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PLATYCEPHALIDAE: FLATHEADS

Globally, there are currently 18 genera and 75 species assigned to the Platycephalidae, a family of fish distributed throughout the Indo-Pacific region (Froese and Pauly, 2013). Flatheads have moderately to greatly depressed heads, often with sharp spines and ridges, and two separate dorsal fins, the first armed with strong and sharp spines (Gomon et al., 2008). Flatheads are well camouflaged, bottom-dwelling fish, and spend much of their life buried in sand or mud, with just the eyes or upper parts of the head exposed (Kuiter, in Gomon et al., 2008). Flatheads are found in a variety of habitats, from shallow estuaries to deep offshore waters.

More than 50 species in the Platycephalidae are found in Australia (CSIRO, 2009), making this region the centre of diversity for the family (Edgar, 2000). Approximately 20 of those species are known from southern Australia (Kuiter, in Gomon et al., 1994).

Examples of species in the Platycephalidae that occur in southern Australia include:

- Longhead Flathead *Leviprora inops*: a shallow-water species (usually to about 30m deep) known mainly from W.A., but extending as far east as Kangaroo Island and Gulf St Vincent in South Australia. The Longhead Flathead is found on sand, amongst seagrass and macroalgae.
- Yank Flathead / Southern Blue-spotted Flathead / Southern Flathead *Platycephalus speculator*: a large species, found in shallow waters across southern Australia and northern Tasmania. The Southern Blue-spotted Flathead occurs in the sandy and weedy areas of estuaries and bays, and off surf beaches, and is taken by both commercial and recreational fishers. Southern Blue-spotted Flathead are taken by beach seines, gill nets and hauling nets, rarely by trawls (Yearsley et al., 1999, cited by Bruce et al., 2002). Flathead is one of the 5 flathead species taken in the Commonwealth-managed South East Trawl sector of the Southern and Eastern Scalefish and Shark Fisheries (SESSF); however it is not the main flathead species landed (Daley et al., 1998; Caton and McLoughlin, 2005; Larcombe and Begg, 2008). Southern Flathead are also taken in N.S.W. and Victorian State waters, and in Tasmania.

- Eastern Blue-spotted Flathead *Platycephalus caeruleopunctatus*: found on sandy bottom in southern Queensland, New South Wales and eastern Victoria.
- Sand Flathead *Platycephalus bassensis*: a common and frequently caught flathead, found across southern Australia and Tasmania in sandy and silty habitats between 0m and about 100m. The species is found in lesser numbers in South Australia, and rarely in Western Australia (Hutchins and Swainston, 1986). In south-eastern Australia, *P. bassensis* spawns in estuaries, coastal embayments and inshore shelf waters, over an extended period between October and March (Jordan, 2001c). Sand Flathead is caught using trawl nets, Danish seine nets, gill nets, beach seine nets and hand lines (Bruce et al., 2002). Sand Flathead occurs abundantly in shallow bays in Victoria and Tasmania; is commercially important in both of those States, and is a highly sought-after species for recreational fishers in Tasmania. In S.A., the species is part of the commercial prawn trawl bycatch in Spencer Gulf (Carrick, 1997) and Gulf St Vincent (Broadhurst et al., 1999), and also part of the bycatch in the Blue Crab fishery (Currie and Hooper, 2006). Sand Flathead is also one of approximately 20 main scalefish species taken in the New South Wales Ocean Trawl fishery (N.S.W. Fisheries web site, 2004). Sand Flathead grow to at least 50cm in length and over 2kg in weight, at which size they are about 16 years old (DPIWE Tasmania, 2004c).
- Rock Flathead / Grass Flathead / Grassy Flathead *Platycephalus laevigatus*: A shallow water species found across southern Australia and Tasmania. The Rock Flathead is found in seagrass beds, and near reefs and jetties, where it sleeps under low-lying marine vegetation during the day. The Rock Flathead is caught commercially and recreationally throughout southern Australia.
- Long-spined (Longspine) Flathead *Platycephalus longispinis*: A smaller flathead species found in weed and sand habitats, in N.S.W., Victoria, S.A. and W.A.. The species occurs between 3m and 75m deep (but more typically between 15m and 20m). Long-spined Flathead is a minor component of the Commonwealth-managed South East fishery component of the SESSF.
- Dusky Flathead *Platycephalus fuscus*: a sub-tropical species that ranges from north Queensland, through N.S.W., to Lakes Entrance in Victoria. The Dusky Flathead generally inhabits shallow bays and inlets, and is also found in estuaries, over mud, silt, gravel, sand, seagrass, and even artificial reefs and wrecks. Dusky Flathead are one of the most valuable commercial estuarine fish in New South Wales, and are also caught commercially in Queensland and Victoria. Dusky Flathead are also an important species for recreational fishers in the eastern States.
- Toothy Flathead / Gold Spot Flathead *Neoplatycephalus aurimaculatus*: a south-eastern and southern Australian species that occurs in bays and other coastal waters, mainly in Victoria and Tasmania. The distribution extends west into South Australia. The Toothy Flathead is a component of the flathead catch in the Commonwealth-managed South East trawl component of the SESSF, and is discussed in a synopsis below.
- Deepwater Flathead *Neoplatycephalus conatus*: a larger flathead species, found at depths of 70m to more than 400m (commonly 200m), across southern Australia. The Deepwater Flathead is taken by commercial trawlers in the Great Australian Bight, and to a lesser extent in southern W.A. and south-eastern South Australia.
- Tiger Flathead *Neoplatycephalus richardsoni*: a south-eastern Australian species that extends west into south-eastern South Australia. Tiger Flathead is a major species taken in Commonwealth-managed trawl fisheries in south-eastern Australia, and is fully exploited. Tiger Flathead are also a popular target of recreational fishers in Tasmania.
- Tassel-snouted Flathead / Rock Flathead *Thysanophrys cirronasus (= T. cirronasa)*: found on shallow coastal rocky reefs across southern Australia, from southern Queensland to south-western W.A., excluding Tasmania. The species has been recorded from a number of locations in South Australia, such as Kangaroo Island, Gulf St Vincent (both Yorke Peninsula and Fleurieu Peninsula sides), Spencer Gulf, and the Great Australian Bight.

(Dredge, 1976; Glover, 1979; Kailola et al., 1993; Kuiter, in Gomon et al., 1994; Kuiter, 1996a; Carrick, 1997; Marine Life Society of South Australia records, 1998; MLSSA, 1999; Daley et al., 1998; Edgar, 2000; K. Smith, unpublished data, 2000, 2001; Hutchins and Swainston, 2001; Australian Museum, 2003v; AFFA web site, 2004; Gomon et al., 2008).

Of the species found in South Australia, the two main commercial species, one lesser commercial species, and two shallow-water, non-commercial species are discussed below.

Deepwater Flathead

Family Name: Platycephalidae
Scientific Name: *Platycephalus (=Neoplatycephalus) conatus* Waite and McCulloch, 1915
Recommended Status: **Commonwealth waters: *Near Threatened***
State waters: *Least Concern*

Rationale: *Deepwater Flathead is included here because (i) it is a large, benthic species associated with specific areas of the continental shelf in southern Australia, which increases its susceptibility to capture with trawl gear; (ii) like other large, southern Australia flathead species, Deepwater Flathead is moderately long-lived and does not reproduce until about 5 or 6 years of age, which is a vulnerable population characteristic if population exploitation (e.g. by fishing) is not closely monitored over time; (iii) the species may aggregate by sex, and for spawning, which can increase the vulnerability of Deepwater Flathead to over-exploitation; (iv) if spawning is temperature-dependent, over the long term the effects of climate change (and consequent ocean warming) in southern Australia may have impacts on populations of Deepwater Flathead, but more research into the relation of flathead distribution and abundance to oceanographic variables is required; (v) the species is caught across its range in south-eastern, southern and south-western Australia by a number of methods, particularly trawling in the Great Australian Bight, where peak catches occurred during the early 2000s, prompting a non-conservative quota which has not been met in any year of the fishery operation. Specifically, in the Commonwealth-managed GAB trawl fishery off South Australia, an initial quota of 3,000t per annum was introduced in 2006 for Deepwater Flathead, yet there was no indication from the catch history, or the highly fluctuating and uncertain biomass estimates, or the high variability in catch rates, that this was a sustainable target. The 2006 quota was set much higher than recent estimates of the long-term potential yield per annum. Only two years later (2008), the GAB quota was reduced significantly (1,400 tonnes), and in 2011-12, was set at 1,650t. Annual quota has not been met since its introduction. Catches in south-eastern Australia (e.g. South East trawl fishery) are not well quantified, and discarding of juveniles of all flathead species occurs, including Deepwater Flathead. Given the continued targeting of this species (particularly in the GAB) despite highly variable biomass estimates, coupled with little information about the sustainability of annual catches, and reduction in the size composition of the catch since the commencement of the GAB trawl fishery, the suggested status is* Near Threatened *in Commonwealth-managed waters. Due to the deep depth range of this species, largely outside of State waters, the suggested status in State-managed waters is* Least Concern.

Current Conservation Status

- No formal listings.
- Since 1992 (and up to 2007), the species was listed as being of *uncertain* status in the GAB Trawl fishery (Caton and McLoughlin, 2005, 2006). In 2007, status was changed to "*not overfished and not subject to overfishing*" (Larcombe and Begg, 2008; Wilson et al., 2009; Moore and Viera 2012).
- It is noted that in the Commonwealth's South East fishery component of the SESSF, although *N. conatus* is not usually listed amongst the 5 main species that comprise the group "flathead", it is taken in that fishery. In 2007, the status of flathead as group was *overfished* (Larcombe and Begg, 2008); however, **the majority (~ 90%) of the catch in the South East fishery is Tiger Flathead *Neoplatycephalus richardsoni***, hence the assessment does not refer specifically to *N. conatus*.

Distribution

Southern Australia

- Deepwater Flathead ranges across southern Australia, from western Bass Strait (across Victoria and northern Tasmania) through to Geraldton in W.A. (Kuiter, in Gomon et al., 1994; Daley et al., 1998; AFMA, 2002a).

- Williams et al. (2001) characterised *N. conatus* as one of the indicator species in "a southern community of the well-defined (continental) shelf break community" in south-western Australia, which contains a number of Flindersian (warm temperate southern Australian) species that occur mainly between 200m and 400m depth, and extend northwards to about 28° S latitude.

South Australia

- Examples of locations in S.A. where the species occurs include the Great Australian Bight (GAB), particularly the mid and outer continental shelf, in the east (e.g. off Eyre Peninsula), in the central region, and the west (towards the W.A. border); south-western Spencer Gulf; bottom of the Fleurieu Peninsula / Backstairs Passage region; northern and western Kangaroo Island; deep waters south-east of Kangaroo Island, and southern Eyre Peninsula (Newton and Klaer, 1991; Brown and Knuckey, 2002; South Australian Museum records, Museum of Victoria records; CSIRO Marine Research records, cited in CSIRO, 2012).

Habitat

- Deepwater Flathead is found on the continental shelf and upper slope, over a variety of substrates (May and Maxwell, 1986; Kailola et al., 1993). The overall depth range of Deepwater Flathead is about 70m to 490m / 510m (Kailola et al., 1993; CSIRO et al., 2001; Gomon et al., 2008), but the species is more common between 100m – 200m deep (Daley et al., 1998) or 150m – 400m (CSIRO et al., 2001).
- In W.A., this species is one which is reported to characterise the southern (e.g. south of Perth) component of a well-defined shelf-break community (200m – 400m) (Williams et al., 2001).

Notes on the Biology

Age and Growth

- The maximum size recorded is 94cm for females (Kailola et al., 1993) and about 70cm for males, but the typical size range in the fished population is about 40 or 45cm to 60cm (Daley et al., 1998; Brown and Knuckey, 2002, and see below, on ***Commercial Fishing***).
- Analysis of age and length data suggests that females grow faster and live longer than males (Kailola et al., 1993, cited by AFMA, 2002a; Stokie and Krusic-Golub, 2005). The maximum weight recorded is around 4kg (a female, from the Great Australian Bight) (Kailola et al., 1993), and males grow to a smaller maximum size, about 2kg. The typical weight range of Deepwater Flathead in the fished population is between 500g and 1.5kg (Daley et al., 1998).
- Otolith analysis of Deepwater Flathead samples from the GAB have shown that the species lives to at least 26 years of age (Stokie and Talman, 2003), although most fish in the commercial catch are less than 10 years old (Tilzey and Wise, 1999, cited by AFMA, 2002a). Validation of age estimates is required (AFFA, 2004b,c).
- Two periods of sampling, during which 652 and 566 otoliths from Deepwater Flathead were collected from the GAB Trawl fishery, showed differences in mean size at age between the sexes from 6 years onwards, with females significantly larger than males. The differences were confirmed by von Bertalanffy growth parameters estimated for both males and females (Stokie and Talman, 2003; Stokie and Krusic-Golub, 2005).

Diet and Feeding Behaviour

- Deepwater Flathead eat small bony fishes (e.g. silverside *Argentina australiae*, Three-spine Cardinalfish *Apogonops anomalus*, cucumberfish *Paraulopus nigripinnis*, and the worm eel *Muraenichthys* sp.), squid and cuttlefish and benthic crustaceans. Minor components of the diet include echinoderms, polychaete worms, gastropods and other benthic invertebrates (Coleman and Mobley, 1984; Kailola et al., 1993).

Migration and/or Aggregation

- Deepwater Flathead probably form aggregations by sex (Burnell and Newton, 1989, cited in Froese and Pauly, 2009).

Reproduction

- Male Deepwater Flathead mature at around 40cm (4 – 5 years old), and females mature at around 45cm (5 – 6 years old) (Kailola et al., 1993).
- In the Great Australian Bight, Deepwater Flathead spawn between October and February, with a spawning peak in late summer (Burnell and Newton, 1989; Kailola et al., 1993). Spawning may extend into the early autumn. It appears that fish aggregate to spawn at about 126°E (Tilzey and Wise, 1999). Little is known about the early life history of this species (AFMA, 2002a).

Other Information

- Deepwater Flathead is a minor component of the diet of Piked Spurdog *Squalus megalops* (Braccini et al., 2005).
- The stock structure of Deepwater Flathead is unknown (AFFA, 2004b; Larcombe and Begg, 2008).

Fisheries Information

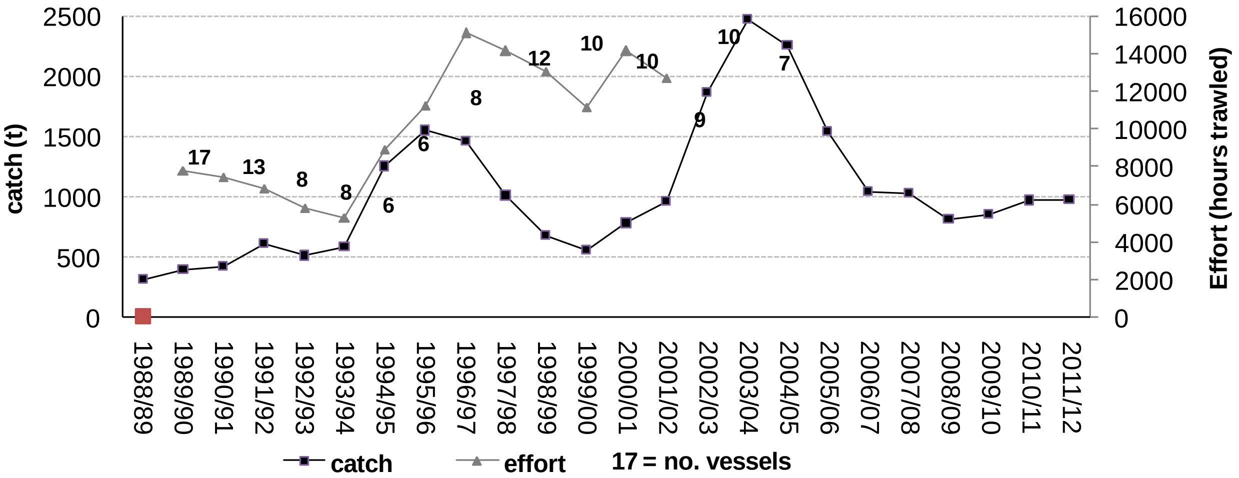
Commercial – Commonwealth Fisheries

- *N. conatus* is a highly regarded food fish, and is regularly sold (as fresh, chilled or frozen fillets) in fish markets in Adelaide, Sydney and Melbourne, using the correct common name for marketing i.e. "Deepwater Flathead" (Seafood Services Australia, 2005). Deepwater Flathead is one of the 8 main fish products sold by one of Australia's largest seafood supply companies, based in South Australia. Marketing of Deepwater Flathead catch has changed greatly since 1988, when 75% of landings were exported, mainly as frozen fillets (Newton and Klaer, 1991). The fish fillets are now sold on the domestic market as a table fish, and the fish heads are sold either for use as rock lobster (*Jasus* species) bait, or to processors producing fish meal.
- Deepwater Flathead is reported to be the most abundant flathead species on the continental shelf of the Great Australian Bight, where it is taken in the Commonwealth-managed GAB Trawl fishery (Daley et al., 1998), which is now a component of the Southern and Eastern Scalefish and Shark Fisheries (SESSF). The species has been trawled sporadically in the Great Australian Bight since the beginning of the 20th century, and a commercial fishery for Deepwater Flathead was set up in 1988 (as part of the Great Australian Bight trawl fishery) (Newton and Klaer, 1991). Deepwater Flathead is one of the major target species of the GAB trawl fishery, particularly the continental shelf component, and accounts for 40-50% of landings. The species is taken throughout the year, but catches and catch rates peak from October to December (Caton and McLoughlin, 2005). Catches and catch rates of Deepwater Flathead are reasonably consistent throughout the year. Deepwater Flathead in the GAB are taken mainly from depths of 100m - 150m (up to 200m) (Tilzey and Wise, 1999), with much targeting between 120m and 160m (Caton and McLoughlin, 2005). There are some high catch rates at depths greater than 200m, but these derive from a very low percentage of the total catch. The majority of the Deepwater Flathead catch is taken between longitude 126^{o}00' and 132^{o}30' (AFMA, 2006h). There is a clear inverse relationship between landings and catch rates of Deepwater Flathead and Bight Redfish, which is reported to be unrelated to any change in fishing practices, and most likely environmentally driven (e.g. changes in water temperature) (Tilzey and Wise, 1999, cited by AFMA, 2002a; AFFA, 2004c; Caton and McLoughlin, 2005). However, changes in trawl-net design were also suggested to be a possible contributing factor (AFFA, 2004b). The most productive grounds for Deepwater Flathead are on the Ceduna Plateau in the central Bight and the Eyre Plateau further to the west. Previously, catches were less frequent on continental shelf grounds south of Kangaroo Island, mainly as a result of lower fishing effort in that region; perhaps consequently, during the 1980s the size of Deepwater Flathead from trawl catches was reported to be significantly greater from grounds near Kangaroo Island than for the western central Great Australian Bight (Burnell and Newton, 1989). During the early 2000s, two periods of sampling of otoliths from Deepwater Flathead collected from the GAB Trawl fishery, showed that fish are fully recruited to the fishery by approximately seven years (both males and females) (Stokie and Talman, 2003), or by least 4 and 5 years for males and females, respectively (Stokie and Krusic-Golub, 2005). During the first period of sampling, the majority (71%) of the fish aged were between 5 and 9 years of age, and another 15% of the sample comprised fish between 10 and 14 years old. It is noted that 5% of the sample were 1 year olds (see Stokie and Talman, 2003, Appendix 1a).

