Australian Government

Department of Sustainability, Environment, Water, Population and Communities

Survey guidelines for Australia's threatened fish

Guidelines for detecting fish listed as threatened under the *Environment Protection and Biodiversity Conservation Act* 1999

Authorship and acknowledgments

This report updates and expands on a report prepared in May 2004 by Australian Museum ichthyologist John Pogonoski and approved by AMBS Senior Project Manager Jayne Tipping. The current (2011) report includes updates to the 2004 report and additional information regarding recently listed species, current knowledge of all the listed species and current survey techniques. This additional information was prepared by Australian Museum ichthyologists Dr Doug Hoese and Sally Reader. Technical assistance was provided by AMBS ecologists Mark Semeniuk and Lisa McCaffrey. AMBS Senior Project Manager Glenn Muir co-ordinated the project team and reviewed the final report.

These guidelines could not have been produced without the assistance of a number of experts. Individuals who have shared their knowledge and experience for the purpose of preparing this report are indicated in Appendix A.

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HOW TO USE THESE GUIDELINES

The purpose of this document is to provide proponents and assessors with a guide to surveying for Australia's threatened fishes listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

These guidelines will help you to determine the likelihood of a species' presence or absence at a site. They have been prepared using a variety of expert sources, and should be read in conjunction with the Department of the Environment's *Significant Impact Guidelines 1.1 - Matters of National Environmental Significance*.

These guidelines are not mandatory. Proposals failing to meet these survey guidelines for reasons of efficiency, cost or validity will not necessarily default to a judgement that referral is required (that is, that a significant impact is likely), especially where the proponent issues an evidence-based rationale for an alternative survey approach. Alternatives to a dedicated survey may also be appropriate. For example, a desktop analysis of historic data may indicate that a significant impact is not likely. Similarly, a regional habitat analysis may be used to form judgement of the likely importance of a site to the listed fish. Proponents should also consider the proposal's impact in the context of the species' national, regional, district and site importance to establish the most effective survey technique(s).

Failing to survey appropriately for threatened species that may be present at a site could result in the department applying the precautionary principle with regard to significant impact determinations. That is, if no supporting evidence (such as survey results) is presented to support the claim of species absence then the department may assume that the species is in fact present. The department will not accept claimed species absence without effective validation such as through these guidelines, other survey techniques (for example, a state guideline or an accepted industry guideline), or relevant expertise. Where a claim of absence is made, proposals should provide a robust evaluation of species absence.

Biological surveys are usually an essential component of significant impact assessment, and should be conducted on the site of the proposed action prior to referral. Surveys assist in the evaluation of impact on matters of national environmental significance by establishing presence or the likelihood of presence/absence of a species. Before undertaking a survey, proponents may wish to contact the Australian Government Department of the Environment's relevant assessment section to discuss their project and seek advice on appropriate survey effort and design.

Executing a survey to this model and identifying listed species presence does not in itself predict a significant impact. Species presence is one of many factors that increase the likelihood of significant impact. Proponents should use species presence as a consideration in establishing whether a significant impact is likely or certain. As part of the assessment process, sufficient information is usually required to determine if a species' presence at a site constitutes a 'population' or 'important population' as defined in the *Significant impact guidelines 1.1* publication. Information on whether the occurrence constitutes a 'population' or 'important population' will not necessarily be generated by surveys conducted using these guidelines.

These guidelines help determine presence or the probability of presence. They **do not** establish or assess species abundance, as the effort in terms of cost and time required for an abundance survey is much greater than that determining presence/absence. Effective abundance surveys would need to compare survey effort and techniques with further exploration of a proposal's context, including important population location(s), habitat importance, ecological function and species behaviour.

INTRODUCTION

These survey guidelines provide guidance on what should be considered when planning and undertaking species presence surveys for threatened fishes relevant to a referral to the federal environment minister under the EPBC Act. The individual taxa (species or subspecies) accounts provide a guide to the survey methods and effort (where available) that are appropriate for assessing whether those listed taxa occur at or near a specified site. Consequently, the guidelines focus on assessing the presence or likelihood of presence of taxa in a study area, rather than assessing the abundance of individuals.

The taxa accounts relate to the 49 fish taxa (species or populations) that are classified as threatened under the EPBC Act as at July 2010 (see Table 1). However, it is recognised that the EPBC Act threatened species list is dynamic and that survey guidelines are likely to be applied to some taxa not currently listed. Conversely, it is hoped that with ongoing conservation programs the populations of some taxa will recover and they can be removed from this list.

Much of the information presented in these guidelines has been obtained from both published and unpublished information (including Recovery Plans and 'grey literature'), and personal communications with experts and representatives of relevant state departments.

The content and integrity of information used for this report differs vastly for different threatened fishes (for example, some species have only recently been described and have rarely been collected by ichthyologists, whereas others were described in the early 1800s and have been collected by ichthyologists for many decades). All listed species now have a scientific name, but the appropriateness of these is still uncertain for a few species (for example, sawfishes). Recent molecular and morphological work on Australian freshwater fishes indicates that many more potentially endangered species are being discovered, with some species that were previously thought to be widespread now considered to have more restricted distributions.

The classification used here follows that found in Hoese and colleagues (2006), updated on the 'Australian Faunal Directory'. Common names used here are those recorded under the EPBC Act listing or the species profiles and threats (SPRAT) database. In some cases these may differ from the Australian Standard (see Yearsley et al. 2006; 'Australian Fish Names Standard 2007').

Note that the three species listed as conservation dependent are all commercial species and survey guidelines are not provided here. Various mechanisms are in place to monitor populations of these species and manage the fisheries through collaboration between local jurisdictions and the Australian Fisheries Management Authority (see AFMA 2006; 2009a; 2009b).

Table 1: Species listed as threatened under the EPBC Act as at July 2010.

Scientific name	Common name	EPBC Act status
Brachionichthys hirsutus	Spotted handfish	Endangered
Brachiopsilus ziebelli (listed under the EPBC Act as *Sympterichthys* sp. [CSIRO #T6.01])	Ziebell's handfish	Vulnerable
Brachiopsilus ziebelli (listed under the EPBC Act as *Sympterichthys* sp. [CSIRO #T1996.01]	Waterfall Bay handfish	Vulnerable
Carcharodon carcharias	Great white shark	Vulnerable
Carcharias taurus (east coast population)	Grey nurse shark (east coast population)	Critically endangered
Carcharias taurus (west coast population)	Grey nurse shark (west coast population)	Vulnerable
Chlamydogobius micropterus	Elizabeth Springs goby	Endangered
Chlamydogobius squamigenus	Edgbaston goby	Vulnerable
Craterocephalus fluviatilis	Murray hardyhead	Vulnerable
Galaxias auratus	Golden galaxias	Endangered
Galaxias fontanus	Swan galaxias	Endangered
Galaxias fuscus	Barred galaxias	Endangered
Galaxias johnstoni	Clarence galaxias	Endangered
Galaxias parvus	Swamp galaxias	Vulnerable
Galaxias pedderensis	Pedder galaxias	Extinct in the wild
Galaxias tanycephalus	Saddled galaxias	Vulnerable
Galaxias truttaceus hesperius	Western trout minnow	Critically endangered
Galaxiella pusilla	Eastern dwarf galaxias	Vulnerable
Galeorhinus galeus	School shark	Conservation dependent
Glyphis garricki	Northern river shark	Endangered
Glyphis glyphis	Speartooth shark	Critically endangered
Hoplostethus atlanticus	Orange roughy	Conservation dependent
Maccullochella ikei	Clarence River cod	Endangered
Maccullochella macquariensis	Trout cod	Endangered
Maccullochella peelii mariensis	Mary River cod	Endangered
Maccullochella peelii peelii	Murray cod	Vulnerable
Macquaria australasica	Macquarie perch	Endangered
Melanotaenia eachamensis	Lake Eacham rainbowfish	Endangered
Milyeringa veritas	Blind gudgeon	Vulnerable
Mogurnda clivicola	Flinders Ranges gudgeon	Vulnerable
Nannatherina balstoni	Balston's pygmy perch	Vulnerable

Scientific name	Common name	EPBC Act status
Nannoperca obscura	Yarra pygmy perch	Vulnerable
Nannoperca oxleyana	Oxleyan pygmy perch	Endangered
Nannoperca variegata	Ewens pygmy perch	Vulnerable
Neoceratodus forsteri	Australian lungfish	Vulnerable
Ophisternon candidum	Blind cave eel	Vulnerable
Paragalaxias dissimilis	Shannon paragalaxias	Vulnerable
Paragalaxias eleotroides	Great Lake paragalaxias	Vulnerable
Paragalaxias mesotes	Arthurs paragalaxias	Endangered
Pristis clavata	Dwarf sawfish	Vulnerable
Pristis microdon	Freshwater sawfish	Vulnerable
Pristis zijsron	Green sawfish	Vulnerable
Prototroctes maraena	Australian grayling	Vulnerable
Pseudomugil mellis	Honey blue-eye	Vulnerable
Rexea solandri (eastern Australian population)	Eastern gemfish	Conservation dependent
Rhincodon typus	Whale shark	Vulnerable
Scaturiginichthys vermeilipinnis	Redfin blue-eye	Endangered
Thymichthys politus	Red handfish	Vulnerable
Zearaja maugeana	Maugean skate	Endangered

CONDUCTING SURVEYS IN SIX STEPS

Step 1: Identify taxa that may occur in the study area

The first stage in the design and optimisation of surveys is to generate a list of threatened fishes that could potentially occur in the study area. A process is suggested below.

i) Characterise the study area

The boundaries of the study area must be clearly established. The study area should include the project area and any additional areas likely to be affected, either directly or indirectly, including areas that may be affected by downstream impacts. A detailed map of the study area should then be constructed revealing the type, locations and condition of native vegetation and important habitat features for fish, such as rivers, lakes, and wetlands. This process is not only critical to establishing which threatened species may occur in the area, but also in selecting appropriate survey methods and effort. An appropriate map will aid almost every survey regardless of survey technique.

ii) Establish the regional context

This stage requires an assessment of the habitat frequency and function. The regional context will help develop judgements of significance associated with the loss or disturbance of habitat. A useful test will involve the following questions:

- Are the habitats rare or common?
- Are the habitats likely to be critical to species persistence?
- Are the habitats permanent or ephemeral?
- How is the species likely to use the site (for example, breeding, foraging, etc.)? Survey design may need to be adjusted to determine these aspects if necessary.

iii) Identify those threatened fishes that are known to, likely to or may occur in the region

This stage involves consulting a range of sources to determine which threatened fishes could occur in the study area and surrounding region. A range of sources should be consulted to create a list of taxa, including:

- databases of the Australian Government Department of the Environment, including the 'Australian Faunal Directory', the protected matters search tool and the species profiles and threats (SPRAT) database that allow you to enter the site of interest and generate predictive maps, and information relating to threatened species distributions
- state, territory and local government databases and predictive models
- threatened species recovery plans and teams

- reference books such as the *Field Guide to the Freshwater Fishes of Australia* (Allen et al. 2002)
- published literature
- local community groups, researchers and anglers.

iii) Prepare a list of threatened taxa that could occur in the study area

This can be determined by comparing the habitat requirements of each threatened taxa identified in stage iii with the habitat types and features present within the study area (stages i and ii).

The taxa identified in this process are henceforth referred to as 'target' taxa.

Step 2: Determine optimal timing for surveys of 'target' taxa

For any proposal, the timing of fieldwork is critical to the whole process of surveying and reporting. Careful consideration of the required lead time is important as it may be necessary to undertake surveys at various times of the year depending on the nature of the assemblages and species in the subject area. Surveys over multiple years may be required where a single year's data is not adequate to determine the faunal assemblage or to address the environmental factors. There may also be a time-lag if appropriate fauna expertise is unavailable. Proponents should allow for this when planning projects. Commissioning fauna surveys as early as practicable in the planning/site selection phase of a development or scheme will help avoid potential delays in project approvals.

If it is not possible to survey for threatened taxa that have been previously recorded in the general location of the study area during the appropriate time of day or season, it should be assumed that these taxa do occur in the study area if suitable habitat exists (NSW DEC 2004). When determining the optimal timing for surveys of targeted fish species the following factors should be taken into consideration.

Time of day

To maximise the chance of detection, survey activities should be conducted at the time of day or night when the target species is most active or detectable. This may also be partially dependant on the survey technique used. For example, seine netting in lakes may be more effective when conducted at night rather than during the day (RIC 1997). Sampling may need to be conducted during the day and at night at some sites in order to obtain a more accurate sample of the fish assemblage of the area (Baumgartner et al. 2008).

Seasonal changes in abundance and detectability

Migratory species will need to be targeted using a different approach to non-migratory species according to the phase of their lifecycle, which affects their spatial and temporal distribution. Many surveys also target particular age classes which may not be detectable at various times of the year.

Changes in abundance between years

Major changes in abundance are common in freshwater environments in temperate Australia. Drought periods can result in localised extinctions. Sampling in early stages of drought can be important in identifying populations of threatened species, allowing removal for captive breeding where localised extinction is probable.

Changes in population size are well documented for the species currently listed as conservation dependent (such as gemfish and orange roughy), where fishing activities can reduce population (Rowling 1990). Ongoing monitoring of fish catch statistics is important for these species.

However, little information is available for most species on abundance changes over time.

