Inland Fisheries Service

Arthur River Estuary Perch Population Assessment

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Introduction

Estuary perch (*Percalates colonorum*) (EP) are native to Southeastern Australia and range from the Richmond River in New South Wales, through to the Murray River in South Australia (McDowall 1980). They were originally established in both the Ansons and Arthur rivers in Tasmania (McDowall 1980; Fulton 1990), however since the 1980's there has been no credible evidence that the Ansons River population is extant (McCarraher and McKenzie 1986). Anecdotal accounts suggest they also inhabited several river systems along the North Coast of Tasmania, but no definitive identification was obtained prior to their apparent disappearance from these systems. As a result, the last known remaining population of estuary perch in Tasmania inhabits the Arthur River on the Northwest Coast (DPIPWE 2014; Van Wyk 2015).

On mainland Australia, EP are a popular angling species and are known for their strong fighting and eating qualities, and their ability to take a range of baits and lures (McDowall 1980; Walsh et al. 2011; Hunt and Ingram 2014). Their popularity as a quality sports fish in Victoria has resulted in a successful stock enhancement program as a way of conserving existing populations and diversifying recreational fishing opportunities.

EP are a catadromous species, form spawning aggregations in lower estuarine waters between late winter and early summer. After spawning, individuals disperse throughout the estuary and may migrate upstream to inhabit the freshwater reaches of the system (McCarraher and McKenzie 1986; Van Wyk 2015). Their eggs are round (1.3-2.4 mm in diameter), non-adhesive, and semi buoyant, and hatch in 2-3 days as larval fish (approximately 2.2 mm long) (Lintermans 2023). EP are highly fecund with egg production increasing with length (Lintermans 2023). Studies on mainland populations have shown a 340 mm female can produce 182,000 eggs, and one measuring 400 mm can have 540,000 eggs (Lintermans 2023).

While adult EP usually spawn annually, juvenile recruitment is highly variable due to environmental influences on the survival and retention of eggs and larvae within the estuarine system. This often results in variable population structures displaying missing, weak or strong cohorts (Walsh et al. 2010; Van Wyk 2015). Due to these population characteristics, if an adult spawning stock size becomes low, there is a risk of insufficient egg production and poor genetic diversification impacting the population's ability to remain self-sustaining. However, as EP are long lived and slow growing (maximum age recorded to be 41 years old), most populations can withstand long periods of recruitment failure, as the strong cohorts are able to replenish the population when recruitment conditions are suitable (Long hurst 2002; Walsh et al. 2010; Van Wyk 2015).

In the last ten years, there have been two surveys in the Arthur River, which highlights that not only are estuary perch present (DPIPWE 2014), but they are reproductively active and self-sustaining (Van Wyk 2015). However, Van Wyk (2015) estimated the spawning adult population size was small (825 to 2,375) and displayed highly variable recruitment. Further genetic work has indicated the population exhibits extremely low genetic diversity (Stoessel et al. 2020). Moreover, due to its geographical isolation from mainland EP stocks, the Arthur River population is genetically distinct (Stoessel et al. 2020).

Another concern highlighted by Van Wyk (2015) was the population structure is dominated (68 per cent) by three age classes, estimated to be between 12 to 14 years old. The remaining survivors of these fish, in 2024, would now be 21 to 23 years of age and it is currently unknown if this population has had successful recruitment events since the 2015 survey.

Taking these population characteristics into account, the species was listed as a "Protected Fish", under Section 131 of the *Inland Fisheries Act 1995* in 2019. Due to the need for ongoing population monitoring, conservation and potential rehabilitation efforts, this survey resurveyed the Arthur River population to assess the current stock structure and to help inform future management strategies for the species.

The objectives of the survey were to:

- Characterise the current stock structure of EP in the Arthur River (using length and age)
- Determine and validate the recruitment year of dominant cohorts by way of otolith analysis.
- Investigate what environmental conditions may be driving recruitment events.
- Provide further management options on the rehabilitation of the Arthur River EP population and the potential to re-establish other populations in Tasmania.

Methods

Survey Design

During 11 – 15 December 2023, two box traps, six small fyke nets (mixture of fine and coarse mesh), three 35 m and two 92 m trammel gill nets (4 inch' inner mesh and 24 inch' outer mesh), one 100 m 3 inch multi-monofilament gill net, one 50 m 2.5 inch monofilament gill net, and two rods and reels were used to survey the Arthur River for estuary perch (304141E, 5453165N). The date of the survey was chosen to replicate and supplement data collected by Van Wyk (2015) where EP reproductive activity was highest.

A 5.8 m side console catamaran was used to set gear throughout a 2.3 km stretch of lower estuarine section of the Arthur River (Figure 1). Box traps were set during the day for soak times of 0.7 to 7 hours, either parallel to the shore due to steep banks or set across the mouths of creeks. Small fyke nets were set overnight along the edges of the shoreline amongst macrophyte and structure (Figure 2). The box traps and small fyke nets were used to specifically target juvenile and young of the year EP. Gill nets were mostly set parallel to the shore ensuring both ends of the net came up onto the shore. Rocky shorelines, sunken logs and areas of structure were targeted. Shorelines fringed with reeds were also targeted (Figure 2). At times, gill nets were set across the width of the river, in the deeper sections.

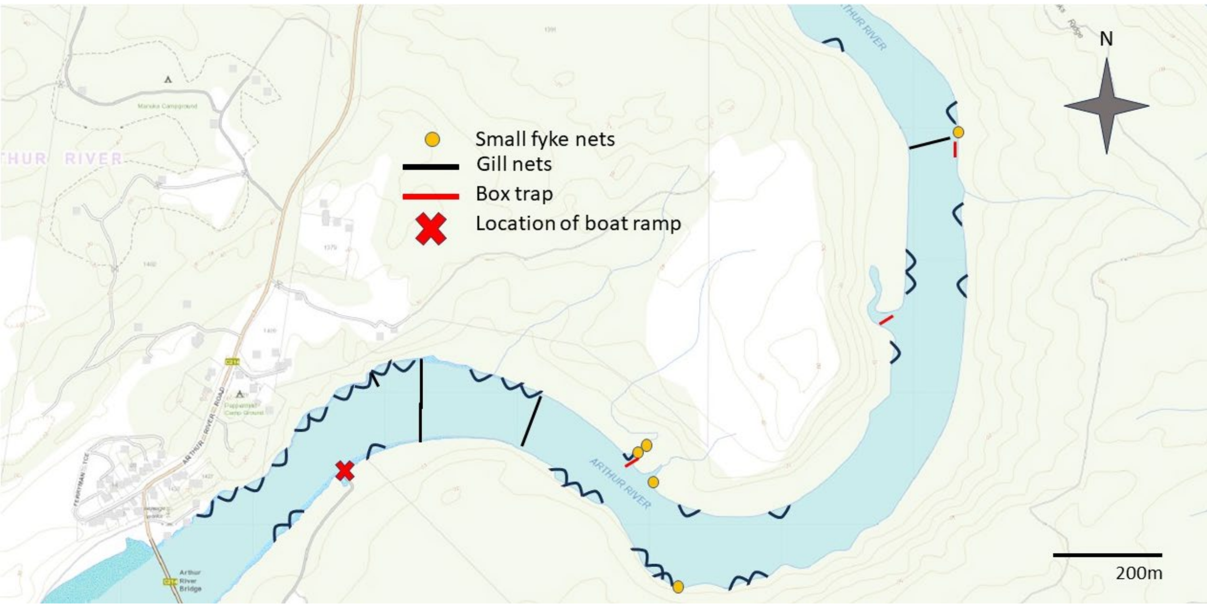

Figure 1. Map of Arthur River showing small fyke net, gill net and box trap sets.

Figure 2. Small fyke nets set amongst aquatic vegetation to target young of the year estuary perch (left), and typical shoreline where gill nets were set (right).