(cont.) The commercial catch consists of fish 3–13 years old, with most 5–10 years old (AFFA, 2004b). The majority of the fish in the GAB catch are between 45cm and 60cm TL; very few individuals shorter than 35cm are caught. Comparatively few juvenile Deepwater Flathead are caught and discarded in this fishery, perhaps due to the depth range fished (AFFA, 2004c). In a bycatch sampling program during the early 2000s, the size range of 6,402 caught specimens was about 32cm – 76cm, with the majority of the catch between 40cm – 60cm (Brown and Knuckey, 2002). During subsequent surveys (for ageing fish using otoliths – see above), the size ranges of various samples were 13cm – 79cm (Stokie and Krusic-Golub, 2005); 25cm - 75cm for a sample of 3,328 fish from the central and west part of GAB in 2004, and 27cm – 77cm for a sample of 4,012 GAB trawl fish measured at a factory in Adelaide during the same year (Talman et al., 2005). In the following year (2005), size ranges included approximately 28cm – 74cm for the central and west GAB sample, and 27cm – 73cm for the Adelaide factory samples (Koopman et al., 2006). The annual catch of Deepwater Flathead from the Great Australian Bight has risen from less than 500t in 1989 to almost 2,500t in 2003/04 (Klaer, 2007). Catch rates have varied significantly over the history of the fishery, from a high of 192 kg/h in 1995, to a low of 48 kg/h in 1999, and increased annually again during the early to mid 2000s (Caton and McLoughlin, 2006), and during the late 2000s (Klaer 2012). During the mid 1990s, increasing industry knowledge of the fishery, more-effective fishing practices and the gradual expansion of known fishing grounds were thought to have enhanced the catch rates. During bycatch sampling in the GAB trawl fishery in 2000 and 2001, Deepwater Flathead were observed in 163 of the 209 trawl shots; almost all Deepwater Flathead that were caught were retained, and the average quantity retained was 396kg per trawl shot (Brown and Knuckey, 2002). The total catch of Deepwater Flathead in the GAB Trawl Fishery between 1989 and 2007 is shown below. A quota of 3,000t per annum was introduced in 2006, and following that time, catch decreased from the record of almost 2,500t in 2003/04, to approximately 1,000t in 2006/07, after quota was introduced. Quota was reduced to 2,100t in 2007, and approximately 1031t of that quota was caught in 2007, and 903t of the further reduced (1,400t) quota was caught in 2008 (Wilson et al., 2009). Quota in 2011-12 was 1,650t, and 1,022t were caught (Moore and Vieira 2012). The numbers on the effort line show the number of vessels operating in each year. Data on effort and number of vessels in 1988/89, and from 2002 onwards, are not available for this report. It is noted that effort in the entire GAB trawl fishery has reportedly averaged approximately 17,000 bottom hours per annum, between 2001 and 2007 (AFMA, 2008c).

Reported Catches of Deepwater Flathead in the GAB Trawl Fishery, 1989 – 2012

(adapted from Lynch and Garvey, 2003;Klaer, 2007; Wilson et al., 2009; Klaer 2012).



- Deepwater Flathead is a lesser component of the flathead catch in Commonwealth fisheries in south-eastern Australia. For example, in the South East fishery (SEF) of the SESSF, Deepwater Flathead is taken in the Western Sector out to 200m (Daley et al., 1998), and that sector includes waters in central and western Victoria, Bass Strait, northern Tasmania, and westwards to south-eastern South Australia, as far west as eastern tip of Kangaroo Island. This species replaces Tiger Flathead (*N. richardsoni*) in the western sector of the SE fishery. Small quantities are caught off western Tasmania and western Victoria (Williams, 1990). A greater amount of discarding of juveniles may occur in the South East fishery compared with the GAB fishery, due to the depths fished.
- Flathead species taken in the Commonwealth fisheries are managed under ITQ management arrangements. For example, ITQs apply for flathead species taken in the SETF (South East trawl fishery component of the SESSF); the ECDWZ (East Coast Deepwater Zone within the SETF, previously called the East Coast Deepwater Trawl Fishery); the CVIT (Commonwealth Victorian Inshore Trawl Fishery), and the GHAT (Gillnet, Hook and Trap Fishery) (AFMA, 2003j). "Flathead" catches in the South East Fisheries (SEF) comprise about 5 or 6 species. The Total Allowable Catches (TAC) and actual catches of flathead species in the SEF in recent years are not included here, because the majority (~ 90%) of the catch comprises Tiger Flathead *N. richardsoni*. Deepwater Flathead is a retained by-product in the otter trawl sub-fishery of the SETF, and catches are recorded in daily logbooks (Wayte et al., 2004). Fishers' logbooks recorded **37 tonnes** of Deepwater Flathead in the bycatch of the SETF during 2000/01, and almost all of that was retained (AFMA, 2002a). The species is also a retained by-product in the East Coast Deepwater Trawl, and in the Gillnet, Hook and Trap Fishery (Bromhead and Bolton, 2005).
- Deepwater Flathead are caught in the southern areas of the Commonwealth-managed Western Deepwater Trawl Fishery (WDWTF) (Williams, 1990; AFMA, 2004f). In some years, Deepwater Flathead is one of several species that dominate the catch in the WDWTF (e.g. AFMA, 2004f), particularly in the depth range 300m – 600m (AFMA, 2007d). During the period 1992 – 2003, a total of 81.7t of Deepwater Flathead was taken in this fishery (AFMA, 2004f), including annual catches as high as 33t (in 2001/02). BRR (1991) reported that during the 1970s and 1980s, catches from W.A. were highly variable, and ranged between 21kg (in 1980/81) and 70 tonnes (in 1977/87). Reported catches were over 10 tonnes per annum in only 4 years during those two decades, including 57t in 1985/86 (BRR, 1991). It is not known for this report what the proportion of the W.A. catch was that was taken in State waters (see below) compared with Commonwealth-managed waters, during that period.

Commercial – State Fisheries
- In W.A. State waters, Deepwater Flathead is a target species in the South Coast Demersal Trawl Fishery, which is managed under W.A. State jurisdiction, and extends offshore to the 200m isobath between Cape Leeuwin and the Australian Bight (Kendrick et al., 2002).

Recreational
- According to AFMA (2002a), there is no specific recreational fishing of this species, and no species-specific recreational fishing information is available. Deepwater Flathead occur in waters deeper than most recreational fishers operate; hence recreational catches of this species are likely to be low.
- Morton et al. (2005) reported that this species is only occasionally caught by recreational fishers in Tasmania.
- It is noted that the Australian Anglers Association holds a record (2.51kg) of a specimen, reported to be *P. conatus*, caught at Cape Jervis in South Australia in 1992. Also, the Australian Anglers Association (W.A. Division) holds a fishing record (2.21kg) reported to be this species, from Rottnest Island, in September 1988.

Vulnerable Characteristics of the Species

- Deepwater Flathead are reported to have a low resilience to exploitation, in terms of minimum doubling time for populations (based on age, growth and reproduction parameters) (Froese and Pauly, 2009), and a high vulnerability to fishing-induced population decline (Cheung et al., 2005, cited in Froese and Pauly, 2009).
- Deepwater Flathead is a large benthic species associated with specific (and known) areas of the continental shelf in southern Australia, which increases its susceptibility to trawl capture.
- Deepwater Flathead is a relatively long-lived species, which does not reproduce until about 5 to 6 years of age.
- Deepwater Flathead may aggregate by sex, and to spawn.

Threatening Processes

- Potential for overfishing is one of the major threats to this species. The status of shelf resources in the GAB is uncertain. Great Australian Bight demersal resources are considered unlikely to support full-time fishing by all 10 licensed vessels (granted licences to operate since 1993, with previously numbers as high as 41 during the development phase in the late 1980s) (AFFA, 2004b). Although only a small number of the ten licence holders had been active in the fishery during any one year over the decade to 2002, there was increased participation in the fishery, and significant increases in fishing effort and fishing efficiency of active vessels during 2003 and 2004 (AFMA, 2006h). Effort fluctuates each year, as do biomass estimates (see below). Given the uncertain status of the stocks, this has raised concerns about future sustainability of the shelf resources. Under this scenario, industry agreed that quota management of the main target species should be introduced. They also agreed on equal allocation of quota between the ten SFR holders (AFMA, 2006h). A non-conservative quota of 3,000t per annum was introduced in 2006 for Deepwater Flathead, but there is no indication from (i) the catch history, (ii) biomass estimates or (iii) high variability in catch rates, that this is a sustainable catch. In the GAB trawl fishery, the reported catch of Deepwater Flathead has not been as high as 3,000 tonnes in any year of operation, and biomass estimates have fluctuated significantly. AFFA (2004) reported that although projections to the year 2020 suggested that the fishery could support annual catches as high as in peak years (e.g. 1,630t in 1995), there were large uncertainties associated with biomass estimates. Similarly, Larcombe and Begg (2008) reported that the long-term potential yield per annum is likely to be close to the current catch levels (i.e. ~ 1,000t per annum), yet the quota was set much higher, at 3,000 tonnes. Only two years later, the quota was reduced significantly (1,400 tonnes), and quota has not been met in any year since its introduction (see Wilson et al., 2009). There is much uncertainty in the biomass and abundance of Deepwater Flathead in the Great Australian Bight, and the estimate of biomass has decreased over time. For example, the biomass prior to the commencement of regular fishing (B_0) was estimated to be **53,760t**, but the range of uncertainty of the estimates was very large (2,488t to 105,032t). The estimate derived from 1992 “swept-area analyses” was 32,000t, and within that broad range (AFMA, 2004b). In 2002, when fishery data were incorporated into the models, the unexploited biomass estimate was **19,900t** (16,400t to 23, 000t, 95% confidence range). At that time, the biomass estimates were lower, but subject to less uncertainty, than those in 1999 and 1992. However, the assessment is very sensitive to the estimate of natural mortality used. For example, using natural mortality rates between 0.15 and 0.35, the corresponding estimates of biomass prior to the commencement of fishing ranged from **12,500t** to **44,400t** (AFFA, 2004b). The 2004–05 stock assessment for Deepwater Flathead estimated that the unexploited biomass was in the order of **27,398t**, with a maximum sustainable yield (MSY) of approximately 2000t per year. This assessment included data up to June 2005 and incorporated the biomass estimates from a stratified trawl survey. However, removing the survey data indicated that the unexploited biomass was **19,260t** and the MSY was in the order of 1660 t per year. Under this assessment, catches would need to be reduced below the previous two years’ landings. Under the harvest strategy framework developed for this fishery, the estimate of recommended biological catch (RBC) was calculated to be 2,300t (AFFA, 2004b). In 2006, the assessment for Deepwater Flathead, updated with additional data and improved methods, estimated the unfished biomass (B0) to be **10,087t** and the current biomass to be at 50% of that level. The assessment was considered to be generally robust to a range of alternative scenarios, the data that were included, the parameter values and the assumptions used. The results were more pessimistic than those of the 2005 assessment (Larcombe and Begg, 2008).

(cont.) In 2009, an industry-supported survey (Knuckey et al., 2009) estimated that the relative biomass of Deepwater Flathead to be **10,181**t (CV=0.04), which is around 30% higher than one of the 2008 estimates, and 16% lower than one of the reported 2005 estimates. Annual estimates of relative biomass of Deepwater Flathead from 2005 to 2011 (with no data for 2010) were **12,152t**, **8,415t**, **8,540t**, **7,725t**, **9,942t,** and **9,227t** respectively, with coefficient of variation being 0.5 to 0.6 for all years (Klaer, 2011, 2012; Moore and Vieira 2012). It is noted that the estimates may exclude fishes below 200m, because the shelf edge was the limit of the survey area. Nevertheless, given that the biomass estimate during the late 2000s was around 10,000 tonnes (down from an initial biomass estimate of almost 54,000t), and there is a quota of 3,000t per year, it is likely that current catches and quota are unsustainable, unless this species can replenish numbers at a fast rate (not likely, given that age at maturity is about 5 years and the majority of fish that are caught have just reached spawning size and age), or unless there is an additional stock not yet recorded in the GAB (also unlikely). In 2007, a stock assessment (see **Management Notes**) indicated that under most scenarios (variations in parameters), the spawning stock biomass in 2007 was approximately half of that estimated for 1980, a depletion of 43% – 56% of the 1980s stock level has occurred, depending on parameters used in the model (Klaer, 2007, Table 4.1). In contrast to the above-mentioned data, more recent assessments (Klaer, 2010, 2011) estimated the spawning biomass at the start of 2011 to be 62 per cent of the unfished (1978) level, and that although the spawning biomass was progressively fished-down in the mid-2000s, the biological stock had apparently "recovered by the start of 2010", likely due to lower fishing pressure in recent years, combined with at least one substantial recruitment event.

- The biologically derived total allowable catch (TAC) for the Great Australian Bight Trawl Sector (Commonwealth) for the 2010–11 fishing season was 1100 tonnes (t), which was subsequently adjusted to 1240 t to account for undercatch and overcatch. Landed catch of Deepwater Flathead from this fishery in the 2010–11 fishing season was 921 t, which was below the TAC. This level of fishing mortality is unlikely to cause the biological stock to become recruitment overfished
- If this species aggregates to spawn (e.g. Tilzey and Wise, 1999), then that would increase the susceptibility of Deepwater Flathead to over-fishing.
- There has been a reduction in the size composition of the catch, since the commencement of the GAB trawl fishery. In that fishery, workshops in 1994 and 1995 which reviewed the catch–effort and size–age data, indicated that from 1988/89 (the formal commencement of the flathead fishery) to 1994, the proportion of fish aged 9 years or more had dropped significantly, and that 5–8-year-olds were dominant. The 1995 and 1996 age-composition data for the deepwater flathead catch showed a continuing reduction in the proportion of fish aged 9 years or more in it (AFFA, 2004b). By 2009, although the length range of sampled fish (1,382 Deepwater Flathead) was 33–65 cm, most fish measured were between 40–46 cm (and it is noted that this is the size at first spawning), and the modal length was 43 cm, similar to the previous three years but smaller than that from 2005. The proportion of larger fish, especially in the 45-60cm size range, appears to have also been reduced since 2005 (Knuckey et al., 2009).
- In 2006, an Ecological Risk Assessment (ERA) for species in the Great Australian Bight Trawl Fishery (Daley et al., 2006), ranked Deepwater Flathead *N. conatus* as a "high risk" species, in terms of population impacts from capture in the GAB trawl fishery, noting also the "endemic" nature of the stock in the GAB. In a Residual Risk Assessment of the Level 2 Ecological Risk Assessment, this species was considered "medium risk" with the assessment noting that a catch quota was introduced in 2006. However, in a "rapid quantitative Level 3 assessment, or Sustainability Assessment of Fishing Effects (SAFE) assessment" undertaken by AFMA, a supplement to the ecological risk assessment (by CSIRO) for the GABTF, this species was ranked as "low risk" of impact from operation of the fishery. According to AFMA (2008c), the Level 3 assessment process considers the mitigating effects of management arrangements that were not explicitly included in the ERAs, or introduced after the process commenced. It is noted that the Level 3 assessment is made proportional to the spatial area in which the fishery operates, compared with the spatial area of distribution of the species, but this does not account for aggregation, rather than even distribution throughout space (the latter of which is unrealistic, for reef-associated species in a heterogeneous benthic environment).

- In a draft ecological risk assessment report for the South East Trawl fishery component of the SESSF (Wayte et al. 2004), 5 "productivity attributes" and 6 "susceptibility attributes" were used to classify *N. conatus* as being a "high risk" species in terms of potential population impacts from trawling. It is also noted that substantial discarding of juvenile flathead is reported to occur in the South East fishery (AFFA, 2004c).
- If environmental variables such as water temperature affect recruitment and also distribution of adults, the effects of climate change (and consequent ocean warming) in southern Australia may have detrimental impacts on populations of Deepwater Flathead. More research over space and time into the distribution and relative abundance of flathead in relation to oceanographic variables may be informative.

Research Notes

- In 1988, a developmental management plan for the GAB trawl fishery included establishment of logbook program, and regular collection of biological information on the major commercial species, including deepwater flathead. This was undertaken, apart from a gap period from end of 1990 to mid 1993. Periodic port-based sampling of catches to determine sex, size and age resumed between mid-1993 and 2001. Fisheries Research and Development Corporation funding was obtained for an onboard catch-sampling program during 2000–01. This program assessed bycatch and discarding practices, collected specific biological information, and calibrated port-based catch sampling. Industry agreed to fund a continuation of the program, which is the main source of catch-composition information. The Central Ageing Facility at Queenscliff, Victoria, examines sectioned otoliths, taken from a sample of the catch, to determine species age-composition (AFFA, 2004b).
- For the GAB trawl fishery, workshops in 1994 and 1995 reviewed the catch–effort and size–age data. A 1996 stock-assessment workshop used a more extensive logbook database to repeat the 1992 'area swept' analysis. A sample from juvenile fish enabled growth parameters to be refined (AFFA, 2004b).
- During the mid to late 2000s, fishery independent research surveys were being undertaken in the GAB to determine the biomass of the Deepwater Flathead stock. These surveys have been supported by Fisheries Research and Development Corporation (FRDC), GAB Industry Association (GABIA), GAB Resource Assessment Group (GABRAG), GAB Management Advisory Committee (GABMAC). The surveys aim to obtain an annual relative abundance index for Deepwater Flathead in the current region of the main GABTF shelf fishery, and to provide a density estimate of Deepwater Flathead inshore of the current fishery (e.g. Knuckey et al., 2009). The surveys will thus provide a time-series of relative abundance indices that can be used as input to stock assessment models (AFMA, 2006h). The surveys also aimed to collect biological and population data on this species (AFMA, 2006c). For example, during the 2009 survey, length-frequency measurements were made on 1,382 Deepwater Flathead, and otolith samples were taken from 230 Deepwater Flathead. These samples were taken from the total catch, the largest haul of which was 430kg of Deepwater Flathead in one shot, and 65 of the 75 hauls conducted caught between 50–250 kg of Deepwater Flathead (Knuckey et al., 2009). The surveys are designed to provide alternative fishery-independent abundance indices for use in quantitative stock assessment.

Research Recommendations

- In the GAB trawl fishery, there is a general need for better biological knowledge of all major species, including estimates of their natural mortality rates (AFFA, 2004b).
- The time-series of available age and length data is adequate for assessment, but Deepwater Flathead age structure requires validation (Wilson et al., 2009).
- Samples of juvenile and pre-recruit fish are required for age determination and growth studies (AFFA, 2004b).
- Because it is uncertain whether catch rates are linked to fish abundance, high priority should continue to be given to developing abundance indices through periodic, fishery-independent trawl surveys by commercial vessels (AFFA, 2004b) (see **Research Notes**, above).