Step 3: Determine optimal location of surveys

Habitat stratification

In some circumstances, the study area of interest will be small enough to allow a comprehensive search of the entire area within a reasonable period of time. The size of a searchable area will depend critically on the nature of the target taxa/taxon and the habitat and topography of the study area. For example, searching for highly cryptic species in dense cover will take far longer than searching for large, conspicuous species in clear water. If a comprehensive search of the whole area or target unit/habitat is feasible, then sampling will not be required and the data collected will be representative of the entire area. In many cases, however, the study area will be too large to permit a complete search within a reasonable timeframe, and selective searches or sampling procedures will be required (Royle & Nichols 2003).

Many study sites will contain a variety of distinct habitat types, especially if the area is extensive. Some of these habitats may be unsuitable for occupancy by the targeted taxa/taxon. An effective strategy to maximise the likelihood of detecting a particular taxon is to concentrate search effort within habitat that is favoured by them (RIC 1998). This will require stratification, or division, of the study area into regions of similar habitat types.

During stratification, the study area is usually partitioned on biophysical attributes first (for example landform, geology, elevation, slope, soil type, aspect, water depth), followed by vegetation structure (for example forest, woodland, shrubland, sedgelands). For fish surveys, this method may be adjusted to include attributes such as water salinity, turbidity, flow rates and habitat structure, for example, whether it is a large main channel, offstream wetland, or tributary. Preliminary assessment of the study area prior to commencing the surveys is useful for checking stratification units and further stratifying the area if necessary (NSW DEC 2004). In other situations, such as the inundation of vast floodplains, there may be little alternative but to implement a form of stratified sampling based on observation of habitat during the course of the survey.

Focussing search effort on favoured habitat can be a valuable strategy to maximise the likelihood of detecting target taxa. However, this approach requires that the habitat preferences of target taxa are adequately known, which for many threatened species may not be the case. The fewer the number of habitat association records that have been reported for a taxon, the more likely that any apparent habitat preference will be an artefact of the small sample. Furthermore, subsequent surveys then tend to focus on these apparently preferred habitats, which can further distort the perception of habitat preference. Therefore, investigators should not exclude particular habitat strata from survey designs unless it is well established that these habitat types are consistently less favoured by the target taxa than other types within the study area.

Targeted searches

An extension of focussing search effort on preferred habitat strata is the targeted search. In this case, search effort is confined to particular resources or habitat features that the target taxa/taxon are known to seek out, at least for some part of the day or season. These may include large woody debris, riffle zones and so on. Once located, these sites can be surveyed at appropriate times to determine whether they are visited by the target taxa/taxon.

The habitat preferences of fishes often vary between different species and also between different populations of the same species, due to variables such as phase of life history (larvae/juvenile/subadult/adult), diet (herbivore/carnivore), behaviour (migratory/non-migratory), available habitat (modified/unmodified) and so on. The ideal collection technique used for a particular species in a particular habitat (for example, a shallow rocky riffle) may differ from the collection technique used in another habitat (for example, a deep pool). This needs to be accounted for in the design and planning stage of the survey.

Step 4: Establish sampling design and survey effort

The previous sections on survey timing and location highlight important strategies to help optimise the chance of detection. Nevertheless, replicated sampling will often be required either to reveal the target taxa/taxon or satisfy the argument that the taxon is absent or occurs at a very low abundance within the study area. Bear in mind that information on species that occur at very low abundance may be important when considering the likelihood of a significant impact from any proposed actions. Sampling can be replicated in space (different locations at the same time) and time (same location at different times) or a combination of both (different locations at different times).

Spatial sampling

Replication in space will often be necessary for detecting populations that are at low density or clumped in distribution. Even after stratification, sampling may still be required if the area of favoured habitat is large or if the habitat preferences of the target taxa/taxon are varied or poorly known. There are two basic spatial sampling designs:

- random sampling, when all locations within the study area (or selected strata) have an equal chance of being sampled
- systematic sampling, when units are spaced evenly throughout the study area (or selected strata).

Systematic sampling will generally be superior because it produces good coverage, is easy to implement and is less subject to site selection errors.

In general, sampling units should be positioned sufficiently far apart such that individuals are unlikely to be detected from more than one sampling location, ensuring that the samples are independent. The distance between sampling positions will usually depend on the territory or home range size of individuals in the target population and their detection distance. The inter-sample distance will also depend on the survey technique being employed.

Ideally, the number of sampling units within the study area (or strata) should be proportional to its size, a principle referred to as “area-proportionate” sampling (MacNally & Horrocks 2002). However, a linear increase in sample number with area will become impractical at very large study areas.

For detection studies, a formal sampling design as outlined above may be less important than for studies aimed at estimating abundance, but it is still preferable, especially if stratification is required (RIC 1998).

Temporal sampling

Temporal replication may be necessary to detect populations that fluctuate in abundance, occurrence or detectability with time, especially when these fluctuations are unpredictable. For example, some taxa are highly mobile, especially in the breeding season, and may travel through or occupy regions within their range only for brief and unpredictable periods of the year. Consequently, regular sampling during and throughout the time of year when the taxa are known to most likely occur at the study area is desirable. Some locations may be occupied by target taxa/taxon in some years but not others, depending on environmental conditions.

However, sampling over many years will rarely be feasible. In some cases, previous records can provide information on the use of such sites by particular taxa. If threatened taxa have been recorded in the general location of the study area when conditions were appropriate, it would be expected that these species will return again, unless the habitat has irreparably changed. Where previous data are few or absent, assessment of the habitat will be vital and may provide the only indication of whether the site is likely to support these species when conditions are suitable in the future.

Temporal sampling may also be essential when the study area is small. In this situation, the individuals of some taxa will have territories or home ranges that include, but are not restricted to, the study area. Consequently, at any one time, some of these individuals will be absent from the study area and go undetected (MacNally & Horrocks 2002). Regular sampling over time is recommended as it will increase the probability that these individuals will be detected on at least one occasion. Off-study area sampling, whereby sampling is conducted in suitable habitat in the area surrounding the study area, is another means of addressing this problem. This effectively increases the study area, allowing greater spatial sampling, and enhancing the probability of detecting individuals with home ranges larger than the core study area. In practice, this is a useful strategy because temporal replication is often more costly to implement than spatial replication, as additional travel may be required to and from the study area.

Step 5: Select appropriate personnel to conduct surveys

The single most essential component of any survey is having competent observers (RIC 1998). It is an expectation of EPBC Act assessors that surveys are conducted by appropriately experienced observers who have excellent identification skills, including a good knowledge of fish ecology, at least in relation to the taxa or group being targeted. Observers should also have access to appropriate equipment (for example nets or electrofishers). Note that using much of this equipment requires appropriate experience and training. The need for excellent field identification skills of observers, and experience with the methods used, cannot be overstated.

Survey leaders should assess all contributors and, where necessary, provide training and guidance to maximise the effectiveness of all observers (for example Saffer 2002). The identity of observers should always be recorded to allow for the detection and possible statistical correction of differences between observers, if necessary (RIC 1998). Some indication of the previous experience of observers with the target taxa/taxon, and the identification challenges inherent in surveying for these taxa, should also be provided to help assess the competency of observers and reliability of observations.

The advice and assistance of relevant experts (ideally local) should be considered in the experimental design of fish surveys targeting nationally listed threatened fishes, and the operation of the equipment used. Such expert knowledge will help in the ultimate aim of the survey which is determining the presence or absence of particular threatened fishes while minimising or eliminating the number of deaths or injuries to the fishes collected. In addition, the nature of the equipment used in surveys of fishes and the physical characteristics of some of the species involved predicates that experts should be used in surveys where possible. For example, few people would be confident about successfully releasing alive a freshwater sawfish entangled in a gillnet.

Step 6: Document survey methods and results

Survey methods and level of search effort vary widely between studies. For this reason it is essential that survey reports include detailed information on the methods used and the level of search effort adopted. This should cover who was involved, what work was carried out and where, when it took place (both date and time of day) and how the survey was conducted, as well as the climatic conditions at the time. The survey report should follow the standard aims, methods, results, and discussion format common to all scientific research. Without this information it is difficult to interpret the survey results, and impossible to replicate the study for comparative purposes (RIC 1998). It is useful to record the GPS location of all sampling units and provide maps of the study area. Detailed descriptions of the habitat should also be recorded. Documenting the habitat occupied by target taxa during the survey process, and a site description, will add value to the survey at minimal extra expense (NSW DEC 2004). Documentation of observers and their skills is also important. Presenting a record of all fish taxa captured is desirable as it can provide a measure of survey effort and effectiveness.

Reports should also carry some justification of the survey design, whether it be opportunistic, systematic or focused on certain likely habitats. This would include information on the habitat types present and the survey effort given to each. For species that might be present at very low abundance, it is important to describe the likelihood of presence based on habitat descriptions made as part of the survey. Explanations on the timing of the survey, suitability of the weather and observations recorded should also be given.

Survey data should also be made available to state and territory environment departments so that it may be included in fauna databases where appropriate.

Welfare and survey impact issues

The welfare of target and other taxa should always be paramount. All persons handling fishes, especially threatened fishes, should be appropriately qualified and experienced in the use of techniques to minimise stress to fishes and to prevent damage after capture. Most states and territories have an Animal Care and Ethics Committee, or a similar body, that sets guidelines for acceptable practices for fish handling and research (for example, see Barker 2009: *A Guide to Acceptable Procedures and Practices for Fish and Fisheries Research*).

Methods such as gillnetting and electrofishing that have significant potential to cause disruption or harm to fish should be conducted in a manner that avoids exposing individuals to harm as far as possible. Brown and colleagues (1998) noted that electrofishing is a hazardous technique with strict safety requirements that needs to be carried out by experts. Methods should also be employed in a way that minimises damage to habitat (for example, trampling of vegetation). Some survey methods can require a permit under the EPBC Act and local or state government regulations. Most sampling of vertebrate species now requires animal care and ethics approval in most jurisdictions. Even visual surveys that might disturb fishes may require approval.

Fish should be handled as little as possible to avoid disturbing their protective mucous layer (RIC 1997). Particular care should be taken with freshwater fishes, which can easily be damaged from handling. All fish should be removed from nets and traps before sampling a new site to avoid disease translocation (Marina et al. 2008).

COLLECTING TECHNIQUES FOR THREATENED FISHES

The survey methods discussed in the following section introduce the main techniques used to survey fishes. They predominantly address freshwater and estuarine species, as few marine fishes are listed under the EPBC Act. This discussion is not intended to be exhaustive and the reader is referred to the following references for additional background information for freshwater, estuarine and marine fish survey techniques: Cadwallader (1984), Chapman (1993), Cowx (1990), Cowx and Lamarque (1990), Faragher and Rodgers (1997), Growns and colleagues (1996) and Nielsen and Johnson (1983).

Choosing appropriate collecting methods

A number of factors will influence what collection methods are chosen to sample fishes. These include, but are not limited to:

- conservation status and rarity of the species (destructive versus non-destructive methods)
- the size of the species to be sampled, which influences mesh size of nets, traps, baits, etc.
- physical habitat parameters such as stream size and characteristics, including flow rate, elevation, depth, width, habitat structure and navigability by boats
- physiochemical attributes of the water, for example, turbidity, temperature and salinity
- behaviours of individual species, for example, migratory or non-migratory, schooling or solitary
- seasons which affect rainfall, water temperature, air temperature and river flows
- costs/benefits.

Fish sampling methods can be broadly categorised into active and passive techniques. These are discussed further below.

Active methods

Electrofishing

Electrofishing is becoming an increasingly useful technique for sampling fishes, particularly in freshwater habitats, and King and Crook (2002) showed it to be particularly effective for small fishes. To promote safe operation and certification of equipment, an Australian Code of Electrofishing Practice (NSW Fisheries 1997) was prepared under the auspices of the Fishery Management sub-committee of the Standing Committee for Fisheries and Aquaculture (SCFFA). The Code was developed to provide a consistent and coordinated approach to training and safety across Australia (NSW Fisheries 1997).

Electrofishing has cost/benefit advantages over passive gear types. It is rapid, relatively less selective of size and species, and can be applied among threatened species, so it is the sampling method of choice for south-eastern Australian fish communities (Faragher & Rodgers 1997). The effectiveness of electrofishing is affected by the conductivity of the water, conductivity of the fish, size of the fish, water temperature and conductivity of the benthic substrate (Smith-Root Inc 1994). Water clarity limits the ease of capturing fish, as the visibility of the fish decreases in turbid water, and effective depth may be limited by clarity and the length of dip net handles. Polarised sunglasses help in locating stunned fish during the day, but generally waters over 3 metres deep cannot be sampled effectively (Smith-Root Inc. 1994). The effectiveness of electrofishing is reduced at very low water temperatures (Pidgeon 2004) and mortality of larger-bodied species (for example, eastern freshwater cod) can occur at elevated water temperatures (Knight, J.T. May 2010, pers. comm.).

The frequency of current output can be tuned to selectively sample for particular species. In general, the larger the body length of the fish being targeted, the lower the frequency necessary to stun the fish and vice versa. For example for smaller fish, a higher frequency of 100–110 Hertz may be appropriate, but for larger fish a lower frequency of 40–60 Hertz may be adequate. Voltage used varies according to water electrical conductivity. A high voltage is necessary in some mountainous areas, but minimal current is still produced due to low conductivity (Raadik, T.A. Mar 2004, pers. comm.).

Three types of electrofishers are generally used for collecting fishes in freshwater and occasionally brackish waters. These are backpack, boat-based and shore-based electrofishers.

Backpack electrofishers

Backpack electrofishing, to a maximum depth of operator hip height, is a useful collection method in shallow freshwater pools and riffles that are unsuitable for boating (Faragher & Rodgers 1997). Backpack electrofishing may be appropriate in shallow upland streams, but is generally not as successful in lowland rivers where water depth is greater than 1 metre.