For daytime gill netting (11:00 – 16:00), 92 – 100 m gill nets were used with soak times between 1 – 2.5 hours. To avoid excessive catch rates associated with increased EP movement during the evening (18:00 – 21:00), the shorter 35 m trammel gill nets were used, with soak times between 20 to 30 minutes.

Rod and line fishing was undertaken opportunistically in the general area where fish were caught in the gill nets. Fishing consisted of casting soft plastic lures while drifting along a shoreline.

Gill net effort was standardised to 100 m net hours, which is equivalent to one 100 m net set for one hour. Box and fyke nets were standardised to net hours, which considers the number of individual nets set and the soak time. Rod and reel fishing effort was recorded as the numbers of hours spent fishing.

Catch and release process

Prior to retrieving set gillnets, a flow-through holding tank (250 L) continuously pumping fresh river water through a spray bar was filled and switched on at the stern of the boat. Captured fish were cut out of the mesh using knives and scissors. They were then placed into the holding tank until all fish had been removed from the net, then the fish were processed. Non target bycatch species were also carefully removed, identified and released. This project aimed to catch and tag up to 200 individuals, however, due to a higher than expected catch rate, not all individuals captured were tagged due to logistical and animal welfare constraints. At capture, all EP had their fork length (±1 mm) and where possible sex and reproductive maturity recorded. Sex and reproductive maturity were assigned by inspecting the urogenital opening structures near the anus (Van Wyk 2015) (Figure 3). External sex determination was validated by internal examinations of the retained fish, with a 100 per cent accuracy. If selected for tagging, individuals were tagged with two t-bar tags at the base of the anterior dorsal fin (Figure 4).

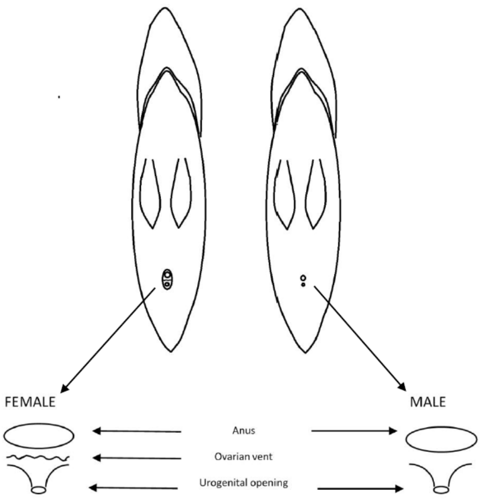

Figure 3. Diagrammatic representation of the external structure of the urogenital opening, comparing female and male estuary perch (Van Wyk 2015).

Figure 4. A double tagged estuary perch being released.

Retained fish process

EP retained for aging (n=31) were selected across the size ranges encountered. Due to the protected status and estimated small population size, terminal sampling was restricted to taking six to eight individuals from preset size classes. The size classes were: fish with a fork length less than 230 mm (n=6), fish between 231 to 260 mm (n=6), 261 to 290 mm (n=8), 291 to 330 mm (n=3), 331 to 360 mm (n=3), and fish over 361 mm (n=3). Fish were euthanised using a bath containing clove oil (2ml per 30 litres) and placed in an ice slurry, before being frozen for later processing. In the laboratory, retained fish were thawed, had their total weight (g), fork length (FL mm), sex, gonad weight (GW g), macroscopic reproductive stage (Table 1), stomach contents recorded, and sagittal otoliths taken. Gonadosomatic Indices (GSI) were calculated as follows; GSI = (Gonad weight/total weight) x 100. Stomach contents were identified and counted to the lowest taxonomic classification possible.

Table 1: Macroscopic characteristics for staging the maturity of male and female fish (Van Wyk 2015, adapted from Walsh et. al. 2011).

Males	
Stages	**Macroscopic characteristics**
1. Indeterminate	Small, moderately translucent to pink, determination of sex is difficult.
2. Developing	Much larger than stage 1, colourless to white, transverse sections triangular.
3. Mature	Testes larger in diameter, white in colour, slightly vascularized.
4. Ripe	Swollen, soft and white testes. Milt flows from the urogenital pore.
5. Spent	Rubbery, reduced in size, bloodshot and grey in appearance.
Females	
Stages	**Macroscopic characteristics**
1. Indeterminate	Small, moderately translucent to pink, determination of sex is difficult.
2. Developing	Much larger than stage 1, colourless to cream with fine granular texture. Slightly vascularized
3. Mature	Ovaries larger in diameter, yellow in colour with extensive vascularization. Oocytes visible, mature
4. Ripe	Hydrated translucent oocytes visible through ovary wall, yellow to amber in colour, gonads take up three quarters of body cavity
5. Ovulation	Oocytes extruded from the genital papilla with gentle gravitational pressure
6. Spent	Ovaries reduced in length, leathery, bloodshot towards posterior end.

Pairs of sagittal otoliths were removed, cleaned, and stored to dry for later age determination. Otoliths were embedded in epoxy resin and transversely sectioned (250 – 300 μm) using a Buehler IsoMet low speed saw. Sections were mounted on glass slides and viewed using transmitted light on an Olympus BX51 compound microscope fitted with an Olympus DP70 camera. Microphotographs of each otolith section were taken and counts of opaque zones were made on the dorsal side of the otolith (Figure 5). Otoliths were read once by one reader, by counting the number of opaque zones and classifying the otolith margin as opaque, narrow or wide. As the sample dates coincided with the increment formation period, count data was adjusted by 1+ when an individual possessed wide or opaque margins.

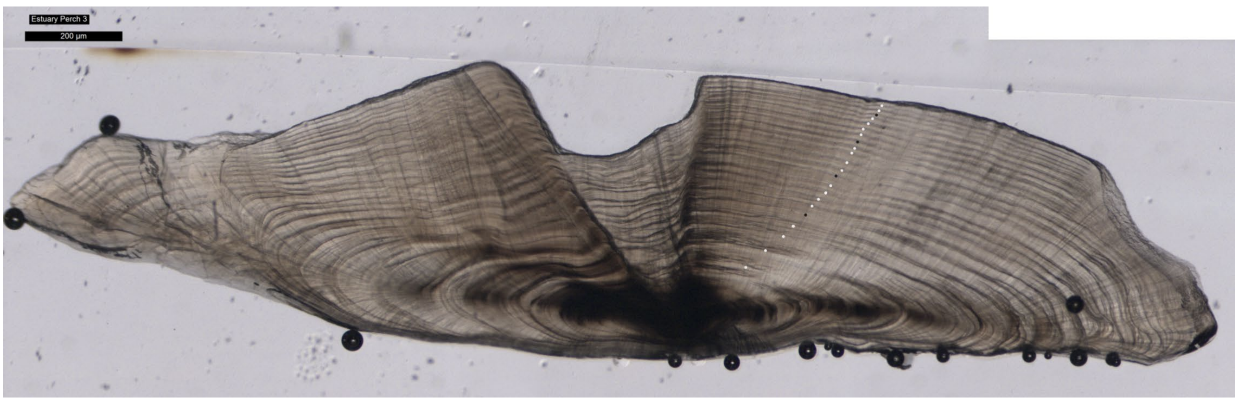

Figure 5. An image of a sectioned otolith of a 23 year old estuary perch from the Arthur River (opaque zone counts are marked with a white circle, with every fifth zone marked with a black circle.

Data analysis

Chi square tests were performed to assess if sex ratios for the entire survey or within gill net sets, where greater than 10 individuals were caught, were different from an expected 1:1 male/female ratio. Biological and tag recapture data from Van Wyk (2015) was collated with the current 2023 survey and used to generate a length weight relationship, sex specific growth curves and comparison of age structure between studies. Growth was determined by fitting sex specific size at age data to the Von Bertalanffy Growth model; where $L_t = L_\infty$ [1-e-K(t-t_0)], where L_t is the fork length at age t, L_∞ is the asymptotic fork length, k is the growth rate and t_0 is the theoretical age at zero length. Individual growth trajectories from recapture data were generated by using the initial size at capture to estimate the age at tagging using the sex specific transformed Von Bertalanffy growth model. Age at recapture was determined by adding the at liberty period to the initial age estimate.