- Catch and effort data from fishing logbooks in the GAB show no overall trend in catch rates and there is little contrast in the data. This is reported to be one reason why, in the stock assessment model for Deepwater Flathead, there is considerable uncertainty surrounding model outputs and estimates of stock biomass (AFMA 2006h). Klaer (2007) recommended a number of ways to improve the stock assessment of Deepwater Flathead in the Great Australian Bight Trawl fishery (including methods of weighting survey values, indices and frequency data; and resolving a conflict between age and length-frequency data).
- The usefulness of catch-rate criteria as a management tool for Deepwater Flathead has been questioned, because of the unclear relationship between catch rates and fish abundance Environmental factors may affect catchability and, hence, influence targeting practices (AFFA, 2004b). Now that quotas have been introduced for Deepwater Flathead in the GAB trawl fishery, it is considered that the use of commercial CPUE data as the main index of abundance in assessment models will be compromised, and will be unlikely to provide the contrast that is needed to improve model outputs. Therefore, it has been recommended that fishery-independent indices of abundance continue (see **Research Notes** above), for inclusion in assessment models (AFMA, 2006h).
- In the fishery-independent trawl surveys (see above), there needs to be some clarification of the actual swept area of the trawl gear if the survey results are to be used as an estimate of absolute biomass (AFMA, 2006h).

Management Notes

- The Great Australian Bight Trawl Fishery is managed by limited entry (10 vessels) and maximum vessel length (40m). Prior to the mid 2000s, only a small number of the 10 Statutory Fishing Right holders had been active in the fishery during any one year over the decade to 2002 (AFMA 2006h), but effort is now increasing (see **Management Recommendations**). It is reported that less than 30% of the shelf area of the GAB is fished (AFMA, 2006h), but it cannot be assumed that the fished species in the GSB trawl sector are evenly distributed across the entire shelf area.
- Assessment of the status of Deepwater Flathead was included in a 1992 stock-assessment workshop for the GAB trawl fishery. Information came from historical data, logbook catch-data, observer data and biological research. At that time, the short history of the managed fishery precluded any stock assessment based on a time-series of catch-and-effort data. Therefore, logbook data were examined on a shot-by-shot basis to estimate the biomass of deepwater flathead. Catch-per-unit-area (kg/km2) was calculated for quarter-degree squares and then scaled up by the total area in which the species had been recorded. The necessarily rough biomass estimate of 32,000t for Deepwater Flathead served as an index of mean abundance from 1986 to 1991. From growth and mortality data, sustainable annual yields were estimated to be 1,500–3,000t (but see above, on **Threatening Processes**). Large uncertainties in the method prevented calculation of error bounds (AFFA, 2004b). An updated stock assessment was undertaken in 2007 (see below).
- A 1992 Great Australian Bight stock-assessment workshop decided that maintaining spawning biomass above 33% of the pre-fishery level would represent a precautionary limit to ensure stock sustainability, but it is also noted that there are large uncertainties associated with the biomass estimates (AFFA, 2004b).
- One of the main management objectives for the Deepwater Flathead component of the Great Australian Bight Trawl Fishery is to maintain mean annual catch rates above 1988–94 minima (namely, the 1991 rate of 77.8 kg/h) (AFFA, 2004b,c).
- In 2006, a quota was introduced for the annual catch of Deepwater Flathead in the Great Australian Bight trawl fishery (see **Fisheries Information**, above).
- In the GAB trawl fishery, an onboard, scientific-observer program is continuing to gather information on bycatch and discarding practices, and also collect specific biological material. It has been reported that this program, which is industry-funded, will continue to provide catch-composition and biological data in future (AFFA, 2004b).

- The section above on **Research Notes** provides more detail about the fishery-independent research surveys, supported by FRDC, GABIA, GABRAG and GABMAC. With the introduction of quotas during 2006, there was concern that the use of commercial CPUE data as the main index of abundance in assessment models would be compromised, and unlikely to provide the contrast needed to improve model outputs (AFMA, 2006h). The surveys aim to obtain an annual relative abundance index for Deepwater Flathead in the current region of the main GABTF shelf fishery, and to provide a density estimate of Deepwater Flathead inshore of the current fishery (e.g. Knuckey et al., 2009).
- An assessment in 2007 incorporated age-at-length and length-frequency data into a growth model, and also utilised estimates of initial recruitment levels (and annual recruitment deviations), trawl selectivity and natural mortality, with catch history and observer data, to provide estimates of spawning stock biomass between 1980 and 2007 (Klaer, 2007).
- In recent years, management of the GAB trawl sector has aimed to set TACs for more than one year, so that annual assessments are not needed and costs are reduced. As part of this process, decision rules have been developed for deepwater flathead based on the results of annual fishery-independent surveys. These rules set the conditions under which a full stock assessment would be required earlier than the preset interval. As at 2009, the rules had not yet been formally evaluated.
- In the GAB trawl sector during the late 2000s, the recommended sustainable catch per annum was 1524t (in 2007), with a long-term estimate of 949t, which matches a target reference point of 40% of unfished biomass (Wilson et al., 2009).
- In the South East fishery, AFMA (2006a) reported that the adoption of 75mm cod-ends in the Danish seine sector, and the use of more selective cod-ends in the otter trawl sector could reduce the discard rates of flathead.

Management Recommendations

- Regular monitoring of fishing effort in the GAB trawl fishery is required. Under the current management plan, catches are controlled indirectly by the allocation of 10 statutory fishing rights, each equating to a single vessel. Shoreward of the 400m depth isobath, vessels over 40m are generally excluded (exceptions are considered by AFMA on a case-by-case basis), in an attempt to protect continental shelf stocks from excessive fishing pressure. However, there have been periods of significant increase in shelf fishing effort (e.g. an increase from between 1994 and 1997 from 4,891h bottom-time to 13,902h, a subsequent decline, and another increase in the 2000s). The entry of freezer-trawlers to the Bight will further increase effort because they can remain at sea for much longer trips than ‘wet’-boats. Furthermore, there is still considerable latent effort in the continental shelf fishery because only about half of the ten permitted vessels have regularly fished there until recent years. Hence, GABMAC and AFMA will need to monitor shelf effort closely, and strengthen controls on fishing mortality rates if catches reach unsustainable levels (AFFA, 2004b).
- Continuation of the mandatory logbook database for all species is considered essential, as is the regular collection of information on the size- and age-composition of Deepwater Flathead. Recent and predicted increases in continental shelf fishing effort in the GAB trawl fishery have heightened the need to refine biomass and yield estimates (AFFA, 2004b).
- Quota management in the GAB trawl fishery needs to consider the interactions of Deepwater Flathead and Bight Redfish, because much of their catch is taken during ‘mixed-species’ fishing. For example, between 1988 and 1999, 71% of shots containing Deepwater Flathead also contained Bight Redfish (AFFA, 2004b).

Tiger Flathead

Family Name:	Platycephalidae
Scientific Name:	*Neoplatycephalus richardsoni* Castelnau, 1872 = *Platycephalus richardsoni* Castelnau, 1872
Recommended Status:	**South Australia: *Least Concern*** **New South Wales, Victoria, Tasmania: *Near Threatened***

Rationale: *Tiger Flathead is included here because (i) south-eastern South Australia is at the edge of the geographic range of the species, and hence the relative abundance of Tiger Flathead is naturally low in South Australia, compared with populations in the eastern States; (ii) the age-related and seasonal migrations of the various life stages of this species, including juveniles and spawning adults, can increase the vulnerability of Tiger Flathead to over-exploitation in some areas of south-eastern Australia, particularly if there is only one stock (uncertain); (iii) Tiger Flathead, like other large, southern Australia flathead species, is moderately long-lived, which is a vulnerable population characteristic if population exploitation (e.g. by fishing) is not closely monitored over time; (iv) the species is caught across its range by a number of methods, particularly trawling and seine netting, and there are documented declines in the size and abundance of Tiger Flathead in parts of south-eastern Australia, where the species has been fished over a long period. There are also significant issues with capture and discard mortality of juveniles, and strong inter-annual variability in abundance of adults. The status of* ***Least Concern*** *is suggested for the species in South Australia, because the fishing-induced declines in stock that have occurred, relate to the fishing activity over the main part of the species range, which is not in South Australia. A higher category of threat (possibly* ***Near Threatened****) is suggested for this species in south-eastern Australia (New South Wales, Victoria, Tasmania), particularly N.S.W., where the species has been heavily fished for a long period, and continues to be fished. In the south-eastern fishery, much stock assessment work has been undertaken over a long period. However, up till the second decade of the 2000s, the commercial quota was still higher than the scientifically recommended sustainable level.*

Conservation Status

- No formal listings, but it is noted that in the Commonwealth's South East fishery, the reported status of "Flathead" (which comprises about 5 species, the main one of which is *N. richardsoni*) collectively has varied considerably over the past decade. Klaer (2001) provided a history of the fishery for Tiger Flathead in the south-eastern Australia, indicating a long period of serial depletion since early 20th century, and a distinct example of over-fishing. During the mid 2000s, flathead (of which the majority of the catch is Tiger Flathead) were classified by the Commonwealth as *fully fished* (AFFA, 2003b, 2004a), and it has been reported that catches at that time cannot be sustained in the long term (Caton and McLoughlin, 2005). Morton et al. (2005) reported that the Tiger Flathead stock is probably fully fished, with evidence that stocks in eastern Bass Strait have been declining since the late 1980's (Caton, 2003). By 2005, Commonwealth assessment considered that flathead in south-eastern Australia were "*not overfished, but overfishing [occurring] if annual landings in excess of 3,000t continue*" (Caton and McLoughlin, 2006). By 2007, the 2005 status was changed to *overfished* (Larcombe and Begg, 2008). However, since 2009, at biomass levels estimated in stock assessments since 2006, flathead have been classified as *not overfished, and not subject to over-fishing* (Wilson et al., 2009; Woodhams et al., 2012).
- In New South Wales, this species is classified as being "fully fished" (New South Wales DPI, 2004, 2008e; Rowling et al., 2010)**.**

Distribution

South-eastern Australia

- The Tiger Flathead occurs from northern New South Wales, south to Tasmania and western Bass Strait, and westwards to south-eastern South Australia (Hutchins and Swainston, 2001; Australian Museum, 2003u). It is noted that Kailola et al. (1993), Kuiter (in Gomon et al., 1994), Edgar (2000) and New South Wales Fisheries (2003f) did not include South Australia in the distribution, the latter reporting that Portland in Victoria is the western geographical limit of the species. However, there are records from both gulfs in South Australia, reported to be this species (see below).

South Australia

- Little information is available regarding the occurrence of Tiger Flathead in S.A.; however it is noted that there are museum records of this species from Pine Point and Price Creek in Gulf St Vincent (Australian Museum record, 1973; Museum of Victoria record, 1986, cited in OZCAM database, 2009), and the species has reportedly been recorded in prawn trawl bycatch in Spencer Gulf (Carrick, 1997; Currie et al., 2009).

Habitat

- Tiger Flathead are demersal, found in sandy and silty / muddy habitats (Daley et al., 1998; Edgar, 2000) across the continental shelf (Australian Museum, 2003u), extending to upper slope waters. Bax and Williams (2001, cited by HSI, 2003) reported that Tiger Flathead are associated with areas of the seabed where soft sediments exist. Williams and Bax (2001) reported that during a sea bed survey in south-eastern Australia, more than 70% of the catches of this species came from soft sediment.
- Little is known about the habitats and biology of juvenile Tiger Flathead. They are assumed to occupy shallow inshore waters, and in Tasmania, small juveniles have been recorded in Frederick Henry Bay (Ford and Lyle, 1992). Small numbers of larger juveniles of 16-18 cm, assumed to be 1+ years old, have been recorded in inner shelf trawl samples in autumn off southern and eastern Tasmania (Jordan, 1997, cited by Morton et al., 2005)
- Occasionally this species enters coastal bays (May and Maxwell, 1986). This species moves closer to shore further south in the range, and enters bays and estuaries in Tasmania (Starling, 2003).
- The species often occurs within the depth range 30m to 160m (Australian Museum, 2003u); however the full depth distribution is reported to be 10m to 400m (Tilzey et al., 1990, cited by Kailola et al., 1993), and some fish have been recorded as deep as 450m. There is a record from off Bermagui (NSW) of a specimen trawled from 428 m - 468m (Australian Museum, 2009). Larger, mature fish dominate in outer shelf waters deeper than 100m off eastern and southern Tasmania (Jordan, 1997, cited by Morton et al., 2005).
- Eggs, larvae and early phase juveniles are thought to be pelagic in nature (e.g. young juveniles have been caught in mid-water trawls in both shelf and slope waters (CSIRO Marine Research data, cited by Bruce et al., 2002). Older juveniles are assumed to occupy nursery areas inshore of fishing grounds (Jordan, 1997, cited by Bruce et al., 2002). The young, which inhabit shallow waters of the continental shelf, move into the outer shelf zone as they reach maturity (Kailola et al., 1993).
- Except for the spawning season, older larger fish are more commonly found (and caught) in outer shelf waters (65m - 200m deep) whereas juveniles and smaller adults are mainly found in inner shelf waters (Smith and Wayte, 2003)
- In summer, spawning Tiger Flathead are found closer inshore (e.g. in coastal bays), and have been recorded in waters as shallow as 10m (May and Maxwell, 1986; New South Wales Fisheries, 2003f). However, during the autumn months, some of the population moves into deeper water between 200m and 350m depth (K. Graham, pers. comm., cited by Australian Museum, 2003u).

Notes on the Biology

Age and Growth

- Tiger Flathead grows to at least 65cm (Kailola et al., 1993; Australian Museum, 2003u; DPIWE Tasmania, 2004c), possibly larger (Smith and Wayte, 2003; Caton and McLoughlin, 2006); however, Tiger Flathead are commonly 33cm – 45cm (Daley et al., 1998). In Tasmania, fish above 50 cm are rare (Ford and Lyle, 1992; Jordan, 1997). Southern and eastern Tasmanian stocks are characterised by a higher proportion of old fish (> 9 years) than those from eastern Bass Strait (Jordan, 1997).
- Females grow larger (possibly to 70cm LCF) than males (55cm – 57cm LCF), and virtually all fish above 50cm are female (Jordan, 1997; Smith and Wayte, 2003).
- Initial growth is rapid until about 2 years of age, with a mean length of about 20cm LCF being attained after one year (Smith and Wayte, 2003). Growth rates are variable, with fish reaching 30cm anywhere between 2 and 5 years old (Jordan, 1997). The growth rate for males is considerably slower than for females, and male fish larger than 50 cm total length are uncommon.

- The maximum weight recorded is around 3kg (Kailola et al., 1993; Kuiter, in Gomon et al., 1994; Hutchins and Swainston, 2001; New South Wales Fisheries, 2003f). One of the largest specimens was 2.963kg, caught by a recreational fisher, off the central N.S.W. coast in 1979 (Australian Anglers Association, 2009). Although the species grow to 3kg, the species most often encountered when 0.5kg to 1.5kg (Prokop, 2000; Starling, 2003).
- Previously, the maximum age was commonly reported to be 12 years for females (Montgomery, 1985 and Jordan 1997, cited by Bruce et al., 2002; Kailola et al., 1993); however Morton et al. (2005) reported a maximum age of 17 years, and ageing using sectioned otoliths has revealed that Tiger Flathead reach a maximum age of around 20 years (Smith and Wayte, 2003).

Diet and Feeding Behaviour

- Generally, Flathead are active foragers, and they also ambush prey, by lying partly concealed in mud or sand and lunging out to catch passing prey. They are also occasional scavengers (Kailola et al., 1993).
- Adult Tiger Flathead eat a variety of small bony fish such as Silverside (*Argentina australiae*) and Three-spine Cardinalfish (*Apogonops anomalus*), Silverbelly (*Parequula melbournensis*) and little conger eel (*Gnathophis longicaudus*) (Coleman and Mobley, 1984, cited by Kailola et al., 1993), and juvenile Ling (Bulman et al., 2001, cited by Bruce et al., 2002).
- Brown (1977, cited by Cottier, 1999) reported that in Port Phillip Bay in Victoria, flatheads such as *N. richardsoni* feeds on clupeids such as *Sardinops sagax* and *Engraulis australis* and gobies such as *Nesogobius hinsbyi* (orange-spotted goby).
- Juveniles eat benthic crustaceans including krill / euphausiid shrimps (*Nyctiphanes australis*) (Fairbridge, 1951; Kailola et al., 1993).
- Tiger Flathead have a swim bladder allowing them to forage higher in the water column than other flathead species. According to Colefax (1938, cited by Kailola et al., 1993), Daley et al. (1998) and Bulman et al. (2001), Tiger Flathead are unusual in that they move up from the bottom at night (aided by their swim bladder), to feed on prey species (fish and crustaceans) which also migrate up the water column.

Migration and/or Aggregation

- There are age-related and seasonal migrations reported for this species. Most recaptures of tagged fish have indicated movements of less than 50 km (Fairbridge, 1951; Rowling, 1994a, cited by Bruce et al., 2002); but there remains a limited understanding of movements. Previously, Kailola et al. (1993), reported that the young inhabit shallow waters of the continental shelf and move into the outer shelf zone as they reach maturity. More recently, K. Graham (pers. comm. cited by Australian Museum, 2003u), reported that spawning Tiger Flathead are found closer inshore, but during the autumn months, some of the population moves into deeper water between 200m and 350m depth. Large individuals (> 45 cm) move into shallower inner shelf water waters during summer (Jordan, 1997). This movement has only been reported in Tasmania. For the rest of the year, average fish size increases with depth (Rowling, 1994; Jordan, 1997, cited by Morton et al., 2005).
- Apart from the general inshore movement of adult fish during the spawning season, there is little evidence of any substantial migrations of Tiger Flathead (Smith and Wayte, 2003)

Reproduction

- Size at maturity is estimated to be about 25cm – 30cm TL for males and 30 – 36cm TL for females, depending on the region (Fairbridge, 1951, cited by Kailola et al., 1993; Jordan, 1997, cited by Bruce et al., 2002). Age at maturity is estimated to be at 3 – 5 years (Kailola et al., 1993; Caton, 2000; AFFA, 2002b; Smith and Wayte, 2003). In eastern Bass Strait, Tiger Flathead reach sexual maturity at approximately 30 cm for females and 25 cm for males, corresponding to around 3-5 years old (Hobday and Wankowski, 1987; Jordan, 1997, cited by Morton et al., 2005).

- In New South Wales, Tiger Flathead spawn over an extended period, between October and May, but mainly from October to December (Fairbridge, 1951, cited by Cottier, 1999). Spawning tends to occur earlier off northern New South Wales than in the south (Fairbridge, 1951, cited by Kailola et al., 1993). Mature adults move inshore to shallower waters prior to the spawning period, and also tend to concentrate in "shoals" on part of the inshore grounds (e.g. in the south of the distribution) (Fairbridge, 1951, cited by Kailola et al., 1993 and Bruce et al., 2002; Morton et al., 2005). Specific spawning grounds have not been defined for Tiger Flathead, and fish in spawning condition have been caught in northern and southern regions of the species' distribution (Rowling 1994a). In eastern Bass Strait and southern and eastern Tasmania, spawning occurs on the continental shelf between December and February (Hobday and Wankowski, 1987a, cited by Kailola et al., 1993; DPIWE Tasmania, 2004c, citing Jordan, 1997), and there is no evidence of spring spawning in that area (Jordan 1997, cited by Jordan et al., 1998). Flathead in Victoria may spawn earlier (e.g. spring) (Morton et al., 2005).
- Fecundity is reported to be high, with an estimate of 1.5 million eggs (or more) per female (Colefax, 1938, and Hobday and Wankowski, 1987a, cited by Kailola et al., 1993 and Bruce et al., 2002). In eastern Bass Strait, females are estimated to have a total annual fecundity of 0.3 million eggs for 30 cm fish and up to 1.5 million eggs in 50 cm individuals (Hobday and Wankowski, 1987, cited by Morton et al., 2005).
- Eggs and larvae are probably pelagic (Rowling, 1994a). There may be an extended pelagic larval or early juvenile phase (Jordan, 2001, cited by Bruce et al., 2002). Small juvenile *N. richardsoni* are common on the shelf of southern and eastern Tasmania (Jordan, 1997, cited by Jordan et al., 1998).