Backpack electrofishing is also limited to water bodies with low to moderate salinity (Hannon 2008).

Boat-based electrofishers

Boat-based electrofishing is generally considered to be most efficient in areas of low turbidity (where fishes can be seen easily) and mid-range conductivity (100–500 ų S cm^{-1}) (Cowx & Lamarque 1990, in Faragher & Rodgers 1997). During the 'NSW Rivers Survey', boat-based electrofishing methods captured the greatest number of fishes and 50 of the 55 species sampled (Faragher & Rodgers 1997). Four of the five species it did not sample were rarely caught in the survey and were mainly estuarine (Faragher & Rodgers 1997). Boat-based electrofishing methods are useful for sampling fishes in areas that are navigable by boats and more than half a metre deep. The efficiency of boat-based electrofishing techniques decreases with increasing water depth, and at depths of greater than 3–4 metres benthic species may not be affected, or capture/recovery efficiency decreases (Raadik, T.A. Mar 2004, pers. comm.).

Shore-based electrofishers

Bank-mounted electrofishing devices involve a control box (or generator) mounted on the back of a truck or a trailer. Bank-mounted electrofishing is used in wadeable habitat, similar to backpack electrofishing, but can be applied in moderate to high salinities as it often uses the same power source as boat-mounted units (Hannon 2008).

Seine nets

Seine nets are lengths of netting, which are weighted at the bottom and supported by floats at the top. Seine nets are set to enclose an area and then dragged to the shore (Pidgeon 2004).

Seine netting typically has low associated fish mortality (cf. Knight et al. 2007), but it is not very effective in areas with moderate levels of vegetation, irregular bottom features or submerged debris, as fish are able to escape under the net (RIC 1997). The species of fish caught depends on mesh size, and is biased towards smaller and/or slower fish that are less able to avoid the net (Pidgeon 2004). For delicate freshwater fishes, pulling a seine onto a beach can result in loss of scales and other damage to individual fishes. In these cases, pulling the seine into a small circle near shore and scooping the fishes directly into a bucket or plastic bag using a fine meshed aquarium net is preferable. Using knotless, non-abrasive, polyester nylon mesh can also reduce damage.

Scoop and dip nets

Fine meshed aquarium scoop nets (stretch mesh of 1–10 millimetres) are particularly useful in freshwater environments. The fine mesh ensures minimal damage to fishes and catches are small and easily handled. The one-person seine nets (portable hand lift nets) commonly used in Japan and other Asian countries are particularly useful for collecting galaxiids and other freshwater fishes in narrow streams. They can also be used in estuarine environments, with minimal impact on the environment (Kanou et al. 2004).

Angling

Angling techniques can be particularly useful for catching larger, predatory threatened fishes such as freshwater cod (Faragher et al. 1993; Douglas et al. 1994). Angling methods include actively fishing with a rod and reel using live or dead baits, using set-lines with live or dead baits (that are often left and checked every hour or every few hours), and actively casting and retrieving lures (preferably with barbless hooks) to entice fish to strike.

Visual census

This technique involves identifying and counting fish by observation, not capture. This is best used in situations where the water is clear, allowing good visibility. It may be difficult to distinguish between some similar looking species (Pidgeon 2004). Visual census technique results can also be biased through the observational skill of the snorkelers, inconsistent or incorrect fish size estimates, and failure to detect fish (especially small individuals or cryptic species) (RIC 1997).

Passive Methods

Gillnets

Gillnets catch fish through the gill region, around the body or by tangling some part of the body such as protruding fin spines or rostral saw in the case of sawfishes (Chapman 1993; Growns et al. 1996). Gillnets are also known as mesh nets or panel nets when panels of gillnet of varied mesh size are attached to each other, and they are biased towards larger species of fish (Pidgeon 2004).

Gillnetting is effective in catching teleosts (bony fishes), but is likely to be one of the more destructive techniques as fishes easily drown if caught in the mesh for too long. Although gillnetting can be a destructive practice, it can also be a very effective non-destructive technique if short soak times are used, and the net is inspected every 30–45 minutes and fishes are carefully removed soon after capture (Lintermans, M. Dec 2003, pers. comm.). Bathing fishes in antiseptic before release may help to prevent any infections of wounds that occur during gillnetting (Raadik, T.A. Mar 2004, pers. comm.).

Panel nets are one of the most efficient methods of sampling large and medium-sized fish, in deep and/or turbid water (Faragher & Rodgers 1997), and can complement catches from boat electrofishing (Growns et al. 1996). Fish commonly caught in panel nets include highly mobile fish species with many spines (for example, Australian bass), and benthic fish. Panel nets consist of a series of short gillnet panels, generally three, with a different mesh size in each section to sample fishes of different size ranges. Panel nets are usually constructed from monofilament or multifilament nylon. It is more difficult to release fish from monofilament nets without causing damage (Lintermans, M. Apr 2010, pers. comm.).

Fyke nets

Fyke nets can be set overnight and the contents examined and counted the following morning. Issues that can arise with fyke nets are drowning (for example if platypus or turtles are captured) and predation of smaller fish if large fish (such as eels) are captured (Raadik, T.A. Mar 2004, pers. comm.). Fyke nets should be set to allow animals such as platypus and turtles to breathe at the surface of the water if they become trapped (Pidgeon 2004). Fyke nets work best (especially for freshwater cods of the family Percichthyidae and young-of-year Macquarie perch) with rising water levels (Douglas et al. 1994).

Other net traps

Small, lightweight, collapsible traps are well suited to sampling small, bottom dwelling, cryptic fishes such as *Nannoperca oxleyana*. Traps require a water depth of at least 20 centimetres to be effective (Knight et al. 2007). Galaxiads are also easily collected in overnight collapsible traps. In this instance, an airspace should be left at the top of the trap to prevent mortality due to drops in dissolved oxygen overnight (Biosis 2004).

GROUPING OF SPECIES

For the purpose of these survey guidelines, listed threatened fishes have been divided into ten groups identified below. Where collection methods, habitat preferences and/or geographical distributions are shared amongst the taxa within each group, the taxa are, in some instances, discussed together.

Group 1: Galaxiids (Family Galaxiidae)

This group consists of 12 species, nine of which occur only in Tasmania. The remaining species occur in South Australia, Western Australia, Tasmania and Victoria.

Group 2: Queensland artesian springs fishes

This group includes two gobies (family Gobiidae) and the redfin blue-eye, which are all exclusive to Queensland).

Group 3: Small south-eastern Australian freshwater fishes

This group includes four pygmy perches (genera *Nannoperca* and *Nannatherina*, family Percichthyidae), Murray hardyhead (family Atherinidae), Australian grayling (family Retropinnidae) and Flinders Ranges gudgeon (family Eleotridae). All but the last species occur in south-eastern Australia.

Group 4: Western Australian cave fishes

This group includes the blind gudgeon and blind cave eel which both occur in Western Australia.

Group 5: Queensland freshwater coastal drainage fishes

This group includes the Lake Eacham rainbowfish and honey blue-eye which both occur only in Queensland.

Group 6: Large freshwater perches and lungfish (Family Percichthyidae and Ceratodontidae)

This group consists of five large endemic percichthyids (perches), namely Mary River cod, Clarence River cod, trout cod, Murray cod, Macquarie perch and the Australian lungfish.

Group 7: Handfishes

This group consists of four endemic species of handfishes which are all restricted to Tasmania: red handfish, spotted handfish, Ziebell's handfish and the Waterfall Bay handfish. Ziebell's handfish and the Waterfall Bay handfish are listed separately under the EPBC Act at the time of writing, but are now considered to be separate morphs of *Brachiopsilus ziebelli*.

Group 8: Tropical Estuarine and Freshwater Elasmobranchs

This group contains the following species that are largely restricted to tropical rivers and estuaries in the Australasian region: speartooth shark, northern river shark, dwarf sawfish, freshwater sawfish and green sawfish.

Group 9: Marine sharks

This group contains three of the larger, ‘charismatic’ marine sharks that probably occur in all Australian states and territories to some extent, and also have populations outside of Australian waters. These are the grey nurse shark (east and west coast populations), great white shark and whale shark.

Group 10: Estuarine skate

This group includes a single species of skate (Maugean skate, Family Rajiidae) confined to harbours in estuarine environments of western Tasmania.

TAXONOMIC ISSUES

The classification presented in this document follows Hoese and colleagues (2006), with updates present on the 'Australian Faunal Directory'.

Family Atherinidae

Currently only one (Murray hardyhead, *Craterocephalus fluviatilis*) of the 36 species in the family is listed under the EPBC Act. The species was previously thought to be widespread, but is now known to be restricted to the lower portions of the Murray-Darling system, particularly in very low saline environments. It is now more restricted in distribution. It occurs with two related species (*Atherinosoma microstoma* and *Craterocephalus fulvus*).

Family Brachionichthyidae

Currently four of the 14 species of handfish are listed under the EPBC Act, most with very restricted distribution. Identification is possible using a study by Last and Gledhill (2009). That study showed that two of the currently listed species, Ziebell's handfish and Waterfall Bay handfish, are variants of a single species. Some species are widely distributed from NSW to South Australia and Tasmania, and others are restricted to narrow areas in Tasmania and/or Victoria. Two or three species can be expected at many localities, so proper identification is critical. Photos or live individuals are particularly important for identification.

Family Carcharhinidae

Currently two freshwater and estuarine sharks (*Glyphis*) are listed under the EPBC Act. These two species occur in many of the same rivers in northern Australia and are easily confused because of their morphological similarity. The two differ in teeth and relative height of the second dorsal fin and some taxonomic experience is required for adequate identification (see Last & Stevens 2009).

Family Ceratodontidae

Only a single lungfish is known from Australia and there are no current taxonomic issues.

Family Eleotridae

Out of approximately 45 species only two, the blind gudgeon (*Milyeringa veritas*) and Flinders Ranges gudgeon (*Mogurnda clivicola*) are currently listed. Both are geographically isolated from related taxa in freshwaters and accurate identification is unlikely to present a problem.

Family Galaxiidae

Currently 24 species (of the genera *Galaxias*, *Galaxiella* and *Paragalaxias*) are recognised in the family in Australia, with approximately half listed under the EPBC Act. The listed species are often geographically isolated from related species and distinctive markings make identification uncomplicated. However, in some coastal streams, up to three species may be found in the same general area, so experience with identification is critical. Current, ongoing studies are indicating that the family may contain an additional 20 or more species in Australia. In coastal streams other non-listed galaxiids can occur with the listed species and identification should follow existing literature, such as that by Allen and colleagues (2002).

Family Gempylidae

Five species of the genus *Rexea* are known from Australia. The commercial catch is predominately the listed species, but precise identification requires taxonomic expertise (Parin & Paxton 1990; Nakamura & Parin 1993).

Family Gobiidae

The family contains over 300 species from marine and freshwater environments. The two species listed under the EPBC Act are restricted to artesian springs in Queensland. Identification requires specialists' aid, but at present there is no evidence that the two species occur together or with other members of the genus *Chlamydogobius*.

Family Lamnidae

Of the four species in the family, the great white shark is the only species listed under the EPBC Act, and it is relatively easy to identify from popular and scientific reference books.

Family Melanotaeniidae

Currently only one of the 16 species in the family, the Lake Eacham rainbowfish, is listed under the EPBC Act . The species is confined to the Atherton Tableland and difficult to separate from *Melanotaenia splendida splendida* (see Allen et al. 2002) and *Melanotaenia utcheensis* from the Johnston River. Adequate identification is often not fully possible without genetic samples due to hybridization between species.

Family Odontaspididae

Of the two species in the family known from Australia, currently the eastern and western populations of grey nurse shark are listed under the EPBC Act. It is unlikely that the two populations mix to any significant degree, if at all.

Family Percichthyidae

The family contains 17 freshwater species from Australia, with the only know relatives in South America. Eight species in the genera *Maccullochella*, *Macquaria*, *Nannatherina* and *Nannoperca* (one with two subspecies) are currently listed under the EPBC Act. The family includes species previously placed in the Nannopercidae, following Hoese and colleagues (2006).

Family Pristidae

The three sawfishes listed under the EPBC Act all occur in northern Australia and can be found in similar habitats, with juveniles commonly found in freshwaters. Each can be identified using the saw shape and teeth on the saw (Last & Stevens 2009).

Family Pseudomugilidae

Two of the seven species in the family are currently listed under the EPBC Act. Species are found in fresh and brackish waters of Australia and New Guinea. One is the only species found in the inland, but the listed honey blue-eye occurs within the range of the unlisted Pacific blue-eye. Markings on the species are distinctive and identification can be confirmed using Allen and colleagues (2002). In visual surveys, care needs to be taken not to mistake the species with the introduced eastern gambusia (mosquitofish).

Family Rajidae

Currently only a single ray (*Zearaja*) is listed under the EPBC Act. Although highly distinctive, it occurs in the same general area as other species in the family in Tasmania and identification should follow Last and Stevens (2009).

Family Retropinnidae

Currently only the Australian grayling is listed under the EPBC Act and identification is not complicated. The family includes at least three species and two genera found largely in freshwaters of south-eastern Australia. Recent molecular work indicates a more complex picture with multiple species and genetic stocks of *Retropinna* (Hammer et al. 2007), but similar work is not available for *Prototroctes.* The Australian grayling is sometimes placed in a separate family (the Prototroctidae).

Family Rhincodontidae

The single species in the family listed under the EPBC Act is the whale shark. It is a highly distinctive species, although it can be confused from the surface with the basking shark. Identification guides, such as Last and Stevens (2009) are widely available.

