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Angling pressure impedes a three-year telemetry study on mulloway (*Argyrosomus japonicas*) in a western Victorian estuary, Southern Australia

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**Abstract:** Mulloway (*Argyrosomus japonicas*) are widely distributed in estuarine and nearshore waters within the Indian and Pacific Oceans. In Australia, it is an iconic recreational species that is also important commercially, with the largest commercial fishery being in the Murray River estuary and nearby coastal environments. To determine habitat preferences and movements between the estuary and the open ocean, 24 mulloway were acoustically tagged and followed for three years. Tagged fish were tracked using 20 receivers deployed along the estuary from its mouth to 65 km upstream. However, during the study thirteen (54%) of the tagged mulloway were caught and kept by anglers, hampering analysis of mulloway movements but providing opportunistic data on angling pressure and sizes of captured fish. Although generalised movement patterns could be gleaned from the remaining data, this case study exemplifies the challenges of telemetric studies of intensively angled fishes in estuaries and other semi-enclosed waters.

**ABOUT THE AUTHOR**

Jason Lieschke works for the Arthur Rylah Institute (ARI), the biodiversity research institute within Victorian government - Department of Environment, Land, Water and Planning (DELWP). The institute generates and shares knowledge, through world-class, applied, ecological research. This knowledge supports and guides sustainable ecosystem policy and management to ensure healthy, resilient ecosystems in south-eastern Australia. The Applied Aquatic Ecology section within ARI has extensive expertise in species and habitat assessment, monitoring and restoration; threatened species conservation and recovery; population dynamics and population modelling; disturbance ecology; ecological modelling, analysis and mapping; developing, testing and implementing innovative survey techniques for biodiversity assessment; developing robust indicators and decision support tools; taxonomy; and science communication. Jason’s research includes threatened species, riverine flows, fish movement and estuarine electrofishing. This paper relates to species conservation, population dynamics and fish movement.

**PUBLIC INTEREST STATEMENT**

Mulloway (*Argyrosomus japonicas*) are an iconic recreational fish species in southern Australia. This study tagged 24 mulloway within the Glenelg River estuary, southwestern Victoria, Australia, and tracked their movements for three years to determine where in the estuary they moved and when they moved into and out of the estuary. Over 90% of fish that exited the estuary, exited between the months of November and January; four fish that exited were subsequently detected > 450 kilometres away, at or near the Coorong (Murray River mouth, South Australia), a known breeding location. However, during the study thirteen (54%) of the tagged mulloway were caught and kept by anglers. Demonstrating the high intensity of angling pressure on mulloway in the Glenelg River estuary, revealing a serious risk of overfishing of juveniles and sub-adults in this estuarine habitat, which should prompt a review of legal size.
1. Introduction
Mulloway, *Argyrosomus japonicas* (Sciaenidae), are widely distributed in the Indian and Pacific Oceans, occurring in estuarine and nearshore areas (Silberschneider & Gray, 2008). Within Australia, it occurs from the Burnett River in Queensland (153°13′E, 25°20′S) south around the continent to north-west Cape in Western Australia (114°01′E, 21°53′S) (Kailola et al., 1993), with four distinct sub-populations (Barnes et al., 2016). Fish in the Glenelg River and western Victoria belong to the same south-east sub-population as the Murray River estuary sub-population (Barnes et al., 2016) which supports a major commercial industry (Ferguson, Ward, & Geddes, 2008).

The species breeds in oceanic waters throughout south-eastern Australia. Small larvae have been collected in estuarine and coastal waters between February and April (Gray & Miskiewicz, 2000; Silberschneider & Gray, 2008) and from the Murray River sub-population from October to February, peaking in December (Ferguson, Ward, Ivey, & Barnes, 2014). Juveniles use estuaries as nursery habitat (Griffiths, 1996; Silberschneider & Gray, 2008) with recruitment driven by years with higher spring flows (Ferguson et al., 2008). Adults are often found around mouths of estuaries, in surf zones and along rocky reefs in offshore waters (Silberschneider & Gray, 2008). Mulloway sub-populations have variable growth rates, and Ferguson et al. (2014) suggest that the south-east Australian sub-population has a low growth rate and a larger size at maturity compared to other sub-populations.