Results

Catch effort

In total, 378 EP were captured over five days of sampling. Of all gear types, trammel gill nets captured the most EP with 311 fish, followed by the 2.5 inch monofilament gill net capturing 60 fish (Figure 6). Trammel gill nets also captured two gummy sharks (*Mustelus antarcticus*), one greenback flounder (*Rhombosolea tapirina*), one Australian salmon (*Arripis trutta*) and one southern rock cod (*Pseudophycis barbata*).

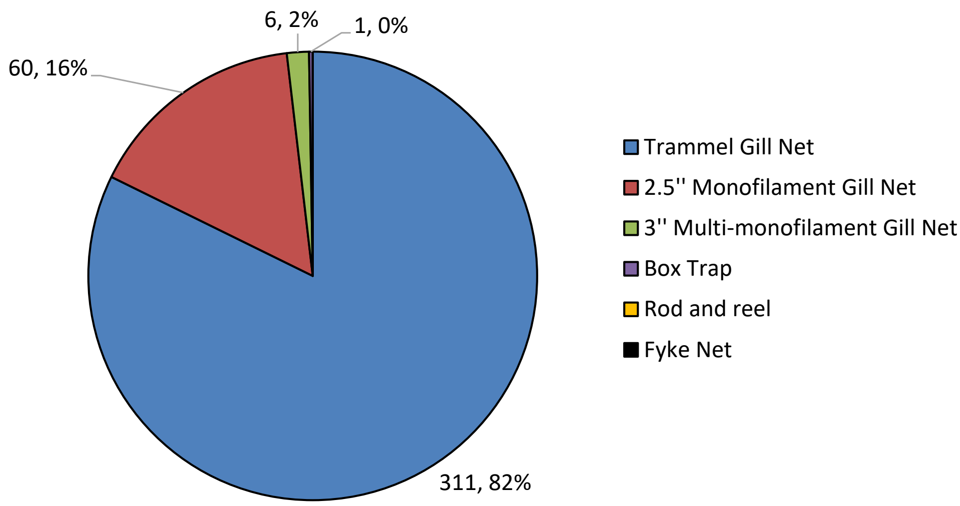

Figure 6. The number and per centage of estuary perch caught by each gear type, Arthur River, Tasmania.

The 3 inch multi-monofilament gill net and box trap caught comparatively fewer EP, with six and one fish respectively (Figure 6). Two yellow eye mullet (*Aldrichetta forsteri*) and one silver trevally (*Pseudocaranx dentex*) were also caught in the 3 inch multi-monofilament gill net, while a southern rock cod was caught in 2.5 inch monofilament gill net. Trammel gill nets were used most extensively given their ability to catch a broader size range, while the smaller meshed gill nets were used less to target smaller size classes <220 mm (Table 2). Box traps resulted in the capture of one adult EP, two greenback flounder, one Australian salmon, one sandy (*Pseudaphritis urvilli*) and numerous crabs (European green crab (*Carcinus maenas*) and a pill box crab (*Halicarcinus* spp.). No EP (young of the year or adults) were caught in the small fyke nets, however 22 short fin eels (*Anguilla australis*), six sandies, eight common galaxias (*Galaxias maculatus*) and a European green crab were captured. Rod and reel fishing was undertaken opportunistically during gill net soak times; however, no EP (or any other species of fish) were caught (Table 2).

Table 2. Fishing effort for each gear type and the number of estuary perch captured.

Technique	Effort (hrs)	Unit of effort	No. of Estuary Perch
Trammel Gill Net	20	100 m net hours	314
2.5'' Monofilament Gill Net	6	100 m net hours	60
3'' Multi-monofilament Gill Net	7	100 m net hours	6
Box Trap	39	Trap net hours	1
Fyke Net	235	Fyke net hours	0
Rod and reel	3.5	Rod hours	0

Trammel gill nets caught a broad size range of EP from 212 mm to 470 mm (Figure 7). The 2.5 inch monofilament gill net selected for smaller fish with most ranging from 199 mm to 268 mm, with some larger fish caught in the 274 mm to 346 mm range (Figure 7). The 3 inch multi-monofilament gill net caught a small number of fish ranging from 255 mm to 395 mm (Figure 7).

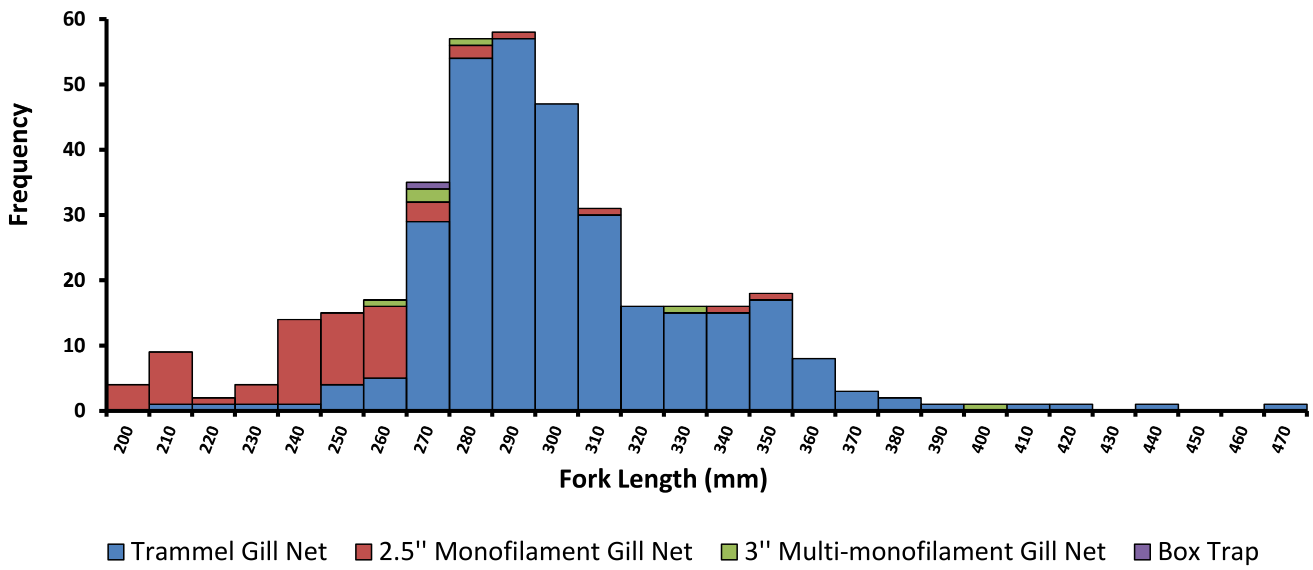

Figure 7. Length frequency distribution of all estuary perch caught in the Arthur River, Tasmania, separated by gear types (N= 378).

The number of EP caught during the day was markedly less compared to evening captures, despite higher fishing effort during daylight hours (Table 3). A total of 109 EP were caught during day sets, compared to 271 for evening sets. Nine of the day sets (45 per cent) failed to catch any EP, whereas only one night set (5 per cent) failed to catch an EP. The catch of 70 fish during the day on the fifth day of the trip was significantly higher than the other day catches, due to the capture of 63 fish in a single gill net set. This was the most fish caught in a single net in both day and evening sets. Day five also had the most fish captured in an evening at 76 fish, which resulted in the largest total daily catch of the trip of 146 fish. The highest CPUE for the trip was achieved on the first evening of sampling, with an average of 99.5 EP per 100 m net hour. The CPUE was significantly less during the day than sampling during the evening. The average daytime CPUE was 3.1 EP per 100 m net hour, compared to an evening CPUE, of 39.7 EP per 100 m net hour.

Table 3. Comparisons of gillnet catch, effort, and catch per unit (CPUE) of estuary perch in the Arthur River, between day and evening sampling sets.