Other Information

- Morphometric studies (Fairbridge, 1951) and tagging programs (Tilzey et al., 1990) indicate the existence of a single stock, despite regional differences in growth rates and spawning periods (Kailola et al., 1993). Genetic studies to determine stock structure have not been undertaken (Smith and Wayte, 2003). Rowling (1994, cited by Bruce et al., 2002) also reported that there is little evidence of more than one Tiger Flathead stock, and a single stock is assumed for management purposes. There is little evidence of morphological variation across the species distribution range, despite observed regional differences in growth and the timing of reproduction, especially off eastern Tasmania (Smith and Wayte, 2003; ShelfRAG, 2008). However, the fishing industry has postulated that flathead off eastern Tasmania are a distinct stock (Caton and McLoughlin, 2006).
- Tiger Flathead are not active fish, and will normally rest on the sea bed during the day in areas of mud and sand substrate (Kailola et al., 1993).
- Predators of Tiger Flathead include John Dory (*Zeus faber*) and larger tiger flathead (Coleman and Mobley, 1984, cited by Kailola et al., 1993). Tiger Flathead also form part of the diet of Australian fur seals (Kirkwood et al., 2008; Deagle et al., 2009).

Fisheries Information

Commercial - Commonwealth

- Tiger Flathead is a very highly regarded food fish, and is regularly sold in fish markets in Sydney and Melbourne, all year round (Kailola et al., 1993).
- Flathead species taken in the Commonwealth fisheries are managed under Individual Transferable Quota (ITQ) management arrangements. For example, ITQs apply for flathead species taken in the SETF (South East Trawl fishery component of the SESSF: Southern and Eastern Scalefish and Shark fisheries); the ECDWZ (East Coast Deepwater Zone within the SETF, previously called the East Coast Deepwater Trawl Fishery); the CVIT (Commonwealth Victorian Inshore Trawl Fishery), and the GHAT (Gillnet, Hook and Trap Fishery) (AFMA, 2003j).
- *History of the Fishery:* Tiger Flathead have been trawled since 1915 in south-eastern Australian waters, when this species formed the primary target species of the Red Funnel Steam Trawlers that operated off N.S.W. (Fairbridge, 1952; Montgomery, 1985; cited by Cui et al., 2006). The fishery was limited to waters between Crowdy Head and Gabo Island up until 1930 when trawling began in eastern Bass Strait. Approximately 5,000 - 6,000t of Tiger Flathead were caught in 1928 – 1929 (FAO, 1997; Caton and McLoughlin, 2005), an amount more than double the total Australian catch in recent years. During the early years, some very high catch rates were recorded. For example, at one site off Botany Bay, CPUE of more than 100 kg/h was recorded for the period 1918 to 1923 (Klaer, 2001).

(cont.) Tiger Flathead accounted for between 80 and 90 % of the New South Wales trawl catch up until 1930, but the stock declined during the decade leading to World War II. The steam trawlers operated until the early 1960s. The Danish seine fishery started in the 1930s and was the main method of catching tiger flathead during the 1950s and 1960s. The era of modern trawling commenced during the 1960s (Cui et al., 2006). Despite the entry of a number of Danish seine vessels into the fishery in 1937, catches did not rise to more than 3,500t in that year (Kailola et al., 1993). Approximately 1,950t per annum were recorded in 1938 and 1939, but catches were under 500t per annum during the 1940s and 1950s (Klaer, 2001). Tiger Flathead is reported to have been the main target species from 1937 to 1943 (Klaer, 2001); however, there was little fishing done during the war due to requisition of trawlers and Danish seiners as mine sweepers. Afterwards fishing effort increased but catches gradually fell to about 1,000 t by 1948-49 and remained at levels near 1,000t until the introduction of diesel powered trawlers in the 1970s (Kailola et al., 1993). In the South East fishery, Tiger Flathead catches declined in the early 1950s, perhaps as a result of recruitment over-fishing before World War II (Bax, 1997). The post-War decline in Tiger Flathead catches encouraged fishers to retain catches of lower-priced species (Fairbridge, 1952; Klaer, 2001). Up till the 1970s this species was one of the main ones targeted, when the fishery operated primarily in continental shelf waters between depths of 50m and 200m. Following declines in Tiger Flathead abundance, and also coinciding with discovery of the spawning run of gemfish (*Rexea solandri*) in slope waters between 300m and 400m, the fishery began targetting other species (Klaer, 2001). Cui et al. (2006) provided a year-by-year history of Tiger Flathead catches in the otter trawl and Danish seine sectors.

- Tiger Flathead is the most important flathead species in the Commonwealth-managed South East Trawl fishery (SETF) component of the SESSF, and has been a major species in the fishery since it began, as indicated in the discussion above, on the history of the fishery. The bulk of historical catches have come from N.S.W., eastern Victoria and Bass Strait zones, accounting for 92% of Commonwealth catches since 1986. Flathead catches in the South East fishery comprise mainly Tiger Flathead, but also include Sand Flathead *Platycephalus bassensis*), and, mainly from 1996 onwards, Southern or 'Yank' Flathead *(Platycephalus speculator*), Bluespot Flathead *(Platycephalus caeruleopunctatus*) and Goldspot/ Toothy Flathead *(Neoplatycephalus aurimaculatus*), and these species are also included in the flathead quota. In the South East fishery, Tiger Flathead is one of the 5 principal species in terms of landings (FAO, 1997). Tiger Flathead makes up about 90% of the flathead catch in the Commonwealth-managed South East Fisheries (Bruce et al., 2002). Rowling (1994), Bax (1997), FAO (1997) and Klaer (2001) provided an overview of the South East fishery, in which Tiger Flathead is one of the 16 species for which ITQs were introduced in 1992. Tiger Flathead catches within the South East trawl fishery component of the SESSF have been limited by a total allowable catch and individual transferable quotas applying to all flathead species since January 1992 (Kailola et al., 1993). Management authorities have introduced effort restrictions, minimum mesh sizes, and a minimum size (Bax, 1997). The Tiger Flathead fishery south of Barranjoey Head in NSW is managed by the Commonwealth of Australia under the provisions of the South East Trawl Fishery management plan (Kailola et al., 1993). The Tiger Flathead fishery north of Barranjoey Head is managed by the New South Wales Government (Kailola et al., 1993). The commercial fishing area for Tiger Flathead extends along the south-eastern coast from Crowdy Head in N.S.W., to the southern tip of Tasmania. Flathead are taken primarily by Danish seine and otter trawlers along the southern New South Wales coast, through eastern Bass Strait, several Victorian bays and inlets, and in Tasmania, particularly off the east and south-east coasts (Jordan, 1994a; Rowling, 1994a).
- The most common bycatch species are Eastern School Whiting (*Sillago flindersi*) and Jackass Morwong (*Nemadactylus macropterus*). Tiger Flathead are also a common bycatch of the Eastern School Whiting fishery. Trawl fishers target Tiger Flathead, especially in eastern Bass Strait but a significant proportion of the catch is taken as bycatch when species such as Jackass morwong and Redfish (*Centroberyx affinis*) are targeted. Jackass Morwong, Redfish and John Dory are also the main bycatch species when trawling for Tiger Flathead (Rowling., 1994a). Tiger Flathead are caught by trawl fishers all year and over a wider depth range than by Danish seine boats. Tiger flathead are reported in trawl catches from western Victorian waters, but Tiger Flathead is not the dominant flathead species in that area (Tilzey et al., 1990). Trawl and Danish seine catches reported as Tiger Flathead from waters east of Bass Strait also include unknown proportions of other flathead species, such as Sand Flathead *(Platycephalus bassensis*) and Yank Flathead *(Platycephalus speculator*) (Tilzey et al., 1990). Historically, most of the catch was taken from eastern Bass Strait by demersal otter trawlers and Danish seine vessels, on the continental shelf.

(cont.) Very few Tiger Flathead are caught by any other method. Otter trawlers catch this species throughout the commercial fishing area but highest catch rates are recorded between Eden in N.S.W. and Flinders Island off northern Tasmania, including the eastern Bass Strait grounds. During the 1980s and 1990s, the Danish seine fleet based at Lakes Entrance in Victoria, restricted its fishing effort mainly to the eastern Bass Strait grounds (Wankowski, 1983). Some Danish seine vessels take Tiger Flathead from central Victorian waters as far west as Apollo Bay. Previously, Prince (2001) considered that Tiger Flathead is largely unfished west of Bass Strait, particularly in waters less than 200m, but more vessels have fished in the western area in recent years. A few Danish seiners also operate in south-eastern coastal waters of Tasmania (Kailola et al., 1993). Most of the Tiger Flathead catch from Danish seine vessels is a result of target fishing. Examination of Danish seine catches in eastern and central Bass Straight during 1994, indicated that in depths greater than 50m, Tiger Flathead constituted 99% of flathead catches in that area (Smith and Wayte, 2001, 2003). Tiger Flathead was still the dominant species (78%) in Danish seine catches from less than 50m, but these catches also included significant proportions of Sand Flathead (9%), Southern / Yank Flathead (7%) and Gold Spot / Toothy Flathead (6%). Like the Danish seiners, most of the trawl catch is taken from depths of 100m to 150m but maximum catch rates are obtained by trawlers in depths between 150m and 200m (Rowling, 1994a). Most fish are caught from October to March in eastern Bass Strait (includes the spawning season). Danish seine catches and catch rates in the Bass Strait Zone are consistently highest in summer, which reflects both seasonal fluctuations in flathead abundance and seasonal switches between Flathead and School Whiting as the preferred target species (Smith and Wayte, 2003). The contribution of Danish seine vessels to total SEF flathead landings declined from around 50% in the late 1980s to less than 30% in the mid 1990s. This trend has reversed during recent years and Danish seine catches again comprise around half of the flathead catch. On average, half of the SEF Danish seine catch of Tiger Flathead is caught in Eastern Victoria and most of the rest is caught in Bass Strait. In contrast, only 6% of trawl catches come from Bass Strait; most of the trawl catch is evenly split between N.S.W. and Eastern Victoria (Smith and Wayte, 2003). Although in past years the bulk of the catch has been taken off New South Wales, eastern Victoria and Bass Strait, from 2002 onwards a significant proportion has been taken off eastern Tasmania. Maximum catch rates are obtained by trawlers in depths between 150m and 200m (Tilzey et al., 1990; Rowling, 1994a), although the species is taken between 50m and 250m (Caton and McLoughlin, 2005). Most Tiger Flathead that are landed are between 33cm and 45cm total length (Fairbridge, 1951; Melbourne Wholesale Fish Markets data). Danish seine and demersal trawl catches differ in size composition and small individuals are likely to be under-represented in catches (Lyle and Ford, 1993). Previous mesh selectivity trials indicated that the length at 50% selection occurs at 27cm for 42mm mesh, and 38cm for 110mm mesh (Wankowski et al., 1986, cited by Bruce et al., 2002). The different sizes at maturity for each sex produce varying sex ratios in the commercial catch; hence most fish below 37cm caudal fork length are male, while females dominate the catch of larger fish (Kailola et al., 1993). Since the establishment of the SETF in 1984, annual Commonwealth landings ranged between 1,650 t (1984) and 3,680 t (1999) during the 1980s and 1990s. Previously, during the 1980s, separate estimates of sustainable yield for the N.S.W. and eastern Bass Strait regions of the Tiger Flathead fishery gave a total of 2,500t as the maximum sustainable yield for the whole fishery (Montgomery, 1985, and Wankowski, 1986). Catch levels during the 1990s were close to this estimate (Rowling, 1994), and the fishery has been fully exploited since the 1980s (May and Maxwell, 1986; Kailola et al., 1993). Average Commonwealth catches have been about 2,600 t per year since 1986 (trawl and Danish seine combined). Discard levels are generally low, around 5% for the trawl sector in recent years (ShelfRAG, 2008). The Total Allowable Catches set by management authority, as well as actual catches, are shown in the table below, for the period 2001-2010. Maps in BRS (2004) indicated that the species is fished heavily all along the N.S.W. coast, eastern Victoria, and eastern Tasmania, with examples including annual catches during the early 2000s of 20 – 200+ tonnes in many 1-degree fishing blocks along the coast. Catches off eastern Tasmania have increased markedly in recent years. Catches off western Tasmania, western Victoria, and South Australia are considerably lower. In the second decade of the 2000s, the annual catch in the South East fishery was around 2,500-3,000 tonnes (ShelfRAG, 2008; Stobutzki et al. 2010). Data in Klaer (2010) showed that in the South East fishery, during the past 25 years Tiger Flathead catch by trawlers in the eastern zone ranged between 1000t and 2000t; catches by Danish seine vessels were more variable (between 500t and 1900t), and the catches by these two sectors were at approximately the same level in 2010. Catches by trawls in Tasmania are an order of magnitude lower, as shown in the figure below.

Flathead Catches in the South East Fishery (NB Majority is Tiger Flathead)

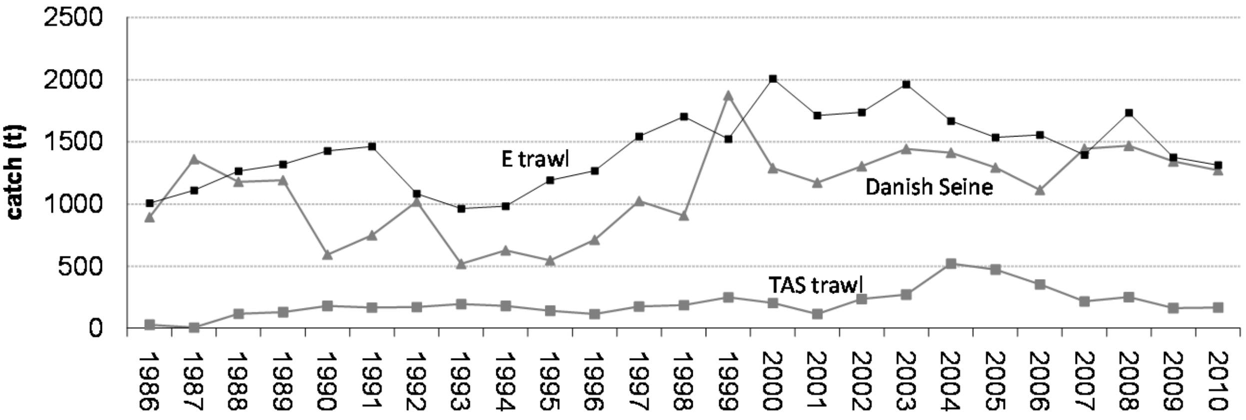
	Total Allowable Catch (TAC)	**Actual Catch**
2001	3,942t (= 3,941t trawl; 1t non-trawl)	2,914t trawl <1 t non-trawl **160t** discards
2002	4,164 t (= 4,163t trawl, 1t non-trawl).	3,143t trawl <1 t non-trawl **194t** discards
2003	Recommended combined TAC = 3,500t Allocated TAC = 3,817 t (3809t trawl; 8t non-trawl)	3,639t trawl 1t non-trawl **178t** discards
2004	Recommended combined TAC = 3,500t. Allocated TAC = 3,631t (3629t trawl; 2t non-trawl)	3,602 t trawl 1t non-trawl **228t** discards
2005	Recommended combined TAC = 3,150t. Allocated TAC = 3,354t	3,003t trawl 1t non-trawl **195t** discards
2006	Recommended combined TAC = 3,000t. Allocated TAC = 2,999t	2,701t trawl <1t non-trawl **202t** discards
2007	Recommended combined TAC = 2,850t. Allocated TAC = (not available)	2,878t trawl <1t non-trawl 0.07t discards *
2008	Recommended combined TAC = 2,850t. Allocated TAC = 3,026t	3,199t *(NB 2007 quota year extended to April 2008)*
2009	Recommended combined TAC = 2,850t.	2,915t <1t non-trawl
2010	Recommended combined TAC = 2,850t.	2,831t <1t non-trawl

(from AFFA, 2004a; Caton and McLoughlin, 2005, 2006; Shelf RAG, 2008; Wilson et al., 2009; Stobutzki et al., 2010)

***** Discards were under-estimated in 2007, reportedly due to poor coverage by observers in that year

Tiger Flathead Catches in the Southern and Eastern Scalefish and Shark Fisheries (SESSF)

(from data in Klaer 2010)



- The species has been recorded as a minor component of the South Australian sector of the Commonwealth-managed Southern Shark Fishery (Walker et al., 2003), which is now part of the Gillnet, Hook and Trap fishery of the SESSF (Southern and Eastern Scalefish and Shark Fisheries). Webb et al. (2004) reported that this species is caught in both the shark hook sector, and the scalefish automatic long-lining. Experiment with hook-size, to assess the number of fishes caught off south-eastern Australia during 1973–76, showed that Tiger Flathead are caught in increasing numbers with increasing hook size. During those experiments, average number of Tiger Flathead caught per 100,000 hook hours ranges from 11 flathead for 3/O hooks, up to 44 for 7/O hooks (Walker et al., 2003).
- The species is also a very minor component of the bycatch in the Commonwealth's Small Pelagic Fishery (AFMA, 2003h).

