a catchment stated on an eel Authority.

An example of (a) would be a public impoundment such as Cressbrook Dam. An example of (b) would be a farm dam. A definition of waters open to eel trapping was developed to confine eel trapping to impounded waters, and so that trapping could not occur in weirs and barrages. If the water above all weirs and barrages was open to adult eel trapping, this could mean entire river systems would be open to the fishery.

Water management agencies for public impoundments such as SunWater and SEQWater have a current policy of no commercial harvesting in storages under their control. Given this, the area of the adult eel fishery comprises mainly private impoundments, such as farm dams, in coastal catchments along the East Coast of Queensland.

### Juvenile Eel Fishery

Migrating juvenile eels form aggregations downstream of barriers, such as weirs, and shallows. Collection locations are limited to sites with relatively specific physical characteristics. In addition to the limited sites available for collection, the apparatus employed in taking juvenile eels incorporates design features that allow significant numbers of juveniles to escape and continue migrating. The irregularity and unpredictability of migration periods may also reduce the relative exploitation rate. These features of the fishery help ensure sufficient adult stocks survive for replenishment.

In Queensland, juvenile eels may be collected at, or downstream of, the most downstream dam or weir and up to 200m either side of the mouths of the rivers open to collection. For the purpose of these conditions, a tidal barrage is not a weir. In the approved rivers, collecting is allowed in tributaries (downstream of the most downstream dam or weir) that enter the main river below the most downstream weir. Because collecting activities have the potential to disrupt the migrations of other fish, collecting may not occur within a 10 metre downstream radius of the opening to the entry bay of any fishway associated with a weir or stream barrier. Collection may occur in closed waters listed under Schedule 3 of the *Fisheries (Freshwater) Management Plan 1999* (closures to fishing upstream and downstream of weirs and dams) provided that only apparatus specified on the Culture Stock Collection Permit is used and collection occurs only in the rivers open for the collection of juvenile eels.

Holders of Culture Stock Collection Permits may collect juvenile eels in any of the 21 rivers presently open for juvenile eel harvesting, at a maximum of three sites at one time (see Map 4, and Appendix 3).



**Map 4 Area open to harvest of juvenile eels/elvers:** The river basins associated with the 21 rivers open to harvesting of glass eels and elvers along the East Coast of Queensland. Within this area, collection of juvenile eels is only allowed at or downstream of, the most downstream dam or weir, and up to 200m either side of the river mouth (a tidal barrage is not considered a weir for the purpose of these conditions). In the approved rivers collecting is allowed in tributaries below the most downstream dam or weir on the river.

*1.1.4 There are reliable estimates of all removals, including commercial (landings and discards), recreational and indigenous, from the fished stock. These estimates have been factored into stock assessments and target species catch levels.*

### Adult Eel Fishery

Documentary evidence of commercial catches and fishing effort in the Queensland adult eel fishery is available from 1985 to present (Table 1). Data are derived from monthly Commercial Eel Trapping Returns for each impoundment fished. Submitting trapping returns is compulsory for all holders of eel Authorities. The catch weight data collected in catch returns is reliable data as it is also recorded at the buyer stage and the buyers name is recorded on the catch return which provides an auditable paper trail (introduced in 1995 in a national strategy to limit illegal fish trafficking).

Catches of adult eels from impoundments (Figure 2a) and the number of Authorities issued (Figure 2b) have fluctuated markedly over recent years. Eel catches increased rapidly up until 1989 as the fishery developed but then decreased when the number of eels available in public impoundments became less. Catches peaked in 1993 as attention turned from public impoundments to increased trapping in private farm dams but declined again in 1994. Fishers indicated that catches decreased further in 1995 and predicted that the trend would continue in the future as the few legally available fishery areas have been fully utilised. The extended period of below average rainfall which Queensland experienced over 1994-1995 could also have been a significant factor in eel catch trends.

**Table 1** Gross annual catch for the Queensland commercial adult eel fishery.

Year	Number of active eel trappers	Catch weight (kg)	Effort Number of trap checks	Trap checks per Authority holder	CPUE (kg/trap check)
1985	7	3766			
1986	22	43572			
1987	28	48585			
1988	31	26102			
1989	30	55940			
1990	19	38267			
1991	17	19583			
1992	28	22201			
1993	51	80620			
1994	42	77029			
1996	61	53966	31262	512.5	1.726
1997	58	56663	36124	622.8	1.569
1998	39	48885	26553	680.8	1.841
1999	34	44801	34005	1000.1	1.317
2000	32	46263	44795	1399.8	1.033
2001	29	51755	53210	1834.8	0.973

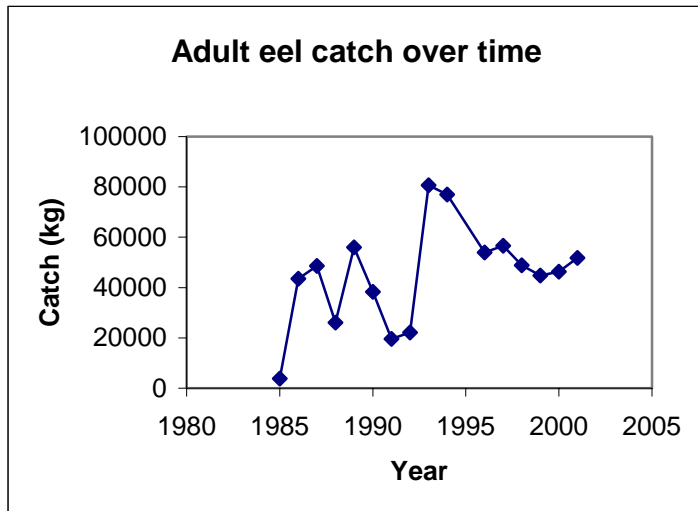
The increased dollar value of eel resources led to the expansion of the adult fishery and juvenile eel culture stock collection. Since 1996, trapping effort per active trapper has increased (trap checks per trapper), while catches have been declining. CPUE values have therefore declined over the past few years (Figure 2c). Suggestions for the declines in catch rates of adult eels in Queensland impoundments have included localized overfishing and limited recruitment from elvers migrating upstream, especially into larger impoundments where access opportunities for elvers are limited. The primary cause of declines in abundance in these large impoundments is the lack of access by eels. Fisheries in some large impoundments are based on eel populations believed to have been established before construction of the dams. In impoundments where access by eels from downstream is impossible, eel populations will eventually disappear with or without fishing.

Since the closure of the adult eel fishery to new applicants in 1999, the number of trappers has been slowly declining, as Authorities are not being renewed for various reasons.

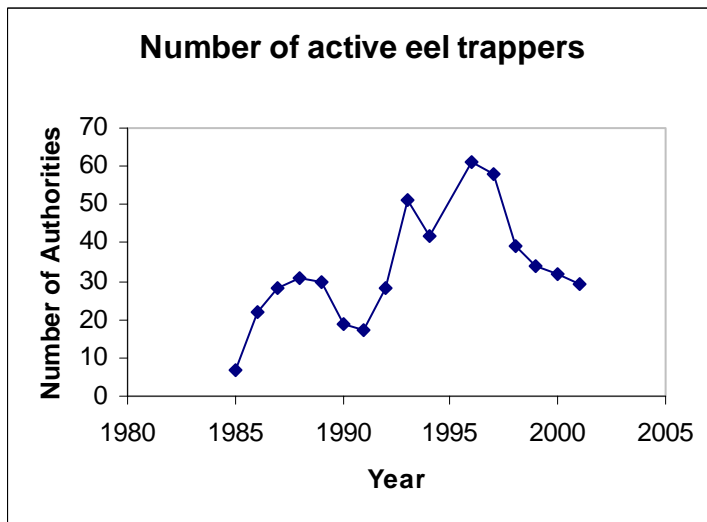
The adult eel fishery has followed a typical catch-effort pattern for a fishery starting with a large, unexploited stock that has variable, and in some cases little, opportunity for recruitment (into impoundments). Initial high catch rates were observed as the fishery went through a process of serially depleting available areas. Catch rates then decreased despite increased effort. Decreases were to be expected as some impounded areas have limited natural recruitment and there is no stocking program to compensate for the removal of adults.