	Fish numbers		Number of sets		Total soak time (hrs)		Total length of net soaked (m)		Standarised 100 M/ hr		Mean CPUE *	
Day no	**Day**	**Evening**	**Day**	**Evening**	**Day**	**Evening**	**Day**	**Evening**	**Day**	**Evening**	**Day**	**Evening**
1	-	57		2		1.5		70		0.5		99.5
2	9	38	6	5	5.8	3.5	297	175	3.2	1.2	2.6	24.0
3	14	30	5	3	8.1	2.4	426	90	6.7	0.7	1.7	36.9
4	16	70	6	4	13.8	2.6	484	170	11.1	1.1	1.2	52.6
5	70	76	3	8	6.0	6.9	276	280	5.5	2.4	10.6	29.4
Trip totals	**109**	**271**	**20**	**22**	**33.7**	**16.8**	**1483**	**785**	**26.5**	**6.0**	**3.1**	**39.7**

Note: Gill net effort consists of trammel gill nets, 2.5'' monofilament gill net, and 3'' multi-monofilament gill net. Day sets classed as nets set from 11:00 to 16:00, evenings sets classed as nets set from 18:00 to 21:00. A dash represents no netting undertaken. * indicates a significant difference in CPUE.

Of the 42 gillnet sets retrieved, 12 sets had catches greater than 10, which allowed further investigations into sex specific schooling behaviour. Two of these schooling capture events occurred during the day with the remainer occurring in the evening. Chi square tests on the sex ratio of these catches indicated several significantly different results with five schools being significantly male dominated, four significantly female dominated, and three having a relatively even split of sex, with no significant difference in sex ratio (Figure 8).

Overall, there were 166 females and 212 males caught with no detectable difference in a 1:1 sex ratio from the total catch (p=0.224) (Figure 8).

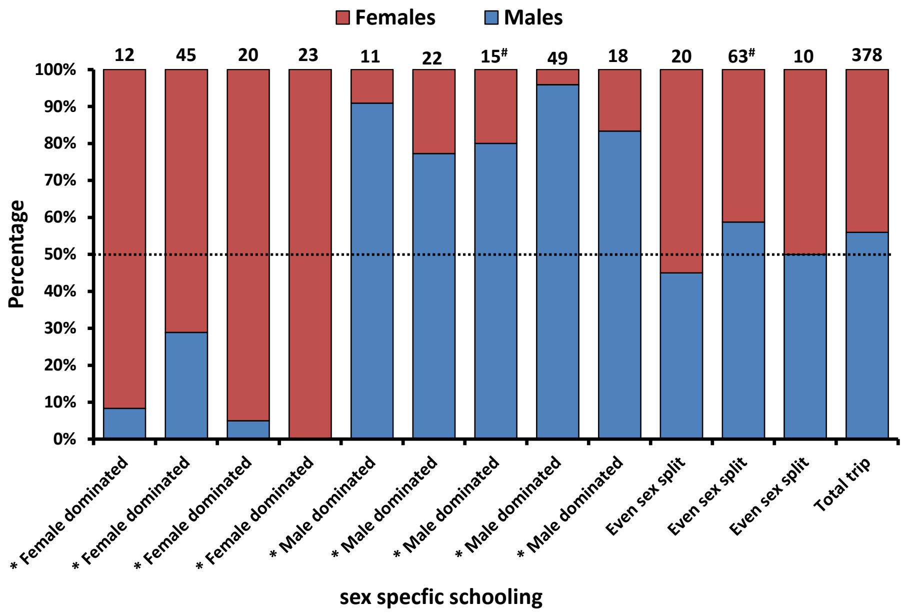

Figure 8. Comparison of estuary perch sex ratios for the 2023 survey in gill net sets, where greater than 10 individuals were caught in a set. The dotted line indicates the 50:50 split. # indicates daytime sets. * indicates significant deviation (Chi square test, p<0.05) from a 50:50 ratio. The number of estuary perch caught per schooling event are listed on top of each bar.

Biological information

Of the 381 EP caught, 31 fish were retained for age analysis with two retained as whole specimens for the CSIRO National Fish Collection, and 191 were tagged and released. Eight fish were tag recaptures from Van Wyk (2015) and three were tag recaptures from the current survey with a further148 assessed and released untagged.

Collection of biological data from released fish was restricted to length, external sex determination and in some cases external sexual maturity staging. Most male fish (99 per cent) were able to have their sexual maturity staged externally due to the presence of freely running milt (Stage 4) (Table 1). In contrast, only five per cent of females could be staged externally with nine females displaying free flowing eggs.

Figure 9. Small mature male estuary perch displaying free flowing milt from the urogenital opening (left), and mature female ovulating estuary perch, displaying free flowing eggs from the urogenital opening (right).

Female EP ranged in size from 226 – 470 mm, whereas males ranged in size from 199 – 366 mm (Figure 10). Although the range in lengths in this survey was similar to Van Wyk (2015), the length frequency distributions between studies were markedly different (Figure 10). Despite the wide size range in the current survey, most females (65 per cent) were between 280 – 300 mm in length. This marked size truncation was not as evident for males, where the size classes for male fish (75 per cent) were broad, ranging from 240 – 320 mm (Figure 10). In contrast with the length frequency distributions observed in the Van Wyk (2015) survey, most females (67 per cent) were between 350 – 390 mm, while most male fish (74 per cent) were between 290 – 330 mm (Figure 10). Several females (n=7) attained a larger maximum size than the biggest male fish. Similarly, the mean size (304 vs 284 mm F:M) and modal peaks (290 vs 270 mm F:M) were also larger for females.

The length-weight relationship of EP showed no signs of a sex specific trend, with fish ranging in weight from 150 g (male 199 mm) to 1,820 g (female 470 mm) and was consistent with the data from Van Wyk (2015) (Figure 11). Of the 212 male fish caught, 210 (99 per cent) were classed as ripe (Stage 4) including several small males (n=15) between 199 to 220 mm with milt freely flowing from the urogenital pore (Table 1; Figure 9). The two individuals that were not milted at capture measured 220 mm and 310 mm respectively.

All males dissected possessed milted testes (Stage 4). The GSI of dissected males ranged from 1.6 – 8.9 per cent with a mean GSI of 5.2 per cent. All females retained for dissection were also reproductively active, with nine individuals (47 per cent) possessing fully mature ovaries (Stage 3) and 12 individuals (63 per cent) possessing ovulated ovaries (Stage 5). The smallest reproductively active female was an ovulated individual measuring 273 mm. The GSI of dissected females ranged from 4.5 – 12.8 per cent with a mean of 8.9 per cent. Reproductive stage had a marked influence on GSI with Stage 3 fish having a smaller GSI (3.2 – 8.7 per cent n =9) than Stage 5 fish (12.1 – 12.9 per cent n =3).