In Australia, mulloway supports an important recreational fishery; over 975 tonnes of this “icon species” were taken by recreational anglers in 2000 (Henry & Lyle, 2003; Taylor, Laffan, Stewart-Fielder, & Suthers, 2006). Recreational fishing pressure focuses on nearshore and estuarine areas that are important nursery areas (McPhee, Leadbitter, & Skilleter, 2002). Mulloway is also commercially important, with the largest Australian fishery based in the Murray River estuary and nearby coastal environment (Ferguson et al., 2008).

To better manage the fishery by understanding habitat preferences and movements of this heavily fished species in the Glenelg River estuary, the present study employed acoustic telemetry for three years to track tagged mulloway. Initially, the aims were to assess (1) habitat preferences within the estuary and (2) movement patterns between the estuary and open ocean.

2. Methods
This study was conducted in the estuarine section of the 400-km long Glenelg River in south-western Victoria, Australia (Figure 1). Under low flow conditions, the estuary extends over 70 km. Although shallow at its mouth, the estuary is around 8 m deep downstream, decreasing gradually to around 4 m at the upstream tidal limit (Nicholson, Jenkins, Sherwood, & Longmore, 2008). It can close seasonally under low flows, with the mouth occasionally artificially opened to alleviate flooding (Glenelg Hopkins Catchment Management Authority, 2006).

Twenty-four juvenile to sub-adult mulloway were captured and tagged between 23/10/2008 and 18/02/2009, and tracked for three years. Tagged fish had a mean (± SD) total length of 622 ± 8 mm, ranging from 501 to 781 mm (Table 1). Four fish were captured by angling, with the remaining fish captured by gill nets (25 m long, 2-m drop with a stretched mesh of 11.25, 12.5 or 15 cm). The gillnets were set in the late afternoon and monitored every 10–20 min so that fish could be removed quickly from the net to minimize capture injury and stress (cf. Sakabe & Lyle, 2010).
Acoustic tagging of fish followed Koster, Dawson, and Crook (2013). Anaesthetised fish were weighed (nearest g) and measured (total length, mm). Implantation of transmitters generally took 4–5 min and recovery to full consciousness was usually 5–8 min. The individually coded transmitters (V16-4x-069k-1, VEMCO) were 68 mm long, 16 mm wide, weighed 11 g in water, emitted a signal at a random pulse interval of 40 to 120 s, and had an expected battery life of 1000 d. An external dart tag (Hallprint) was also inserted into the muscle surrounding the dorsal fin spine. Information on the dart included an individual tag number, a phone number for reporting the capture of a tagged fish and offered a reward.

VEMCO Model VR2W acoustic receivers were used to monitor individual mulloway movements for up to three years. An array of 20 receivers was deployed throughout the estuary from within 1-km upstream of the estuary mouth to 65 km upstream (Figure 1). As the downstream 600–700 m of the estuary is often very shallow (<0.5 m), the lowest receiver in this study was placed upstream of this shallow water. Distances between receivers were 2–3.5 km, increasing to 7–8 km for the four most upstream receivers. The read-range of the test tags was greater than 400 m.

Daily discharge records were obtained from a gauging station at Dartmoor, just above the tidal limit (Figure 1). Daily observations of the condition of the estuary entrance (open or closed) were obtained from the Glenelg Hopkins Catchment Management Authority. Water temperatures and electrical conductivity were measured using data recorders (Odyssey salinity/Temperature Data Recorders) at every receiver.

To assess relationships of mulloway movement and habitat preferences with different environmental factors (e.g. entrance condition, flows, salinities) in the estuary, Generalised Linear Mixed Models (GLMMs) were intended to be used. However, it soon became clear that the reduced sample sizes caused by heavy angling pressure severely weakened the power of the planned analysis. Therefore, nonparametric analyses (Wilcoxon rank-sum and Kolmogorov-Smirnov tests) had to be
used to determine whether environmental variables differed between days when fish moved or did not.

3. Results and discussion

3.1. Mulloway movement and habitat preferences

During this three-year study, there were only 13 acoustically tagged fish in the system with >100 days’ data on movement (Table 1) because heavy angling pressure halved the original sample size (see Angling pressure). The available data indicate that mulloway in the Glenelg River estuary spent more time near the mouth than in upstream habitats, although movements of fish were detected up to 58 km upstream (Figure 2). These upstream movements were recorded in December 2008 to May 2009, coinciding with low freshwater inflows and peak salinities (Figure 3).