Recreational fishers take a small number of eels each year. Queensland RFISH diary surveys are undertaken approximately every two years and provide an ongoing reference for recreational fishing. Surveys conducted during 1997 and 1999 revealed that less than 1000 freshwater eels are harvested annually in Queensland. A further survey is being undertaken in 2002 with results expected to be available in 2003.

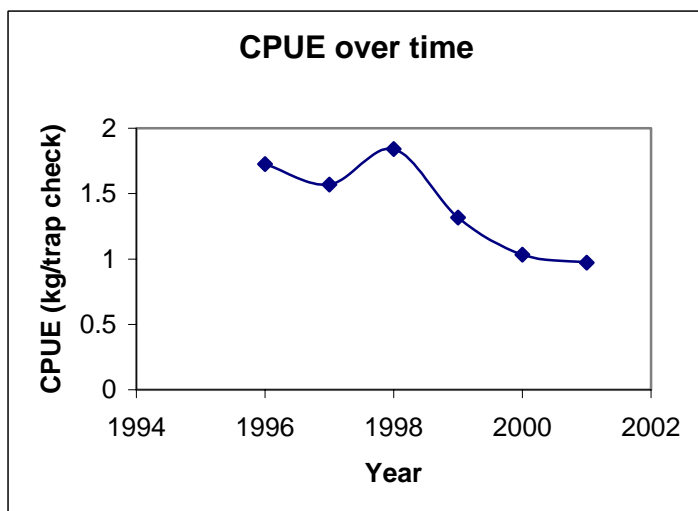
2a.



2b.



2c.



**Figure 2.** Annual catch (2a), number of active trappers (2b), and CPUE over time (2c) in the adult eel fishery.

The National Recreational and Indigenous Fishing Survey (NRIFS) will also provide data on the recreational catch in the eel fishery. The NRIFS results are expected in 2003.

The catch of freshwater eels of various species by Aboriginal and Torres Strait Islander fishers in Queensland is currently unknown. Interest does remain in the use of this food resource, particularly in North Queensland, and estimates of fishing community activity are currently being analysed for Queensland as part of the NRIFS with results expected in 2003. Preliminary comparisons of raw data collected from 11 indigenous communities in northern Queensland suggest that “eels” accounted for 0.05% of the total number of organisms harvested by indigenous fishers interviewed during the surveys. Once final estimates of the indigenous harvest are calculated as part of the NRIFS, these estimates will be incorporated into the management process for eel harvest in Queensland.

### Juvenile Eel Fishery

Holders of Culture Stock Collection Permits are required to provide monthly reports on catches of glass eels and elvers, as a condition of their Permit. The quantity of glass eels and elvers caught for grow out in Queensland aquaculture facilities is reported annually in the QDPI publication ‘Aquaculture Information: Report to Farmers’ (for example, Lobegeiger 2002). Aquaculturists are required, as a condition of their Licence, to report annually on their production of each species listed on their Aquaculture Licence. Figures have been collected since the commencement of the industry and are set out in the Table 2.

**Table 2** Eel farm stocking by aquaculturists in Queensland 1996/97 to 2000/01

Stocks (kg)	1996/97	1997/98	1998/99	1999/2000	2000/01
Elvers	0	6.0	3.0	0	0
Glass eels	105.5	67.4	30.1	35.7	60.0

One kilogram of glass eels may contain up to seven thousand individuals. However, the impact on wild stocks from the quantities harvested should be considered in perspective. Elver natural mortality rates can be extremely high. Jessop (2000) found 99.5% of elvers died during 1.3 km of movement over 2 to 4 months, due to density dependent effects, predation by resident larger eels, and the effects of low pH (acidity) in the particular river. The effects of density dependence on growth and survival suggest that the level of glass eel fishing that occurs in Queensland may have quite limited effects on eel populations. Highly variable juvenile eel recruitment into the fishery, which includes intermittent large pulses of recruitment, further limits the potential detrimental effects of glass eel/elver harvesting.

Recreational harvest of eels less than 30cm is not allowed. There is no known recreational or indigenous harvest of glass eels. The size of any indigenous harvest of eels less than 30cm is not known.

#### *1.1.5 There is a sound estimate of the potential productivity of the fished stock(s) and the proportion that could be harvested*

### Adult Eel Fishery

The QDPI-FRDC Adult Eel Project is developing appropriate management strategies for ensuring the sustainability of eel fisheries. These strategies should be completed in 2002. Preliminary modelling carried out by the QDPI-FRDC Adult Eel Project supports that the current management strategy of prohibiting adult eel trapping in un-impounded waters can effectively maintain eel spawning biomass, and limit the proportion that can be harvested. Since all long fin eels *A. reinhardtii* are thought to form a single interbreeding population, fished areas are replenished via egg production from all female eels. This includes both eels in unfished areas and those few females in fished areas that survive and are able to migrate downstream past impoundment

barriers. The preliminary modelling also allows recommendations to be made about the most efficient way to maximise yield in fished waters.

### Juvenile Eel Fishery

Based on the best available information on Australian glass eels stocks, primarily McKinnon et al.'s (2000) 'Assessment of Eastern Australian *A. australis* and *A. reinhardtii* glass eel stocks', commercial glass eel harvesting, albeit perhaps in smaller quantities than seen elsewhere in the world, may be a reality for the Australian eel fishing and aquaculture industries. As previously described, management of adult stocks is perhaps the most important determinant of the sustainability of juvenile and adult eel stocks.

### **Management responses**

1.1.6 *There are reference points (target and/or limit) that trigger management actions including a biological bottom line and/or a catch effort upper limit beyond which the stock should not be taken.*

### Adult Eel Fishery

Due to the small-scale nature of the fishery (26 active trappers in 2001) and the limited waters open to trapping there is no set total allowable catch. The limited information currently available on eel population dynamics renders the introduction of trigger points for the eel fishery (such as a biological bottom line or an upper catch effort limit) impractical. The results of current research under the QDPI-FRDC Adult Eel Project will enable a better understanding of appropriate reference points. At present, commercial CPUE is used to assess trends, but has limitations due to the serially depleting nature of the fishery and ongoing management changes, both of which tend to reduce catch and CPUE while allowing appreciable increases in the wild populations. Although there are no trigger points in place for the adult eel fishery, precautionary management arrangements were brought into place in 1997 in response to concerns from fishers about declining catch rates and the fishery was changed to limited entry. The widespread existence of what are effectively spatial closures ensures an appreciable proportion of the population is unexploited. The adult eel fishery continues to be managed on a precautionary basis through the arrangements provided under the *Fisheries (Freshwater) Management Plan 1999* including a change from limited entry to a closed fishery (closed to new applicants).

Given that the areas closed to fishing provide most of the egg production, population status in these areas is fundamental for fishery sustainability. The QDPI-FRDC Adult Eel Project is developing a fishery-independent CPUE indicator to be used with Long Term Monitoring Program data from annual surveys at sites closed to fishing. Development of the model to be used for this indicator is anticipated by December 2002.

### Juvenile Eel Fishery

See adult section above.

1.1.7 *There are management strategies in place capable of controlling the level of take.*

### Adult Eel Fishery

The adult eel fishery is managed under the *Fisheries Act 1994* (the Act) and its subordinate legislation the *Fisheries (Freshwater) Management Plan 1999* (the Plan). A copy of the plan, which provides control measures, is available at [www.legislation.qld.gov.au/Legislation.htm](http://www.legislation.qld.gov.au/Legislation.htm).