Commercial - States

- Catch statistics reported by BRR (1991), indicate large tonnages of Tiger Flathead (in some cases combined with Toothy / Gold-spot Flathead *P. aurimaculatus*) taken from each of New South Wales, Victoria and Tasmania, and since the mid 1980s, these largely refer to catches under Commonwealth management, as part of the South East fishery (see above). Examples of catches include (i) from New South Wales: approximately 1,000t to 1,500t per annum during the mid 1960s to mid 1970s, and a range of 550t to 890t per annum from the mid 1970s to at least 1990; (ii) from Victoria: 1,231t in 1984/85, (with range of about 400t to 900t per annum recorded for that State from the 1960s to the 1980s); (iii) Tasmania: 110t in 1977/78 and 186t in 1978/79, and a range of approximately 11t to 60t per annum during the 1980s (apart from a low of 2t in 1988/89).
- ShelfRAG (2008) reported that State catches of Tiger Flathead amounted to 208t in 2004, 292t in 2005, 319t in 2006 and 187t in 2007.
- Within New South Wales State waters (south of Barrenjoey Headland, and including waters 3 nautical miles east of the coastal baselines), there is a 200kg daily trip limit for the combined take of 4 flathead species (of which Tiger Flathead is one) by the South East trawl fishery component of the SESSF. The trip limit is effective all year round, from 1st May 2003 to 30th April 2008 (N.S.W. Government Gazette, 14th February, 2003).
- Tiger Flathead is one of approximately 20 main scalefish species taken in the New South Wales Ocean Trawl fishery (N.S.W. Fisheries web site, 2004). Trawling for fish off N.S.W. originally concentrated on targeting Tiger Flathead, and the species remains significant in recent trawl landings despite being overfished during the middle of the 20th century. Landings of Tiger Flathead in N.S.W. waters are difficult to separate from landings made under Commonwealth jurisdiction in the South East trawl fishery component of the SESSF. For the N.S.W. Ocean Trawl fishery, landings in Ocean Zones 4 to 6 (from Smoky Cape to Sydney) should have minimal overlap with Commonwealth waters, and landings in this area have been relatively stable, reportedly at 80t to 120t from the late 1980s to late 1990s, with an increase to 140t at the end of the 1990s, and subsequent reduction back to around 80t during the early 2000s (New South Wales DPI, 2004). However, NSW DPI (2008e) indicated that Tiger Flathead landings from the Ocean Trawl fishery averaged about 180t – 220t per annum from 1996 to 2009, except for 2005/06, when more than 250t were landed.
- Tiger Flathead is also a minor bycatch species in the New South Wales ocean prawn trawl fishery (Broadhurst and Kennelly, 1997).
- The species is retained when caught in the New South Wales estuarine fish haul fishery (Gray and Kennelly, 2001), including locations such as Botany Bay.
- Tiger Flathead are reported in trawl catches from western Victorian waters although it is not the dominant flathead species caught commercially in Victoria (Tilzey et al., 1990). Tiger Flathead are sold on the domestic market, usually as whole fresh fish. Commercial catches of Tiger Flathead (in tonnes whole weight) from Victorian waters are provided below (from NRE Victoria, 2002, 2003; DPI Victoria, 2008b):

Commercial Catch of Tiger Flathead in Victorian Waters 1998 – 2003

Year	Catch (t)
1998/99	1
1999/00	4
2000/01	4
2001/02	9
2002/03	5
2003/04	2
2004/05	0
2005/06	1
2006/07	2

- In Tasmania, the commercial catch of Tiger Flathead is unknown, because catches of this species are pooled with *Platycephalus bassensis*, in commercial records. Morton et al. (2005) and Ziegler et al. (2006) provided overviews of the flathead catch in Tasmania; however, most of the information refers to species other than Tiger Flathead. Morton et al. (2005) reported that commercial catch of flathead from Tasmanian waters fluctuated from a low of less than 20t in 1983/84 to about 150-160t tonnes in one year of each of the 1970s, 1980s and 1990s. Since the early 1990s, catches have declined to about 50 tonnes or less per annum during the 2000s. A reduction in inshore trawl fishing effort since 1990 and prohibition of demersal otter board trawling in State waters since 2001 are reported to be major factors in the decline in the flathead catch (Morton et al., 2005). The species of flathead are rarely recorded on catch returns and thus there is uncertainty as to total catch of Tiger Flathead.
- In South Australia, Tiger Flathead has also been recorded as a minor component of bycatch in the Spencer Gulf prawn trawl fishery. For example, 45 Tiger Flathead were recorded from 32 trawl tows, in a sampling program during the mid 1990s (Carrick, 1997).

Recreational

- Tiger Flathead are caught by anglers "drift fishing" in New South Wales and Victoria, usually in waters deeper than 40m. According to results of surveys by N.S.W. DPI, in conjunction with the results of a national recreational fishing survey (Henry and Lyle, 2003), about 20t – 60t are estimated to be taken annually by recreational and charter boat fishers in N.S.W. (New South Wales DPI, 2008e). During a survey of the catch of recreational fishing boats from September 1993 to February 1994i (Steffe and Murphy, 1994), Tiger Flathead was reported to comprise 4% of the catch from boats surveyed at the Crowdy Head boa tramp, 13% of the catch from boats at Bermagui boat ramp, and 6% of the catch from boats at Eden boat ramp.
- Tiger Flathead are also commonly caught by recreational fishers in Tasmanian bays and estuaries during spring (September-November) (Last et al., 1983, cited by Kailola et al., 1993), but the species is of secondary importance compared with the catch of Sand Flathead *Platycephalus bassensis* (Morton et al., 2005). In Tasmania, Tiger Flathead are taken using lines (mainly), and grab-all nets (sometimes as a bycatch when Blue Warehou is targeted) (Lyle and Campbell, 1999). MacLeay et al. (2002) estimated that 64t of flathead (mixed species) were caught by recreational fishers in Tasmania in the year 2000, with 8t of that catch being taken by line fishers. The flathead catch in Tasmania reportedly comprises *Platycephalus bassensis* (mostly), *Platycephalus laevigatus*, and *Neoplatycephalus richardsoni* (Macleay et al., 2002). In one Tasmanian study, about 94% of the flathead catch was identified as Sand Flathead, with Tiger Flathead accounting for most of the remainder (Lyle 2005).
- An estimated 2.1 million flathead (all species) were caught by recreational fishers in Tasmania during 2000/01 (Henry and Lyle, 2003, cited by Morton et al., 2005). Of this catch, 1,378,000 (about 65%, equating to 360t) were retained, and about 7% of the catch was estimated to be Tiger Flathead (Morton et al., 2005). Over 90% of the 2000/01 flathead catch in Tasmania was taken by boat-based anglers, and line fishing was the primary (99%) capture method.

- Some recreational fishing clubs and associations keep records of the maximum sizes caught (e.g. Australian Anglers' Association, Victorian division). One of the largest Tiger Flathead recorded by the Australian Anglers Association was 3kg, caught off the central N.S.W. coast (Kailola et al., 1993).
- The National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) reported that 71,815 Tiger Flathead were caught and kept by recreational fishers during the survey time period (May 2000 to April 2001), of which 70,257 of those specimens were caught in Tasmania, and 1,558 were caught in New South Wales. Catches from other southern Australian States were not reported; however the authors noted that this species was caught regularly off N.S.W., Victoria and Tasmania. In the national survey, of the 1.38 million flathead taken in Tasmania, about 94% was Sand Flathead *P. bassensis*, and 6% was Tiger Flathead (Henry and Lyle 2003). (Lyle 2005). Morton et al. (2005) reported that Tiger Flathead is of secondary importance in terms of flathead species caught by recreational fishers in Tasmania (the dominant species taken is Sand Flathead). The dominance of Sand Flathead in Tasmanian catches has also been confirmed from creel surveys (Lyle and Campbell 1999; Lyle et al. 2002).

Vulnerable Characteristics of the Species, and Threatening Processes

- In areas where this species moves inshore to spawn, peak catches during the summer months may be a threatening process for the spawning stock.
- Tiger Flathead has been fished since the early 1900s in south-eastern Australia, and serial depletion of stocks appears to have occurred in some areas. Stocks off New South Wales and in eastern Bass Strait are probably fully exploited (SIV, 2004; New South Wales DPI, 2004, 2008e).
- Significant declines occurred in the abundance of Tiger Flathead in the early years of the fishery (pre-1950s) off New South Wales, and in some cases localised (and almost complete) depletions occurred, without recovery (Klaer, 2001; Gowers, 2008). In the Commonwealth's South East fishery (component of the SESSF), examination of 64,371 steam trawler records from the periods 1918-23, 1937-43 and 1952-57, showed that over time, the catch-rate of Tiger Flathead (which was a primary target species) dropped considerably from the early, very high, catch-rates. According to Klaer (2001), in some areas, the local depletion of flathead was much greater than indicated by aggregated catch-rates for the whole fishery. In the early period of good fishing in the Botany Bay ground, the bulk of the catch was flathead that were 'very large and bursting with roe' (Colefax, 1934). The timing of the heavy fishing period was predictable from early September to early December, and vessels fishing then often returned to port with full holds well before the normal cruise time of 4–6 days. At the time, the heavy catch period was referred to as the 'Botany Glut'. This glut period became a yearly expectation, but failed to occur by 1926. The overall catch-rate of flathead was sustained by the movement of vessels to new grounds or deeper waters. There were cases of localised, almost complete, depletion but there are no indications of cases of localised recovery of flathead catches. The abundance of flathead was considerably decreased due to the heavy fishing effort on the shelf, to the point of over-exploitation in some years (Colefax 1934; Fairbridge, 1948; Houston, 1955, all cited by Klaer, 2001). The catch-rates of the main commercial species followed a similar pattern in a number of regions within the fishery. The changes observed in the composition and abundance of species in the fishery, including reduced catches of target species, may be due to high fishing pressure alone, or to a combination of fishing pressure, changes in the shelf habitat possibly caused by the trawl gear, and environmental fluctuations (Klaer, 2001). In the aforementioned analysis of per-haul records of Tiger Flathead catches by steam trawlers on the south-eastern Australian continental shelf from 1918 to 1957 (Klaer, 2004), catch rates (in weight per haul per species) were standardised to annual indices of abundance using a log-linear model, and the results of the standardised annual index trends showed a *strong to severe decline* during the period covered by the data (Klaer, 2004). Similarly, a study of a million measurements of the 3 principal species in the NSW demersal net fishery, made over a 22 year period, showed that the recovery of Tiger Flathead stocks after the most intense fishing period (1948 to 1958) was only partial, because fishing intensity declined much less than for species such as Morwong and Redfish (Blackburn, 1978). Ward and Butler (2006) reported that the spawning biomass of *N. richardsoni* in south-eastern Australia was reduced from about 27,000 tons in 1915 to about 7,000 tonnes in 2004. Gowers (2008) discussed in detail the collapse of the Tiger Flathead trawling industry which operated between 1915 and 1961 (steam trawlers) in south-eastern Australia, and considered that social and cultural pressures had as much to do with the decline in stocks as did the increase in numbers of fishers targeting the species.

- In south-eastern Australia, there have been indications since the 1980s that the catches may not be sustainable; catch rates have fluctuated significantly over time, and fishing mortality is high. In both the trawl and Danish seine fisheries, there appears to be a cyclical element to the annual fluctuations in catch and catch per unit effort. In the Danish seine fishery, there was a record peak in catch rates of 94 kg/shot in 1999, and catch rates have declined since that time. In some years (e.g. 2004), the catch in south-eastern Australia exceeds the recommended TAC (Caton and McLoughlin, 2006). It is noted that the lower mortality rates and higher maximum ages for Tiger Flathead reported by Jordan (1997) reportedly suggests that exploitation may have had a lesser impact on Tiger Flathead in southern and eastern Tasmania, compared with New South Wales and eastern Bass Strait (Morton et al., 2005). During the late 1980s and early 1990s, there was a decrease in the proportion of larger, older Tiger Flathead (seven years or more) in eastern Bass Strait and southern New South Wales' catches, with other indications that the Tiger Flathead abundance in the eastern Bass Strait area had been declining, both in number and biomass, from the late 1980s. However, trawl catch rates have remained comparatively stable since 1995, and Danish seine catch rates have improved from 1996 onwards (Caton and McLoughlin, 2006). Nevertheless, the flathead TAC remains (even to 2011) above previous estimates of long-term sustainable yield (about 2,500 tonnes, based on surplus production model and fishery data estimates from NSW and eastern Bass Strait combined: Rowling, 1994a, as well as more recent model-based assessments: e.g. Cui et al., 2006). A number of assessments have indicated that catches above 3,000 tonnes per annum are not sustainable in the long term (Cui et al., 2006; Caton and McLoughlin, 2006). Previous collapses of the flathead fishery have been attributed to high annual catches (>3,000 t) maintained over a number of years. More recent stock assessment work (Cui et al., 2006) has indicated that (i) at that time, the stock was assessed as being close to the target reference level of 40% of the unfished spawning biomass, but that catch levels were at a high point in the cycle, and at the highest levels since the 1960s, and that catch levels of the mid 2000s were unlikely to be sustainable in the medium- to long-term; (ii) there is a low probability of the spawning biomass being above 40% of the unfished spawning biomass, if future annual catch levels are higher than 2,000 to 2,500t, and average catch levels of less than 2,500t should be the aim in the longer term. It is noted that Klaer (2010) reported the spawning stock biomass to be about 44% of the unfished biomass. The 2006 analysis cited above indicated (as have previous analysis during the early 2000s) that annual catches of 3,000 to 3,500t cannot be sustained. The TAC for flathead was reduced from 3,500t in 2004 to 2,850t from 2007 onwards, but is still above the recommended sustainable level. The longer term sustainable yield for the three main fishing zones in south-eastern Australia zones has been estimated to be between 2,000t and 2,500t in total. Targeting of flathead has increased in recent years, with more use of 'flathead gear' by the trawl sector and higher catches by the Danish-seine fleet (Caton and McLoughlin, 2006; Cui et al, 2006). In some recent years (e.g. 2003, 2004, 2008, 2009) the catches have exceeded the recommended TAC. A projection in 2008 indicated that a ~300t reduction should occur in the total quota in 2009 (ShelfRAG, 2009), but this did not occur during the second decade of the 2000s (e.g. Woodhams et al. 2012).
- "High grading" and consequent discarding of juveniles has been an issue in the South East fishery for many years, and in recent decades, the level of discarding has been quantified. For example, an onboard scientific monitoring program indicated that from 1993 to 1995, 31% of the total number of Tiger Flathead caught by demersal trawl in NSW waters were discarded because they were less than the legal size (G. Liggins, NSW Fisheries Research Institute, Cronulla, NSW, pers. comm., cited by Bax, 1997). Discard rates (by number) may also be high in Victorian waters where Tiger Flathead is a bycatch in the Danish seine fishery for school whiting (*Sillago flindersi*), which uses smaller mesh net than the trawl fishery (Bax, 1997). Based on estimates from an integrated scientific monitoring program (which collected onboard data), examples of high discard rates across the fishery include 13% (511t) in 2000, and 6% (267t) in 1999 (Smith and Wayte, 2003). During the early to mid 2000s, discards in the Commonwealth-managed South East fishery amounted to about 160t – 230t per annum (see **Fisheries Information** section above).

- The reduced size structure in catches over time has been reported as a concern in both New South Wales and Tasmania. Catches of flathead below 33 cm significantly reduce the relative yield per recruit (*growth overfishing*); also, fish of that size are unlikely to be mature and their ongoing capture in the long-term could reduce the reproductive capacity of the stocks, and hence recruitment (*recruitment overfishing*), at least in localised areas (Smith and Wayte, 2003). The comparatively smaller size of flathead off the N.S.W. coast is considered to be a probable result of protracted and significant fishing pressure, but may also be confounded by changes in targeting towards smaller fish in recent years (Smith and Wayte, 2003). In Tasmania, the average length of 39 cm (and 480g) and maximum recorded size of 52cm in 2000/01, compared with 42 cm (650g) for the 1997/98 sample, which also included individuals of up to 66 cm (Lyle et al., 2002, cited by Morton et al., 2005).
- In Tasmania, the current legal minimum length (30cm TL) is not considered adequate for providing protection from mortality for reproductively immature Tiger Flathead) (Morton et al., 2005). Catches of flathead shorter than 33 cm significantly reduces their relative yield per recruit (growth overfishing). Moreover, fish of this size are unlikely to be mature, and their ongoing capture could reduce stock reproductive capacity and recruitment.
- There appear to be significant inter-annual changes in flathead availability that may not be related to stock size, and “environmental factors” and “environmental influences” are reported to be the probable cause of variations, including possible cyclic patterns (Smith and Wayte, 2003; AFFA, 2004a; Caton and McLoughlin, 2005). ShelfRAG (2008) reported that the Southern Oscillation Index may cause these cycles in availability. This variability increases the susceptibility of the Tiger Flathead stock to over-fishing, if quotas are not set at a precautionary level that accounts for years of lower abundance. On the other hand, it is reported to be difficult to discern cyclical nature of the catches if the TAC is reduced (as has occurred, compared with earlier highs of 3,500 – 3,900t), and if fishing effort on the continental shelf increases (as occurred in recent years) (ShelfRAG, 2008).
- It has been reported that Danish seine fishers target flathead that aggregate on schooling prey (Smith and Wayte, 2003). The capture of aggregations over space and time may adversely affect abundance, if serial depletion occurs.
- In a draft ecological risk assessment report for the South East Trawl Fishery (Wayte et al. 2004), 4 “productivity attributes” and 5 “susceptibility attributes” were used to classify *N. richardsoni* as being a “high risk” species in terms of potential population impacts from trawling. It is also noted that substantial discarding of juvenile flathead is reported to occur in the South East Fishery (AFFA, 2004c). Bycatch of undersized Tiger Flathead off southeast Australia is a management issue (Bax, 1997), and may be a threatening process to populations. In this quota-controlled fishery, “high-grading” (in which smaller specimens are discarded, leading to a larger total catch than is recorded under quota) may be a problem (FAO, 1997). AFFA (2004a) reported that, despite increased landings of small fish, discarding is still significant.
- In 2006, an Ecological Risk Assessment (ERA) for species in the Great Australian Bight Trawl Fishery (Daley et al., 2006), ranked Tiger Flathead *N. richardsoni* as a “medium risk” species, in terms of population impacts from capture in the GAB trawl fishery, but it is noted that the Great Australian Bight is west of the main distribution of this species, so few are likely to be caught there.
- Webb et al. (2004) reported that in south-eastern Australia, this species is at low risk from the operation of the Gillnet, Hook and Trap fishery (i.e. the shark fishery, and the non-trawl fishery for scalefish).

Research Notes

- There has been some stock assessment of Tiger Flathead, particularly in the Commonwealth-managed South East fishery (Cui et al. 2001; Punt, 2005; Cui et al., 2006; ShelfRAG, 2008; Klaer, 2010). Earlier assessments were hampered by issues of data quality (Bruce et al. 2002). Early models included (i) stock reduction method and a time series (1928-1934) of declining commercial fishery catch rates early in the development of the tiger flathead fishery (used to obtain an estimate of the unexploited biomass that existed in the late 1920s); (ii) an assessment in 1993, in which Tiger Flathead age and length data were examined together with catch and effort data up to 1992, and total mortality estimates were derived from the age structure of catches in 1982-83 and in 1991-92; (iii) a 1994 assessment, in which catch/effort data, size composition data and age composition data were examined, in conjunction with information from the on-board Scientific Monitoring Program (SMP) on Tiger Flathead discards; (iv) a 1995/96 assessment, which included SEF catch/effort data to 1995, port-based size composition data, scientific monitoring program observations of size composition and discarding rates for 1993 to 1995 and updated age-length keys and length-at-age tables. Preliminary research trawl survey information on the distribution, relative abundance and population characteristics of Tiger Flathead in eastern Tasmanian waters was also included. The main assessment approach was the examination of key fishery indicators such as catch/effort data and the size and age composition of catches.
- In 2002, an Integrated Analysis assessment model was used, which incorporated length, age, catch, discard, catch rate (i.e. catch per unit effort: CPUE) and auxiliary data. Processes such as growth, recruitment and mortality were explicitly modelled, and parameters estimated using maximum likelihood methods. Data include length frequency information and weight of the retained and discarded catch (from scientific monitoring program on-board monitoring data); length-frequencies of the landed catch of Tiger Flathead, and data from Tasmanian landings. Correlations of flathead catch and catch rates against various environmental data sets were made (including sea surface temperature, the Southern Oscillation Index, chlorophyll A and wind direction). Industry has suggested that the most important environmental variables driving the fishery are water temperature, currents and wind direction. The analysis in 2002 indicated that over the last 16 years, standardised catch rates in all sectors of the fishery along the east coast appeared to be cyclical, with catch rates rising from a low during the mid 1980s to a peak during the early 1990s, dropping to another low during the mid 1990s and rising again to a peak in 2000. Significant positive correlations between catches and catch rates and sea surface temperature were evident in many cases and accounted for between 25-50% of the variation in catches or catch rates. Significant positive correlations were also apparent between the Southern Oscillation Index (SOI - lagged 2 years) and catch rates in all sectors/areas of the fishery. These correlations explained 40-70% of the variation in catch rates. There are significant positive correlations between annual Tiger Flathead catches/catch rates and water temperature and SOI. These tend to indicate that there may be cyclical inter-annual changes in the availability of flathead to the fishery that may be related to environmental conditions. The underlying processes behind these cycles are not clear, but they bring into question the validity of using unstandardised catch rates as indicators or reference points for the fishery. It also has implications for the process and value of setting the TAC on an annual basis (Smith and Wayte, 2003). The preliminary Integrated Analysis model assumed that there is only a single stock of Tiger Flathead in the SEF, and no spatial variations were considered. The model divided catches across the two fleets (otter trawl and Danish seine), with each fleet having its own selectivity function. Standardisations of CPUE were performed, with vessel, region, depth and season as factors, for the trawl and Danish seine fleets separately (Smith and Wayte, 2003). The preliminary assessment showed that the Integrated Analysis model is able to fit the age, length and catch rate data reasonably well. However, there was considerable sensitivity to the data weighting and to the choice of error function for the length and age data. Smith and Wayte (2003) provided various suggestions for improvement to the model, including the incorporation of spatial dis-aggregation into the model; the separation of trawl fishery data into regions; separate modelling of the Danish seine fishery; use of depth data in CPUE standardisation; verifying source and reliability of historical catch and catch rate data; modifying the analysis to include a spatial component into the model; and inclusion of correlations of catch rates with environmental variables, amongst other suggested improvements.