Family Synbranchidae

Four species of one-gilled eels are known from fresh and brackish waters of Australia. Currently only the blind cave eel (*Ophisternon*) is listed under the EPBC Act. It is a blind species found in caves in north-western Australia and not likely to be confused with other species.

Family Trachichthyidae

Currently the orange roughy is the only species of fourteen in the family known from Australia listed under the EPBC Act. Of the six species of *Hoplostethus* found in Australia, three exist in the same area and over a similar depth range as the orange roughy, so identification is not straightforward. Reliable identification requires experience identifying the species or specialist taxonomic knowledge (Gomon et al. 2008).

Family Triakidae

Of the eight species in the family, currently only the school shark is listed under the EPBC Act. It is a relatively well known commercial shark and identification is not particularly difficult, but experience with shark identification is necessary as other sharks occur in the same areas as the school shark.

SURVEY GUIDELINES FOR THREATENED FISHES

Group 1: Galaxiids

General information

Note that general identification, distribution and ecological information is available from Allen and colleagues (2002) for all species, and Jackson (2004) and Hardie and colleagues (2006a) for Tasmanian species.

Common name	Scientific name	Distribution
Golden galaxias	*Galaxias auratus*	Known only from freshwaters of Lake Sorell, Lake Crescent and associated streams in central Tasmania.
Swan galaxias	*Galaxias fontanus*	Known only from freshwaters of narrow sections of the Swan and Macquarie rivers in south-western Tasmania.
Barred galaxias	*Galaxias fuscus*	Found in highland streams of the Goulburn River system of Victoria.
Clarence galaxias	*Galaxias johnstoni*	Known only from freshwaters of Clarence Lagoon and associated streams in central Tasmania.
Arthurs galaxias	*Paragalaxias mesotes*	Known only from freshwaters of Woods Lake, Arthurs Lake and Lake River, central Tasmania.
Swamp galaxias	*Galaxias parvus*	Known from freshwaters of Huon and Gordan rivers and associated creeks and Lakes.
Pedder galaxias	*Galaxias pedderensis*	Originally known only from freshwaters of Lake Pedder and associated streams in Tasmania. Now listed as Extinct under the Tasmanian *Threatened Species Protection Act 1995*, although two populations have been established as part of a recovery plan in Lake Pedder and nearby Lake Oberon.
Saddled galaxias	*Galaxias tanycelphalus*	Known from freshwaters of Arthurs Lake and Woods Lake in central Tasmania.
Western trout galaxias	*Galaxias truttaceus hesperius*	Found in a small area in freshwaters of southern Western Australia.
Eastern dwarf galaxias	*Galaxiella pusilla*	Known from coastal rivers of south-eastern Australia from Mount Gambier, South Australia and the Mitchell River in Victoria and Flinders Island in Bass Strait.
Shannon galaxias	*Paragalaxias dissimilis*	Known from freshwaters of Great Lake, Shannon Lagoon, Shannon River and the Penstock Lagoon in central Tasmania.
Great Lake galaxias	*Paragalaxias eleotroides*	Known from freshwaters of the Great Lake in central Tasmania.

Survey methods

Survey techniques and methodologies applicable to most galaxiids are outlined below. Where special circumstances exist for particular species, these are discussed in the following section.

Best time of day for sampling

Most galaxiids have been collected during daylight hours when identification of individual species (and therefore subsequent release) is easier. However, Hardie and colleagues (2006b) found that night sampling gave the best results for the golden galaxias. Increasing evidence is now favouring night sampling, where quantitative assessment is being made. Also, many of the species are more active at night and found closer to shore. During the day some species are in depths where electrofishing is not feasible. Safety and logistics relating to habitat location need to be taken into account when selecting time of day for sampling.

For the Pedder galaxias and western trout minnow see the 'Additional information for particular species' section.

Season and weather considerations

With the exception of the swamp galaxias, time of year is not important for sampling Tasmanian galaxiid species as they are not migratory within freshwater (as far as is known) and they live for several years in the same habitat (Jackson, J., June 2003, pers. comm.). Some work has shown higher numbers found during the spawning season in autumn and early winter in Tasmania (Hardie et al. 2006b) for the golden galaxias. Fulton (1982; 1990) noted that some species may breed in summer (*Paragalaxias*).

See 'Additional information for particular species' for the swamp galaxias and galaxiids outside of Tasmania.

Most appropriate methods

In general, electrofishing or small scoop nets are commonly used to sample galaxiids. Electrofishing gives more quantitative estimates, but scoop nets are generally less likely to be harmful to individual fish. Small plastic traps are also sometimes used, but often have a low catch rate.

The methods used for collecting threatened galaxiids in Tasmania are outlined below. These methods were provided by Dr. Jean Jackson of the Inland Fisheries Service (IFS) Tasmania, and have been approved by the DPIWE Ethics Committee. See 'Additional information for particular species' for the swamp galaxias and galaxiids outside of Tasmania.

Combinations of methods are used for threatened galaxiids in Tasmanian waters. Electrofishing is used for streams and lake shores, according to the Australian Code of Practice (NSW Fisheries 1997), and operated in a way to minimise possible damage to fish. A flat dip net is used so fish can be slid into a bucket. At each monitoring site, a standardised time of electrofishing is undertaken. Electrofishing settings for galaxiids generally consist of 60Hz and 2 or 4 mS (I 3 or 4 on Smith Root 12B model backpack electrofisher). Voltage settings vary depending on water conductivities, but are generally between 200–700 V. The appropriate setting is usually determined by turning up the voltage until the sound is a broken beep, then backing off one setting to get a continuous beep. Generally the aim is to use as low a voltage as possible (Jackson, J. June 2003, pers. comm.).

Survey effort required for the collection of Tasmanian galaxiids depends on the habitat to be sampled. At least 30 minutes of backpack electrofishing is necessary for streams and lake shores.

Fine soft mesh fyke nets are used in lakes and left overnight. These nets are efficient for collecting galaxiids whilst having minimal impact on them. Nets are constructed and set according to Inland Fisheries Service requirements to prevent drowning of platypus, they are fitted with a screen to prevent access of large trout (and platypus), and cod ends are out of the water or buoyed (Jackson, J. Apr. 2003, pers. comm.). For fine-mesh fyke netting in lakes (for example, for the saddled galaxias), one or two nights' sampling is usually adequate if using approximately 10 nets (Jackson, J. June 2003, pers. comm.).

Night snorkelling is used for visual observations or capture with small hand nets. This is also a useful method as at least some galaxiid species are found in the open at night. This method is used for the Pedder galaxias (Jackson, J. April 2003, pers. comm.).

Larvae can be collected from lakes by towing a fine mesh net behind a boat. The net contents are preserved in ethanol or formalin for later sorting. As most larvae are impossible to identify without the aid of a microscope, it is not practical to try to keep the larvae alive (Jackson, J. April 2003, pers. comm.).

Handling

For temporary holding, fish are kept in a bucket part full of water and measured at monitoring sites. Depending on the species, they may need to be anaesthetised using a small amount of Aqui-S, a clove oil-based anaesthetic used in the salmon industry that is thought to be more gentle on fish than other products such as MS222 (Tricane methanesulphonate). Note that animal care and ethics approvals may be required.

Additional information for particular species

Barred galaxias (*Galaxias fuscus*)

In small streams with low electrical conductivity, electrofishing with a backpack electrofisher on a setting of 1000 volts and 110 Hertz produces the best results (Raadik, T.A. Apr 2010, pers. comm.). A single pass may be all that is necessary to collect a representative sample of barred galaxias in areas where they are present (Raadik, T.A. May 2003 pers. comm.).

Rapids are best sampled by using a combination of fine mesh seines and electrofishing techniques. The first step is to secure a fine mesh seine with an attached bag (effectively a 'cod-end') to the bank downstream of the electrofishing site, that is, rapids or riffles. Fishes are briefly stunned by electrofishing and flow downstream into the fine mesh net (Raadik, T.A. Mar 2004, pers. comm.).

December through to April are the best months for sampling fishes in Victoria as water flows are lower (Raadik, T.A. May 2003, pers. comm.). March through to May are the drier months in southern states and sampling then may maximise the chances of fish capture (Raadik, T.A, May 2003, pers. comm.).

Swamp galaxias (*Galaxias parvus*)

This species needs to be sampled seasonally to detect its presence in ephemeral areas (Hammer, M. June 2003, pers. comm.). It can move out of permanent waters into shallow temporary waters such as drains, shallow swamps and wheel ruts in wet conditions (Jackson, J. June 2003, pers. comm.). It should be noted that the swamp galaxias appears to be an annual species (that is, lives for about one year). It is unlikely to be found between about September (after adults spawn) and December–January (when juveniles start appearing) (Jackson, J. June 2003, pers. comm.).

Due to its preference for shallow water habitat, which is also often ephemeral, dip-netting is likely to be the most effective method of capture. Backhouse and Gooley (1979) collected swamp galaxias in Bridgewater Lakes (Victoria) by dip-netting thick aquatic vegetation. They noted that this species was secretive and rarely seen in open water.

Eastern dwarf galaxias *(Galaxiella pusilla)*

December through to April are the best months for sampling fishes in Victoria as water flows are lower (Raadik, T.A. May 2003, pers. comm.). March through to May is drier in southern states and sampling then may maximise the chances of capture of fishes (Raadik, T.A, May 2003, pers. comm.).

Overnight sets of small collapsible traps baited with phosphorescent chemical sticks have proved highly effective in surveying galaxias, particularly eastern dwarf galaxias, in areas of heavy cover or where conductivity is too high for backpack electrofishing.

Golden galaxias *(Galaxias auratus)*

Hardie and colleagues (2006b) extensively sampled a translocated population using several survey methods, including visual surveys from snorkelling, electrofishing and fyke nets. The fish were found to be primarily nocturnal, moving into shallow water near shore at night, and deeper water during the day. The appropriate sampling method varied with time of day and size of individuals. Night sampling gave highest number of individuals and fyke netting at night appeared to give best overall results for numbers of individuals and size range.

Pedder galaxias *(Galaxias pedderensis)*

In Tasmania, experts at the IFS have had success observing the Pedder galaxias at night while snorkelling (Jackson, J. Apr. 2003, pers. comm.).

Stream surveys for the Pedder galaxias can take hours, due to the rarity of the species. The species is now believed to be extinct in the wild, although introduced populations are known. They were last recorded in their natural habitat (Lake Pedder) in 1996. Translocated populations exist at Lake Oberon and Strathgordon Dam (TSSC 2005).

Western trout minnow *(Galaxias truttaceus hesperius)*

The species was found to be most common during the day by Morgan and Beatty (2004), but larger individuals were taken at night. The fish spawn in autumn and early winter. The species is migratory, with larvae and young juveniles in estuarine or lacustrine environments.

A variety of sampling techniques have been used including seine nets, larval tow nets and sweep nets. The seine nets used were 1, 5, 10 and 26 m long, and were each made of 3 mm woven mesh and fished to a depth of 1.5 m, except the 26 m long net, which consisted of a 10 m pocket of 3 mm mesh and two 8 m wings of 6 mm mesh. The conical larval tow net had a diameter of 800 mm and consisted of 500 mm mesh (Morgan 2003). Funnel traps have also been used (Morgan & Beatty 2004).

The distinctive coloration allows separation of the common galaxias (*Galaxias maculates*) found in the same areas of Western Australia and the western galaxias (*Galaxias occidentalis*) also is found in the same general areas (see Allen et al. 2002).

Group 2: Queensland artesian springs fishes

General information

Common name	Scientific name	Distribution
Elizabeth Springs goby	*Chlamydogobius micropterus*	Known only from a single group of mound springs in western Queensland
Edgbaston goby	*Chlamydogobius squamigenus*	Known only from artesian springs in central Queensland
Redfin blue-eye	*Scaturiginichthys vermeilipinnis*	Known from artesian springs in central Queensland

Survey methods

Best time of day for sampling

Unknown.

Season and weather considerations

Unknown, although sampling is probably best completed during dry periods, because of the difficulty in reaching sampling sites during wet periods.

Most appropriate methods

These species inhabit shallow artesian springs amongst emergent vegetation or artesian bore drains. The water depth in the springs is generally less than 10 cm (Wager 1995a; 1995b). Experts familiar with the springs have had success with visual census techniques, as many of the fish that live there can be seen out in the open (Wager 1995a; 1995b).

Effort required

The amount of effort required in determining the presence or absence of gobies and redfin blue-eye in the artesian springs would be low to moderate for experts who can identify the different species by visual census techniques. It should be noted that the areas are very isolated, will require considerable travel time to get to and are on private land, so it is recommended that experts from relevant Queensland state departments are used.

Additional information for particular species

The redfin blue-eye occurs in schools, which break up when disturbed, making abundance estimates difficult (Fairfax et al. 2007).

Taxonomic issues

The redfin blue-eye might be confused with small eastern gambusia (mosquitofish, *Gambusia holbrooki*), which are in some of the springs (Fairfax et al. 2007) during visual censes.

Group 3: Small south-eastern Australian freshwater fishes

General information

This group includes pygmy perches and small temperate freshwater fishes (south-eastern Australia and south-western Australia, Families Atherinidae, Retropinnidae, Eleotridae, Percichthyidae).