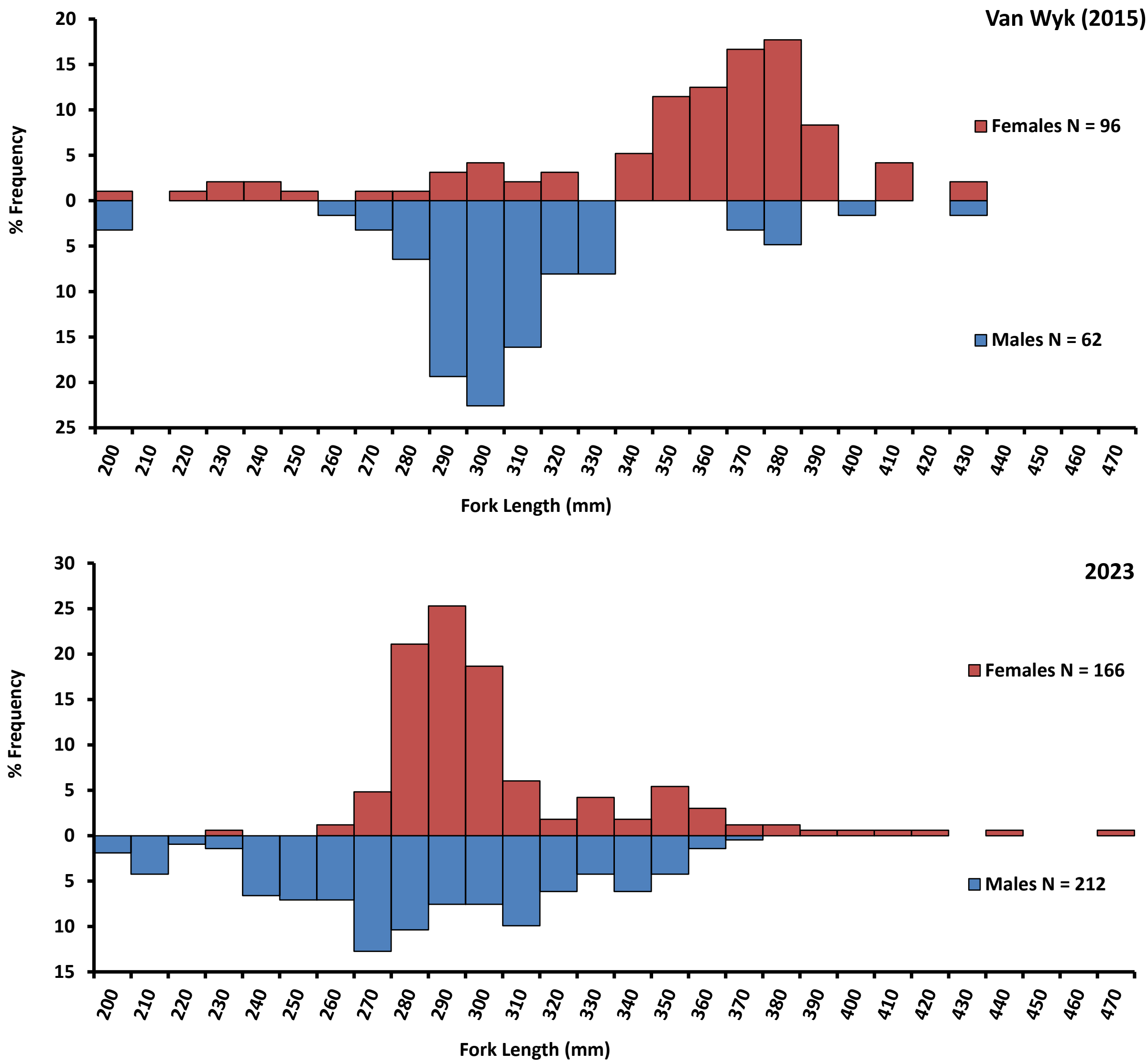

Figure 10. Length frequency of all estuary perch caught in the Arthur River, Tasmania, separated by sex comparing the current 2023 survey (bottom) and Van Wyk (2015) survey (top).

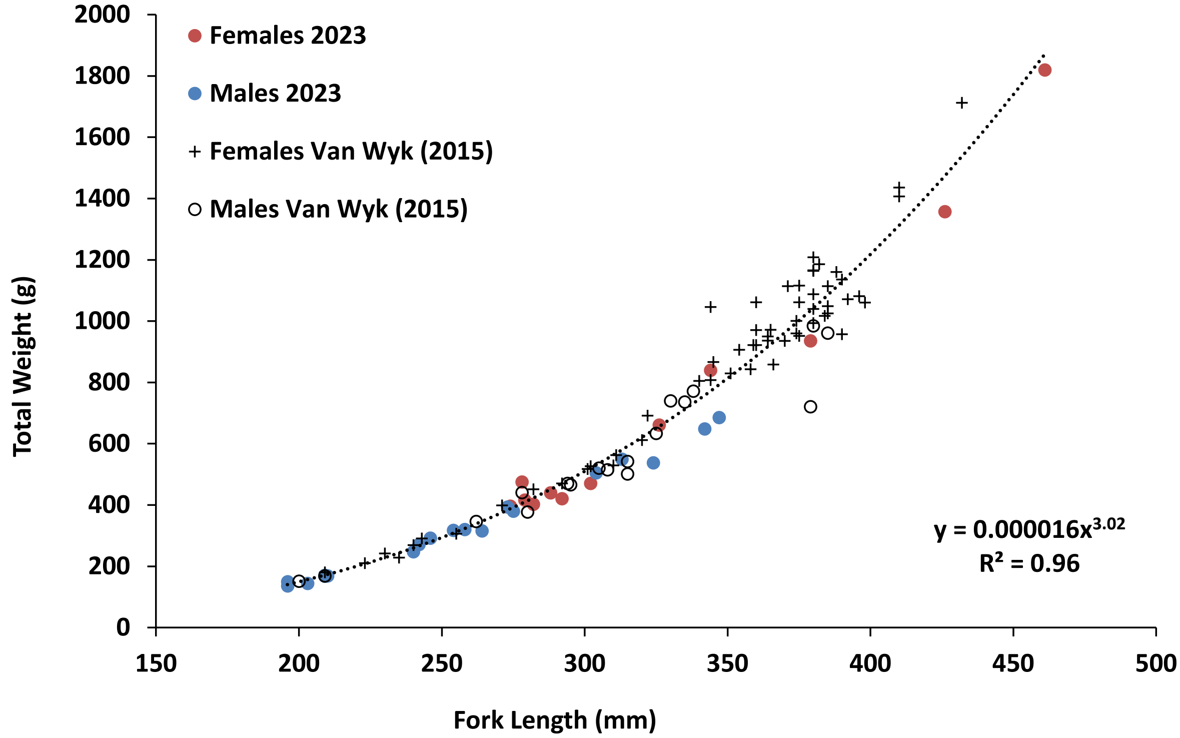

Figure 11. Length and weight of all estuary perch caught in the Arthur River, Tasmania, separated by sex comparing the current 2023 survey and Van Wyk (2015) survey. The length weight trendline is pooled data with sex and both surveys combined. 2023 survey N= 31, Van Wyk (2015) survey N= 76.

Of the 31 stomachs examined, most were empty, however, seven individuals (23 per cent) contained prey items. These prey items consisted of numerous small shrimps (*Paratya* spp.*;* n=2) unidentified fish (n=2) and four pill box crabs (n=3).

Aging and cohorts

Age determinations from the 31 EP retained during the 2023 survey, indicated there were three dominant age cohorts (Figure 12). An eight year old cohort consisting of seven females (274 – 302 mm) and four males (240 – 254 mm), accounting for 35 per cent of the retained fish, followed by a 23 year old cohort (23 per cent) consisting of two females (379 – 426 mm) and five males (304 – 357 mm), and lastly a five year old cohort (16 per cent) consisting of five males (199 – 210 mm) (Figure 12). Small numbers of fish at 6, 10, 11, 14-16, and 28 years were also present. EP of the ages 7, 9, 12, 13, 17-22, 24-27 were not detected.

While the overall size range encountered in this survey was similar to Van Wyk (2015), the age frequency distributions between studies were markedly different (Figure 12). However, due to the difference in samples sizes between the surveys, care should be taken when interpreting the results. From the 81 estuary perch retained by Van Wyk (2015), three dominant cohorts were observed. A 13 year old cohort consisting of 23 females (344 – 410 mm) and seven males (280 – 379 mm) accounting for 40 per cent of the retained fish, followed by a 12 year old cohort (19 per cent) consisting of 11 females (322 – 398 mm) and three males (295 – 335 mm), and lastly a 14 year old cohort (12 per cent) consisting of seven females (364 – 410 mm) and two males (325 – 338 mm) (Figure 12). A small percentage (11 per cent) of four year old fish were present, as well as small numbers of fish from 5 – 8, 10 – 11, 19, and 33 – 34 years. Estuary perch of the ages 9, 15 – 18, 20 – 32 years were not detected.