- Throughout the early and mid 2000s, stock assessment workshops for Tiger Flathead were held (Smith and Wayte 2003; ShelfRAG, 2008). The 2004 stock assessment (Cui et al., 2006) used a two-sector (otter trawl and Danish seine) age- and length-structured quantitative model, and examined the implications of future catch levels on the stock. The objective function included contributions from discard rates, fishery landed age-composition data, fishery landed size-composition data, catch-rates, and a penalty on the recruitment residuals. The assessment used 89 years (1915-2003) of historical fishing data to estimate the virgin spawning biomass and current relative biomass and provided a detailed picture of the dynamics of the Tiger Flathead fishery (Cui et al., 2006).
- Data analysis has indicated that catch rates from the Danish seine sector (as distinct from the trawl sector) are likely be a more reliable indicator in stock assessment, as this sector has more spatial and temporal stability and reduced changes in gear selectivity and targeting. (If catch rates from the trawl sector are used in assessments, it was agreed in workshops during the early 2000s that only catches with >100 kg/shot of flathead should be used, or catches in which flathead comprised 50% or more of the catch). The stability of the length frequency pattern of Danish seine catches is also considered as a potential indicator. Any shift from current 10 year stable pattern in size range is considered to warrant examination.
- A number of workshops have been held to analyse time series of age distributions of the Tiger Flathead population in south-eastern Australia, using data from trawl and Danish seine samples (Smith and Wayte, 2003).
- Research has been undertaken to determine the optimum mesh size and fishing depths for trawlers, to reduce the bycatch of undersized Tiger Flathead (Bax, 1997).
- In south-eastern Australia, biomass estimates per square kilometre have been calculated for this species (Savina et al., 2008, cited by Forrest, 2008).
- Sectioned otoliths are now used for ageing of Tiger Flathead, as these are considered more reliable than whole otoliths, which were used prior to 1998 (Smith and Wayte, 2003).
- Using Tiger Flathead data from Danish seiners as an example, recent work has been undertaken into correction of gear-selectivity bias and retention effects, in estimation of fish growth using length-at-age and length increment data. To correct for bias, a maximum-likelihood estimator that incorporates gear selectivity, a size-dependent retention function and several stochastic growth models has been developed (Trioynikov and Koopman, 2009). Correction of gear selectivity bias in length at age estimates is important for accurate stock assessment.

Research Recommendations

- There have been no genetic studies of stock structure in commercial flathead species (Ward and Elliot, 2001, cited by Bruce et al., 2002). Although a single stock of Tiger Flathead has long been assumed, stock structure is not well known, and movements are poorly documented (Bruce et al., 2002; Smith and Wayte, 2003). More recent stock assessments (ShelfRAG, 2008) assume one stock across NSW and eastern Bass Strait, with a separate stock off eastern Tasmania. The relationship of the Tasmania stock with the eastern Australian stock should be assessed. It is noted that larger and older individuals are caught off Tasmania compared with catches from eastern Bass Strait.
- The distribution and habitat requirements of larvae, early juveniles (< 10cm) and older juveniles are poorly documented, and should be determined (Bruce et al., 2002; Smith and Wayte, 2003).
- Movements of Tiger Flathead are poorly documented (Bruce et al., 2002), including both seasonal and life stage movements. Rates of movement should be determined (Smith and Wayte, 2003).
- The relationship between inter-annual changes in Tiger Flathead availability / relative abundance and environmental factors (such as the Southern Oscillation Index) should be investigated. - Methods should be developed to incorporate cyclical correlations of catch rates with the environment (representing availability) into quantitative stock assessment models (Smith and Wayte, 2003). It has been suggested that in some years, lower than average occurrence of warm water eddies may adversely affect flathead catches, and also that warmer summers in N.S.W. may precipitate the movement further south of flathead into Tasmania waters (Smith and Wayte, 2003). Such observations indicate a possible relationship between flathead movements and oceanographic variables.

- Stock assessment may be improved by including: more adequate information on standardised catch rates for each sector (e.g. trawl versus seine); incorporating historical gear changes and catch rates into the assessment with further inclusion of historical length data where available; age-size composition over the full range; data on changes in fishing practices, and redistribution of trawl effort; data on fluctuations in rates of high grading and discarding small specimens (which is significant in some years); species composition of the catches between sectors; improvements to the quality of fishery logbook data; sensitivity tests to data and model assumptions (Bruce et al., 2002; ShelfRAG, 2008). Other recommendations have included development of a reliable recruitment index; better understanding of species interactions, and environment factors that influence flathead distribution, abundance and catch rates (including incorporating environmental data into catch rate standardisations); fleet dynamics, and net selectivity/gear configuration - particularly for trawlers. Importantly, since the fishing area for Tiger Flathead has expanded in recent years, the stock assessments should include data for the full area of the fishery, not just the 3 main areas that have traditionally been fished (ShelfRAG, 2008). Klaer (2010) provided a recent stock assessment for this species, which included estimates of spawning stock biomass.
- It has been recommended that in south-eastern Australia, the inverse relationship between catches of school whiting and Tiger Flathead by the Danish seine fleet be recognised in examination of potential indicators (Smith and Wayte, 2003).
- State catches compared with Commonwealth-regulated catches need to be better quantified (Bruce et al., 2002).
- The size of the recreational catch needs to be ascertained, in south-eastern Australian States.

Management Recommendations

- During the history of the fishery, whenever annual catches have exceeded 3,000 t for extended periods, this has always resulted in subsequent reduced catch rates and reduced catch levels (Cui et al., 2006). A number of assessments have indicated that the annual catch should not exceed 2,000 – 2,500 tonnes (Smith and Wayte, 2003; Cui et al., 2006), yet at the end of the 2000s, the TAC for the South East fishery remained above 2,500t.
- Given the inter-annual variability in relative abundance, permissible catches should be set at a precautionary level, rather than at the estimated maximum sustainable catch level
- There is concern that reduction in the TAC may not reduce the total mortality, because the fish may continue to be caught with currently used gear and in currently fished areas, leading to higher discarding or undeclared catches (Shelf Resource Assessment Group, 2008). Therefore, measures should be developed to ensure as far as possible that any TAC reduction is more effective.
- There is concern that the TAC is set based on assessment for only part of the stock. For example, although catches in the 3 main south-eastern fishery zones (N.S.W., eastern Victoria and Bass Strait) account for 94% of total Commonwealth flathead catches since 1986, the percentage has been lower in recent years, following expansion of the trawl fishery off eastern Tasmania. Although the fish off Tasmania are unlikely to represent a separate biological stock, it is clear that they do not fully mix with the fish to the north, and the size distribution appears to be larger (Cui et al., 2006).
- One of the management objectives for the South East fishery is to ensure that the biomass of Tiger Flathead does not significantly decline below its current level; however, issues that hamper this aim include current jurisdictional boundaries and varying approaches to management by the States and Commonwealth. These issues must be reconciled if the objective is to be achieved (Smith and Wayte, 2003).
- The interpretation of flathead catch data is reportedly confounded by inadequate information on catch rates, age/size composition, changes in fishing practices, redistribution of trawl effort, fluctuations in rates of “high-grading” and discarding, and the species composition of catches between sectors (Bruce et al., 2002). These variables need to be included in stock assessments.
- Catch rate data between the Danish seine and trawl sectors should be standardised (Bruce et al., 2002).
- There are some concerns about the quality of fishers’ logbook data, and its suitability for use in stock assessment, including the lack of species’ breakdown (Bruce et al. 2002).

- Efforts should be made to reduce targeting of fish less than 33cm (Smith and Wayte, 2003). However, recent research on flathead behaviour (see Yanase et al., 2009) indicates that it may be difficult for trawls to avoid undersize flathead, and if they are caught, difficult to release them unless some means is found to stimulate the fish to actively swim out of the net. In New South Wales, a modelling study has demonstrated that there may be a relation between the mortality of young Tiger Flathead in the inshore grounds, and the yield per recruit of adult Tiger Flathead obtained in the fishing grounds further offshore (Chen et al., 1998). This may indicate the need to consider the size-dependent difference in spatial distributions of Tiger Flathead in the management of the stock and the fishery.

Management Notes

- One of the major management aims for the South East fishery has been to set a TAC for the Commonwealth managed portion of the fishery that maintains the standardised catch per unit effort (CPUE) in the fishery above its lowest annual average from 1986 to 1994 (Smith and Wayte, 2003).
- In the management of quota, a "Tier 1 harvest control rule" specifies a target and a limit biomass reference point, as well as a target fishing mortality rate. Since 2005, various values have been suggested and used. Tier 1 calculations are based on a target fishing mortality rate for fully selected fish, which is proportional to the fishing mortality that will result in a obtaining a target biomass (ShelfRAG, 2008).
- One of the other major aims is to manage all sectors of the fishery (Commonwealth and State) in a complementary manner. However, there are issues with catches from other jurisdictions, that are not included in the Commonwealth TAC (see **Management Recommendations**, above).
- Periodically, there have been some issues with misreporting, i.e. the claiming of some Commonwealth catches from State waters (e.g. 1993-94). In recent years (early 2000s), concern was also expressed about flathead catches being misreported in Commonwealth waters to avoid the N.S.W. size limit.
- Other issues in the management of the fishery include grading of catches and discarding of smaller, low-priced flathead, particularly by some trawl operators with quota limitations towards the end of the year (Smith and Wayte, 2003). However, this issue has been complicated by the lack of standardisation in legal minimum lengths between State and Commonwealth waters, and also by market changes in the acceptability and popularity of smaller flathead. For example, traditionally the levels of discarding by Victorian-based Danish seiners and trawlers were lower than those by southern N.S.W. trawlers, because a 33cm size limit applied in N.S.W. and virtually all undersized fish were discarded. In Victoria, the size limit was 27 cm and the size range of fish captured (by both trawls and seines) was larger, resulting in less discarding. This trend has changed in recent years as fishers realised that the N.S.W. size limit did not apply to fish caught in Commonwealth waters (Smith and Wayte, 2003). Greater proportions of fish less than 33cm have been retained in some parts of south-eastern Australian fishing area in recent years. Compounding this trend, the high value of flathead has resulted in good market prices for small flathead. Consequently, fishers have been targeting small flathead (rather than moving away from them) and have been using cod-ends with a twist in the double-braid in order to retain smaller fish (Smith and Wayte, 2003).
- There are many technical issues in the fishery, with some examples including (i) increased trawl shots over hard bottom using rubber or bobbin gear, leading to more shots containing flathead as by-catch (which depresses flathead catch rates in the main fishery); and (ii) poor weather in some years, which restricts target flathead catches by Danish seiners in outer shelf waters and increases the proportion of flathead taken as a by-catch of shallow water whiting fishing (Smith and Wayte, 2003).
- The large proportion of smaller flathead in catches taken off N.S.W. is reported to be a concern. This contrasts to the larger size of flathead in historical catches, and is reported to reflect the high and protracted fishing pressure occurring off the N.S.W. coast (Smith and Wayte, 2003). Prior to 2000, most fish less than 33cm were also discarded in the eastern Victorian sector of the fishery. However, during the early 2000s, more of the smaller fish were retained as fishers realised that N.S.W. size limit (33 cm) did not apply to fish caught in Commonwealth waters. Tiger Flathead taken by Danish seiners in Bass Strait are generally smaller than those taken by trawlers in eastern Bass Strait and fish as small as 27cm may be retained, as they are not restricted by the N.S.W. minimum size limit (Smith and Wayte, 2003).

- During the mid to late 2000s, an increased number of operators in both trawl and Danish seine vessels in south-eastern Australia were beginning to use larger mesh to reduce the capture of small fish, including flathead. Large mesh cod-ends or escape panels are now mandatory for trawlers, and nearly all Danish seiners are reported to be using larger mesh (ShelfRAG, 2008).
- Stock assessment reports have been regularly produced for flathead in the Commonwealth-managed South East fishery, during the 1990s and 2000s (e.g. Smith and Wayte, 2003) (see **Research Notes**). In the South East fishery, the various assessments aim to (i) estimate catches and catch rates, and monitor shifts in effort and changes in fishing practices; (ii) monitor length distributions in commercial catches and undertake ageing work as required; (iii) obtain estimates of the spawning biomass at the onset of significant commercial fishing, and (iv) obtain estimates of the current spawning biomass through catch-at-age analyses using existing catch/effort, age composition and length composition information. The analyses are also used to determine future data requirements and sampling strategies (Smith and Wayte, 2003).
- Information is also available from monitoring of the size composition of catches taken under NSW jurisdiction in the early 1990s and also for recent years (New South Wales DPI, 2004).
- In the South East trawl fishery, AFMA (2006a) reported that the adoption of 75mm cod-ends in the Danish seine sector, and the use of more selective cod-ends in the otter trawl sector could reduce the discard rates of flathead.
- In New South Wales, there is a minimum legal length of 33cm for Tiger Flathead taken by commercial and recreational fishers, and a recreational bag limit of 20 flathead (all species) (N.S.W. Fisheries web site, 2004; Macbeth et al., 2008; Rowling et al., 2010).
- In Victoria, there is a minimum legal size of 27cm for flathead. The previous bag limit / possession limit was 30 flathead, of which no more than 2 fish may be equal to or exceed 60cm in length (Starling, 2003; Victorian Recreational Fishing Guide 2003-2004, DPI Victoria web site, 2004), and more recently this has been reduced to 20 flathead (Victorian Recreational Fishing Guide 2009-2010).
- In Tasmania, there is a minimum legal size of 30cm (Morton et al., 2005). Previously, there was a daily bag limit of 30 flathead, and a possession limit of 45 flathead (DPIWE Tasmania, 2004c), but this has been reduced to a total possession limit of 30 flathead (DPIW web site, December, 2009).
- In South Australia, the minimum legal size for flathead is 30cm, and there is a bag limit of 10, and a daily boat limit of 30 (PIRSA web site, December,. 2009).

Toothy Flathead / Gold-spot Flathead

Family Name: Platycephalidae
Scientific Name: *Platycephalus aurimaculatus* Knapp, 1987
= *Neoplatycephalus aurimaculatus* Knapp, 1987
Recommended Status: ***Data Deficient*** **(all States, and Commonwealth waters)**
Rationale: *Toothy Flathead is included here because (i) South Australia is at the edge of the species range, and hence the relative abundance of Toothy Flathead is naturally low in S.A., compared with populations in the eastern States; (ii) Toothy Flathead, like other large, southern Australia flathead species, is moderately long-lived, which is a vulnerable population characteristic if population exploitation (e.g. by fishing) is not closely monitored; (iii) the species is associated with sandy bays and, in some areas, estuaries, hence any processes that degrade such habitats may threaten populations, but there are no specific data; (iv) commercial fishing data, although limited for this species, suggest that this species might be naturally lower in abundance than more common flathead species with which its range overlaps (such as Tiger Flathead), and the lower abundance of Toothy Flathead is also a vulnerable population characteristic, considering that the species is fished commercially; (v) the species is taken commercially, mainly by Commonwealth-managed otter trawls and Danish seines, and to a lesser extent by shark-fishing gear, but catches are not well documented and quantified, because flathead catches are aggregated by species, and Toothy Flathead is a lesser component of a commercial catch of 5 species in south-eastern Australia.*

Conservation Status

- No formal listings known.
- It is noted that in the Commonwealth's South East fishery, "Flathead" comprises about 5 species, one of which is *N. aurimaculatus*, although the majority of the catch is *N. richardsoni*. Therefore, stock status classifications for flathead (see synopsis for Tiger Flathead *N. richardsoni*) do not specifically apply to N. *aurimaculatus*.

Distribution

Southern Australia

- The Toothy Flathead is found in south-eastern and southern Australia, particularly in eastern Bass Strait, Victoria and northern Tasmania, but the distribution extends west into South Australia (Kuiter, 1993; Kuiter, in Gomon et al., 1994). Daley et al. (1998) also included the S.A. / W.A. border area in the distribution.
- Yearsley et al. (1999) listed New South Wales as the northern limit.
- The species is reported to be most abundant in eastern Bass Strait (Cottier, 1999; New South Wales DPI, 2004).
- It is noted that during extensive sampling of southern and eastern Tasmania shelf waters and inshore waters, no juvenile or adult specimens of *P. aurimaculatus* were found (Jordan, 1997; Jordan et al., 1998). The northern coast of Tasmania (Bass Strait) appears to be the southern limit of distribution (Jordan et al., 1998).

South Australia

- Examples of locations in S.A. where the species is reported to occur include the Great Australian Bight; the "heel" of Yorke Peninsula; Spencer Gulf (central to southern area); southern Gulf St Vincent (e.g. Rapid Bay) and other parts of that gulf, and the upper South East of S.A. (e.g. Robe / Guichen Bay area) (Australian Anglers Association, 2005; South Australian Museum records, Museum of Victoria records; CSIRO Marine Research record, cited in CSIRO, 2010; Currie and Sorokin, 2010).

Habitat

- Toothy Flathead are found in sandy bays and other coastal waters (Kuiter, 1993).
- There are occasional records from shallow estuarine waters (e.g. Salt Creek in Victoria: Museum of Victoria record, 1980).
- The reported depth range is 10m – 160m (Kuiter, 1993; Kuiter, in Gomon et al., 1994; Daley et al., 1998), but the species is more often found within the range 25m – 100m (CSIRO et al., 2001).

Notes on the Biology

- There is little published information on the biology of the Toothy Flathead, but it is noted that in 1999, a Master of Science thesis (J. Cottier, Deakin University) was written on the biology of *N. aurimaculatus*, based on sampling in eastern Bass Strait, and that volume should be consulted for details of the biology that are not included in the brief descriptions below.