Common name	Scientific name	Distribution
Murray hardyhead	*Craterocephalus fluviatilis*	Once widespread in lower Murray and Murrumbidgee rivers, but now confined to scattered localities in saline environments from western Victoria to the lower Murray River in South Australia, but not in coastal rivers.
Flinders Ranges gudgeon	*Mogurnda clivicola*	Known from northern Flinders Rangers, South Australia, in fresh waters. Possibly also from Bullo River, but not confirmed.
Balston's pygmy perch	*Nannatherina balstoni*	Found in drainages and wetlands within 30 km of the south-western coast of Western Australia between Margaret River and Albany.
Yarra pygmy perch	*Nannoperca obscura*	Known from flowing streams and lakes in coastal drainages from Frankston (Melbourne) Victoria to Bool Lagoon South Australia.
Oxleyan pygmy perch	*Nannoperca oxleyana*	Known from freshwater coastal streams in wetlands and isolated ponds between central Queensland and northern NSW.
Ewens pygmy perch	*Nannoperca variegata*	Known only from Ewens ponds, South Australia and the Glenelg River system south-western Victoria.
Australian grayling	*Prototroctes maraena*	Found in fresh and brackish waters of coastal lagoons from Shoalhaven River, NSW to Ewan Ponds, South Australia. Historical records as far north as just north of Sydney, NSW.

Survey methods

Survey techniques and methodologies applicable to most fishes within this group are outlined below. Where special circumstances exist for particular species, these are discussed in the following section.

General

Care should be taken when handling these fish as they are relatively sensitive and easily stressed, and their scales are easily lost. Handling should be done with wet hands and involve minimal contact with the fish (Knight et al. 2007; Knight, J. June 2003, pers. comm.).

Sampling should be carried out in a manner to avoid modifying fish communities and their habitat. Fish should be out of their habitat for the minimum amount of time and when out of their habitat should be kept in a container of water.

Ranges for all species have contracted due to habitat degradation and care must be taken when determining presence or absence of species in historically recorded distributions.

Best time of day for sampling

Unknown.

Seasonal and weather considerations

December through to April are the best months for sampling fishes in Victoria as water flows are lower and migratory fishes (for example the Australian grayling) are more likely to be collected (Raadik, T.A. May 2003, pers. comm.).

The Yarra pygmy perch and Oxlyean pygmy perch have a breeding season encompassing September to December and, depending on the water temperature, extending to May for the Oxleyan pygmy perch. Populations are often largest following recruitment during this season; however, disturbance to breeding populations and breeding habitats should be minimised by sampling in seasons when the species is not breeding, that is, late autumn and winter.

Balston's pygmy perch breeds in the winter and this time should be avoided when surveying this species (see 'Additional information for particular species' section).

Most appropriate methods

A wide variety of methods have been recorded for surveying pygmy perches and other members in the category. The methods used often depend on variables such as access, water depth and salinity, and a combination of methods can maximise results. Boat-based electrofishing is generally not suitable for most members of the group. Backpack electrofishing and trapping have similar detection rates and are effective for detecting pygmy perch, with low mortality rates (Knight et al. 2007).

Backpack electrofishing can be used in streams, wetlands and lakeshores, conducted according to the Australian Code of Practice (NSW Fisheries 1997) and operated in a way to minimise damage to fish. This technique is suitable for wadeable still water, shallow flowing streams and riffles.

Backpack electrofishing may be used in combination with fine mesh seines by securing the fine mesh seine with an attached bag (effectively a 'cod-end') to the bank downstream of the electrofishing site (rapids or riffles). Fishes are briefly stunned by electrofishing and flow downstream into the fine mesh net (Raadik, T.A. May 2003, pers. comm.). Electrofishing can also be effective using a person following with a dip net to pick up missed fish. The technique can be conducted in association with trapping and dip-netting.

Bait traps (collapsible wire framed traps approximately 250 x 250 x 450 mm, with 3 mm mesh) can be set for a period of 30–60 minutes. Traps should be thoroughly checked for fish. Trapping can be conducted in association with backpack electrofishing and dip-netting.

Small, two-person seine nets with a 2–5 mm mesh size can be used, taking care not to disturb littoral or submerged vegetation. Seine netting should be avoided (unless electrofishing is not possible) as this technique is associated with high mortality rates and it disturbs the habitat.

Small one-person nets (Japanese scoop net and dip nets) can be used; however, this technique may be of limited value at times. For example, the Oxleyan pygmy perch is a mobile and evasive species, and individual fish are easily missed. When dip-netting, care needs to be taken not to disturb the habitat. For temporary holding, fish are to be kept in a bucket part full of water.

Additional information for particular species

Australian grayling (*Prototroctes maraena*)

In smaller creeks, backpack or bank-mounted electrofishing is suitable. In larger, deeper systems electrofishing boats are a better method. This species has also been observed by SCUBA diving in clear water environments in Ewens Ponds, South Australia (Hammer, M. March 2004, pers. comm.) Passive techniques, for example mesh nets, are not used as often as they cause fish mortality and capture non-target fauna (Raadik, T.A Mar 2004, pers. comm.).

Balston's pygmy perch (*Nannatherina balstoni*)

Balston's pygmy perch occurs in drainages and wetlands within 30 kilometres of the south-western coast of Western Australia between Margaret River and Albany. The species prefers shallow freshwater pools, streams and lakes in sandy areas, often acid and tannin stained. Flooding stimulates breeding in the middle of winter, with spawning from June through to September, and this time should be avoided when surveying this species. It is commonly found in association with tall sedge thickets and riparian vegetation. They co-occur with the western pygmy perch (*Edelia vittata*) in some areas but are usually the less abundant species.

All discussed survey techniques can be used to survey for the species.

Ewens pygmy perch (*Nannoperca variegata*)

All discussed survey techniques can be used to survey for this species. In South Australia, the best collection method is using seine-nets through littoral or submerged vegetation, or fyke nets in more open water environments, and bait traps work well in confined environments (Hammer, M. March 2004, pers. comm.).

Flinders Ranges gudgeon (*Mogurnda clivicola*)

Flinders Ranges gudgeon inhabit spring fed pools in the northern Flinders Ranges in South Australia and the Bulloo River basin in Queensland (Allen & Jenkins 1999). Individuals of the species are best collected using baited traps (Hammer, M. June 2003, pers. comm.).

Murray hardyhead (*Craterocephalus fluviatilis*)

Generally, scoop nets and small seines are most suited for collecting this species. Care needs to be taken to remove fish from seines with dip nets, placing them directly into water before the seine is brought onto shore. The fish are delicate and loss of scales is likely, and mud can clog the gills during capture in wetlands with deep sedimentary deposits (Hammer, M. Mar 2004 pers. comm.). Visual observation may be possible in some environments, but typically the fish occur in environments where visual observation is limited or not possible. Selection of sampling sites can be facilitated by testing water chemistry first (see Wedderburn et al. 2007, 2008). The species is generally found in saline waters (see Ellis 2005, 2006). Bice and colleagues (2008) used fyke nets set perpendicular to the banks (where macrophyte vegetation was present), seine nets and unbaited traps. Sampling was selected according to habitats and potential hazards.

Oxleyan pygmy perch (*Nannoperca oxleyana*)

The species inhabits streams, lakes and swampy areas of low-lying coastal plains from south-east Queensland to north of Coffs Harbour (north-east NSW) and particularly favours Banksia dominated heathlands or wallum. Wallum country has a well-distributed annual rainfall (1016–1778 millimetres) and freshwater lakes, creeks and wetlands are a prominent landscape feature (Arthington & Marshall 1993). Any coastal acidic fresh to estuarine water body surrounded by or near wallum heathlands north of Coffs Harbour (NSW) is potential habitat for this species.

The species prefers still to slow-flowing water bodies with dense vegetation, including sedges. Waters often have a pH of 5.4–6.0 and low conductivity (Knight & Arthington 2008). They are secretive fish, mostly found individually, or in pairs and occasionally small groups, but do not form schools. Groups generally comprise smaller individuals (Arthington 1996). The Oxleyan pygmy perch tends to occupy roughly the bottom 70 percent of the water column (Arthington 1996).

As the dispersal capabilities of Oxleyan pygmy perch among isolated water bodies depend on high rainfall, habitats that are desiccated during dry periods could be extremely important habitats during wet periods (Knight et al. 2009). There is strong evidence to suggest that Oxleyan Pygmy Perch are more prevalent and widely distributed after a wet year (Knight 2000).

Expertise is required when sampling for this species as it is difficult to catch, and population numbers fluctuate (Knight, J.T. pers. comm. February 2004).

Research in Queensland showed that higher abundances of Oxleyan pygmy perch were caught around 4.00 pm than 8.00 am, and populations were largest during spring and summer following recruitment during the breeding period (Arthington 1996). However, sampling during late autumn and winter is preferable to sampling in spring and summer when the breeding period of this endangered species occurs. Spawning occurs mainly between September and December, but can extend to April or May (Arthington 1996).

An electrical output of 500v, 60Hz pulsed DC when electrofishing will induce galvanotaxis, or forced swimming, in Oxleyan pygmy perch sufficient to allow capture, without causing tetany (muscle rigidity) (Knight et al. 2007).

Collapsible wire framed traps (250 x 250 x 450 mm with 3 mm mesh) can be set for a period of 30–60 minutes. Unbaited traps should be used, as baiting does not increase the probability of attracting fish (Knight et al. 2007). Glow sticks may improve capture in areas of low population and where overnight trapping is undertaken. When attempting to determine the presence or absence of this species using traps, as many traps as possible (up to 40) should be employed, with a minimum of 10, set 1.5–2 metres apart (Knight et al. 2007; Knight & Arthington 2008). Traps need to be thoroughly checked, including all corners and under the seams in the netting, because this species is relatively small, has a habit of burrowing under the seams of the meshes and does not actively move around in the trap like other fishes. Once all visible fish are removed, shaking the trap is recommended so that any fish that have been missed can be located and removed. Stringing monofilament across the entrance in a # shape can reduce the incidence of in-trap predation by preventing entry to larger gudgeon species.

Seine netting should be avoided, as this technique is associated with high mortality rates and it disturbs the habitat. This technique should be reserved for situations where an electrofisher is non-deployable. Seine netting has been shown to be reasonably effective in detecting the Oxleyan pygmy perch, but the decision to use the technique must consider its potential destructiveness against the importance of accurately documenting the species' distribution (Knight et al. 2007).

Dip-netting may be useful in areas unable to be sampled effectively with other sampling techniques (e.g. too shallow to trap) (Knight et al. 2007).

Yarra pygmy perch (*Nannoperca obscura*)

Yarra pygmy perch are difficult to capture except in mid to late summer (Pierce, B. pers. comm. in Wager & Jackson 1993). They are most easily captured following recruitment events in late summer and early autumn, which corresponds to concentrated water levels and better sampling conditions. Sampling should be avoided in spring (September to October) as this coincides with breeding and spawning (Hammer, M. May 2004 pers. comm.). Capture is more difficult at other times of year, particularly in mid-winter with high water levels, but may be achieved with appropriate gear and local experience.

All discussed survey techniques listed in this section can be used to survey for this species. Bice and colleagues (2008) used fyke nets set perpendicular to the banks (where macrophyte vegetation was present), seine nets and unbaited traps. Sampling was selected according to habitats and potential hazards.

Backhouse and Gooley (1979) collected Yarra pygmy perches in Bridgewater Lakes in Victoria using baited drum nets (5 mm mesh) and fine mesh dip nets, and Donnelly and Grieves (1992) collected Yarra pygmy perches in Victoria's Fitzroy River using a triangular dip net with 1.5 mm mesh.

Electrofishing has been used successfully in Victoria. Fine mesh seines can also work well, except in areas of dense weed where collapsible or concertina traps are more appropriate (Raadik, T.A. May 2004, pers. comm.).

Taxonomic issues

Throughout its distributional range in Queensland and NSW, the distinctiveness and habitat associations of the Oxleyan pygmy perch (*Nannoperca oxleyana*) precludes it from being confused with any other species by a trained ichthyologist (Knight and Trnski in press). However, in Victoria and South Australia, individual pygmy perches can be very difficult to distinguish from each other (Backhouse & Gooley 1979; Kuiter et al. 1996; Raadik, T.A. May 2003, pers. comm.; Hammer, M. Jun 2003, pers. comm.).

It is notable that three species of pygmy perch occur in both Victoria and South Australia; one (southern pygmy perch *Nannoperca australis*) is not listed on the EPBC Act. Balston's pygmy perch (*Nannatherina balstoni*) occurs with and can be confused with the western pygmy perch (*Edelia vittata*). Experience with the group is essential for identification (see Allen et al. 2002).

Two hardyheads can easily be confused with the Murray hardyhead. In the lower reaches of the Murray River, particularly in estuarine areas, the species occurs with the smallmouth hardyhead (*Atherinosoma microstoma*). Farther inland in South Australia and Victoria the Murray hardyhead occurs with and is easily confused with the unspecked hardyhead (*Craterocephalus fulvus,* which is sometimes treated as a subspecies of *Craterocephalus stercusmuscarum*). Details can be found in Ellis (2005, 2006).

There are no known taxonomic issues with Australian grayling (*Prototroctes maraena*) and the Flinders Ranges gudgeon (*Mogurnda clivicola*), although molecular work in South Australia on the *Mogurnda* in Australia could modify current knowledge. Eastern gambusia (mosquitofish) does occur with the Flinders Ranges gudgeon and these can be confused in visual surveys with juveniles by inexperienced observers.

In areas where taxonomic problems are likely it is recommended that experts undertake the fieldwork.

Group 4: Western Australian cave fishes

General information

Common name	Scientific name	Distribution
Blind gudgeon	*Milyeringa veritas*	Known only from limestone caves at North West Cape, Western Australia.
Blind cave eel	*Ophisternon candidum*	Known only from limestone caves at North West Cape, Western Australia.