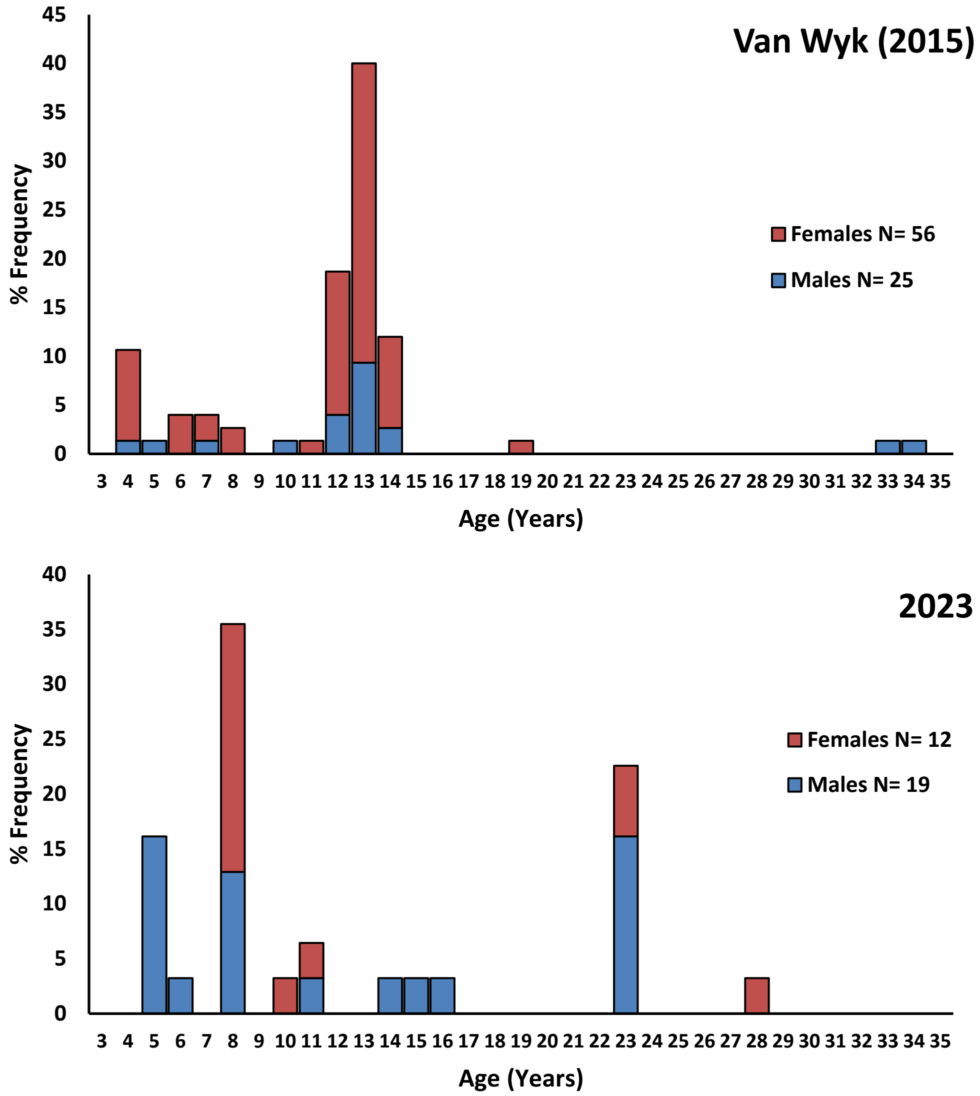

Figure 12. Age percentage frequency distributions for estuary perch, Arthur River, Tasmania, separated by sex, comparing the 2023 survey (bottom) and the Van Wyk (2015) survey (top).

Size at age data indicates that sex specific variation in growth is evident, with females being larger than males of the same age. This finding is consistent with Van Wyk (2015) data and allowed the generation of sex specific growth models from pooled data. The parameters of the Von Bertalanffy growth curve for females were L_∞ = 469 cm FL, k = 0.10 and t_0 = -2.91, and L_∞ = 359 cm FL, k = 0.12 and t_0 = -2.11 for males. The combined data set also suggests that size at age variation increases with increasing age (Figure 13).

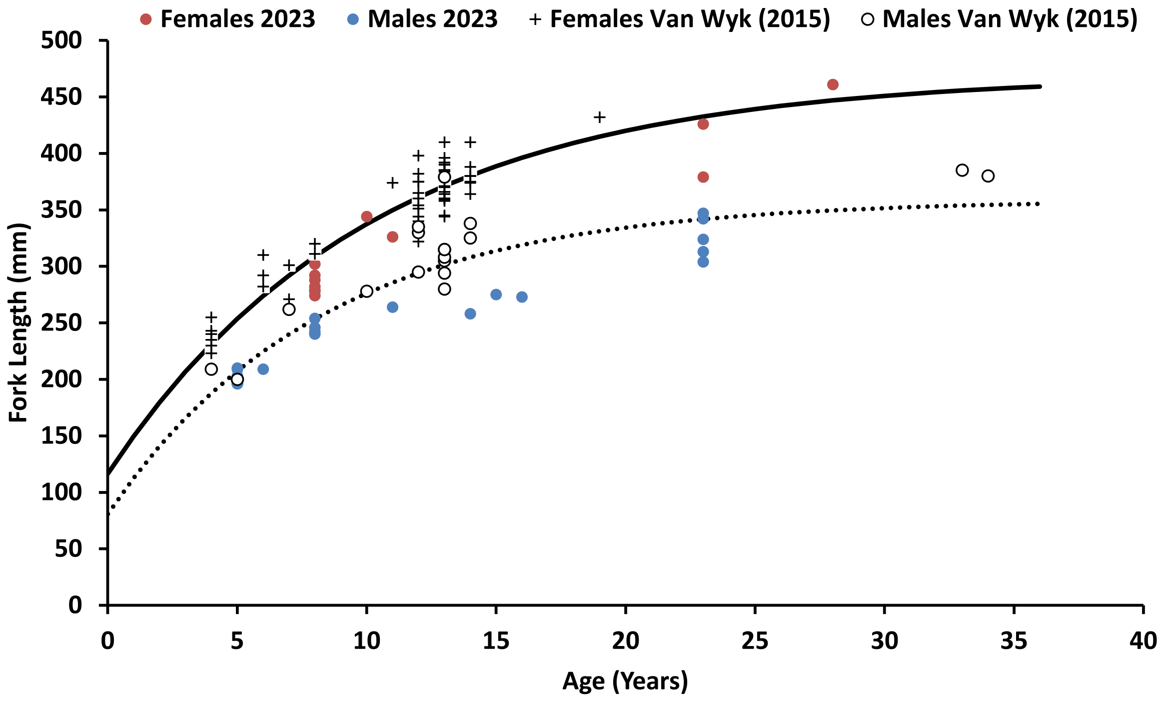

Figure 13. Size at age of all estuary perch caught in the Arthur River, Tasmania, separated by sex and comparing the 2023 survey and the Van Wyk (2015) survey. Solid line indicates the female growth model and dotted line the male growth model. N values are given in Figure 12.

Recaptured tagged fish

Since the Van Wyk (2015) survey where 87 EP were tagged and released, there have been 22 reported incidental recaptures where fork length was recorded by recreational fishers. In combination with 12 recaptures from the current survey, a total of 32 individuals (16 females, 15 males and one sex not determined) have been recaptured, with two individuals recaptured twice.