Thirteen mulloway exited the Glenelg River (Figure 4), with almost 90% of exits between November and January. On the days when these fish left the estuary, discharge was significantly higher (Wilcoxon rank-sum test, P = 0.041). Seven of the 13 fish that exited the estuary re-entered between four and 18 months later. Mulloway did not re-enter the estuary at a consistent time of the year, although five of the seven fish re-entered between June and October (austral winter/spring). One mulloway made multiple exits and entries, leaving four times between August and December and entering twice in May and once each in October and December. This included entering and leaving on the same day on one occasion. As the lowest receiver was not placed at the extreme mouth of the river, other mulloway may have exited and re-entered the estuary within a day without being detected, and daily entry/exits have been recorded in South Africa (Naesje et al., 2012). Four fish that exited the system were detected at the Murray River estuary >450 km away (Figure 1), and exited at similar times of the year (December 2008, November 2009, November 2010 and December 2010). One of these fish was captured by an angler on the beach adjacent to the Murray River estuary, while two returned to the Glenelg River estuary in June or July the year after exiting.

Based on growth rates presented in Ferguson et al. (2014), the predicted sizes of these fishes when they exited the Glenelg River estuary (712, 787, 839 and 900 mm) and predicted sizes at the Murray River estuary (731, 906, 1013 and 1050 mm) match those of mature or near-mature fish. It has been proposed that the ocean near the Murray River estuary is a mulloway breeding area (Ferguson et al., 2008). The results indicate these four fish may have migrated from the Glenelg River estuary to the area around the Murray River estuary for breeding. Furthermore, the timing of detection in the Murray River estuary coincides with the breeding period of spring-summer for this sub-population.

3.2. Angling pressure

During this three-year study, 13 of the 24 tagged mulloway were confirmed as caught and kept by recreational anglers, with recreational anglers phoning in and reporting the fish as captured and kept; another individual fish was phoned in and reported as captured and released. An additional fish went missing between arrays, and it is highly likely this fish was also angled but not reported, as the tag was constantly detected later the same day at a receiver opposite a boat ramp. All fish captured and kept by anglers were caught during the warmer months (7 November to 2 April). Ten fish did not leave the estuary before being captured and kept by recreational anglers (Figure 4), with four of these fishes captured within 100 days of tagging (Figure 5). Recreational anglers captured three fish that left the estuary; one on an ocean beach near the Murray River estuary and two (94 and 167 days) upon returning to the Glenelg River estuary. This intense angling pressure and retention of captured tagged fish highlight the major impact that recreational angling had on the original sample size in this study, severely limiting the intended analyses of movements and habitat preferences of this target species. However, it did allow some assessment of the size of the fish being angled in the Glenelg River estuary.
Table 1. Summary data for acoustically tagged mulloway