Age and Growth

- Research in eastern Bass Strait indicated that the growth rate is significantly different for males and females, and the latter grow faster, and reach a larger length at age (Cottier, 1999).
- Previously, the maximum size recorded was 55cm (Kuiter, 1993; Kuiter, in Gomon et al., 1994), but in eastern Bass Strait, Cottier (1999) recorded females as large as 59.5cm. Toothy Flathead are more commonly found between 30cm and 40cm (Daley et al., 1998).
- The maximum weight is 2.5kg, but the specimens are more commonly less than 1kg (Daley et al., 1998).
- Toothy Flathead are reported to be moderately long-lived, with ages in an eastern Bass Strait study estimated to be 16+ years for females and 18+ years for males (Cottier, 1999).

Diet

- Toothy Flathead is an ambush predator (Cottier, 1999). Previously, Toothy Flathead were reported to feed on cephalopods (Coleman and Mobley, 1984, cited by Bruce et al., 2002). In eastern Bass Strait, Toothy Flathead feed mainly on eels *Gnathophis* spp. and Eastern School Whiting *Sillago flindersi* (Cottier, 1999). Small individuals eat small, slower-moving fishes such as flounders and sandfishes (Cottier, 1999). As Toothy Flathead increase in size, Arrow Squid *Nototodarus* sp. and eels become important prey items (Cottier, 1999).

Reproduction

- Both males and females reach sexual maturity at about 300 – 349mm, equivalent to age 2 - 3 (Cottier, 1999).
- Bass Strait and northern Tasmania may be a spawning and larval development area for Toothy Flathead (Jordan et al., 1998). In eastern Bass Strait, Toothy Flathead breed over an extended period, from mid to late spring to mid summer, with most activity in November and December (Cottier, 1999).
- Large females (e.g. 55cm) can carry in excess of 1.6 million mature eggs and are more than 40 times as fecund as smaller females (e.g. 30cm) (Cottier, 1999).

Other Information

- Toothy Flathead does not have a swim bladder, but some other species of *Neoplatycephalus* (*N. richardsoni, N. conatus*) do (Daley et al., 1997, cited by Cottier, 1999).

Fisheries Information

Commercial

- Toothy Flathead is a bycatch species in the Commonwealth-managed SESSF (Southern and Eastern Scalefish and Shark Fisheries) (AFMA, 2002a). When taken outside of 3 nautical miles (NM) from the coast, catches of Toothy Flathead are managed by the Commonwealth, and when taken inside 3 NM, are managed by the States (AFMA, 2002a). The species is marketed as "Tiger Flathead", along with *Neoplatycephalus richardsoni* (Seafood Services Australia, 2003), but it is only the latter for which Tiger Flathead is the correct common name. It is easy to confuse *N. aurimaculatus* (which is common in southern N.S.W. / eastern Bass Strait) with Tiger Flathead *N. richardsoni.* According to BRR (1991), the reported "Tiger Flathead" catches from each State includes Toothy Flathead catches. Throughout the period 1964/65 to 1989/90 (i.e. the limit of the statistics cited by BRR, 1991), combined catch of both species ranged from 517t (in 1989/90) to 1,509t (in 1964/65) in New South Wales, with annual catches usually over 1,000 tonnes from the mid 1960s to mid 1970s, and between 500t and 850t during most years from the mid 1970s to 1990 (BRR, 1991). The proportion of these catches that comprise *N. aurimaculatus* cannot be determined, but is likely to be low, given that *P. richardsoni* is the main species taken in the fishery. Throughout the period 1964/65 to 1989/90, catches of "Tiger Flathead" (including Toothy Flathead) from Victoria ranged between 435t (1964/65) and 1,232t (1984/85), with most catches between 500t and 950t per annum. During the same period, recorded catches from Tasmania of the two flathead species combined, were considerably lower (from 2t to 186t) (BRR, 1991).
- Toothy Flathead is one of the 5 flathead species taken under quota in the Commonwealth-managed South East Trawl fishery (SETF) component of the SESSF, but Tiger Flathead is the main flathead species landed, comprising about 90% of the catch (Daley et al., 1998; Caton and McLoughlin, 2005), and up to 99% in waters deeper than 50m (Smith and Wayte, 2002). Only a small proportion of the annual catch in the Commonwealth-managed fishery comprises Toothy Flathead, Sand Flathead (*Platycephalus bassensis*), Blue-spot Flathead (*P. caeruleopunctatus*) and Southern Flathead (*P. speculator*) (Caton and McLoughlin, 2005). There is an annual quota for the take of flathead in the SETF, but the quota is not species-specific. Total Allowable Catches (TACs) and actual catches of Flathead species in the SETF are not presented here, because the majority refer to Tiger Flathead. Flathead species taken in Commonwealth fisheries are managed under ITQ management arrangements. For example, ITQs apply for flathead species taken in the SETF; the ECDWZ (East Coast Deepwater Zone within the SETF, previously called the East Coast Deepwater Trawl Fishery); the CVIT (Commonwealth Victorian Inshore Trawl Fishery), and the GHAT (Gillnet, Hook and Trap Fishery component of the SESSF) (AFMA, 2003j).
- Toothy Flathead are usually taken in otter board trawlers and Danish seine net fisheries (e.g. in the South East fishery: SETF), but are occasionally taken on hook and line (Kuiter, in Gomon et al., 1994; Cottier, 1999; Bruce et al., 2002). In the South East fishery, catches of flathead taken west of Bass Strait are most likely to consist of *N. aurimaculatus*, and also *N. conatus* (see synopsis). In the SETF component of the SESSF, on-board examination of Danish seine flathead catches taken in eastern and central Bass Strait during 1994 indicated that in depths less than 50m, Tiger Flathead was the dominant species (78%), but these catches also included significant proportions of 3 other flathead species, and Toothy Flathead comprised 6% of the catch (Smith and Wayte, 2004). *P. aurimaculatus* is reported to be a significant bycatch at depths of less than 60m (mainly 30m – 50m) in the Danish seine sector of the South East fishery, when Tiger Flathead *N. richardsoni* and Eastern School Whiting *(Sillago flindersi*) are targeted in eastern Bass Strait (Cottier, 1999). However, results from an integrated scientific monitoring program indicate that in some areas, catches using Danish seine are low (e.g. 4kg recorded in 24 shots, in a bycatch survey during the early 2000s) (Wayte et al., 2004). Small quantities are taken by otter board trawler off the east coast of Victoria, when fishers are targetting Eastern King Prawns *Penaeus plebejus*, Sand Crab *Ovalipes australiensis*, or Shovel-nosed Bugs (*Ibacus* spp.) (Cottier, 1999). In the SETF, specimens of Toothy Flathead less than 25cm are uncommon, due to the size selectivity of the fishing gear used (Cottier, 1999). In 1998, a bycatch study of Danish seine vessels targetting Tiger Flathead N. *richardsoni* showed that the majority of the Toothy Flathead catch was in the size range 31cm – 55cm in summer, and 36cm – 45cm in winter. The size range over the year, based on all specimens, was 27cm – 60cm (Cottier, 1999). During that bycatch study, in the fishery for Eastern School Whiting *S. flindersi*, the Toothy Flathead in the bycatch were smaller, with modal size classes of 21-25cm in both winter and spring; 31-35cm in autumn, and the size class of 46-50cm was also prevalent (Cottier, 1999).

- This species is reported to be a retained by-product in the Commonwealth-managed Gillnet, Hook and Trap fishery (GHAT) component of the SESSF (Bromhead and Bolton, 2005), a fishery that comprises the South East Non-Trawl fishery and the Southern Shark fishery. A study by Walker et al. (2003) of the bycatch in the Southern Shark Fishery, showed that in Bass Strait, during a study in 1973-1976, the average number of Toothy Flathead caught per 1,000 km hours using 6-inch nets, was 47 (S.E. = 47). In 1998-2001, when the study was repeated, no Toothy Flathead were caught. During a study which examined the bycatch of nets with 8 different mesh sizes, Toothy Flathead was one of the top 6 bony fish caught, in terms of numbers, with the greatest numbers taken in gillnets of 2-inch and 3-inch mesh size (Walker et al., 2003); however it is noted that these mesh sizes are not currently used in the Southern Shark sector of the GHAT fishery. The species was also caught in lower numbers during experiments using different hook sizes in the Southern Shark fishery (e.g. 2/O and 4/O hooks) (Walker et al., 2003).
- Within New South Wales State waters (south of Barrenjoey Headland, and including waters 3 nautical miles east of the coastal baselines), there is a 200kg daily trip limit for the combined take of 4 flathead species (of which Toothy Flathead is one) by fishers in the inshore trawl fishery, because Toothy Flathead is a Commonwealth-managed species, under the Offshore Constitutional settlement (OCS) arrangements between the Commonwealth and N.S.W. (AFMA, 2004e). The trip limit is effective all year round, from 1st May 2003 onwards (N.S.W. Government Gazette, 14th February 2003 and 24th April 2008; AFMA, 2004e).

Recreational

- There are no recreational fishing statistics specifically referring to Toothy Flathead. The National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) reported that, during the survey time period (May 2000 to April 2001), the number of flatheads caught and kept by recreational fishers were 3,026,533 in Victoria, 174,870 in Tasmania and 75,566 in South Australia. The proportion of the catch that was Toothy Flathead is not known.
- Toothy Flathead is reported to be occasionally caught by recreational fishers in Tasmania (Morton et al., 2005).
- Various clubs and associations keep records of the maximum sizes caught. For example, the Australian Anglers Association holds a record of a specimen of 1.046kg, caught at Rapid Bay in South Australia in 1989.

Vulnerable Characteristics of the Species

- Toothy Flathead are reported to have a medium resilience to exploitation, in terms of minimum doubling time for populations (based on age and growth parameters), and moderate vulnerability to fishing-induced population decline (Cheung et al., 2005, cited in Froese and Pauly, 2009).
- Toothy Flathead, like other large, southern Australia flathead species, is moderately long-lived, which is a vulnerable population characteristic if population exploitation (e.g. by fishing) is not closely monitored.
- Commercial fishing data, although limited for this species, suggest that this species might be naturally lower in abundance than more common flathead species with which its range overlaps (such as Tiger Flathead), and the lower abundance of Toothy Flathead is also a vulnerable population characteristic, considering that the species is fished commercially.
- This species is associated with sandy bays and, in some areas, estuaries, hence any processes that degrade such habitats may threaten populations, but there are no specific data.

Threatening Processes

- The potential for over-fishing is the major threat to this species. In the Commonwealth-managed fisheries, although stock assessments do not separate Toothy Flathead from the total catch of all flathead species, it is notable that Flathead as a group is considered to be *fully fished* (AFMA, 2004a).
- Habitat degradation in sandy bays and estuaries may also be a threatening process in some areas, but there are no species-specific data.

Research Recommendations

- There have been no genetic studies of stock structure in commercial flathead species (Ward and Elliot, 2001, cited by Bruce et al., 2002). Although a single stock of Toothy Flathead is assumed, as is the case with other commercial flathead species, stock structure is not well known, and movements are poorly documented (Bruce et al., 2002).
- Estimates of biological parameters for commercial flathead species are poorly known, influenced by a lack of data for smaller specimens (Bruce et al., 2002).
- The relation between flathead distribution and abundance and environmental variables (such as sea temperatures, and the Southern Oscillation Index) should) should be further explored.
- More information on the relative abundance (over space and time), growth, movements / size composition over space, and reproduction should be made available, to improve management of commercial fisheries for Toothy Flathead, and better protect the stock from over-exploitation.
- In South Australia, the presence or absence of this species in the bycatch of prawn trawl fisheries (in Gulf St Vincent, Spencer Gulf, and the eastern Great Australian Bight) should be determined. Although the closely related Tiger Flathead (*N. richardsoni*) has been recorded in the bycatch of the Spencer Gulf Prawn Trawl Fishery (Carrick, 1997), it is likely that *N. aurimaculatus* is also a bycatch species, given its presence in habitats fished by prawn trawlers across South Australia.

Management Recommendations

- The effect of fishing on minor flathead species in the SETF is listed as a "key uncertainty" (Bruce et al., 2002).
- There are some concerns about the quality of fishers' logbook data, and its suitability for use in stock assessment, including the lack of species breakdown (Bruce et al., 2002).
- Toothy Flathead catches should be separated from the total flathead catch taken under quota in Commonwealth-managed fisheries. It is difficult to determine the status of the Toothy Flathead stock when all 5 commercial flathead species in the SETF are grouped for analysis and reporting.
- The interpretation of flathead catch data is reportedly confounded by inadequate information on catch rates, age/size composition, changes in fishing practices, redistribution of trawl effort, fluctuations in rates of "high-grading" and discarding, and the species composition of catches between sectors (Bruce et al., 2002).
- In prawn fisheries, adoption of gear designs that reduce the bycatch of sand-dwelling species such as flatheads should be encouraged.

Management Notes

- In the South East trawl Fishery for flathead (which mainly comprises Tiger Flathead *N. richardsoni*, but Toothy Flathead *N. aurimaculatus* is also a minor component), one of the objectives in setting a Total Allowable Catch (TAC) for the Commonwealth-managed portion of the fishery is to maintain the standardised catch per unit effort (CPUE) in the fishery above its lowest annual average from 1986 to 1994 (Smith and Wayte, 2004). In this fishery, part of the southern and eastern scalefish and shark fisheries (SESSF), there is a so-called "recommended biological catch", which is the total level of fishing mortality (from all sources) that a stock should sustain each year under the "harvest strategy framework" (AFMA, 2006a).
- In the South East trawl fishery, AFMA (2006a) reported that the adoption of 75mm cod-ends in the Danish seine sector, and the use of more selective cod-ends in the otter trawl sector could reduce the discard rates of flathead.
- In Tasmania, there is a minimum size limit of 30cm, and a possession limit of 30 flathead (all species combined) (DPIW, 2008). In Victoria, there is no minimum size limit, and the bag / possession limit is 40 (DPI Victoria, 2009). In South Australia, there is legal minimum sizes of 30cm, a bag limit of 10, and a boat limit of 30 flathead (all species) (PIRSA, 2009). In both the South Coast and West Coast bioregions of W.A., there is a legal minimum size of 30cm, and a bag limit of 8 flathead and flounder combined (all species) (Department of Fisheries, WA, 2008c, 2009a).

Rock Flathead / Grass Flathead / Grassy Flathead

Family Name: Platycephalidae
Scientific Name: *Platycephalus laevigatus* Cuvier, 1829
Recommended Status: **South Australia: *Data Deficient***
Victoria: *Data Deficient, possibly Near Threatened*
Other States (W.A., N.S.W., Tasmania): *Data Deficient*

Rationale: *Rock Flathead is included here because (i) it is a site-associated benthic species with a narrow depth range in upper continental shelf waters, and may thus be susceptible to site-specific impacts; (ii) the species is strongly associated with seagrass beds and shallow macroalgae-covered reefs, hence any processes that degrade such habitats (e.g. nutrient enrichment, and sedimentation) may threaten populations in some areas. There is indirect evidence (via commercial catches) that pollution-induced declines in seagrass cover in Victoria may have adversely affected populations of this species; (iii) the species is taken commercially (mainly in Victoria), with no catch limits, and is also reported to be a bycatch species in some trawl fisheries, including prawn fisheries in South Australia; and (iv) there is little information on the biology and population dynamics of this species.*

Distribution

Southern Australia

- A shallow water species found across southern Australia and Tasmania (including Bass Strait islands). Geographical range is from the Queensland / New South Wales border through to at least Geographe Bay in Western Australia (Hutchins and Swainston, 1986; Gomon et al, 2008).
- In W.A., Lek et al. (2006) reported this species from as far north as Jurien Bay, but the validity of the record has not been ascertained for this report.

South Australia

- Examples of locations in S.A. where the species has been recorded include northern Spencer Gulf (e.g. Whyalla); mid-eastern Spencer Gulf (e.g. Balgowan) and south-western Spencer Gulf (e.g. Port Lincoln area); western Gulf St Vincent (e.g. Port Julia, Port Giles and Edithburgh); "heel" of Yorke Peninsula (e.g. Hillock Point); metropolitan Gulf St Vincent (e.g. Christies Beach, and Outer Harbour), southern Fleurieu Peninsula (e.g. Carrickalinga; Rapid Bay), and N and NE Kangaroo Island (Branden et al., 1994; Fairhead et al., 2002a,b; Tanner et al., 2003; Marine Life Society of S.A. record, cited by Baker et al., 2008b; Australian Underwater Federation Inc., 2004; photograph by J. Lewis, 2006; Kinloch et al., 2007; Australian Anglers Association, 2009; Museum of Victoria records; S.A. Museum records).

Habitat

- Rock Flathead is found in sheltered to moderately exposed seagrass beds (often in bays and inlets), and near low-relief, vegetated reefs and jetties (Last et al., 1983; Hutchins and Swainston, 1986; Edgar, 2000).
- This species is strongly associated with seagrass (e.g. in Victoria Bays) (Klumpp and Nicholls, 1983; Connolly et al., 1999) and low macroalgae. In Corner Inlet, Klumpp and Nicholls (1983) reported *P. laevigatus* to be a major predator in a *Posidonia australis* seagrass bed. In Swan Bay in Victoria, this species is associated with shallow *Zostera* and/or *Heterozostera* seagrass beds (Plummer et al., 2003). Edmunds et al. (2006) reported that *P. laevigatus* is strongly associated with sediments in seagrass beds.
- In Port Phillip Bay and Western Port in Victoria, Rock Flathead use sand / unvegetated areas as a nursery habitat until the juveniles reach approximately 20 mm in size, and then move to seagrass beds (Jenkins et al., 1993; Edgar and Shaw, 1995, cited by EPA Victoria, 2001), and macroalgae-covered reefs (Parliament of Victoria, 1991; Government of Victoria, 1996, cited by EPA Victoria, 2001). In various parts of Victoria, there are also records of juveniles from mud flats adjacent to mangroves (EPA, 1996, cited by Plummer et al., 2003; Hindell and Jenkins, 2004).

- In south-western W.A., juveniles have been recorded in habitat types described as (i) "highly sheltered from wave activity, with the substrate containing areas of dense seagrass within 50m of the shoreline, and also further offshore", and (ii) "moderately sheltered from wave activity, with the substrate containing patches of sparse seagrass within 50m of the shoreline, and also further offshore" (Valesini et al., 2004).
- There are records of this species in estuaries, in W.A. (e.g. Potter et al., 2000), and Bass Strait islands (Edgar et al. 1999).
- This species rarely buries, but remains amongst low vegetation during the day (Gomon et al., 2008).
- Reported depth range is from 0m to about 20m (Edgar, 2000; Gomon et al., 2008), but there may also be records from deeper water (unverified).

Notes on the Biology

Growth

- The species grows to around 81cm (Hutchins and Swainston, 1986), but the species does not usually reach more than about 50cm. The maximum weight recorded is 2.1kg (Hutchins and Swainston, 1986), being a specimen caught at Carrickalinga in South Australia in 1977 (Australian Anglers Association, 2009).
- Apparently, longevity is not known (Plummer and Jenkins, 2003).