The four tagged fish from the Van Wyk (2015) survey that were caught and retained for age determination during this survey, were found to be 23 years old. Linear growth rates from recapture data were relatively slow for males and ranged from 1.5 - 7.0 mm per year (mean 4 mm/yr) (Table 4). In contrast, female growth was typically faster and ranged from 2.2 – 13.0 mm per year (mean 8.9 mm/yr) (Table 4). The individual growth trajectories were relatively consistent with the projected sex specific growth models and confirms the species growth is sexually dimorphic (Figure 14). The indetermined sex individual grew the fastest at 14.7 mm/yr during its 2.7 years liberty period. Liberty refers to the time elapsed between initial tagging and subsequent recapture. The largest increase in size was a female that grew 100 mm over 7.7 years. In comparison, the largest size increase in males was 52 mm over 7.7 years. The individual with the slowest growth rate was a 302 mm male that increased an average of 1.46 mm per year, growing 13 mm over nine years. Similarly, the slowest growing female increased 20 mm over nine years. This female had been recaptured previously during 2017 and originally had grown 15 mm over 2.7 years, however its growth slowed markedly thereafter. During the current survey three individuals that were caught and tagged were also recaptured after 2 – 3 days at liberty.

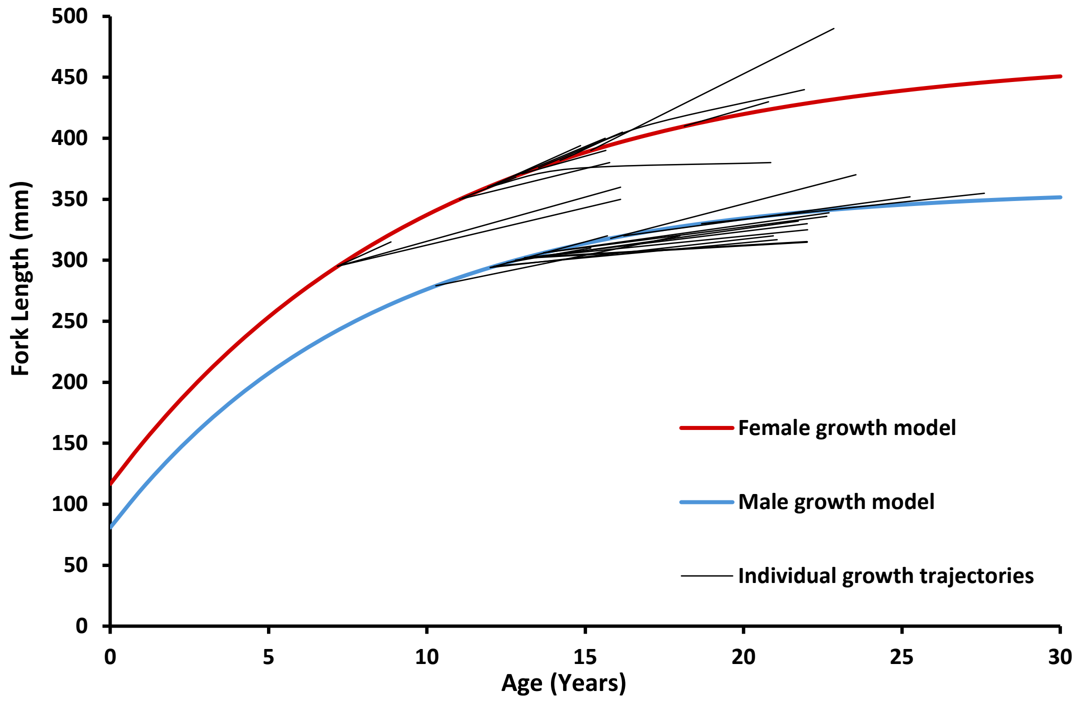

Figure 14. Sex specific size at age models with observed individual growth trajectories (black lines) for recaptured estuary perch tagged during Van Wyk (2015) survey. A total of 32 individuals recaptured, 22 from incidental capture by recreational fishers and 12 from the 2023 survey (Males, N= 15, Females, N= 16, 1 sex not determined and not plotted).

Tag retention in recaptured fish from the current survey indicated a tag retention rate of 75 per cent, with three of 12 individuals possessing one tag (all fish were double tagged) over the nine year period at liberty. Similarly, from the recreational fisher returns five from 21 fish possessed one tag (tag retention = 76 per cent). In addition, after two years of liberty, the cumulative tagged retention rates appeared to have stabilised ranging 69 – 76 per cent (Figure 15).

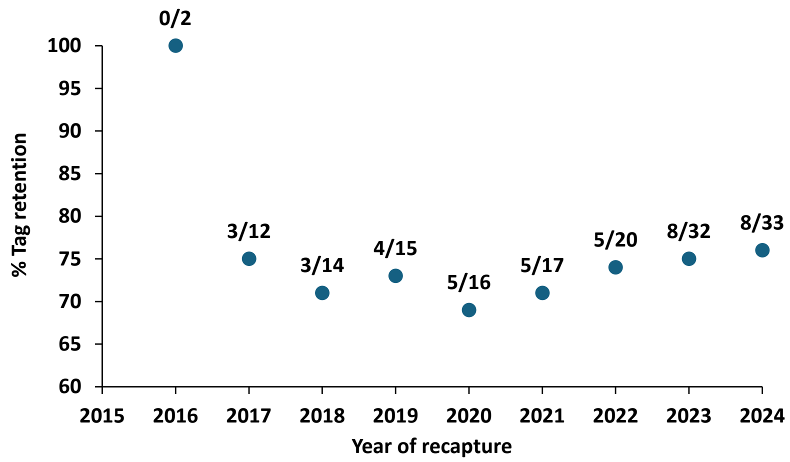

Figure 15. Percentage tag retention rates from annual recapture data. Values above data points are the number of individual fish with one tag, out of the total cumulative recapture numbers of fish over time.

Table 4. Measurements of growth from recaptured estuary perch, tagged during the Van Wyk (2015) survey, Arthur River, Tasmania. * Indicates fish recaptured in the current survey, all other fish were caught incidentally by recreational fishers.

Recapture year	Initial Length (mm)	Recapture Length (mm)	Time at liberty (yrs)	Total Growth (mm)	Growth per year (mm)	Sex (F/M/I)
2017	298	310	2.7	12	4.5	M
2018	294	320	3.7	26	7.0	M
2020	385	420	5.1	35	6.9	M
2022	279	320	7.7	41	5.3	M
2022	318	370	7.7	52	6.7	M
2023*	302	315	8.9	13	1.5	M
2023*	300	332	8.9	32	3.6	M
2023*	302	330	8.9	28	3.1	M
2023*	330	355	8.9	25	2.8	M
2023*	295	317	8.9	22	2.5	M
2023*	294	320	8.9	26	2.9	M
2023*	306	336	8.9	30	3.4	M
2023*	302	325	8.9	23	2.6	M
2023*	320	352	9.0	32	3.5	M
2024	306	339	9.0	33	3.7	M
2017	306	345	2.7	39	14.7	I
2016	295	315	1.7	20	11.8	F
2016	351	368	1.7	17	10.0	F
2017	356	380	2.6	24	9.1	F
2017	386	420	2.6	34	12.8	F
2017	382	410	2.6	28	10.6	F
2017	363	394	2.7	31	11.7	F
2017	371	390	2.7	19	7.2	F
2017	376	405	2.7	29	10.9	F
2017	360	375	2.7	15	5.7	F
2017	410	430	2.7	20	7.5	F
2018	360	400	3.7	40	10.8	F
2019	350	380	4.7	30	6.3	F
2021	355	420	6.7	65	9.7	F
2022	390	490	7.7	100	13.0	F
2022	382	440	7.7	58	7.5	F
2023*	360	380	8.9	20	2.2	F
2023*	295	350	8.9	55	6.1	F
2023*	295	360	8.9	65	7.3	F

Discussion

Population structure

The survey resulted in the capture of a wide size range of EP, with sufficient numbers to ensure a sound understanding of the population size structure. The survey was timed to coincide with the spawning season where fish are more mobile and aggregate in the lower estuary, making them vulnerable to capture. This behaviour was apparent during this survey, particularly during the evening, when the highest catches were achieved. Given 99 per cent of the males caught were running ripe and all females were able to be sexually staged, the timing of the survey was appropriate. It is likely that the majority of the females that were unable to be staged were also mature. Overall, the EP caught appeared to be mature fish that were undertaking spawning activity.