Survey methods

Best time of day for sampling

The blind gudgeon has sometimes been observed swimming in sunlight (Humphreys 2001), so a sunny day may be an advantage to visual observation from the surface.

Season and weather considerations

Although no systematic sampling has been conducted, it is clear that both the distribution and abundance of the blind gudgeon differs between years (Humphreys 1999b).

Additional considerations

Most of the caves in the Cape Range are vertical and require specialised roping skills to enable entry and exit. The caves are mostly dry, but many are unstable and contain dangerous concentrations of carbon dioxide (Humphreys & Blyth 1994). Caving experts should be used in surveys if descending into the caves is necessary, and especially if such work is to be conducted at night.

Most appropriate methods

The information available (see below) suggests that successful detection methods include visual observations during the day (either by looking down into the wells and sinkholes or snorkelling) and night observation with headlamps (from above the wells or holes). The blind gudgeon is generally easy to survey for, but the blind cave eel is rarely seen and difficult to observe without extensive effort.

Effort required

The remote locations of these cave fishes and their subterranean habitat restricts observation (Humphreys 2001). However, despite the general remoteness of the area, the populations are at sufficiently accessible locations to facilitate sampling (Humphreys 2001). The blind gudgeon generally can be located in a short time (less than one hour), but the rarity of the blind cave eel can result in no sightings after several hours in most areas.

Additional information for particular species

Blind cave eel (*Ophisternon candidum*)

The blind cave eel inhabits the surface of and burrows into the flocculent faecal ooze characteristic of crustacean-rich cave habitats (Humphreys 2001), so it is more likely to be found near the bottom of the water column. Cawthorne (1963) observed a blind cave eel in deeper water, but failed in an attempt to catch it.

Moyle and Cech (1982 in Humphries & Feinberg 1995) noted that members of the Synbranchidae family (to which the blind cave eel belongs) are nocturnal predators. However, methods not involving direct sunlight prior to capture have never been successful for the species (Humphreys 2001).

Blind gudgeon (*Milyeringa veritas*)

Aquarium observations by Young (1986) suggest that the blind gudgeon is extremely lethargic and slow moving, but Humphreys (2001) noted that the gudgeon could move quickly at times. At Bundera sinkhole, divers have observed the blind gudgeon through the full depth of the water column (to 33 metres), but the vertical distribution differs markedly between years (Humphreys 2001).

Allen (1982) noted that the blind gudgeon was regularly found swimming slowly or suspended near the surface at wells and sinkholes, particularly at night. However, methods not involving direct sunlight prior to capture have rarely been successful for the species (Humphreys 2001).

Cawthorne (1963) noted that the blind gudgeon was easily observed in shallow waters and a number were easily caught. The fish feed on insects that fall into the water and placing a small dip net in the water will attract the fish into the net. They are now fully protected and normally would not need to be collected.

Taxonomic issues

The blind cave eel and the blind gudgeon are the only two known native fishes that occur in subterranean cave environments in Australia (Humphreys & Adams 1991), but in one cave a feral tropical aquarium fish was observed (Humphreys 1999a). There is unlikely to be any taxonomic confusion between the species that occur in these cave habitats as an eel and a gudgeon are easily separated by size and swimming behaviour. Both fishes are blind and have skin over the eye area.

Group 5: Queensland freshwater coastal drainage fishes

General information

Common name	Scientific name	Distribution
Lake Eacham rainbowfish	*Melanotaenia eachamensis*	Known only from Lake Eacham and surrounding streams on the Atherton Tableland, Queensland.
Honey blue-eye	*Pseudomugil mellis*	Known only from lagoons, small lakes and small streams in freshwater between Brisbane and Fraser Island, Queensland.

Survey methods

Best time of day for sampling

Traps were found to be most effective for collecting fishes (including honey blue-eye) when set within two hours after dawn and before dusk and cleared (fishes removed) 15–45 minutes after setting (Arthington & Marshall 1993).

Season and weather considerations

Arthington and Marshall (1993) collected honey blue-eye from the Noosa River in all months of the year except July, but abundances were higher from October to December.

Additional information for particular species

Honey blue-eye (*Pseudomugil mellis*)

The honey blue-eye has a patchy and restricted distribution in south-east Queensland in running waters, swamps and dune lakes with low pH, low conductivity and water colour ranging from clear to darkly stained (Arthington & Marshall 1993). The species is also found in close association with aquatic macrophytes that provide shelter and breeding habitat (Arthington & Marshall 1993).

Arthington and Marshall (1993) used a combination of seine nets (seine net length 2.5 m, mesh size 2–5 mm and constructed from 70 percent shade cloth), commercially available bait traps, direct observations and visual observations made during snorkelling. Commercially available bait traps are constructed from 3 mm mesh covering a box-like collapsible wire frame with an open inverted funnel at each end and measuring 250 x 250 x 450 mm. The traps have two zippered openings on one side to enable access to both the body of the trap (for removing fish) and the bait compartment (Arthington & Marshall 1993). Arthington and Marshall (1993) tested the effectiveness of different baits and catch rates (number of species and individuals) and found that the results were similar for baited and unbaited traps. Given these results, Arthington and Marshall (1993) used unbaited traps set within an hour after dawn and within an hour after dusk.

Seine nets, hand held dip nets and bait nets have been used with success to collect honey blue-eyes by the Australian New Guinea Fishes Association (ANGFA) in the months of October to January (Anon. 1984; Anon. 1986).

Sampling effort is variable for the honey blue-eye. Access to their habitats can be time consuming.

Lake Eacham rainbowfish (*Melanotaenia eachamensis*)

A combination of seines and baited and unbaited traps are the best methods for sampling the Lake Eacham rainbowfish. Small seine net and scoop nets have also been used.

Sampling can require considerable effort for the Lake Eacham rainbowfish, mainly because of difficulties identifying specimens. Field identifications are often not completely reliable and fin clips may be required for genetic studies to confirm identification. In such cases, a selection of a few individuals for fin clipping may be required. Alternately, keeping the fish alive in aquaria for a few hours and obtaining high quality 'side-on' photos can help separate the species from others.

Previous experience with rainbow fishes is essential for surveys targeting the species. See 'Taxonomic issues' below.

Taxonomic issues

Honey blue-eye (*Pseudomugil mellis*)

According to Ivantsoff and Crowley (1996), the honey blue-eye can be confused with the Pacific blue-eye (*Pseudomugil signifier*) and juvenile sand mullet (*Myxus elongates*). The former is a close relative of the honey blue-eye that occurs in some of the same localities (Arthington & Marshall 1993) and the latter is a member of the family Mugilidae. Juvenile sand mullet are more slender bodied and can be separated using Allen and colleagues (2002). Because of the potential for confusion over identification, visual censuses are often not fully reliable.

Lake Eacham rainbowfish (*Melanotaenia eachamensis*)

The species is difficult to separate from the eastern rainbowfish *Melanotaenia splendida splendida* (see Allen et al. 2002) and the Utchee rainbowfish *Melanotaenia utcheensis (McGuigan 2001)*. High quality photos will often separate the Utchee rainbowfish from the others. However, identification is often not possible without genetic samples due to hybridization between the species. Translocations and historical dispersal have produced a complicated distribution pattern (Hurwood & Hughs 2001; Burrows 2004).

Group 6: Large freshwater perches and lungfish

General Information

Common name	Scientific name	Distribution
Clarence River cod	*Maccullochella ikei*	Currently only known from clear rocky streams in the Clarence River system and as a re-stocked population in limited sections of the Richmond River system, after its extant population disappeared. Captive breeding and dispersal occurred from 1988-2002. Also referred to as eastern freshwater cod.
Trout cod	*Maccullochella macquariensis*	Confined to the Murray-Darling River system, with small naturally occurring population; now bred in captivity and dispersed artificially in NSW, Victoria and the ACT. Translocated populations in coastal rivers often hybridise with Murray cod.
Mary River cod	*Maccullochella peelii mariensis*	Known only from Mary River in Queensland, usually in side branches of the river; now artificially stocked in impoundments.
Macquarie perch	*Macquaria australasica*	Known from the Murrumbidgee, Lachlan and Murray catchments in NSW; the Goulburn, Broken, Ovens and Mitta Mitta catchments in Victoria; and the Paddys, Cotter and Murrumbidgee rivers in the ACT. Coastal populations in NSW are thought to represent a different species.
Australian lungfish	*Neoceratodus forsteri*	Known only from rivers in southern Queensland, naturally in Burnett and Mary rivers, but translocated to other rivers in southern Queensland.
Murray cod	*Maccullochella peelii peelii*	Widespread in Murray Darling River system in warmer waters.

Survey methods

Best time of day for sampling

In general, cod are more active at dawn, dusk and at night; however, sight-dependant methods such as snorkelling are best during the daytime. Dawn and dusk were considered the best times to target trout cod using angling methods (Faragher et al. 1993). Electrofishing is considered most efficient during the day in areas of low turbidity, but can be inefficient for cod in good visibility as they often hide during the daylight hours.

Australian lungfish are nocturnal, with maximum activity around midnight, and for angling to be successful sampling should be during this period.

Season and weather considerations

Angling methods have generally been considered to be more effective in spring and summer when the fish are more active (Faragher et al. 1993; Douglas et al. 1994). No trout cod were collected using fyke nets and drum nets from the Murray River in spring 1992 when water levels were falling (Douglas et al. 1994). However, all of the cod species spawn in spring and sometimes into summer (depending on area and species) and these periods should be avoided so breeding is not affected. Where relevant, further information regarding specific cod species is presented in the ‘Additional information for particular species’ section below.

The recommended survey period for the Macquarie perch is March to September. Surveys should not be conducted throughout the breeding season of October to mid January.

Australian lungfish spawn between August and December and surveys should avoid this period so that breeding is not affected.

Most appropriate methods

Survey techniques and methodologies applicable to most fishes within this group are outlined below. These methods are best suited for determining the presence or absence of these species and generally considered to be non-destructive when used correctly and handling of fish is kept to a minimum. The methods can be used individually, but it is often found that a combination of methods provides the best results. Some of these methods are more effective for particular species and individual species are discussed in the 'Additional information for particular species' section.

When angling, lure fishing with barbless hooks can be relatively fast and easy at times and has less impact on the fish than when a heavy line is used. However, the amount of effort required to detect the presence or absence of these species is difficult to determine, as sometimes the fish may be present, but not interested in taking a bait or lure. Lure fishing methods are most successful at dawn, dusk and at night when cod are more active and should target habitats with submerged or partly submerged trees or logs and snags.

Set-lines can be used, but these need to be checked at regular intervals (every hour for example) to avoid stress and mortality.

Daytime snorkelling using visual observation in clear water can be a productive method.

Gillnets and panel nets can be used effectively. Gillnets are set for six hours rather than overnight and checked regularly, as this minimises the time a fish can be entangled in the net and therefore the potential for stress and damage. Unweighted nylon multi-filament mesh (usually 3 inch to 5 inch stretch mesh) is used to reduce the mortality of platypus, which are often found in the same habitat (Lintermans, M. June 2003, pers. comm.).

Fyke nets can be used, but do not operate efficiently in deeper fast-flowing waters. The addition of a polystyrene float inserted in the cod end provides airspace to prevent mortality of non-target animals such as platypus.

Unbaited gee or bait traps (approximately (250 x 250 x 450 mm with 3 mm mesh) are suitable for small/juvenile specimens only. Light traps are suitable for larval and juvenile specimens.

Boat-based or backpack electrofishing can be conducted according to the Australian Code of Practice (NSW Fisheries 1997) and operated in a way to minimise possible damage to fish. Electrofishing is considered most efficient during the day in areas of low turbidity. However, the technique can be inefficient for cod in good visibility as they often hide during the daylight hours. This includes stocked and naturally occurring fish, depending on the type of habitat. If used at night with lights it can be effective. Electrofishing has its drawbacks as fish may be stunned, but the operator cannot see them. Electrofishing is not efficient in deeper faster flowing waters. Backpack electrofishing can be useful in shallow pools and riffles to a depth of hip height. Mortality of Clarence River cod can occur at elevated water temperatures (Knight, J.T. May 2010, pers. comm.).

Handling

All Australian freshwater cod species are susceptible to 'lock jaw' from electrofishing methods. This occurs when the mouth remains locked open, and severely compromises opercula movement and hence ability to breathe. Electrofishing frequencies need to be adjusted to compensate for these effects. If cod do become shocked it is imperative that a holding facility for shocked fish has flow-through water capacity and adequate aeration (Lintermans, M. pers. comm. December 2003). Gently massaging the jaw area and closing the mouth can assist in the recovery of electrofished cod species (Knight, J.T. Feb 2004 pers. comm.).

Regardless of capture method, if fish are retained out of their habitat for any length of time they should be retained and/or revived in an aerated tank before release. Placing fish in an aerated tank and assisting revival by pumping water across their gills (achieved by holding the jaw of the fish and gently moving them back and forth in the aerated tank) assists their recovery from shock or stress.

Additional information for particular species

Clarence River cod (*Maccullochella ikei*)

This species is most abundant in rivers with slow flow, with rocks, timber or tussocks for cover (Rowland 1996), but also around boulders in faster-flowing water, although limited information is available about habitat for the species (NSW Fisheries 2004). Sampling effort should focus on, but not be restricted to, the following techniques in these habitats:

- fyke nets
- boat-based electrofishing conducted according to the Australian Code of Practice (NSW Fisheries 1997) and operated in a way to minimise possible damage to fish
- lure fishing and angling using barbless hooks.