| Fish Number | Length | Weight | Date tagged | Date captured by recreational angler | Last date detected | No of days detected | Total period tracked | Exit Date | Re-entry Date |
|-------------|--------|--------|-------------|--------------------------------------|--------------------|---------------------|---------------------|-----------|---------------|
| 1           | 515    | 1540   | 23/10/2008  | 18/01/2009 ²                        | 14/12/2009         | 392                 | 418                 | 4/11/2009 | 27/03/2010    |
| 2           | 704    | 3298   | 25/10/2008  | 2/04/2010 ³                        | 15/12/2010         | 601                 | 782                 | 5/01/2009 | 2/04/2010     |
| 3           | 501    | 1312   | 28/10/2008  | 2/04/2010 ³                        | 2/04/2010 ³        | 5/01/2009           | 69                  | 70        |               |
| 4           | 610    | 1960   | 28/10/2008  | 2/04/2010 ³                        | 27/12/2009         | 27/12/2009          | 163                 | 426       | 7/01/2009     | 24/09/2009 |
| 5           | 543    | 1576   | 28/10/2008  | 2/04/2010 ³                        | 7/11/2009          | 6/11/2009           | 363                 | 375       |               |
| 6           | 594    | 1988   | 28/10/2008  | 2/04/2010 ³                        | 9/03/2009          | 8/03/2009           | 126                 | 132       |               |
| 7           | 617    | 2238   | 29/10/2008  | 2/04/2010 ³                        | 8/12/2010          | 483                 | 771                 | 30/12/2009 | 7/10/2010    |
| 8           | 664    | 2626   | 29/10/2008  | 2/04/2010 ³                        | 12/01/2009         | 12/01/2009          | 74                  | 76        |               |
| 9           | 557    | 1736   | 29/10/2008  | 2/04/2010 ³                        | 19/09/2011         | 740                 | 1056                | 25/11/2010 |               |
|             |        |        |             |                                      | (Murray River estuary 24/05/2011) |                   |                     |           | 30/07/2011    |
| 10          | 589    | 2000   | 11/12/2008  | 2/04/2010 ³                        | 17/10/2011         | 534                 | 1041                | 5/11/2009 |               |
|             |        |        |             |                                      | (Murray River estuary 29–31/12/2009, 18/10/2011) |                   |                     |           | 18/06/2010    |
| 11          | 612    | 2086   | 11/12/2008  | 2/04/2010 ³                        | 26/03/2010         | 26/03/2010          | 337                 | 471       |               |
| 12          | 781    | 4770   | 11/12/2008  | 2/04/2010 ³                        | 3/12/2010 ³        | 28/12/2008          | 15                  | 18        | 28/12/2008    |
|             |        |        |             |                                      | (Murray River estuary 3/12/2010) |                   |                     |           |               |
| 13          | 598    | 1782   | 11/12/2008  | 2/04/2010 ³                        | 18/11/2009         | 18/11/2009          | 185                 | 343       | 8/01/2009     | 4/06/2009 |
| 14          | 640    | 2332   | 12/12/2008  | 2/04/2010 ³                        | 21/02/2009         | 21/02/2009          | 36                  | 72        | 21/02/2009    |
| 15          | 658    | 2320   | 12/12/2008  | 2/04/2010 ³                        | 15/02/2009         | 14/02/2009          | 61                  | 65        |               |
| 16          | 706    | 3020   | 15/12/2008  | 2/04/2010 ³                        | 27/12/2009         | 26/12/2009          | 76                  | 377       |               |

(Continued)
| Fish Number | Length | Weight | Date tagged | Date captured by recreational angler | Last date detected | No of days detected | Total period tracked | Exit Date | Re-entry Date | Date tagged | Date captured by recreational angler | Last date detected | No of days detected | Total period tracked |
|-------------|--------|--------|-------------|-------------------------------------|--------------------|--------------------|---------------------|-----------|--------------|-------------|-------------------------------------|--------------------|--------------------|---------------------|
| 17          | 585    | 1970   | 15/12/2008  | 27/10/2011                          |                    | 32                 | 1047                | 18/12/2008| 18/12/2008   | 27/10/2011 | 18/12/2008                          |                    |                    | 1047                |
| 18          | 556    | 1570   | 15/12/2008  | 18/12/2008                          | 16/12/2008         | 4                  | 2                   | 18/12/2008| 18/12/2008   | 3           | 18/12/2008                          |                    |                    | 3                   |
| 19          | 655    | 2265   | 15/12/2008  | 18/12/2008                          | 16/12/2008         | 4                  | 2                   | 18/12/2008| 18/12/2008   | 41          | 18/12/2008                          |                    |                    | 41                  |
| 20          | 583    | 1916   | 15/12/2008  | 18/12/2008                          | 17/12/2008         | 3                  | 3                   | 18/12/2008| 18/12/2008   | 603         | 18/12/2008                          |                    |                    | 603                 |
| 21          | 656    | 2644   | 15/12/2008  | 18/12/2008                          | 17/12/2008         | 3                  | 3                   | 18/12/2008| 18/12/2008   | 603         | 18/12/2008                          |                    |                    | 603                 |
| 22          | 653    | 2510   | 17/02/2009  | 17/02/2009                          | 17/02/2009         | 38                 | 41                  | 17/12/2010| 17/12/2010   | 603         | 17/12/2010                          |                    |                    | 603                 |
| 23          | 723    | 3254   | 17/02/2009  | 17/02/2009                          | 17/02/2009         | 283                | 283                 | 17/12/2009| 17/12/2009   | 283         | 17/12/2009                          |                    |                    | 283                 |
| 24          | 628    | 2136   | 18/02/2009  | 18/02/2009                          | 18/02/2009         | 220                | 220                 | 12/10/2009| 12/10/2009   | 220         | 12/10/2009                          |                    |                    | 220                 |