QFS has various mechanisms available under the Act to respond in a timely manner to threats to the sustainability of any fishery. These include the power to:

- (a) declare a closed season, closed waters or closed species (section 43 of the Act);

- (b) declare a quota for a fishery (section 44 of the Act);
- (c) make an emergency fisheries declaration (section 46 of the Act) where urgent action is needed to meet a significant threat to fisheries resources or habitat;
- (d) refuse to issue or renew an Authority (section 59 of the Act) where it is necessary or desirable for the best management or protection of fisheries resources;
- (e) impose conditions on issue or renewal of an Authority (section 61 of the Act);
- (f) amend an Authority through a 28-day 'show cause notice' (section 63 of the Act); and
- (g) amend an Authority by written notice (section 63 of the Act) – where the quota is to be changed.

The renewal of an 'Authority to Take Eels for Trade or Commerce' was recently refused by QFS for consistent failure to submit catch returns. The submission of 'Eel Trapping Catch Returns', under Section 118(1) of the Act, is viewed as a significant means of obtaining information about the Queensland Eel Fishery and an important basis for future management decisions. Further, QFS recognises that the long-term success and sustainability of the fishery are directly dependant upon all fishers providing timely and accurate catch and effort data. Failure to provide catch returns is taken seriously.

The adult eel fishery has been managed as a closed fishery (closed to new applicants) since 1999. This is the major input control on the fishery, along with the restricted area open to trapping and the limited number of traps allowed for use in each area.

Input controls in the adult eel fishery include the following:

- Closed to new applicants
- Restrictions on type and design of traps used;
- Limits to the number of traps used (number stated on each Authority);
- Restricted area open to trapping;
- Minimum mesh sizes for traps;
- Restrictions on when trapping can occur, that is, trapping cannot occur on weekends and public holidays in waters open to the public;
- Traps must be checked daily ie. within 24 hours of being set.

Adult freshwater eels are the only species that may be retained for trade or commerce by fishers in the Queensland Eel Fishery; no other species can be kept. There is a minimum size limit of 30 cm on eels for commercial and recreational fishers, and a combined in-possession limit of 10 eels (a combined total of 10 for all three species: long fin eel, short fin eel, South Pacific eel) for recreational fishers.

Schedule 2 of the Plan sets out the objectives for the management of the freshwater fishery and how these objectives are to be achieved and measured. The objectives of the Plan are to:

1. manage the taking of freshwater fish in a way that ensures –
  - (i) their sustainability and maintains or improves their conservation status;
  - (ii) a fair division of access to freshwater fish among commercial, recreational and Aboriginal and Torres Strait Islander fishers;
2. (2) manage the freshwater fishery to give optimal, but sustainable, community benefit; and
3. minimise the risk of damage to freshwater fish and their dependent ecosystems from non-indigenous and noxious fisheries resources.

The Plan sets out how the achievement of these objectives is to be measured. With regards to the adult eel fishery, achievement of objective (1) is measured by data collected from catch returns provided by eel fishers about eels taken and CPUE in the eel fishery. Further, objective (2) is achieved by measurement of recreational catch of eels through the Queensland RFISH telephone and diary surveys. A major review of the management plan must start at least five

years, but no more than 9 years, after the plan commenced (between 2004 and 2008) and the performance measures for the eel fishery will be reviewed as part of this major review.

The QFS retains the power through the legislative framework described above to alter management arrangements with respect to the harvest of adult eel populations in Queensland waters.

### Juvenile Eel Fishery

Culture Stock Collection Permits are not transferable however they may be amended. Aquaculture Licence's can be transferred, however the Culture Stock Permit associated with the Licence must be surrendered and the transferee must apply for a new Permit. Issue of a new Permit is not automatic, as it is dependent on QFS policies at the time of application.

Primary output controls on the juvenile eel fishery include:

- Quota related to the capacity of the associated aquaculture facility;
- Restriction on types of collecting gear;
- Maximum limits for net dimensions;
- Restrictions on waters open to collection of juvenile eels;
- Minimum cod end clearance times, that is, the cod end must be cleared of juvenile eels and any bycatch at least every 30 minutes.

Quota arrangements were introduced to address an unwanted trade in glass eels that was developing in the absence of quota controls and to match harvest to the carrying capacity of the grow out facility.

The management objectives of the juvenile eel fishery are the generic objectives applicable to all freshwater fisheries managed under the *Fisheries (Freshwater) Management Plan 1999* (the Plan). Schedule 2 of the Plan sets out the objectives for the management of the freshwater fishery (see section on adult trapping above for the objectives) and how these objectives are to be achieved and measured. The achievement of objective 1, which relates to sustainable harvesting (of juvenile eels), may only be measured by:

- data obtained from catch returns provided by eel fishers about eels taken and CPUE in the eel fishery; or
- data about catches of juvenile eels compared with fishing effort in rivers open to the collection of juvenile eels; or
- data about the number of culture stock collected by aquaculturists in particular locations compared with estimates of the status of freshwater fish stocks at the locations.

These performance measures will be re-evaluated during the review of the management plan.

The QFS retains the power through the legislative framework described above to alter management arrangements with respect to the harvest of juvenile eel populations in Queensland waters.

#### *1.1.8 Fishing is conducted in a manner that does not threaten stocks of by-product species.*

### Adult Eel Fishery

There are no by-product species utilised in the commercial adult eel fishery as no other species may be taken for trade or commerce and any bycatch is required to be released. For a description of the fishing apparatus see section 2.1.3.

Recreational fishers may take adult eels with any prescribed recreational freshwater fishing apparatus as defined in the Plan. These include fishing lines, funnel traps, collapsible traps, canister traps and dip nets.

### Juvenile Eel Fishery

Holders of Culture Stock Collection Permits may collect juvenile eels in any of the 21 rivers presently open for their harvesting in Queensland. Glass eels or elvers are collected for aquaculture immediately below spillways, generally weir spillways in upper estuaries. The collecting methods allowed (see section 2.1.3) ensure that sufficient eels remain for recruitment to the stock of adult eels within the river catchment. This is partly achieved through the operational mechanics of actively fyke nets. Although the diameter of the fyke net may be up to 4 metres, the height of the net mouth, when in use, fishes less than 2 metres through the river profile.

Also, cod ends are required to be fitted with a float to provide breathing space for mammals in the event of an incidental capture.

There are no by-product species taken in the glass eel fishery. Glass eel/elver collectors are not allowed to harvest other species for trade or commerce as an associated activity to glass eel collection.

Holders of Culture Stock Collection Permits are required to quickly return to the water at the place of capture all non-target, non-approved species.

*1.1.9 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.*

### Adult Eel Fishery

The objective referred to in this criterion is that “the fishery shall be conducted at catch levels that maintain ecologically viable stock levels at an agreed point or range, with acceptable levels of probability”.

Prior to the implementation of the Plan in 1999, a number of precautionary arrangements were introduced to maximise the probability that the Queensland eel resource would remain ecologically sustainable in the long term. These arrangements included limiting entry into the adult eel fishery and making adult eel trapping Authorities non-transferable. Authorities became non-transferable to prevent further expansion of the fishery and help limit effort levels and therefore limit pressure on the fished stock. Additionally, all natural water bodies were declared as refuge areas for eel stocks. This effectively confined eel trapping to artificially impounded waters. This provides the opportunity for all eels in natural waterways to mature and migrate to the sea to spawn without exposure to commercial fishing pressure, which increases the potential for successful recruitment back to both fished and unfished areas, and for maintaining the ecological viability of the stock. These arrangements have led to a spatial decrease in fishing effort; further restricting the waters open to trapping, while affording additional protection to stocks through closure of specified waters. Current water authority policies accentuate such conservation measures.

As there is no by-product in this fishery, there is presently no prescribed management response with respect to this component of the ecosystem.

### Juvenile Eel Fishery

In the case of juvenile eel/elver collection, only 21 river systems in Queensland are open to collection. In addition to the likely low impact to recruitment in these catchments from collection activities (see section 1.1.4, and Jessop 2000), the exclusion from fishing in the remaining rivers ensures adequate replenishment of stock occurs in this fishery.

As there is no retention of by-catch in this fishery, there is presently no prescribed management response with respect to this component of the ecosystem. In accordance with Queensland's commitment to sustainable fishery management, the issue of bycatch will continue to be monitored and should any negative trends arise, appropriate precautionary management responses will be implemented.