Depending on habitat suitability, Faragher and colleagues (1993) used a combination of different methods for sampling Clarence River cod in the Richmond and Clarence Rivers. The methods used included boat-based and backpack electrofishing, fyke nets, drum nets, light traps, yabby traps and angling with lures (Faragher et al. 1993). Fyke nets, angling and electrofishing were the most effective techniques in Clarence River cod surveys conducted in November to January, after the spawning period (Faragher et al. 1993). April to June are the best months for electrofishing for the Clarence River cod (Knight, J.T. Feb 2004 pers. comm.).

At the time of writing an all-inclusive fishing closure was in force between 1 August and 31 October in the Mann and Nymboida Rivers and their tributaries, in order to protect this species during the breeding season.

Mary River cod (*Maccullochella peelii mariensis*)

The Mary River cod prefers large and deep (0.8 to 3.2 m) shaded pools with abundant, slowly flowing water within relatively undisturbed tributaries where the waters are cooler than the main river channel (Wager & Jackson 1993; Simpson & Jackson 2000). They are also found in areas with submerged logs and woody debris (Simpson & Mapleson 2002). Sampling should focus on these habitats. Spawning takes place in hatcheries between August and October, and these times should probably be avoided for sampling.

The best methods for this species include a combination of angling, electrofishing and visual observation via snorkelling during the daylight hours (where habitat allows for sufficient visibility). None of the above collection methods are necessarily more efficient that any other for Mary River cod (that is, there is no 'foolproof' method that works all the time). Generally, in bigger dams, better catches are made at night by electrofishing (Pogonoski, J. and Simpson, B., Queensland Department of Primary Industries, June 2003 pers. comm.).

Small spangled perch (*Leiopotherapon unicolor*) are occasionally confused with juvenile Mary River Cod, but by involving experts in surveys to detect their presence or absence, these taxonomic uncertainties can be avoided.

Murray Cod (*Maccullochella peelii peelii*)

The species occurs naturally in the waterways of the Murray Darling Basin in a wide range of warm water habitats, from clear, rocky streams to slow-flowing turbid rivers and billabongs (McDowall 1996). Wood debris and overhanging banks are important for the species and sampling should focus on habitats for adults. The species migrates upstream prior to spawning when water temperatures increase, with spawning occurring around mid-October and mid-December (Humphries 2005; Koehn & Harrington 2005a; 2005b). The preferred survey period is March to August. Surveys should not be conducted in September to December.

Generally, they are found in waters up to 5 m deep and in sheltered areas with cover from rocks, timber or overhanging banks (Kearney & Kildea 2001). The species is highly dependent on wood debris for habitat, using it to shelter from fast flowing water (Koehn 1997).

In general, sampling protocols for this species should follow those for the trout cod (below). Consideration should be given to larval sampling, which disturbs the fishes and environment to a lesser degree. Kohn and Harrington (2005a) have successfully sampled larvae using drift sampling. Because of identification complications, larvae need to be preserved and identified following methods outlined by Koehn and Harrington (2005a). The following survey techniques are also appropriate:

- boat-based electrofishing conducted according to the Australian Code of Practice (NSW Fisheries 1997) and operated in a way to minimise possible damage to fish
- daytime snorkelling
- lure fishing and angling using barbless hooks.

Trout cod (*Maccullochella macquariensis*)

The species is most abundant where there is a large amount of woody debris in deep water, often close to the riverbanks. They have a relatively small home range, with no evidence for any large scale or migratory movements such as a spawning migration (Douglas et al. 1994; Brown et al. 1998). Spawning is around October to November (Koehn & Harrington 2005a). Sampling effort for adults should therefore focus on these areas, but avoid the spawning period. However, sampling for larvae, if undertaken, is best done during the spawning season. Drift nets can be used to capture larval trout cod (Koster et al. 2004).

Faragher and colleagues (1993) surveyed trout cod in the upper Murray River using boat-based and backpack electrofishers, fyke nets, drum nets, angling and set-lines, light traps, yabby traps and set-lining gillnets. Angling was proven to be the most effective method for sampling adult trout cod in these surveys (Faragher et al. 1993). Boat-based electrofishing and angling caused the death of one fish each in these surveys (Faragher et al. 1993). Rod and line fishing for trout cod by experienced anglers was the best method in the upper Murray and Murrumbidgee Rivers (that is, sites with stocked fish) in the early 1990s (Faragher et al. 1993). Douglas and colleagues (1994) also concluded that trout cod were susceptible to angling techniques. Electrofishing methods resulted in the death of three out of four trout cod in Seven Creeks (Victoria) in January 1991, while trying to relocate individuals after a bush fire combined with heavy rain threatened to pollute the creek (Douglas et al. 1994).

There is some evidence that trout cod in low densities may be inaccessible to conventional survey methods in deep waters, such as dams or near weirs (Lintermans 1995 in Brown et al. 1998). Trout cod co-occur with the Murray cod (*Maccullochella peelii peelii*) in the Murray River (NSW) and hybrids also occasionally occur (Douglas et al. 1995). Any surveys of trout cod in this area should involve species experts. Engaging experts in such surveys also provides the benefit of limiting the stress on trout cod collected.

An assessment of trout cod populations in the Goulburn River (Victoria) by Brown (1998) using angling and boat-based electrofishing techniques showed that, in combination, these methods capture a more representative sample of the population than either method would individually. Both boat-based electrofishing and angling appear to have some size-selective bias relative to each other. The size selectivity of angling was positive relative to electrofishing (Brown 1998).

Macquarie Perch (*Macquaria australasica*)

The species prefers cool clear waters in slow-flowing deep rocky pools of rivers as well as lakes and reservoirs. Adults are solitary near the bottom or midwater, but form small shoals during the spawning season (October to December), moving into shallow feeder streams to spawn. Juveniles are often in shoals.

Efforts should focus on:

- boat-based electrofishing conducted according to the Australian Code of Practice (NSW Fisheries 1997) and operated in a way to minimise possible damage to fish
- fyke nets
- snorkelling in clear streams for juveniles.

The best techniques for Macquarie perch include the use of fyke nets (Lintermans, M. June 2003, pers. comm.) and boat-based electrofishing (Raadik, T.A May 2003, pers. comm.). Lintermans (2008) reported the high efficiency with which fyke nets capture age 0+ and 1+ Macquarie perch (approximately 93 percent of the catch), making these nets an extremely effective technique for detecting recent recruitment in this species. However, capture rates of adults drops considerably (Lintermans, M. June 2003, pers. comm.). Other sampling techniques such as boat electrofishing may be more efficient at capturing larger, adult Macquarie perch, although backpack electrofishing can also be effective at capturing this species in shallow, relatively confined habitats. Electrofishing in deep habitats can be unreliable. Fyke nets should be equal to or less than 9 mm mesh to prevent mortalities, and placed in preferred habitat (for example emergent macrophytes and areas where banks are undercut) between February and April. To prevent drowning of trapped non-target mammals (such as platypus), fyke nets should be set partially out of the water to create an air space.

Snorkelling has also been used in clear water habitats to detect the presence of Macquarie perch adults and larvae (Lintermans, M. Dec 2003, pers. comm.; Broadhurst et al. 2007).

Australian lungfish (*Neoceratodus forsteri*)

Electrofishing is generally the most effective sampling method for Australian lungfish (Frentiu et al. 2001). Angling is also used and the species is frequently taken accidentally by anglers. Angler surveys could therefore help establish presence of this species in some areas. Juveniles are typically found in dense vegetation and are not easily sampled (Brooks & Kind 2002).

Group 7: Handfishes

General information

Common name	Scientific name	Distribution
Spotted handfish	*Brachionichthys hirsutus*	Known only from Derwent Estuary and surrounding embayments in south-eastern Tasmania, but historically more widespread, including east coast; known from depths of 1–60 metres.
Ziebell's handfish and Waterfall Bay handfish	*Brachiopsilus ziebelli*	Known only from scattered localities in eastern and southern Tasmania in 10–20 metres. See 'Grouping of species' and 'taxonomic issues' for a discussion of the species' listing under the EPBC Act at time of writing.
Red handfish	*Thymichthys politus*	Known from scattered localities in south-eastern and northern Tasmania in depths of 1–20 metres.

Survey methods

Best time of day for sampling

The time of day for sampling is probably not critical for handfishes, given that they are likely to have small home ranges. Anecdotal evidence suggests that some species are more active at night, but they are still likely to be seen and/or collected during the day (Green, M. June 2003, pers. comm.).

Season and weather considerations

Spring appears to be the breeding season for at least three species of handfishes (including spotted, red and Ziebell's). There are some indications that handfishes are more abundant in particular areas (where there is spawning substrate) during this time, but this information is of limited use if their precise localities are unknown (assuming that the precise locations are small) (Green, M. June 2003, pers. comm.).

Most appropriate methods

All the information below was sourced from personal communications with Mark Green of CSIRO in Hobart unless otherwise indicated.

There are at least 14 species of handfish that occur in south-eastern Australia, most of which are confined to Tasmanian waters (Last & Gledhill 2009). The method of survey is dependent on the target species and the depths of the areas to be searched. Handfish have been collected alive by hand (divers), using benthic sled trawls (scientific and scallop trawls) and Danish seines (see Chapman 1993 for a discussion of these methods). The use of benthic sled trawls and Danish seines for collecting handfish is limited to soft sediment habitats as the gear would be inappropriate over rocky bottom habitats. Some species prefer rocky bottomed habitats and/or live in shallow caves and crevices that are typically covered with seaweed and/or sponges. These rocky-bottomed handfish are probably best detected by visual diver surveys. Visual census techniques are probably the most appropriate method for the detection of handfishes in depths within safe SCUBA diving range (feasibly to approximately 40 m, but practically to about 21 m, due to the limitations of decompression tables), because such methods are non-destructive. For continental shelf species a benthic sled is the best method, but this requires a relatively large vessel and may not be necessary for the handfishes listed on the EPBC Act. Smaller sleds could be deployed from smaller vessels in shallower coastal waters.

Effort required

The effort required for a SCUBA diving survey is dependant on the intention of the investigation and the species being studied. If reliable quantitative population data is required (for example to monitor the relative abundance of a known population of spotted handfish) then approximately 10 percent of the survey area needs to be searched. The greater the effort, the better the result. Thus, for a survey area of 10 hectares, a minimum of one hectare needs to be searched by divers. If the survey area is limited to 12 m depth then this could be done by four divers (in rotation) over a period of four days (Green, M. Apr 2010, pers. comm.).

Where the objective is to determine presence or absence and collect some basic data on relative abundance of a species at a small site, then the effort required is a factor of the depth and complexity of the bottom. Given that handfishes are rare and cryptic in nature, an estimated six hours of searching for each hectare of potentially suitable substrate is recommended. A minimum team of three persons is needed (one boat attendant and two divers). For shallower areas, six hours of survey could be undertaken over two days, but in deeper regions the time spent at the bottom during diving is shorter and more days may be required. Note that teams of four divers rotating between the duties of diver and boat attendant are more efficient and are recommended (Green, M. April 2010, pers. comm.).

Additional information for particular species

Spotted handfish (*Brachionichthys hirsutus*)

Known populations of spotted handfish are most common in 5–14 m of water, but have been seen as shallow as 2 m and as deep as 25–60 m. As this species occurs on soft benthic substrate, benthic trawls and Danish seines could collect them. However, such methods are not as desirable as visual diver surveys conducted by CSIRO experts, because the latter method is likely to yield better results and is non-destructive (Green, M. June 2003, pers. comm.).

The likely success of surveys using a Remotely Operated Vehicle (ROV) is unknown, but the method could be tested for this species over a site where divers have found fish. An ROV can cover a large area without any depth complications or associated safety hazards of diving. However, fishes living in weed habitats are likely to be very difficult to find with an ROV. Divers usually move the weed apart to uncover fish. This would bias the result (Green, M. June 2003, pers. comm.).

Taxonomic issues

The family has recently been revised by Last and Gledhill (2009), with several species added and some changes in scientific names. Two species have been listed under the EPBC Act as *Sympterichthys* sp. (Ziebell's handfish and Waterfall Bay handfish). These have been treated as distinct species and sometimes as colour variants. Last and Gledhill now refer to these forms as Ziebell's morph and Loney's morph (Waterfall Bay handfish). They were not able to distinguish the two as separate species and Loney's morph occurs within the geographical range of Ziebell's morph. Genetic studies have not been possible, but there is considerable variation in colour and a specimen with intermediate coloration is known. In addition, the listed species *Brachionichthys politus* is now placed in the genus *Thymichthys* by Last and Gledhill (2009). Because up to three species can occur in any given area, it is important to obtain live photos where possible and to use Last and Gledhill (2009) for proper identification.

Group 8: Tropical freshwater and estuarine Elasmobranchs

General information

Common name	Scientific name	Distribution
Northern river shark	*Glyphis garricki*	Known from scattered localities, including Ord River, King River, King Sound and Joseph Bonaparte Gulf, Western Australia and South and East Alligator Rivers and Wessel Islands, Northern Territory, and also from New Guinea; typically found in freshwater estuaries and coastal environments.
Speartooth shark	*Glyphis glyphis*	Known from Adelaide and Alligator Rivers, Northern Territory and Wenlock and Bizant rivers, Queensland, but probably more widespread. Also found outside of Australia. Exact distribution poorly known. Commonly in freshwater and estuaries, but also in nearshore coastal areas.
Dwarf sawfish	*Pristis clavata*	Known only from estuaries and coastal environments from the Kimberley coast, Western Australia to Cairns, Queensland.
Freshwater sawfish	*Pristis microdon*	Widespread in fresh and brackish waters in Australia in rivers including the Fitzroy, Durack and Ord rivers, Western Australia, the Adelaide, Victoria and Daly rivers, Northern Territory and the Gilbert, Mitchell, Norman and Leichhardt rivers, Queensland. Also widely distributed in the Indo-west Pacific.
Green sawfish	*Pristis zijsron*	Widely distributed in Australia in freshwaters, estuaries and coastal environments from Broome, Western Australia to Sydney, NSW and one record from South Australia. Also widely distributed in the Indo-west Pacific.