- Released transmitter stopped working on 5/01/2009; fish recaptured by a recreational angler on 2/04/2010
- Recaptured by a recreational angler outside of the Glenelg estuary
- Not used in the estuarine analysis

Lieschke, Cogent Environmental Science (2019), 5: 1602101
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3.3. Size of fish angled

Based on the growth rates determined by angler-capture lengths compared to lengths at tagging, an estimated growth rate of 11 cm/year was calculated. This is similar to the rate (13.6 cm/year) documented for the Murray River sub-population by Ferguson et al. (2014). There was a propensity for anglers to catch immature mulloway in the 63 to 75-cm range (Figure 6). As the legal size for mulloway is 60 cm in Victoria, the data show that in the Glenelg River estuary, the species is likely to be caught within one year of reaching legal length. Mulloway from the Murray River sub-population reaches maturity at 85 cm for females and
78 cm for males (Ferguson et al., 2014), implying that they are being captured and removed from the population before reaching maturity.

Over 80% of the commercial catch of mulloway in South Australia is taken from the Murray River estuary, with most of these being juvenile or sub-adult fish. The potential impacts of recreational fishing on fish stocks can be great, even rivalling that of commercial fisheries (Cooke & Cowx, 2006). In the Clarence River estuary, New South Wales, recreational catch of mulloway equalled the commercial catch (West & Gordon, 1994), and 78% of mulloway caught in the Clarence River by anglers were below the minimum size (45 cm at the time, with this sub-population maturing at around 50 cm). Mulloway are overfished in New South Wales for females that are immature (Silberschneider, Gray, & Stewart, 2009), and the species is also overfished in South Africa (Griffiths, 1997) and other parts of eastern Australia (Silberschneider et al., 2009). Data from the present study indicate that in the Glenelg River estuary, there is an age- or size-dependency for mulloway to be captured by anglers. This population is also vulnerable to fishing as juveniles in estuarine habitats and as adults in spawning aggregations around the Murray River estuary (Ferguson et al., 2014). A review of the effects of overfishing juveniles in conjunction with reassessing the legal size of mulloway within Victoria is recommended.

3.4. Conclusions and implications
Despite the truncated sample size, the acoustic telemetry study revealed that mulloway in the Glenelg River estuary shows a habitat preference for the downstream end of the estuary, seldom moving further than 50 km upstream except during low flows. Continuity of the sub-population in this estuary with that in the Murray River estuary appears to be maintained by
movements from the Glenelg River estuary to the breeding area in the ocean near the Murray River estuary.

This study also demonstrates the high intensity of angling pressure on mulloway in the Glenelg River estuary, revealing a serious risk of overfishing as juveniles and sub-adults in this estuarine habitat which should prompt a review of legal size. So intense was the angling pressure that over 50% of the tagged fish were captured by recreational anglers. This reduction in sample size severely limited the intended analyses of movement and habitat preference of these species. Although tagged fish have been captured in other telemetry studies, this appears to be the first time it has been documented that anglers capturing and keeping acoustically tagged fish can severely impact the intended analyses. This cautionary tale exemplifies the challenges of telemetric studies of intensively angled fishes in estuaries and other semi-enclosed waters. A key recommendation is that practitioners should inflate their sample size in heavily fished waters to compensate for the impact of angling.