**Objective 2 Where the fished stock(s) are below a defined reference point, the fishery will be managed to promote recovery to ecologically viable stock levels within nominated timeframes.**

### ***Management responses***

1.2.1 *A precautionary recovery strategy is in place specifying management actions, or staged management responses, which are linked to reference points. The recovery strategy should apply until the stock recovers, and should aim for recovery within a specific time period appropriate to the biology of the stock.*

### **Adult Eel Fishery**

In response to concerns by researchers about the future sustainability of the fishery and taking into consideration international declines in eel stocks, interim management arrangements were introduced in 1997 for the adult eel fishery which:

- Excluded trapping from all naturally impounded waters to allow natural waters to remain as refuge areas for eels to mature and migrate to the spawning grounds; and
- Created a limited entry fishery where special circumstances were required to enter the fishery, such as demonstration of a past dependence on the fishery, until the management plan was gazetted.

The current precautionary management approach, based largely on spatial refugia, is analogous to population modelling of *A. australis* and *A. dieffenbachii* (the New Zealand long fin) in New Zealand (Hoyle and Jellyman in press), and similar preliminary modelling for *A. reinhardtii* in Australia. The modelling demonstrates that leaving a significant proportion of production unfished is an effective way of ensuring continued egg production, and therefore maintenance of the glass eel and adult eel fisheries. Traditional stock assessment techniques are not possible for freshwater species with such an unusual life cycle as *A. reinhardtii* and *A. australis*. The prevailing management approach is designed to ensure that ecologically viable stock levels are maintained.

The Act provides powers to review or revoke management plans or to take emergency action to rectify threatening actions should any be identified through established monitoring of the adult eel fishery and eel resource.

### **Juvenile Eel Fishery**

The glass eel fishery is not considered to be in need of a recovery strategy due to the apparent small impact of glass eel harvesting on the resource. However, the importance of managing the adult eel population with regard to recruitment suggests that the approach adopted for adult eel stocks is indirectly applicable to management of juvenile stocks. Similarly, necessary management responses can be invoked under the Fisheries Act 1994 where required.

1.2.2 *If the stock is estimated as being at or below the biological and/or effort bottom line, management responses such as a zero targeted catch, temporary fishery closure or a 'whole of fishery' effort or quota reduction are implemented.*

### Adult Eel Fishery

Given the present closure to fishing of the stock component that produces the majority of eggs, the adult eel fishery is highly unlikely to be responsible for stock decline.

The adult eel fishery is impoundment based. As impoundments are artificial waters that have resulted in increased permanent habitat, the benefits are in the larger survival and increased growth rates for eels in these waters.

QFS has the legislated power under the Act to apply management responses in a timely manner should such a situation arise that threatens the sustainability of the fishery such as declaring a closed season or closed waters (see powers listed in section 1.1.7).

### Juvenile Eel Fishery

See adult section.

## PRINCIPLE 2

**Fishery operations should be managed to minimise their impact on the structure, productivity, function and biological diversity of the ecosystem.**

**Objective 1 The fishery is conducted in a manner that does not threaten bycatch species.**

### *Information requirements*

*2.1.1 Reliable information, appropriate to the scale of the fishery, is collected on the composition and abundance of bycatch.*

### Adult Eel Fishery

No studies have yet been undertaken specifically to document and quantify the bycatch taken in adult eel traps. This is due to the small scale of the fishery and the fact that all eel trapping takes place in artificially impounded waters, mostly privately owned farm dams. The take of bycatch is assumed to be relatively low, given the nature and configuration of equipment used in the fishery.

A study currently underway by Dr Bruce Pease of NSW Fisheries is assessing bycatch in NSW where fishing techniques are similar to those used in Queensland (B. Pease, unpublished data, 2002). Preliminary results from the project are fishery independent but commercial gear was used to estimate levels of bycatch expected during commercial trapping activities. The NSW eel fishery operates primarily in estuarine waters but limited Permits are given for freshwater impoundments.

Research was carried out in both estuarine and freshwater areas. The freshwater traps used in this project were very similar to traps used in the Queensland adult eel fishery including the long cod end with rigid rings and a float attached. Estuarine traps were similar to freshwater traps with a much shorter 1.5 m cod end. The bait used in the project was the same as is used in the Queensland fishery - pilchards and mullet. Traps were set overnight in natural freshwaters, mostly flowing, and a few impoundments. Bycatch results (Table 3) are from 143 trap days with freshwater traps and 102 trap days with estuarine traps from November 1998 to September 2001.

No bycatch was recorded in the few impoundments where traps were used. This subset of data offers the best comparison with the Queensland eel fishery. Recorded bycatch in unimpounded waters included freshwater turtles, crayfish and fish. The only mortalities were in estuary traps and comprised approximately 10 long necked turtles. Some turtles were unconscious when removed from traps but recovered after some time in the sun. The “mortalities” are turtles that did not recover before the researchers left the area.

**Table 3** Preliminary results of a study of bycatch caught in eel traps in NSW (Source: B. Pease, unpublished data, 2002).

Common Name	Scientific Name	Number	Weight (g)
Long necked turtle	<i>Chelodina longicollis</i>	129	39540
Short necked turtle	<i>Emydura macquarii</i>	86	26135
Sydney crayfish	<i>Euastacus spinifer</i>	22	7320
Freshwater catfish	<i>Tantanus tandanus</i>	4	950
Striped gudgeon	<i>Gobiomorphus australis</i>	2	120

The results from the NSW study suggest that bycatch in eel traps is minimal and that trapping in impoundments is likely to result in even lower instances of non-target species being caught. Incidental catch of aquatic animals such as other fish species, freshwater turtles, waterfowl and

native water rats, may occur during fishing operations in the Queensland adult eel trapping fishery. Isolated reports from members of the public have suggested that the Queensland eel fishery has had an undetermined but low level of incidental capture (though not necessarily mortality) of non-target species such as freshwater turtles.

In combination, the restrictions on traps used, the restriction of fishing effort to artificially impounded areas and the closure of waters in which eel fishing is considered a risk to other aquatic fauna, contributes to sustainable adult eel fishing in terms of bycatch minimisation.

### Juvenile Eel Fishery

Whilst no specific assessments or analyses have been conducted, McKinnon et al.'s (2000) Assessment of Eastern Australian *A. australis* and *A. reinhardtii* glass eel stocks documented the species and abundance of bycatch caught in selected rivers of eastern Australia between 1997 and 2000 (see Table 4 for available sample data).

Anecdotal evidence from participants in the study suggests minimal mortality to bycatch taken in the fishery. This is achieved through the:

- apparatus used to take juvenile eels and the use of bycatch excluding devices;
- conditions on the Culture Stock Collection Permit that require cod ends to have an interface with the river surface, and a minimum cod end clearance time requirement;
- locations fished - low flow rate enables larger specimens to swim out of nets, and
- the short time nets are set (to take advantage of tidal flows).

Glass eel/elver collectors are licensed to use nets, dip nets and flow traps.