Survey methods

Survey techniques and methodologies applicable to most fishes within this group are outlined below. Where special circumstances exist for particular species, these are discussed in the following section.

Best time of day for sampling

Unknown.

Season and weather considerations

Both river sharks and two of the sawfish species are commonly found in tropical freshwater rivers and estuaries in northern Australia. However, it is suspected that larger adults are probably found near the mouths of estuaries and in coastal environments. Fisheries catch data and fisheries observers have recorded the sharks and sawfishes from coastal environments (Field et al. 2008). During the wet season, flooding limits road access to many of these rivers and sampling may be restricted to the dry season in northern Australia (approximately from April to October). The best time to collect the freshwater sawfish is at the start of the dry season (after the wet season finishes) in the upper reaches of rivers, while the rivers are still flowing, but water temperatures are high and access is not limited by flooding. However, Thorburn and colleagues (2004) sampled in June and November in Western Australia using boats.

Most appropriate methods

Sampling methods are extensively reviewed by Field and colleagues (2008) and Thorburn and colleagues (2004). Which method is most appropriate depends to a large extent on the area sampled and various logistic difficulties associated with those sites. The primary methods used include:

- lure fishing and angling using barbless hooks
- gill nets (20 m, 2 m drop) monofilament gill net panels of 5, 7.5, 10, 15 and 20 cm stretched mesh, set times varying from 1 to 16 hours
- monitoring of commercial fisheries statistics (logbooks, etc.), as all species are commonly taken as bycatch in some northern commercial fisheries.

Effort required

Sampling within estuarine and nearshore environments in northern Australia is some of the most difficult sampling in Australia. Thorburn and colleagues (2004) emphasised logistic difficulties relating to the huge tidal range in Western Australia. They often sampled using boats, which limited the areas surveyed. Weather presented major obstacles, as did crocodile abundance in many of the northern rivers. The limited knowledge of the sharks and sawfishes in these environments is in a large part due to difficulty in sampling the environments. Catches from commercial fisheries in the Northern Territory indicate catch rates of one every three to four days for the speartooth shark, dwarf sawfish and green sawfish each (Field et al. 2008).

Additional information for particular species

Glyphis sharks

All of the sampling methods mentioned above have been used with success. No single method will give full information on all stages of the life cycle (Field et al. 2008). Commercial catch data has indicated that larger and more mature individuals may be more likely to be found near the mouths of estuaries and in coastal environments.

Thorburn and colleagues (2004) reported that earlier surveys in Western Australia of 137 sites did not find any sharks, but a later survey of 22 sites sampled for over 200 hours in total resulted in 46 elasmobranchs, of which six were the northern river shark (*Glyphis garricki*). Field and colleagues (2008) indicated that previous surveys of the Northern Territory found few sharks and sawfishes. Broadening survey methods suggested that species might be more abundant than previously thought.

Freshwater sawfish

All of the information provided on the freshwater sawfish was from personal communications with Stirling Peverel of Queensland Department of Primary Industries (Cairns) unless otherwise stated.

Because of their long tooth-studded saw, all sawfishes are disproportionately subject to incidental capture in nets set for other species (Cook et al. 1995). Sawfishes are highly vulnerable to gillnet fishing (Last & Stevens 1994) and can also be collected by cast nets or seine nets (Wilson 1999). Gillnets are probably the most efficient method for collecting sawfishes as their rostrum (or saw) is easily entangled in the mesh (J. Stevens, CSIRO May 2003, pers. comm.). Wilson (1999) noted that angling with fish or prawns for bait was also effective. Anglers have recently caught sawfishes with baits or lures, so either method can be used. Gillnets are either made of monofilament, multifilament or cord. Cord nets (similar to string and softer than mono or multifilament) are ideal for freshwater sawfish surveys because they are efficient at catching sawfishes, while bycatch of bony fishes is limited because they drop out of the mesh. The ideal mesh size of gillnets is 6 inch mesh.

The ideal gillnet soak times for collecting sawfishes are a compromise between not disturbing the gear too frequently and ensuring that animals are alive when the nets are checked. Experience suggests that a soak time of 4–5 hours would be appropriate. When sawfishes are caught in gillnets, the nets need to be cut and the gear sacrificed to free animals easily. While one person cuts the net free, the other needs to keep the sawfish in the water and cover its eyes to reduce the stress to the animal. A catch and release protocol has been developed for sawfishes in northern Australia. Experts should be involved in sawfish surveys to minimise harm to captured sawfishes and to set nets in the correct position.

Other sawfishes

All of the general methods outlined above can be used. Thorburn and colleagues (2004) reported 26 dwarf sawfish and seven freshwater sawfish from surveys of 22 sites in Western Australia.

Taxonomic issues

The species of *Glyphis* are morphologically distinctive and genetically distinct (Wynen et al. 2009), but not easily identified in the field without specialist knowledge of sharks. Juveniles are particularly difficult to identify (Field et al. 2008).

Sawfishes have not been studied in detail and a number of taxonomic problems exist relating to the identity and number of species in Australia (Last & Stevens 2009). Three species can be found together and identification can be difficult on live and active fishes. Photos of the saw will assist. Identification should follow Last and Stevens (2009).

The dwarf sawfish (*Pristis clavata*) and to a lesser degree the green sawfish (*Pristis zijsron*) are occasionally found in brackish and freshwater reaches of tropical rivers in Queensland, and can be confused with the freshwater sawfish.

Group 9: Marine sharks

General Information

Common name	Scientific name	Distribution
Great white shark	*Carcharodon carcharias*	Known from southern Queensland south to central Western Australia in nearshore and offshore environments.
Grey nurse shark East Coast population	*Carcharias taurus*	The species is widely distributed, but the population from central Queensland to southern NSW is listed separately. Found near the bottom in rocky areas to depths of over 100 metres.
Grey nurse shark West Coast population	*Carcharias taurus*	The species is widely distributed, but the population south-western Western Australia is listed separately. Found near the bottom in rocky areas to depths of over 100 metres.
Whale Shark	*Rhincodon typus*	Known from continental shelf and oceanic waters around most of Australia.

Survey methods

Best time of day for sampling

Variable, although most surveys are carried out during the day.

Most appropriate methods

None of the listed species can be reliably collected from an area where they might occur without potentially adverse affects. Visual surveys to determine the presence or absence of the species are more desirable and less destructive practices, but such surveys may be expensive and time consuming. Perhaps the most practical method for establishing the likelihood of these species being in a particular area is to first search the available literature. For example, consult recovery plans and the species profile and threats database, and then contact relevant experts (see Appendix 1) for additional advice. Other potentially useful information sources include local fishing groups or underwater diving groups, and this information should be sought where available prior to conducting any survey.

There are various observational monitoring programs now in existence, such as the Great Australian Shark Watch (see Australian Underwater Federation, www.auf.com.au), involving a national monitoring program with a few thousand observations. Similarly, various jurisdictions monitor commercial and angling catches of sharks.

Effort required

Variable, from a few hours to several days, and depending on a variety of factors such as weather, location, habitat availability, season and target species. Experts should be consulted to determine survey effort.

Additional information for particular species

Grey nurse shark (*Carcharias taurus*)

Grey nurse sharks on the east coast of Australia undergo some migratory movements (probably associated with breeding). Any visual techniques to sample for these animals will need to account for such movements before it could be assumed that there are no sharks in a particular area.

Determining the presence of grey nurse sharks in inshore areas could be attempted by visual SCUBA diving surveys in a particular area to determine whether the habitat is appropriate and/or to conduct targeted surveys for the sharks.

Great white shark (*Carcharodon carcharias*)

Great white sharks have been demonstrated to make significantly large movements, although the reasons for these movements are unknown. Some feeding migrations are known, with sharks common around seal colonies.

The study of the great white shark has often involved 'chumming', whereby sharks are lured to boats by providing a berley trail that takes advantage of the sharks' keen sense of smell. The great white shark, if in the area and hungry, then follows the boat and observations can be made. It is unknown how successful the method is in determining the presence or absence of the species in an area and is a practice that may change the behaviour of the animal towards any boats in the area. Determining presence or absence will require discussion with relevant experts or locals (fishermen or diving groups) rather than active observational efforts.

Whale shark (*Rhincodon typus*)

Known aggregations of whale sharks occur off Ningaloo Reef (Western Australia) in the autumn months (March to May), coinciding with the coral spawning (and therefore plankton blooms) in this area. Aggregations also probably exist off the Great Barrier Reef at particular times of year (possibly in late spring when the coral spawns).

The most reliable method of determining if whale sharks are present in an area is probably the use of spotter planes with trained pilots and observers. Many hours may be needed.

Group 10: Estuarine skate

General information

Common name	Scientific name	Distribution
Maugean skate	*Zearaja maugeana*	Known only from Bathurst Harbour and Macquarie Harbour, western Tasmania, in brackish and almost fresh waters.

Survey methods

Best time of day for sampling

Dependent on the sampling method used.

Season and weather considerations

Unknown.

Most appropriate methods

Two methods have been used to survey for the species: gillnet and underwater observation. Underwater observation is the method least likely to have adverse affects on the population, but observations are hampered by the dark tannin stained water and silty bottom, which is easily disturbed. If gillnets are used, they should be checked frequently (around 30 minute intervals) as outlined under "Collecting techniques for threatened fish".

Effort required

Last and Gledhill (2007) reported divers observing only one individual in Port Davey with over 100 hours of underwater observations, although it is reported to be more common in Macquarie Harbour. Extensive gillnetting also has discovered few individuals.

Taxonomic issues

The species was previously known as *Raja* sp. L, but recently described by Last and Gledhill (2007). There is currently no formal Australian standard name, but the species has consistently been referred to as the Maugean skate or Port Davey skate. Other species of rajids (*Dentiraja* and *Dipturus* spp.) are known from the continental shelf off western Tasmania and might be expected to occur rarely in the harbours with the Maugean skate, but those species are morphologically distinctive and unlikely to be confused with the Maugean skate.

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APPENDIX A: EXPERTS AND THEIR AREAS OF EXPERTISE

A number of experts on various Australian fish species listed on the EPBC Act are listed in the table below. Experts who provided information that contributed to the text of this report via personal communications are indicated with an asterisk*.

Name (alphabetical by surname)	Area of expertise	Department
Lee Baumgartner	Trout Cod Macquarie Perch	Narrandera Fisheries Centre NSW Industry & Investment
Andrew Bruce	Macquarie Perch	Port Stephens Fisheries Institute NSW Industry & Investment
Barry Bruce	Handfishes Great White Shark Grey Nurse Shark	CSIRO
*Mark Green	Handfishes	CSIRO
*Michael Hammer	Yarra Pygmy Perch Ewens Pygmy Perch Swamp Galaxias Murray Hardyhead Trout Cod	Adelaide University
Bill Humphreys	Blind Gudgeon Blind Cave Eel	Western Australian Museum
*Dr Jean Jackson	Tasmanian Galaxiids Australian Grayling	Native Fish Conservation Inland Fisheries Service
Dr Mark Kennard	Lake Eacham Rainbowfish	Research Fellow Griffith University
*Dr Jamie Knight	Oxleyan Pygmy Perch	Port Stephens Fisheries Institute NSW Industry &Investment

Name	Area of expertise	Department
Dr. Helen Larson	River Sharks Freshwater Sawfish	Museum and Art Gallery of the Northern Territory
Dr. Peter Last	Sawfishes River Sharks Handfishes	CSIRO
*Assoc. Prof. Mark Lintermans	Macquarie Perch Trout Cod	Institute for Applied Ecology University of Canberra
Simon Nicol	Trout Cod	Arthur Rylah Institute Department of Sustainability and Environment
Dr Nick Otway	Grey Nurse Shark	Port Stephens Fisheries Institute NSW Industry & Investment
*Stirling Peverel	Sawfishes River Sharks	Tropical Resource Assessment Program Department of Primary Industries
*Tarmo Raadik	Barred Galaxias Murray Hardyhead Yarra Pygmy Perch Ewens Pygmy Perch	Arthur Rylah Institute Department of Sustainability and Environment
*Bob Simpson	Mary River Cod	Department of Primary Industries
*Dr John Stevens	River Sharks Sawfishes Grey Nurse Sharks Great White Shark	CSIRO
Rob Wager	Elizabeth Springs Goby Edgbaston Goby	Raintree Aquatics Pty Ltd
John Pogonoski	Fish Taxonomy	CSIRO

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FRONT COVER IMAGES (left to right)
Spotted Handfish (T. Carter) Trout Cod (Gunther E Schmida) Honey Blue Eye (Gunther E Schmida).

BACK COVER IMAGES (left to right, top to bottom)
Aquatic ecologists hauling fyke net set to cathc aquatic fauna (Andrew Tatnell & the Department of Sustainability, Environment, Water, Population and Communities) Honey Blue Eye (Gunther E Schmida) Ewens Pygmy Perch (Department of Conservation and Environment - Vic).

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