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PROPOSED DETERMINATION

***Prototroctes maraena* – Australian Grayling as an Endangered Species.**

The Fisheries Scientific Committee, established under Part 7A of the *Fisheries Management Act 1994* (the Act), is proposing to list *Prototroctes maraena* - Australian Grayling, as an ENDANGERED SPECIES in NSW in Part 1 of Schedule 4 of the Act.

The listing of Endangered Species is provided for by Part 7A, Division 2 of the Act.

The Fisheries Scientific Committee, with reference to the criteria relevant to this species, prescribed by Part 16, Division 1 of the *Fisheries Management (General) Regulation 2010* (the Regulation) has found that:

Background

1) Australian Grayling – *Prototroctes maraena* (Gunther, 1864) is a valid, recognised taxon and is a species as defined in the Act.

2) The species is a small to medium-sized (maximum size ~ 300 mm) pelagic fish of the family Retropinnidae.

3) The historical distribution of *P. maraena* in NSW includes freshwater, estuarine and marine waters south of and including the Hunter catchment (Krefft 1874). However, a majority of records are from the south coast region (Bell *et al.* 1980). Outside NSW, the species' distribution extends west into south-eastern South Australia and south to Tasmania including King Island (Bell *et al.* 1980). In Victoria, abundance and prevalence are reportedly greatest in eastern Victoria (Jackson and Koehn 1988).

4) *Prototroctes maraena* is an obligate diadromous fish with an amphidromous life history strategy (Crook *et al.* 2006). Spawning occurs in the lower freshwater reaches of rivers (Saville-Kent 1886, Bacher and O'Brien 1989, Koster *et al.* 2013). Incubation of the demersal non-adhesive eggs lasts 10-20 days (12 days at 16.5^{o}C), larvae hatch at about 6.5 mm long and are pelagic and phototactic (Bacher and O'Brien 1989). They drift/disperse into marine waters before migrating back into freshwaters in spring at ~ 45–55 mm long and ~ 4-6 months of age. Individuals then remain within freshwater habitats for the remainder of their lives (Crook *et al.* 2006, Koster *et al*. 2013). The lack of population genetic substructure suggests natal homing by juveniles is unlikely (Schmidt *et al.* 2011).

5) During the freshwater phase of the life-cycle, *P. maraena* inhabit both large rivers and smaller streams (Wager and Jackson 1993, greater than ~15 ML day^{-1} discharge in NSW, Fisheries NSW Freshwater Fish Research Database and OZCAM database) and in both relatively undisturbed as well as highly disturbed catchments (Jackson and Koehn 1988, Hall and Harrington 1989). The species is mostly reported from the coastal plain and lowland zones of rivers (< 200 m above sea level; ASL), with a majority of records from NSW being < 100 m ASL. However, a single museum specimen (Australian Museum specimen No I.3659) is described as being collected from the Snowy catchment at >1,200 m ASL in 1897. Although Waite (1901, 1902) and Stead (1903) acknowledged this sample location as the "upper reaches of the

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Snowy River near Mount Kosciusko", the spatial accuracy of the collection location is questionable given its dissimilarity with all other subsequent records.

6) Nothing is known of the specific environmental requirements or habitats occupied during the estuarine or marine phase of the life-cycle, with very few specimens being collected from, or recorded in estuarine or marine environments.

7) Sexual maturity is reached at age-1+ for males and age-2+ for females. The species is relatively short-lived with a maximum known age of 5 years, but with very few surviving to 3+ years of age (Bishop and Bell 1978, Berra 1982, Berra and Cadwallader 1983).

8) Spawning is thought to occur within a brief synchronised period between late summer and mid winter (depending on location and varying annually), with spawning activity initiated by an increase in flow (Berra 1984, Hall and Harrington 1989, Koster *et al.* 2013). Temperature and lunar phase may also be influential (Hall and Harrington 1989). In Victoria, Koster *et al.* (2013) observed a peak in drifting egg densities in early to mid May. Oocytes are reabsorbed in winter if suitable spawning triggers have not occurred (O'Connor and Mahoney 2004). Average fecundity is 47,000 eggs per female (Berra 1982). It had been postulated that adults may die after spawning (McDowall 1976, Bishop and Bell 1978), however, the collection of post-spawn fish (Berra 1982) and observed return upstream migrations of post-spawning fish disproves this hypothesis (Koster *et al*. 2013).