Diet

- Rock flathead eat a variety of animals, as well as seagrass and macroalgae.
- Larval Rock Flathead are thought to feed on zooplankton, but little is known of the diet of larval stages (G. Jenkins, cited in Plummer and Jenkins, 2003). Adult Rock Flathead eat mainly organisms associated with seagrass beds (Klumpp and Nichols, 1983b, cited by Plummer and Jenkins, 2003). In some areas, larger juveniles (e.g. 25 - 33cm) feed on carid prawns / shrimps, squid and small fishes (Klumpp and Nichols, 1983b; Hall and McDonald, 1986). At Corner Inlet in Victoria, a study showed that the diet of adult Rock Flathead includes about 60% crabs (particularly *Nectocarcinus integrifrons,* with low numbers of the shore crab *Paragrapsis laevis,* the sand crab *Ovalipes australiensis,* and the spider crab *Halicarcinus ovatus*), but also bony fishes (such as Common Weedfish *Heteroclinus perspicillatus* and Bridled Leatherjacket *Acanthaluteres spilomelanurus*), and squid (the latter especially in winter) (Klumpp and Nichols, 1983b). Crabs and fish are also important components of the diet of Rock Flathead in Port Phillip Bay and Western Port (Parry et al., 1995; Edgar et al., 1993, cited by Plummer and Jenkins, 2003).
- In one study in Western Port, Victoria, syngnathids (*Mitotichthys semistriatus*, *Urocampus carinirostris*, *Vanacampus phillipi* pipefishes) represented 33% of fish consumed by *Platycephalus laevigatus* (Edgar and Shaw, 1995b, cited by Martin-Smith, 2008).

Reproduction

- Apparently, size and age at maturity are not known (Plummer and Jenkins, 2003).
- Rock Flathead in Corner Inlet spawn from November to December (Klumpp and Nichols, 1983b; Nicholson 1992, cited by EPA Victoria, 2001; Plummer and Jenkins, 2003). There is a reduction in feeding intensity during the spawning period (Klumpp and Nichols, 1983b).
- Rock Flathead larvae have also been captured at the southern end of Port Phillip Bay, near the South Channel (Neira and Tait, 1996, cited by Plummer and Jenkins, 2003). New recruits have also been captured in Port Phillip Bay in summer (Jenkins et al., 1996, cited by Plummer and Jenkins, 2003).

Behaviour

- Rock Flathead are most active at dusk, and often move around at night. During the day, they sleep in low algae (Gomon et al., 2008) and seagrasses.
- During a study in Corner Inlet, Victoria, Rock Flathead and its main prey, the crab *N. integrifrons*, both moved more at night (especially during nocturnal or crepuscular high tides) than at other times (Klumpp and Nichols, 1983b).

Other Information

- Predators of Rock Flathead reportedly include Bronze Whaler *Carcharhinus brachyurus* (Jones, 2008).

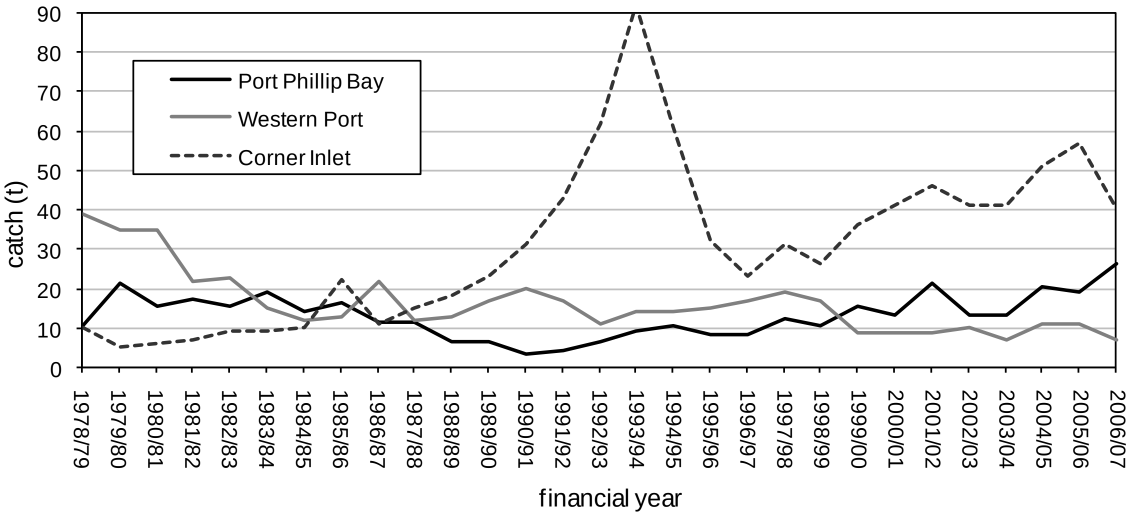
Fisheries Information

Commercial - Southern Australia

- Rock Flathead is caught commercially throughout southern Australia, and it is highly regarded as a food fish (Edgar, 2000). The marketing name is Rock Flathead (Seafood Services Australia, 2003).
- It is noted that Wayte et al. (2004) reported *P. laevigatus* as a minor, incidental catch in the otter trawl sub-fishery of the South East Trawl fishery (part of the Commonwealth-managed Southern and Eastern Scalefish and Shark Fisheries: SESSF), and Bromhead and Bolton (2005) also listed this species as a bycatch in the South East Trawl component (also the Gillnet Hook and Trap component) of the SESSF; however, given the shallow depth distribution, it is unlikely to be caught in these Commonwealth-managed fisheries, which operate in deeper waters. Also, this is a prohibited species for Commonwealth-licensed fishers operating in State waters, because *P. laevigatus* is a State-managed commercial species (AFMA, 2003m).
- Rock Flathead is an important commercial catch from bays in Victoria, and is regularly sold in the wholesale fish markets in Melbourne. The figure below shows the commercial catches between 1978/79 and 2006/07, for the three main regions in which this species is fished (from DPI Victoria, 2008b). The main commercial fishery is in Corner Inlet, with smaller quantities taken in Western Port Bay and Port Philip Bay. In Port Philip Bay, the majority of the commercial catch of this species comes from the western side (e.g. north-east of Swan Island, around into Geelong arm and Corio Bay, and up to Werribee). Also important is an area between Mud Islands and Sorrento. Small catches are taken from the northern part of the bay (e.g. Werribee to Brighton) (Fisheries Victoria data, cited by Plummer and Jenkins, 2003). In Victoria, Rock flathead are mostly targeted with mesh nets (Coutin, 2000, cited by Plummer and Jenkins, 2003), but hauling seines are also used. The largest catch taken from any of the 3 main regions was in 1993/94, when 92t were taken from Corner Inlet. Total recorded catches per annum from all of Victoria, have ranged between 61t and 88t during the 5 years to 2006/07 (DPI Victoria, 2008b). Hauling seine catch rate have increased significantly during the 2000s in Port Phillip Bay, compared with the 1990s. Mesh net catch rates in Port Phillip bay were highest during the late 1970s / early 1980s and early 2000s; low during most years of the 1990s, and declined, after a record high in 2000/2001, back towards 1990s levels. Catch rates of Rock Flathead using mesh nets and hauling seines in Corner Inlet have shown peaks during the early 1990s (e.g. 1992 – 1994) and early 2000s. Haul seine fishing effort has risen during the past few years to the mid 2000s, but mesh net effort has declined over the same period (Fisheries Co-Management Council of Victoria, 2005).

Reported Catches of Rock Flathead from Victorian Bays, 1978 – 2007

(DPI Victoria, 2008b).



Commercial - South Australia

- Species-specific records from flathead catches in the South Australian Marine Scalefish Fishery are not available. Rock Flathead may be one a of a number of species caught. Example of "Flathead" catches include between 500g and 1t per annum during the mid-late 1990s, from northern Gulf St Vincent, and incidental catches (100 – 200kg per annum) from areas such as eastern Kangaroo Island and southern Fleurieu Peninsula, central-western and central-eastern Spencer Gulf, Investigator Strait, and Encounter Bay.
- Rock Flathead is reported to be a bycatch species in the Spencer Gulf prawn fishery (PIRSA, 2003).

Recreational

- Rock Flathead is caught by recreational fishers throughout southern Australia, but is not often targeted. In Port Phillip Bay in Victoria, for example, this species is sometimes caught when fishers are targeting King George whiting in seagrass beds, or over reefs (P. Coutin, pers. comm., cited by Plummer and Jenkins, 2003).
- In Tasmania, this species is taken almost exclusively be nets (Smith and Heran, 2001). Estimated tonnages of "flatheads" taken per annum refer mostly to Sand Flathead (*Platycephalus bassensis*) and thus will not be presented here.
- This species is also taken by spear fishers. One of the maximum sizes recorded is 1.93kg, being a specimen taken from Balgowan in South Australia (Australian Underwater Federation Inc., 2004).
- The National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) reported that, during the survey time period (May 2000 to April 2001), the numbers of flatheads caught and kept by recreational fishers were 3,026,533 in Victoria, 174,870 in Tasmania and 75,566 in South Australia. The proportion of this catch that was Rock Flathead is not known.
- Some angling clubs and associations keep records of the maximum sizes caught.

Vulnerable Characteristics of the Species and Threatening Processes

- *P. laevigatus* is a site-associated benthic species with a narrow depth range in upper continental shelf waters, and may thus be susceptible to site-specific impacts in the nearshore area.
- Both juveniles and adults are strongly associated with seagrass beds, hence any processes that degrade such habitats (e.g. nutrient enrichment, and sedimentation) may threaten populations in some areas. It is noted that a decline seagrass habitat during the 1970s to mid 1980s in Corner Inlet, and during the 1980s to early 1990s in Port Phillip Bay, resulted in corresponding sharp declines in catch of Rock Flathead in both of these areas (MacDonald, 1992; M. MacDonald, pers. comm., cited by Connolly et al., 1999). Similar results were noted in Western Port Bay, where the decline in Rock Flathead catches paralleled the decline in 75% of the seagrass cover over a 15 year period (MacDonald, 1992, cited by Connolly et al., 1999).
- Rock Flathead are reported to have a medium resilience to exploitation, in terms of minimum doubling time for populations (based on age, growth and reproduction parameters) (Froese and Pauly, 2009), and a moderate vulnerability to fishing-induced population decline (Cheung et al., 2005, cited in Froese and Pauly, 2009).
- Francesconi et al. (1997) reported that *P. laevigatus* is one of the predatory fish species which maintained elevated mercury concentrations in the muscle tissue for decades, following mercury contamination (via effluent discharge) of Princess Royal Harbour in W.A., despite initial decreases in mercury concentration in these fish in the 10 years following cessation of pollution discharge.

Management Notes

- In Tasmania, there is a minimum size limit of 30cm, and a recreational possession limit of 30 flathead (all species combined) (DPIW, 2008).
- In Victoria, there is no minimum size limit, and the recreational bag / possession limit is 40 (DPI Victoria, 2009).
- In South Australia, there is legal minimum sizes of 30cm, a bag limit of 10, and a boat limit of 30 flathead (all species) (PIRSA, 2009).
- In both the South Coast and West Coast bioregions of W.A., there is a legal minimum size of 30cm, and a bag limit of 8 flathead and flounder combined (all species) (Department of Fisheries, WA, 2008c, 2009a).

- In South Australia, Rock Flathead has been identified as a suitable indicator species, to indicate how well the prawn trawl fishery in Spencer Gulf responds to practices which have potential to reduce by-catch mortality (PIRSA, 2003).

Other Information

- It is noted that, in a draft ecological risk assessment report for the South East Trawl fishery component of the SESSF (Wayte et al. 2004), 5 "productivity attributes" and 6 "susceptibility attributes" were used to classify *P. laevigatus* as being a "medium risk" species in terms of potential population impacts from trawling; however, given the shallow distribution of this species, it is very unlikely that specimens would be caught in the fishery. Fishers in the SESSF are prohibited from possessing any specimens of this State-managed species.
- *P. laevigatus* is one of the species monitored by the Reef Watch Victoria community-based monitoring program.
- In Victoria, this species has been reported in a number of marine national parks (MNPs) and marine sanctuaries (MS) such as Swan Bay (part of Port Phillip Heads MNP), Yaringa MNP (Western Port), French Island MNP, Churchill MNP, Corner Inlet MNP, and Ricketts Point MS (Plummer et al., 2003).

Longhead Flathead / Long-headed Flathead

Family Name: Platycephalidae
Scientific Name: *Leviprora inops* (Jenyns, 1840)
Recommended Status: ***Data Deficient*** **(SA and WA)**
Rationale: *Longhead Flathead is included here because (i) the central South Australian coast is at the eastern edge of the geographic range; (ii) it is a site-associated benthic species with a narrow depth range in upper continental shelf waters, and may thus be susceptible to site-specific impacts; (iii) the species is strongly associated with seagrass beds and shallow macroalgae-covered reefs, hence any processes that degrade such habitats (e.g. nutrient enrichment, and sedimentation) may threaten populations in some areas, but there are no specific data, and (iv) there is very little information on the biology and population dynamics of this species.*

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Distribution

Southern Australia

- The Longhead Flathead is found in mainly in Western Australia (as far north as Shark Bay – e.g. Travers and Potter, 2002), but extends into South Australia, with central S.A. coast being the recorded eastern limit (Hutchins and Swainston, 1986; Paxton et al., 1989; Hureau, 1991; Kuiter, in Gomon et al., 1994; Gomon et al, 2008).

South Australia

- Examples of locations in S.A. where the species has been recorded include mid-eastern Spencer Gulf (e.g. Port Hughes, Port Victoria, Cape Elizabeth), mid-western Spencer Gulf (e.g. waters off Franklin Harbour); south-eastern Spencer Gulf (e.g. off Port Victoria, and northern Hardwicke Bay); western Gulf St Vincent (e.g. Port Giles, Wool Bay and Edithburgh); "heel" of Yorke Peninsula (e.g. vicinity of the *Clan Ranald* shipwreck); metropolitan Gulf St Vincent (including the Glenelg area), southern Fleurieu Peninsula (e.g. Yankalilla Bay, Rapid Bay), and north-eastern Kangaroo Island (Hutchins and Swainston, 1986; Paxton et al., 1989; Hureau, 1991; K. Smith, unpubl. data, 2001; Fairhead et al., 2002a; Marine Life Society of S.A. records, undated; D. Muirhead, pers. comm., 2005, 2007; photograph by J. Lewis, 2006; photograph by D. Teubner, 2008; photograph by J. Peake, 2008; Australian Museum records, South Australia Museum records, cited in OZCAM database, 2009; Currie and Sorokin, 2010).
- In South Australia, D. Muirhead (Marine Life Society of South Australia, pers. comm., 2005) has recorded the species on numerous occasions during dives (particularly in Gulf t Vincent) over the past 10 years.

Habitat

- Longhead Flathead occurs in shallow water in the vicinity of low, rocky reefs covered with dense vegetation (Kuiter, in Gomon et al., 1994), and also in seagrass beds, where adults sit on the sand rather than burying (Edgar, 2000). The species has been recorded in both *Amphibolis* and *Posidonia* seagrass beds (Smit et al., 2005, 2006). Juveniles are sometimes found buried in sand, amongst seagrass (Kuiter, in Gomon et al., 1994). Hutchins and Swainston (1986) reported that the species is "reasonably common" in coastal sand and "weed" areas.
- This species is reported to be abundant in seagrass beds in south-western Australia (Vanderklift et al., 2007). In that region, juveniles have been recorded in a habitat type described as "highly sheltered from wave activity, with the substrate containing areas of dense seagrass within 50m of the shoreline, and also further offshore" (Valesini et al., 2004). During another survey in south-western Australia, *L. inops* was recorded rarely at Israelite Bay, in seagrass, and in other habitat, such as "soft bottom" (Hutchins, 2005). In Western Australia, the species has also been recorded in sandy surf zones (Ayvazian and Hyndes, 1995), and in estuaries (e.g. Loneragan et al., 1990; Potter et al., 1990).
  The reported depth range is 0m – 30m (Gomon et al., 2008), with most records to 10m (Edgar, 2000). There are unverified records (CSIRO Marine Research survey 1979 and 1981) from the Great Australian Bight at 45m - 50m.

Notes on the Biology

Growth and Age

- The species grows to around 61cm (Hutchins and Swainston, 1986; Kuiter, in Gomon et al., 1994). The maximum weight recorded is 2.55kg, being a specimen taken by spearfishing in Yanchep (W.A.) in 1977 (Hutchins and Swainston, 1986; Australian Underwater Federation, 2003). Another example of a large specimen is 2.52kg, taken by angling at Woodmans Point (W.A.), in 1978 (Australian Anglers Association Inc., W.A. Division, 2005).
- Longevity is not recorded.

Diet

- *L. inops* is a benthic feeder that is reported to be piscivorous (Smit et al., 2006), but also eats crabs (Vanderklift et al., 2007).
- During a survey in Spencer Gulf in 2007, the gut contents of 1 specimen was examined, and found to contain 95% fish, and 5% algae (Currie and Sorokin, 2010).

Fisheries Information

- The Longhead Flathead is not a commercial species.
- Longhead Flathead are caught by anglers, mainly in Western Australia. Some fishing clubs and associations keep records of the maximum sizes caught (e.g. Lancelin Angling and Aquatic Club; Quinns Rocks Fishing Club Inc.; Australian Anglers Association, W.A. Division).
- There are records of *L. inops* being taken by spearfishing in W.A. (Hutchins and Swainston, 1986; Australian Underwater Federation, Inc., 2003).
- Given the species distribution, and the depth range and location of records in Spencer Gulf (e.g. 4 Currie and Sorokin, 2010), it is likely that *L. inops* is a minor part of the bycatch in the Spencer Gulf prawn trawl fishery in South Australia.
- The National Recreational and Indigenous Fishing Survey (Henry and Lyle, 2003) reported that, during the survey time period (May 2000 to April 2001), fishers in South Australian and Western Australia caught and kept 75,566 and 79,633 flatheads (all species) respectively. The proportion of this catch that was Longhead Flathead is not known.

Vulnerable Characteristics of the Species

- South Australia is at the eastern edge of the geographic range, with the central coast being the recorded eastern limit, therefore *L. inops* has a limited distribution in this State.
- *L. inops* is found over a narrow depth range, in seagrass beds, and may thus be vulnerable localised population impacts.

Threatening Processes

- *L. inops* is a site-associated benthic species with a narrow depth range in upper continental shelf waters, and may thus be susceptible to site-specific impacts in the nearshore area, but there are no species-specific data.
- *L. inops* is strongly associated with seagrass beds, hence any processes that degrade such habitats (e.g. nutrient enrichment, and sedimentation) may threaten populations in some areas, but there are no specific data.
- Given the species distribution, and the depth range and location of records in Spencer Gulf, it is likely that *L. inops* is a minor part of the bycatch in the Spencer Gulf prawn trawl fishery in South Australia, but there is no information on the potential population impacts of trawling on this species.

Management Notes

- In South Australia, there is legal minimum sizes of 30cm, a bag limit of 10m, and a boat limit of 30 flathead (all species) (PIRSA, 2009).
- In both the South Coast and West Coast bioregions of W.A., there is a legal minimum size of 30cm, and a bag limit of 8 flathead and flounder combined (all species) (Department of Fisheries, WA, 2008c, 2009a).

Management Recommendations

- Measures to reduce bycatch in prawn trawl fisheries should be implemented where possible.

Other Information

- This species has been recorded in the Jurien Bay Marine Park in W.A. (Potter et al., 2006).