**Table 4** Bycatch species list in order of abundance, compiled from Stanmore Rd Crossing, Albert River, over the duration of the project (Source: McKinnon et al. 2000)

<b>Species</b>	<b>Total Catch (Individuals)</b>
Glass perch ( <i>Ambassis marianus</i> )	25216
Freshwater shrimp ( <i>Paratya australiensis</i> )	20453
Sea mullet ( <i>Mugil cephalus</i> )	13290
Fork-tailed catfish ( <i>Arius graeffei</i> )	6144
Flathead gudgeon ( <i>Philypnodon grandiceps</i> )	5335
Freshwater prawn ( <i>Macrobrachium australiense</i> )	3399
Greasy prawn ( <i>Metapenaeus bennettiae</i> )	770
Elver ( <i>Anguilla</i> spp.)	673
Silver biddy ( <i>Gerres ovatus</i> )	365
Bony bream ( <i>Nematolosa erebi</i> )	352
Empire gudgeon ( <i>Hypseleotris compressa</i> )	214
Bullrout ( <i>Notesthes robusta</i> )	176
Spotted scat ( <i>Scatophagus argus</i> )	120
Striped gudgeon ( <i>Mogurnda australis</i> )	105
Herring ( <i>Thryssa aestuaria</i> )	104
Hardyhead ( <i>Atherinomorus ogilbyi</i> )	71
Snub-nosed garfish ( <i>Arrhamphus sclerolepis</i> )	65
Juvenile crab (spp.?)	47
Bream ( <i>Acanthopagrus australis</i> )	33

Bearded worm goby ( <i>Taenioides cirratus</i> )	30
Pike eel ( <i>Muraenesox cinereus</i> )	25
Putty-nosed perch ( <i>Polydactylus sp.</i> )	22
Giant herring ( <i>Elops hawaiiensis</i> )	18
Adult longfin eel ( <i>Anguilla reinhardtii</i> )	16
Striped butterfish ( <i>Seleotoca multifasciata</i> )	15
Bridled goby ( <i>Arenigobius bifrenatus</i> )	10
Butter-bream ( <i>Monodactylus argenteus</i> )	6
Banded toadfish ( <i>Marilyna pleurosticta</i> )	6
Australian bass ( <i>Macquaria novemaculeata</i> )	5
Spangled perch ( <i>Leipotherapon unicolor</i> )	5
Winter whiting ( <i>Sillago maculata</i> )	5
Adult short fin eel ( <i>Anguilla australis</i> )	5
Blue-eye ( <i>Pseudomugil signifer</i> )	4
Large-toothed flounder ( <i>Pseudorhombus arsius</i> )	4
Jewfish ( <i>Argyrosomus japonicus</i> )	3
Mud crab ( <i>Scylla seratta</i> )	3
Dusky flathead ( <i>Platycephalus fuscus</i> )	3
River garfish ( <i>Hyporhamphus ardelio</i> )	2
Luderick ( <i>Girella tricuspidata</i> )	2
Goldfish ( <i>Carassius auratus</i> )	1

## **Assessments**

2.1.2 There is a risk analysis of the bycatch with respect to its vulnerability to fishing.

### Adult Eel Fishery

There are no specific assessments or risk analyses on bycatch species in the adult eel fishery as the impact is believed to be low. The fact that trapping only occurs in artificial impoundments reduces the likelihood of interactions between trapping apparatus and other non-target species. Evidence from a study in NSW on bycatch in eel traps showed only a very small incidence of bycatch being caught in eel traps in freshwater (see results in section 2.1.1).

Bycatch minimisation was taken into consideration when developing management strategies for the Queensland adult eel fishery, including trap design. Provisions for eel traps to provide access to surface air for trapped individuals and the requirement to check traps regularly helps to ensure that non-target individuals that may occasionally become trapped in eel traps can be returned to the water unharmed. However, there is still a low possibility that small fish could become meshed in the trap netting or that an air-breathing animal may become trapped and drown if it cannot access the surface while in the cod end.

### Juvenile Eel Fishery

The scale of the juvenile eel harvest fishery has not warranted a risk analysis of bycatch, however, the research performed by McKinnon et al. (2000) suggests that bycatch reduction devices fitted to nets and the use of dip nets and flow traps may prove effective in reducing bycatch. Anecdotal evidence suggests the incidence of bycatch mortality is minimal in the Queensland glass eel fishery.

## **Management responses**

*2.1.3 Measures are in place to avoid capture and mortality of bycatch species unless it is determined that the level of catch is sustainable (except in relation to endangered, threatened or protected species). Steps must be taken to develop suitable technology if none is available.*

### Adult Eel Fishery

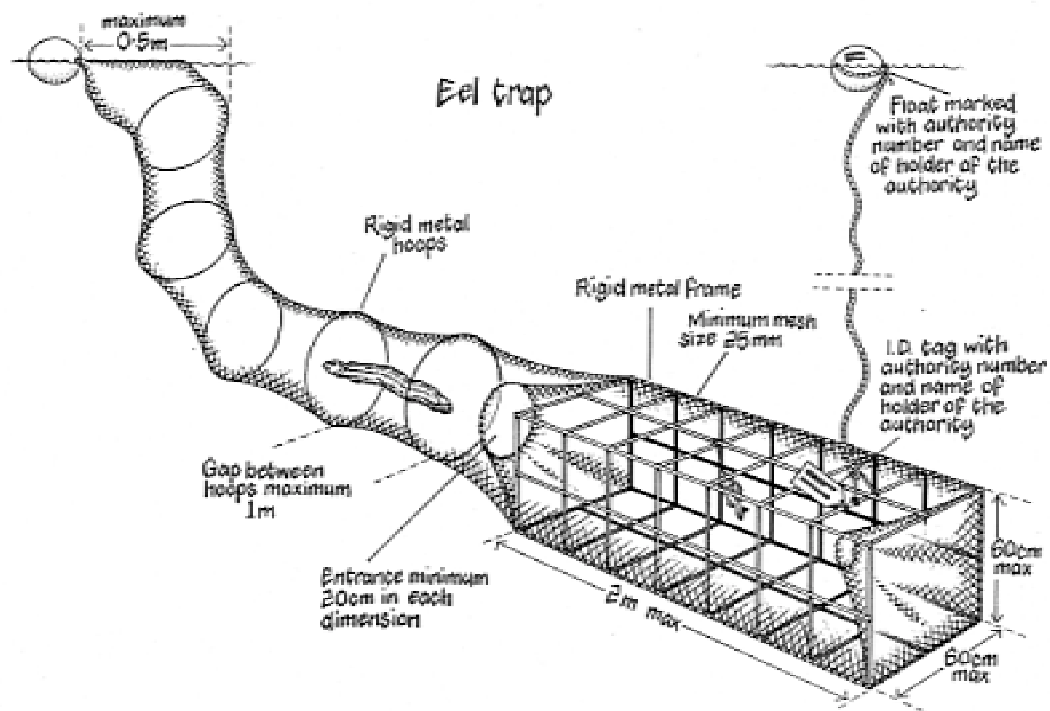
The issue of incidental capture of non-target indigenous species (e.g. platypus, turtles and water rats) was taken into consideration in the early development of management strategies for commercial adult eel trapping. Gear restrictions, such as the use of traps only in freshwater, limiting trap entrances to one, and the requirement to buoy cod-ends, are all aimed at minimising the impacts of commercial adult eel trapping on all non-target species.

Reports of non-target, native species mortality in winged fyke nets, once used for adult eel capture, resulted in this apparatus being banned in Queensland freshwaters for catching adult eels.

By restricting adult eel trapping to artificially impounded freshwaters, the probability of encountering any natural populations of endangered, threatened or protected species is reduced.

In Queensland, adult eels may only be taken commercially using baited eel traps (see Figure 3) or round traps that are usually set on the bottom of the impoundment. Traps are generally baited with pilchards or mullet.

- An eel trap may have maximum dimensions of 2.0 x 0.6 x 0.6 metres when set and round traps a maximum diameter of 1 m and 0.6 m height.
- The frame of the trap must be made of a rigid material and is usually covered by knotted or knotless nylon net.
- A trap (other than its pocket) must have a mesh size of at least 25 mm however any rigid meshes on the trap must be at least 22 mm in each of its dimensions.
- A float of at least 150 mm in each of its dimensions must be attached to each trap.
- The trap and trap float must be marked with the Authority number and full name of the holder of the Authority.
- A trap may have only one entrance, a one-way funnel, through which the eel enters as it attempts to reach the bait. Once inside, the small aperture of the funnel makes it nearly impossible for an eel to escape.
- A cod-end/pocket is attached at the opposite end of the trap to the entrance and holds the catch until the eels can be removed. The pocket must be long enough to reach the water surface. The cod end may also have only one funnel entrance from the trap itself to the pocket and it must have an aperture of at least 20 cm in each of its dimensions.
- The tail of the cod-end must be attached to a float or buoy of adequate size so that at least some of the cod-end floats at the surface to allow trapped animals access to surface air.
- The pocket must also have rigid frames, no more than 1 m apart and at least 20 cm in each of its dimensions. The first must be no further than 1 m from the exit of the trap into the pocket and the last frame no more than 0.5 m from the end of the pocket. This reduces the likelihood that eels will be exposed to stress and anaerobic conditions in situations of high catch numbers. This also enables non-target species such as turtles to breathe at the surface and avoid drowning if caught in a trap.