9) Population genetic analysis covering approximately one quarter of its continental range (central Victoria) suggests that the species consists of a single panmictic population rather than as discrete breeding populations in individual catchments (Schmidt *et al.* 2011). Given the otolith microchemical evidence that adults remain within a single river system (Crook *et al.* 2006), this suggests the mixing of larvae that are hatched in individual river systems during the marine phase of the life-cycle.

10) It is suggested that only a few river systems may provide conditions suitable for successful spawning and recruitment to the population (Jackson and Koehn 1988).

11) *Prototroctes maraena* are omnivorous, feeding predominantly on macro-invertebrates, zooplankton, algae and diatomaceous biofilm (Jackson 1976, Bishop and Bell 1978, Berra *et al.* 1987).

12) The sole congener of Australian Grayling, the New Zealand Grayling (*Prototroctes oxyrhynchus*) declined to extinction between the 1870s and 1923 (McDowall 1996). The causes of its extinction are unclear; although could be attributed to habitat degradation through deforestation and the impacts of alien salmonids (McDowall 1996). But the species also disappeared from areas where salmonids were absent and from largely undisturbed catchments (Lake 1971), suggesting the influence of additional unidentified factors.

Criteria – reduction in abundance, geographic distribution or genetic diversity (Regulation clause 271)

1) Major declines of *P. maraena* had been observed in several catchments throughout the species range by as early as the late 1800s (see Jackson and Koehn 1988 for references).

2) Lake (1971) suggested that the species was one of Australia's four most seriously threatened freshwater fishes.

3) By 1980 the species was considered scarce across most of its range and many populations were considered "unstable" (Bell *et al.* 1980).

4) In 1980 the species was one of the first three freshwater fish species listed as nationally Endangered by the Working Group on Endangered Fauna of the Standing Committee of the Council of Nature Conservation Ministers (Burbidge and Jenkins 1984).

5) In 1985 the species was listed as 'Potentially Threatened' by the Australian Society for Fish Biology under its threatened species classification (this category is the equivalent of Vulnerable under the IUCN classification and criteria; Harris 1987).

6) There was considerable conjecture and debate regarding the conservation status of the species until the early 1990s, largely fuelled by a lack of data. This uncertainty was perpetuated by the perception that populations of *P. maraena* experience great fluctuations in abundance, with Stead (1903) and Berra (1982) suggesting that population abundance may vary through a 14 - 17 year cycle.

7) By the mid1990s it was generally agreed that a widespread reduction in distribution and abundance had occurred across the species' range (Wager and Jackson 1993), with larger populations being restricted to a few river systems.

8) A review of the distribution of *P. maraena* in 1980 (Bell *et al.* 1980), highlighted a southern contraction of the distribution of the species in NSW of ~ 160 km. Assessment of recent data (1994 – 2014) from the Fisheries NSW Freshwater Fish Research Database, and acknowledging a 'new' historical record (1874) of the species in the Hunter catchment and a more recent (1974) record from the Lake Macquarie catchment suggests up to a ~350 km contraction of the species historical distribution along the NSW coastline and representing a 65% reduction in distribution in NSW (Fisheries NSW, unpublished data).

9) During the period 1993 – 1995, Fisheries NSW recorded *P. maraena* at 22 locations between the Shoalhaven and East Gippsland catchments (R. Faragher, unpublished data, Harris and Gehrke 1997). Re-sampling of 17 of these sites in 2003/04 recorded *P. maraena* at only 35% of these locations (Fisheries NSW, unpublished data). Further sampling in 2006/07 (16 sites), 2008/09 (7 sites) and 2011/12 (20 sites) failed to detect any individuals at sites where they had been present in 1993-95 (Fisheries NSW, unpublished data).