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References
Barnes, T. C., Junge, C., Myers, S. A., Taylor, M. D., Rogers, P. J., Ferguson, G. J., ... Gillanders, B. M. (2016). Population structure in a wide-ranging coastal teleost (Argyrosomus japonicus, Sciaenidae) reflects marine biogeography across southern Australia. Marine and Freshwater Research, 67, 1103–1113. doi:10.1071/MF15044
Cooke, S. J., & Cowx, I. G. (2006). Contrasting recreational and commercial fishing: Searching for common issues to promote unified conservation of fisheries resources and aquatic environments. Biological Conservation, 128, 93–108. doi:10.1016/j.biocon.2005.09.019
Ferguson, G. J., Ward, T. M., & Geddes, M. C. (2006). Do recent age structures and historical catches of mulloway, Argyrosomus japonicas (Sciaenidae), reflect freshwater inflows in the remnant estuary of the Murray River, South Australia? Aquatic Living Resources, 21, 145–152. doi:10.1051/alr:2008034
Ferguson, G. J., Ward, T. M., Ivey, A., & Barnes, T. (2014). Life history of Argyrosomus japonicus, a large sciaenid at the southern port of its global distribution: Implications for fisheries management. Fisheries Research, 151, 148–157. doi:10.1016/j.fishres.2013.11.002
Glenelg Hopkins Catchment Management Authority. (2006). Glenelg estuary management plan. Glenelg Hopkins Catchment Management Authority, Hamilton, Victoria, Australia. ISBN 07594 10070.
Gray, C. A., & Miskiewicz, A. G. (2000). Larval fish assemblages in south-east Australian coastal waters: Seasonal and spatial structure. Estuarine, Coastal and Shelf Science, 50, 549–570. doi:10.1016/ecs.1999.0595
Griffiths, M. H. (1996). Life history of dusky cob Argyrosomus japonicus (Sciaenidae) off the east coast of South Africa. South African Journal of Marine Science, 17, 135–154. doi:10.1071/PC020040
Griffiths, M. H. (1997). Management of the South African dusky cob Argyrosomus japonicus (Sciaenidae) based on per-recruit models. South African Journal of Marine Science, 18, 223–228. doi:10.1071/MS970223
Henry, G. W., & Lyle, J. M. (2003). The national recreational and indigenous fishing survey. Canberra: Australian Government Department of Agriculture, Fisheries and Forestry.
Kailolo, P. J., Williams, M. J., Stewart, R. C., Reichelt, R. E., McNee, A., & Grieve, C. (1999). Australian Fisheries Resources. Canberra: Australian Bureau of Resource Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation.
Koster, W. M., Dawson, D. R., & Crook, D. A. (2013). Downstream spawning migration by the amphidromous Australian greyling (Prototroctes maraena) in a coastal river in south-eastern Australia. Marine and Freshwater Research, 64, 31–41. doi:10.1071/MF12119
McPhee, D. P., Leadbitter, D., & Skilliter, G. A. (2002). Swallowing the bait: Is recreational fishing in Australia ecologically sustainable. Pacific Conservation Biology, 8, 40–51. doi:10.1071/PC020040
Naessje, T. F., Cowley, P. D., Diserud, O. H., Childs, A. R., Kerwath, S. E., & Thorstad, E. B. (2012). Riding the tide: Estuarine movements of a sciaenid fish. Argyrosomus japonicus. Marine Ecology Progress Series, 460, 221–232. doi:10.3354/meps09780
Nicholson, G., Jenkins, G. P., Sherwood, J., & Longmore, A. (2008). Physical environmental conditions, spawning and early-life stages of an estuarine fish: Climate change implications for recruitment in intermittently open estuaries. Marine and Freshwater Research, 59, 735–749. doi:10.1071/MF07197

Sakabe, R., & Lyle, J. M. (2010). The influence of tidal cycles and freshwater inflow on the distribution and movement of an estuarine resident fish Acanthopagrus butcheri. Journal of Fish Biology, 77, 643–660. doi:10.1111/j.1095-8649.2010.02821.x

Silberschneider, V., & Gray, C. A. (2008). Synopsis of biological, fisheries and aquaculture–Related information on mulloway Argyrosomus japonicas (Pisces: Sciaenidae), with particular reference to Australia. Journal of Applied Ichthyology, 24, 7–17.

Silberschneider, V., Gray, C. A., & Stewart, J. (2009). Age, growth, maturity and the overfishing of the iconic sciaenid, Argyrosomus japonicas, in south-eastern, Australia. Fisheries Research, 95, 220–229. doi:10.1016/j.fishres.2008.09.002

Taylor, M. D., Laffan, S. D., Stewart-Fielder, D., & Suthers, I. M. (2006). Key habitat and home range of mulloway Argyrosomus japonicas in a south-east Australian estuary: Finding the estuarine niche to optimise stocking. Marine Ecology Progress Series, 328, 237–247. doi:10.3354/meps328237

West, R. J., & Gordon, G. N. G. (1994). Commercial and recreational harvest from two Australian coastal rivers. Australian Journal of Marine and Freshwater Research, 45, 1259–1279. doi:10.1071/MF9941259