**Figure 3** Diagram of a commercial adult eel trap used in the Queensland eel fishery.

Eels share freshwater environments with a number of other aquatic species that may occasionally enter eel traps. Most of these animals have a high conservation value and include platypus, freshwater turtles, waterfowl and native water rats.

Reports of mortality of non-target species resulting from adult eel trapping brought into question the degree to which this activity would impact on natural freshwater habitats such as streams, lagoons and swamps, and their fauna (eg. Beumer et al. 1981). As a result, natural freshwaters were closed to adult eel trapping, reducing the likelihood of bycatch. The closure to trapping of the natural freshwaters has the added benefit of allowing these habitats to act as reservoir (unexploited) areas of eel stock for growth and development.

In waters open to eel trapping (impoundments formed by a dam or privately owned artificially-created freshwater impoundments), the requirement to have a pocket long enough to reach the water surface, and an adequate float attached to its end, is to ensure that any air-breathing, non-target bycatch such as turtles, waterfowl and platypus that enter the trap can reach the surface to breath. It is also a requirement that traps must be checked and cleared within 24 hours of being set. This is primarily for quality maintenance of captured eels but also increases the probability that any trapped bycatch is released alive.

No by-product species are taken in the Queensland adult eel fishery. Eels are the only freshwater species that can be taken for trade or commerce. Any by-catch trapped is required to be released in good condition as soon as possible.

### Juvenile Eel Fishery

See 2.1.2.

Under a Culture Stock Collection Permit, juvenile eels may be collected by the holder, in any of the 21 rivers presently open for their harvesting in Queensland. Glass eels or elvers are collected for aquaculture below spillways, normally on weirs in upper estuaries or near shallows. Although bycatch is not considered a significant concern, licensing requirements are in place to minimise



*2.1.5 There are decision rules that trigger additional management measures when there are significant perturbations in the indicator species numbers.*

#### Adult Eel Fishery

Indicator bycatch species are not monitored in this fishery (see 2.1.4 above).

#### Juvenile eels

Indicator bycatch species are not monitored in this fishery.

*2.1.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.*

#### Adult Eel Fishery

Adult eel traps are highly selective for eel capture which reduces the likelihood of interactions between the fishing gear and other non-target species. All natural waters are closed to adult eel trapping therefore any impact on the natural ecosystem is minimal. The artificial nature of impoundments that are open to adult eel trapping also reduces the probability of encountering significant amounts of bycatch. Trap design also takes into consideration the possibility that non-target species may occasionally enter the traps and provides mechanisms to ensure the survival of these species. There is a provision to ensure access to surface air in the cod end of the trap to enable any air-breathing species such as turtles, waterfowl and platypus that may be caught to have access to air. These management arrangements act to ensure that the fishery is conducted in a manner that does not threaten bycatch species.

#### Juvenile Eel Fishery

Current arrangements are considered adequate for the level of risk associated with impact on non-target species.

**Objective 2 The fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.**

#### **Information requirements**

*2.2.1 Reliable information is collected on the interaction with endangered, threatened or protected species and threatened ecological communities.*

#### Adult Eel Fishery

There have been very few reports (all of which have been anecdotal) of non-target species such as freshwater turtles being caught in adult eel traps.

The provision that some of the trap pocket must be buoyed at the surface is to ensure air-breathing non-target species such as turtles and platypus can survive until traps are cleared (within 24 hours of being set). Additionally, trapping is not allowed in natural waterways such as creeks, streams, rivers, swamps and lagoons where these species are more likely to occur.

Adult eel trapping activities are not authorised in any threatened ecological communities as defined in the Environment Protection and Biodiversity and Conservation Act 1999 (EPBC Act).

### Juvenile Eel Fishery

Whilst no specific assessments or analyses have been conducted, the research performed by McKinnon et al (2000) documents the species and abundance of bycatch caught in selected rivers of eastern Australia. No high conservation species were recorded in the assessment.

Juvenile eel/elver harvesting activities are not authorised in any threatened ecological communities as defined in the EPBC Act.

### **Assessments**

2.2.2 *There is an assessment of the impact of the fishery on endangered, threatened or protected species.*

### Adult Eel Fishery

There is no formal assessment of the impacts of fishing activities on endangered, threatened or protected species. Management measures to minimise impacts on non-target species, such as turtles, include the specifications that traps must have a floated pocket long enough for any trapped animals to have access to surface air. Trapping is not allowed in any natural water bodies, only in artificially created impoundments, therefore the chance of fishing gear interacting with endangered, threatened or protected species is minimal.

There are a number of freshwater turtles (about 9 species) found in Queensland catchments that are open to adult eel trapping (about 9 species). Two species, the Fitzroy River tortoise (*Rheodytes leukops*) and the Mary River tortoise (*Elusor macrurus*), are listed as vulnerable. *R. leukops* is a riverine tortoise found only in the Fitzroy River and its tributaries (McDonald et al. 1981). It prefers fast flowing water and high water clarity relatively free of turbidity and sedimentation (Cogger et al. 1993). Both of these factors decrease the chance of *R. leukops* encountering adult eel trapping equipment in impoundments. *E. macrurus* is also a riverine tortoise, known only in the Mary River in south-east Queensland (Cogger et al. 1993). It prefers deep pools in the moderately broad mid-reaches of the river and has never been recorded in isolated waterholes such as farm dams. Accordingly, there is only a limited chance of *E. macrurus* encountering adult eel traps (Col Limpus, personal comment).

Platypus (*Ornithorhynchus anatinus*), while listed as common, is a fully protected species living in rivers east of the Great Dividing Range. Platypus use electrical receptors in their bill to find food (they swim with their eyes, ears and nostrils shut) and eat small water animals such as insect larvae, freshwater shrimps, and crayfish. It is likely that the bait used in adult eel traps (dead mullet or pilchards) do not attract platypus as the bait is not alive and does not produce any electrical currents.

No interactions between platypus and eel traps were recorded during sampling conducted in Queensland under the QDPI-FRDC Adult Eel Project (S. Hoyle, unpublished data, 2002), or in New South Wales (B. Pease, unpublished data, 2002).

Lungfish (*Neoceratodus forsteri*) and Mary River cod (*Maccullochella peelii mariensis*), both protected species, are also found in catchments open to adult eel trapping. However due to the nature of the waters open to eel trapping (artificially created impoundments, mostly private farm dams) these species are not encountered by adult eel trappers.

### Juvenile Eel Fishery

There has been no requirement for juvenile eel/elver harvesters to record any interactions with species of high conservation status. In addition, no monitoring program exists to record such data. However, the areas fished and apparatus and methods used in the fishery present minimal risk to high conservation status species.

2.2.3 *There is an assessment of the impact of the fishery on threatened ecological communities.*

Adult Eel Fishery

As mentioned under criteria 2.2.1, adult eel trapping activities are not authorised in any threatened ecological communities as defined in the EPBC Act.

Juvenile Eel Fishery

As mentioned under criteria 2.2.1, juvenile eel/elver harvesting activities are not authorised in any threatened ecological communities as defined in the EPBC Act.

**Management responses**

2.2.4 *There are measures in place to avoid capture and/or mortality of endangered, threatened or protected species.*

Adult Eel Fishery

In a direct attempt to decrease the probability of capturing non-target species including endangered, threatened or protected species, natural waters are not open to adult eel trapping. There is also a requirement to check traps within 24 hours of setting. Though this requirement is primarily aimed at ensuring the high quality of captured eels, it also increases the probability that any trapped bycatch is released alive. These measures, along with the requirement for the trap pocket to be buoyed at the surface to enable air breathing animals access to surface air, should ensure that any non-target species captured in traps can be released alive and in good condition.