10) Miles (2005) undertook targeted surveys for *P. maraena* across the NSW distribution of the species in 2004. Only a single *P. maraena* was caught and a further 14 individuals were observed at 5 of 47 sites (11% of sites). The five sites were in the Clyde (2 sites), Deua (1 site), Towamba (1 site) and Womboyn (1 site) catchments.

11) *Prototroctes maraena* were collected at two of 81 (2.5%) randomly selected sites < 200 m ASL within the species historic range during fish assemblage sampling in 2007 - 2008 and at one of 86 (1.2%) sites sampled in 2010 - 2011 (Fisheries NSW, Freshwater Fish Research Database).

12) Meta-analysis of time-series data from six long-term monitoring sites spanning a 17-year period (between 1994 and 2011) was not able to detect any statistically significant decline in abundance of *P. maraena* at these sites over that period (Fishers Z = -0.649, $p = 0.516$; D. Gilligan, unpublished data). However, due to high

variance in CPUE estimates within sites, the tests lack power to detect statistically significant trends.

13) *Prototroctes maraena* is listed as a Protected fish under Part 2 of the *Fisheries Management (General) Regulation 2010*.

14) Nationally, *P. maraena* is classified as Vulnerable under the *EPBC Act 1999*, Vulnerable on the IUCN Red List of threatened species (IUCN 2003) (criteria A1c – version 2.3, 1994) and is considered Vulnerable by the Australian Society for Fish Biology (Lintermans 2013). The species is listed as Threatened in Victoria under the *Flora and Fauna Guarantee Act 1988* (considered Vulnerable) and listed as Vulnerable in Tasmania under the *Threatened Species Protection Act 1995*. The species is listed as Endangered in the *Action Plan for South Australian Freshwater Fishes 2009* (Hammer *et al.* 2009).

15) In light of the above, the Fisheries Scientific Committee has found *Prototroctes maraena* meets the criteria of an ENDANGERED species.

Criteria – threatening processes (Regulation clause 272)

1) Fish passage barriers, river regulation, loss of riparian vegetation, sedimentation (habitat degradation and alteration of macro-invertebrate assemblages), sand and gravel extraction and salmonid predation have previously been proposed as the threatening processes (Wager and Jackson 1993, Backhouse *et al*. 2008).

2) As the species is obligately diadromous (Crook *et al*. 2006), fish passage barriers restrict access to otherwise suitable habitats (Bell *et al.* 1980, Pethebridge *et al.* 1998, Gehrke *et al.* 2002). The installation of fishways has successfully re-established fish passage for *P. maraena* at some locations in Victoria (Backhouse *et al.* 2008) and fishways have been constructed or barriers removed in NSW specifically to enhance movement of the species.

3) River regulation threatens populations by eliminating or suppressing migration and spawning cues (O'Connor and Mahoney 2004, Koster *et al.* 2013). O'Connor and Mahoney (2004) determined that females undertake ovarian involution in the absence of flow trigger during the spawning season and Koster *et al.* (2013) reported that adults discontinue downstream spawning migrations in the absence of elevated flows. Excessive water extraction from catchments terminating in ICOLLs (Intermittently Closed and Open Lakes and Lagoons) and barrier estuaries may limit opportunities for the seaward migration of larvae and the return re-colonisation migrations of juveniles (Crook *et al.* 2006, Schmidt *et al.* 2011).

4) Loss of riparian vegetation, sedimentation as well as sand and gravel extraction represent local to catchment scale threatening processes, which have led to general declines in aquatic ecosystem health. There has never been any assessment of the direct influence of any of these factors on *P. maraena* populations.

5) Salmonid predation has previously been proposed as a potential threatening process – particularly of juvenile individuals (Jackson and Koehn 1988, Wager and Jackson 1993, Backhouse *et al*. 2008). However, the distribution of alien salmonids does not extend into the lowland reaches occupied by *P. maraena* in NSW and therefore salmonid predation is unlikely to pose a significant threat to *P. maraena* populations in NSW.