Juvenile Eel Fishery

Present management arrangements require flow traps to include an effective by-catch excluder screen and for the cod-end on fyke nets to be cleared of juvenile eels and any by-catch at least every 30 minutes once submerged, to avoid mortalities. Also, cod ends are required to be fitted with a float to provide surface contact for breathing.

2.2.5 *There are measures in place to avoid impact on threatened ecological communities.*

Adult Eel Fishery

Adult eel trapping activities are not authorised in any threatened ecological communities as defined in the EPBC Act.

Trapping is only allowed in artificially created impoundments, the majority of which are privately owned farm dams, hence limiting the potential impact on threatened ecological communities. No naturally standing and/or flowing water bodies, such as lagoons, swamps, rivers and creeks are open to adult eel trapping.

The five coastal island catchments in Queensland (Hinchinbrook, Whitsunday, Curtis, Fraser and Stradbroke Islands) were closed to adult eel trapping in 2000/2001. The catchments were closed to trapping on the basis that they either fall within national parks and/or World Heritage Areas, or they do not contain waters that meet the criteria to be included in the fishery area (i.e. artificially created impoundments).

### Juvenile Eel Fishery

Juvenile eel harvesting activities are not authorised in any threatened ecological communities as defined in the EPBC Act. The footprint created from juvenile eel collection activities is considered insignificant due to the gear and methods employed during collection.

*2.2.6 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.*

### Adult Eel Fishery

At present, no formal trigger has been developed, and no formal management response outlined, in relation to bycatch in the Queensland adult eel fishery. However, if impacts on endangered, threatened or protected species are identified through public advice or directly by eel trappers, powers to control fishing activity directly are provided for under the Act, as listed in section 1.2.2. The management responses most likely to be used to mitigate adverse impacts on endangered, threatened or protected species include declaring a closed water if the impact is in a specific catchment, or declaring a closed season if the impact is due to seasonal patterns of behaviour in the species in question. An emergency fisheries declaration can also be made if urgent action is needed to meet a significant threat to fisheries resources or habitat. Likely emergency management responses include actively removing adult eel trapping activities from areas or times when interactions with sensitive species become apparent.

The restricted nature of the waters open to eel trapping and the provisions for trap design increase the likelihood that the fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.

### Juvenile Eel Fishery

The juvenile eel fishery in Queensland, similar to the adult eel fishery, has no formal trigger and no formal management response in relation to bycatch. However, the small size of the fishery, the restrictions imposed on the use and type of fishing gear, the limits on where fishing can take place, and the current management arrangements, all taken collectively, result in a high chance that the fishery is conducted in a manner that avoids mortality of, or injuries to, endangered, threatened or protected species and avoids or minimises impacts on threatened ecological communities.

**Objective 3 The fishery is conducted in a manner that minimises the impact of fishing operations on the ecosystem generally.**

### ***Information requirements***

*2.3.1 Information appropriate for the analysis in 2.3.2 is collated and/or collected covering the fisheries impact on the ecosystem and environment generally.*

### Adult Eel Fishery

The fishery is largely directed into areas where there has been appreciable change in the natural environment (e.g. dam construction), and towards artificially dense populations of eels in artificial habitats. It is therefore unlikely that the fishery will significantly impact on the productivity and functions of natural ecosystems.

No information is being collected specifically to quantify the impact of the adult eel fishery on the ecosystem and environment generally. All adult eel trapping in Queensland occurs in artificially created environments (eg. farm dams) and therefore has minimal impact on natural waterways. The lack of information is largely due to the very small-scale nature of this fishery and the suspected low impact it has on the environment in general.

The QFS LTMP freshwater surveys are fishery independent and use electrofishing rather than eel trapping apparatus. Accordingly, estimates of bycatch cannot be recorded but an indication of other species found in the area is attained. It should be noted however that the LTMP surveys do not focus on impoundments therefore the other species encountered in surveys are not an indication of those found in artificial impoundments where adult eel trapping is allowed.

### Juvenile Eel Fishery

Data on juvenile eel/elver harvest activities is required to be submitted for each month. The data is used for the best management of the eel aquaculture sector and for the purpose of monitoring quota. No detailed ecological information is collected.

### **Assessments**

2.3.2 *Information is collected and a risk analysis, appropriate to the scale of the fishery and its potential impacts, is conducted into the susceptibility of each of the following ecosystem components of the fishery.*

1. *Impacts on ecological communities*
  - *Benthic communities*
  - *Ecologically related, associated or dependent species*
  - *Water column communities*
  
2. *Impacts on food chains*
  - *Structure*
  - *Productivity/flows*
  
3. *Impacts on the physical environment*
  - *Physical habitat*
  - *Water quality*

### Adult Eel Fishery

Farm dams are often recognised and utilised for stocking with recreational or sportfish such as silver perch, sooty grunter, barramundi and crayfish (McCormack and Jackson 1991).

Adult eels are carnivores and major predators of young/small fish and crustaceans. However, eels generally only consume other fish less than 10% of their own body length (McCormack and Jackson 1991). Comprising a major part of stream biomass, eels are probably the most important predators in many freshwater ecosystems and play a key role in regulating populations of other organisms.

The fishery area for the harvest of adult eels is confined to artificially created impounded waters in order to minimise the likelihood of catching bycatch species such as platypus and turtles, which are more likely to be found in natural waterways. Abundant food resources in freshwater impoundments provide favourable conditions for eel growth.

The major impact on the natural ecosystem is probably the exploitation of the target species and its impact on the size of the spawning biomass of eels. Another potential issue is the reduction in biomass of a major predator from the food chain and how that effects the interactions of other species in the natural ecosystem. Significant changes to stream ecology by major reductions in

eel biomass have the potential to destabilise ecosystems, facilitating invasion by exotics among other problems. However, because the adult eel fishery is confined to artificial freshwater impoundments, natural ecosystems and food chains should not be affected by reductions in biomass in impoundments, as eel numbers in natural systems should remain the same.

The impacts of impoundment construction on eel movement in natural systems and any consequential impacts on food chain relationships are not documented.

The capture of adult eels using traps is unlikely to pose a significant threat to the physical environment. The fishing procedure involves setting traps on the bottom, where the water is shallow enough for the cod-end to reach the surface, or suspended above the bottom in deeper waters so the cod-end may reach the surface. Loss of traps is unlikely, as the fishery comprises only impounded waters.

Biological waste discharge is not a problem as traps are checked daily and catch is transferred to a holding facility.

Toxic or dangerous chemicals are not required for the fishing operation. However there may be minimal water pollution due to the use of small outboard motors on the small boats used for setting and retrieving traps.

### Juvenile Eel Fishery

To date, little information has been collected on the susceptibility of ecosystem components of the juvenile eel fishery. Available resources have been focussed on providing a better understanding of the target species itself – its basic biology and behaviour, population dynamics and factors related to capture processes.

The juvenile eel fishery is considered to have only a minimal impact on the ecosystem generally. Juvenile eel fyke nets are staked or weighted such that they have little impact on riparian, instream, or benthic habitat. In addition, nets must be at least 10 metres from the entry bay of any fishways associated with weirs or water barrages to limit the potential disruption to the migrations of other fish species.

Although most research to date has been focussed on the target species, data from current eel research projects (S. Hoyle, unpublished data, 2002; B. Pease, unpublished data, 2002) suggests that very little bycatch, including endangered, threatened and protected species, is caught in the juvenile eel fishery. Any bycatch that is caught is likely to have high survivability due to the management controls in the fishery, specifically: a 30 minute minimum cod-end clearance time; the requirement that floats must be attached to cod ends; and the requirement that all bycatch must be immediately returned at the place of capture.

Only 21 rivers in Queensland are open to juvenile eel collecting. The spatial scale of collecting is even more restricted however as only two rivers in 2001, and three rivers in 2000, were actually accessed for juvenile eel collecting.

The size of the juvenile eel harvest is also minimal. In 2001, three fishers collected approximately 8.7kg of juvenile glass eels while in 2000 six fishers collected approximately 13.3kg.