6) Many river systems on the south coast of New South Wales remain free of significant fish passage obstructions, have unregulated flow regimes, have few or possibly no alien fishes present, and many catchments remain dominated by native forest. As a result, although the processes above can affect *P. maraena* populations at a local or catchment scale, these threats may not be significant across the entire distribution of the species in NSW. Broader processes and factors affecting populations at a larger scale, such as disease epidemics, increased temperatures and reduced stream discharge resulting from climate change, or oceanographic processes affecting the marine phase of the life cycle (the survival or dispersal of larval *P. maraena*) are likely to be of more relevance.

7) Johnston (1883) reported the widespread collapse of formerly abundant grayling populations within most Tasmanian rivers around 1868 as a result of a postulated widespread disease epidemic. Stead (1903) reported that "In some places it is stated that thousands of dead fish were seen floating down the river. The fins, eyes and gill covers appeared to be covered with fungus. It is therefore likely that at particular periods they are subject to the widespread attack of some species of *Saprolegnia*". Although, McDowall (1976), Bishop and Bell (1978) and Berra (1982) argued that these observed mass mortalities were more likely a result of natural post-spawning mortalities, the absence of any observations of similar post-spawning mortality events in any river at any time supports Johnston's initial conclusion. Outbreaks of pathogens introduced with alien species during the 1800s could potentially have been a principal cause of collapse of populations.

8) In a similar manner to the threat posed by river regulation, climate-induced reductions in stream discharge in south-eastern Australia (Jones and Durack 2005) is likely to disrupt migration and spawning cues as well as contribute to reproductive failure. Specifically, Murphy and Timbal (2008) report that most of the observed declines in rainfall across south-eastern Australia since 1950 have been in autumn; the season within which *P. maraena* relies on high flows to initiate downstream migration and spawning, and are therefore most critical. Given the relatively short life-span, several consecutive years of poor recruitment is likely to result in the localised extinction of populations (Schmidt *et al.* 2011).

9) Cai *et al.* (2005) and Ridgway (2007) report on the intensification of the East Australian Current (EAC) and associated changes to meso-scale features and regional oceanography off south-eastern Australia. Specifically, Ridgway (2007) reports a southward extension of ~ 350 km over the period 1944 – 2002. Increased southward penetration of the EAC could impact on populations of *P. maraena* in NSW rivers by sweeping larval grayling southward during the marine larval phase of the life cycle and limiting recruitment into rivers in the northern parts of its range. However, it should be noted that Ridgway (2007) found that the summertime trends in temperature and salinity are greater than those in winter, the period within which larval grayling are present in the marine environment (autumn-spring).

10) Intensification of the EAC has been implicated in observed changes in broader biological assemblages, with a number of marine and estuarine species steadily ranging further southward over recent decades (Edgar *et al.* 1997, Thresher *et al.* 2003, Figueira and Booth 2010, Hobday and Lough 2011, Last *et al.* 2011). Commercial and recreational fishing pressure has simultaneously contributed to changes in these biological assemblages. Such alterations to biological assemblages can affect marine and estuarine food webs through processes such as trophic cascades (Pace *et al.* 1999, Casini *et al.* 2009, Salomon *et al.* 2010) and meso-predator release (Ritchie and Johnson 2009, Brashares *et al.* 2010), with potential

but unquantified implications for larval *P. maraena* via competition for food and/or intensified predation.

Conclusion pursuant to section 220F(3) of the Act

In the opinion of the Fisheries Scientific Committee:

(a) *Prototroctes maraena*, Australian Grayling has experienced a very large reduction in abundance, prevalence and distribution is facing a very high risk of extinction in New South Wales in the near future, as determined in accordance with the criteria prescribed by the regulations as discussed above; and

(b) it is not eligible to be listed as a critically endangered species.

The species is eligible to be listed as an ENDANGERED species.

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