### **Management responses**

*2.3.3 Management actions are in place to ensure significant damage to ecosystems do not arise from the impacts described in 2.3.1.*

### Adult Eel Fishery

QFS has acted to minimise damage to natural ecosystems by closing all natural waters to adult eel trapping. As the fishery is restricted to artificially created impoundments such as weirs and dams, the potential for impacts on natural ecosystems is negligible. If impacts from the adult eel fishery are identified, appropriate management responses as provided for in the Act, such as closing waters, will be employed by QFS to prevent damage to the ecosystem.

### Juvenile Eel Fishery

Current management arrangements are considered to afford adequate provision to ensure that significant damage to ecosystems does not arise from fishery impacts. Net size and placement restrictions, the requirement to regularly check nets (every 30 minutes) and immediately release all bycatch, and the prohibition on retaining byproduct, all minimise the potential for ecosystem impacts. If potential impacts are identified, appropriate management responses as provided for in the Act will be employed by QFS to prevent damage to the ecosystem.

*2.3.4 There are decision rules that trigger further management responses when monitoring detects impacts on selected ecosystem indicators beyond a predetermined level, or where action is indicated by application of the precautionary approach.*

### Adult Eel Fishery

As described in 2.3.3, the fishery is restricted to artificially created impoundments such as weirs and dams therefore the potential for impacts on natural ecosystems is negligible. The necessity of formal triggers and ecosystem indicators is therefore not applicable.

### Juvenile Eel Fishery

No specific decision rules or ecosystem indicators have been formally developed as part of the management arrangements for the juvenile eel fishery. Monitoring of the fishery is based on fisher catch returns and annual fishery-independent sampling conducted under the Long-Term Monitoring Program. Given the current limited activity in the fishery, the potential for unforeseen ecosystem impacts is minimal. Should any impacts arise, QFS will respond through the processes and arrangements available under the *Fisheries Act 1994*.

*2.3.5 The management response, considering uncertainties in the assessment and precautionary management actions, has a high chance of achieving the objective.*

### Adult Eel Fishery

Under the current management regime, the impacts of the adult eel fishery on the ecosystem generally are considered to be minimal. Precautionary measures are in place, primarily the closure of all natural waters to adult eel trapping, which maximise the potential that adequate eel stocks remain in natural ecosystems and that the balance of interspecies interactions are not disrupted. The closure of natural waters also provides the opportunity for migration of mature eels to the sea to spawn thereby maximising the potential for sustainable levels of recruitment. The artificial nature of the waters open to adult eel trapping, and the specificity of eel traps for catching eels further minimise the impact of fishing operations on the ecosystem generally.

### Juvenile Eel Fishery

Bearing in mind the current state of the Queensland juvenile eel fishery, the current management arrangements are considered adequately precautionary to minimise the impact of fishing operations on the ecosystem generally.

Juvenile eel nets have little impact on riparian, in-stream, or benthic habitat and present limited potential disruption to the migrations of other fish species. No byproduct is allowed in the fishery and very little bycatch is taken. Any bycatch taken must be released immediately, and is considered to have high survivability due to the management requirement for regular net checks, and cod end floats.

Over the past two years, very little activity has occurred in the fishery. During 2000, only three rivers were accessed for juvenile eel collecting for a total catch of 13.3kg. In 2001, the activity dropped even further; two rivers were accessed for a total catch of 8.7kg.

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## Appendix 1 Guidelines for glass eel/elver quota applications

The following guidelines for determining glass eel/elver quotas have been prepared by QFS in consultation with the eel aquaculture industry representatives on the Glass Eel Working Group. Applications for a glass eel/elver quota need to justify the quantity of glass eels required to stock a production facility.

### Quota application procedures

Assumptions:

- Glass eel pieces per kg = 7000; therefore one glass eel weighs 0.143g
- Harvest size = average of 150g (average 6.7 pieces per kg).

**Note:** The legally marketable size for eels remains at 30 cm. This is Commonwealth legislation.

- Mortality rate = 50% (from glass eel to harvestable product)
- Grow out period = 12 months
- Super Intensive Recirculation system includes for example: oxygen injection, backup generator, denitrification unit, ultra-violet or ozonisation disinfection

GLASS EEL REQUIREMENTS BY PRODUCTION SYSTEM			
Production System	Production Unit	Yield (per production unit)	Glass eels required per production unit per grow out period
Super Intensive Recirculation	m <sup>3</sup>	400 kg	764g
Intensive Recirculation	m <sup>3</sup>	40 kg	76.4g
Ponds	m <sup>2</sup>	4 kg	7.64g

Note: Pond production is given for lined or earthen ponds at the equivalent of 40 tonne per hectare. That is: 10,000 m<sup>2</sup> (one hectare) X 4 kg per m<sup>2</sup> = 40 tonne

### Examples

(1) tank recirculation system

grow out tanks = 6 X 2500 litres each (6 X 2.5 m<sup>3</sup>) = 15 m<sup>3</sup>

15 m<sup>3</sup> @ 40 kg production per m<sup>3</sup>

= 600kg of harvestable product at 150 g each

= 4002 pieces (average of 6.67 pieces per kg)

@ 50% mortality = 8004 pieces of glass eels required

8004 X 0.143g (per glass eel)

= 1145 grams (total glass eels required for this system), the quota

**Quick method** = 15 m<sup>3</sup> @ 76.4 g (glass eels per m<sup>3</sup> from table) = 1146 g

(2) earthen pond(s)

ponds = 4 X 1600m<sup>2</sup> each (40 metres X 40 metres) = 6400 m<sup>2</sup>

6400 m<sup>2</sup> @ 4 kg production per m<sup>2</sup>

=25600 kg of harvestable product at 150 g each

= 170,752 pieces (average of 6.67 pieces per kg)

@50% mortality = 341,504 pieces of glass eels

341,504 X 0.143 g (per glass eel)

= 48.84 kg (total glass eels required for this system), the quota

**Quick method** = 6400 m<sup>2</sup> @ 7.64 g (glass eels per m<sup>2</sup> from table) = 48.89 kg

**Appendix 2** Number of eel trappers that have access to each catchment

<b>CATCHMENT NUMBER</b>	<b>CATCHMENT NAME</b>	<b>NUMBER OF TRAPPERS WITH ACCESS</b>
1	Jacky Jacky Creek	4
2	Olive-Pascoe River	4
3	Lockhart River	4
4	Stewart River	4
5	Normanby River	4
6	Jeannie River	4
7	Endeavour River	7
8	Daintree River	6
9	Mossman River	6
10	Barron River	7
11	Mulgrave-Russell Rivers	7
12	Jhonstone River	8
13	Tully River	6
14	Murray River	6
15	Hinchinbrook Island	0
16	Herbert River	9
17	Black River	7
18	Ross River	9
19	Haughton River	8
20	Burdekin River	12
21	Don River	10
22	Proserpine River	14
23	Whitsunday Island	0
24	O'Connell River	13
25	Pioneer River	14
26	Plane Creek	16
27	Styx River	14
28	Shoalwater Creek	11
29	Water Park Creek	12
30	Fitzroy River	20
31	Curtis Island	0
32	Calliope River	13
33	Boyne River	12
34	Baffle Creek	13
35	Kolan River	14
36	Burnett River	20
37	Burrum River	14
38	Mary River	19
39	Fraser Island	0
40	Noosa River	13
41	Maroochy River	15
42	Pine Rivers	15
43	Brisbane River	22

44	Stradbroke Island	0
45	Logan-Albert Rivers	19
46	South Coast	19

**Appendix 3** Rivers open to the harvest of juvenile eels and elvers for aquaculture

Albert River  
Burdekin River  
Caboolture River  
Fitzroy River  
Logan River  
Mooloolah River  
Noosa River

Barron River  
Burnett River  
Coomera River  
Johnstone River  
Maroochy River  
Mulgrave River  
Pine River

Brisbane River  
Burrum River  
Currumbin River  
Kolan River  
Mary River  
Nerang River  
Tully River