There were three dominant cohorts present. An eight year old cohort comprising the majority of the samples (35 per cent), followed by a 23 year old cohort (23 per cent) and five year old cohort (16 per cent). In addition to these, there appeared to be numerous missing and weak age cohorts. However, this result should be interpreted with caution, given it may be a consequence of the small number of fish aged. A higher sample size could provide more information regarding missing cohorts or other dominant year classes.

The 12 – 14 year old dominant cohorts observed in the Van Wyk (2015) survey are likely to be reflective of the dominant 23 year old cohort seen during this study. Missing and weak cohorts indicate high inter-annual recruitment variability of EP from the Arthur River (Van Wyk 2015). Highly variable recruitment has been observed in populations of EP in Victoria and NSW (Walsh et al. 2010; Morrongiello et al. 2014; Stoessel et al. 2018), however, the actual cause can be difficult to determine. Generally, in estuarine fish, it is related to environmental rather than human factors (Feyrer et al. 2007; Morrongiello et al. 2014). Recruitment variability in the Arthur River is likely related to numerous interrelated factors such as temperature, dissolved oxygen (DO), salinity, larval retention, and food availability, which are linked to freshwater flows (Van Wyk 2015, Stoessel et al. 2018).

Recruitment rates of EP are dependent on river flows during the spawning period (McCarraher and McKenzie 1986, Walsh et al. 2011; Stoessel 2018), however, river flow can have a positive or negative impact on recruitment of estuarine fish (Haddy and Pankhurst 2000; Staunton-Smith et al. 2004; Walker and Neira 2001). In mainland populations, strong recruitment of EP is linked with high freshwater flows. (Walsh et al. 2011; Stoessel et al 2014). This did not appear to be the case with the Arthur River population, with two younger cohorts (five and eight years old) spawned during 2018-2019 and 2015-2016 coinciding with an El Niño season (BOM 2024). Based on this information, warmer and drier conditions associated with the El Niño season may have influenced stronger recruitment events. However, the older 23 year cohort spawned in 2000-2001 was during a La Niña season (BOM 2024) that is associated with cooler temperatures, higher rainfall and stronger river flows. Although high freshwater flows can be beneficial to recruitment strength, flooding events can also delay or prevent spawning (McCarraher and McKenzie 1986, Walsh et al. 2011). The Arthur River often experiences anoxic states in the more saline waters during spawning (Beard et al. 2008), where low DO can negatively impact the survivability of the eggs. The continued survival of EP in the Arthur River will depend on the reproductive success of the dominant cohorts, particularly the two younger cohorts, until multiple successful spawning seasons replenish the stock to stable levels (Van Wyk 2015).

In Victorian populations, a major spawning factor for EP was found to be suitable habitat, specifically structurally complex woody debris adjacent to deep saline drop offs (Walsh et al 2011). This habitat increases egg survival and larval fish retention that increases recruitment success. The Arthur River has an abundance of this habitat (DPIPWE 2014) and therefore is not a limiting factor. The area with the consistently highest catches of EP was a one kilometre stretch in the lower region of the river. Given the time limitations of the survey, areas further upstream were not sampled extensively. It would be useful to confirm the upper limits of spawning activity as mainland populations generally spawn at the mouths of estuaries (McDowall 1996). EP are irregular spawners, with unfavourable conditions either delaying or preventing spawning (McCarraher and McKenzie 1986, Walsh et al. 2011). Consequently, further research into the spawning duration and key environmental factors that promote strong recruitment are necessary.

The summer spawning period for EP in the Arthur River is significantly delayed compared to mainland populations that spawn in winter and spring (Walsh et al. 2011). It is possible that spawning occurs a few months either side of December, as monthly sampling has not been undertaken in the Arthur River. The delayed spawning is likely to be related to latitudinal climate differences influencing water temperature and rainfall (Van Wyk 2015). In winter, the lower reaches of the Arthur River can have water temperatures as low as 5 to 10ºC and is consistently fresh during high rainfall events (Beard et al. 2008). In comparison to Victorian and NSW rivers, these temperatures and salinities would not be favourable for spawning (Trnski et al. 2005).

Both sexes of EP appeared to be of similar size, however fish larger than 380 mm were solely females, while most fish under 260 mm were males. This is consistent with the fact that they are sexually dimorphic, with females on average growing to a larger size than males at maturity (McCarraher and Mckenzie 1986, Walsh et al 2011, Stoessel et al 2018). Males are also known to reach maturity at a smaller size than females, reaching maturity at 222 mm, while females reach maturity at around 251 mm (Walsh et al. 2011). However, females grow faster and reach greater asymptotic lengths than males (Van Wyk 2015). The size ranges reflected by both sexes during this survey supports the fact that the population was spawning, with immature females under 260 mm absent from the estuarine area.

In comparison to the Van Wyk (2015) survey, there was a lack of larger females in the 340 to 430 mm size class. Based on the age data collected, these fish were approximately 12 to 14 years old during that study, but due to natural mortality, most have been lost from the population. There were more males and females in the 240 to 350 mm size class during the current survey compared to the Van Wyk (2015) survey, which reflects the cohorts of fish that have recruited into the population during the past nine years. In particular the dominance of the smaller size class ranging from 200 to 240 mm that were absent in the Van Wyk (2015) survey. This demonstrates the strength of the five and eight year old cohorts within the current survey.

There were significant variations in growth observed between sexes of EP caught. The youngest dominant cohort of five year olds had the least variation at 14 mm, while the oldest cohort of 23 years had the most variation at 122 mm. This is due to the variation in growth between the sexes, with females growing faster and larger than males. This was supported by the growth rates observed from the Van Wyk (2015) survey.

Growth rate information was analysed from EP tagged during the Van Wyk (2015) survey, which were recaptured by recreational fishers and from the 2023 survey. Overall male growth rates were slow (1.5 – 7 mm per year), while female growth was typically faster (2.2 – 13 mm per year). The pooling of the 32 tagged fish recaptures (recreational fishers and the 2023 survey) resulted in the development of a more robust growth model for both sexes. The growth trajectories of individual fish closely matched the models, which further supports the observed sexual dimorphism at age.

The combination of longevity and varying growth rates means that there can be a wide variation of cohorts of fish in the 240 to 300 mm range, and length alone may not be a good predicator of population structure. Growth is also known to be closely linked with temperature, where juveniles grow more during cooler years, while adults grow faster in warmer years (Stoessel et al. 2018). Taking this into account and given the latitudinal and climate differences compared to mainland populations, the EP in the Arthur River are generally slower growing.

Of the 87 EP tagged during the Van Wyk (2015) survey, 32 (37 per cent) were recaptured by both recreational fishers and during the 2023 survey. This suggests that post release survival after the netting process was high and natural mortality is low. Moreover, given some of these fish have been recaptured multiple times, it suggests the Arthur River EP population is small. Only three EP that were tagged during the current survey were recaptured during the survey period, which suggests that the fish may not resume normal behaviour following release or had moved to a different section of the estuary where gill netting was not undertaken. The loss of one tag in approximately 25 per cent of recaptured fish from the Van Wyk (2015) survey, highlights the need to continue to double tag fish to increase the probability of tag returns.

Catch effort

Gill nets were highly effective at catching EP, in particular the trammel gill net and the 2.5 inch monofilament gill net that accounted for the majority of the catch. By using scissors to cut entangled fish from the nets, then placing the fish in an aerated bin with flow through water, recovery of fish was high. Although the trammel gill nets were able to capture most size classes present, the use of the 2.5 inch monofilament gill net caught a much higher proportion of fish under 270 mm. Despite the use of fyke nets and box traps, no young of the year EP were caught. Although one young of the year EP was caught in the lower estuary in a fyke net in a previous survey (DPIPWE 2014), it is possible that most fish in this size class are further upstream in the freshwater reaches (VFA 2024). Alternately, there may have been recruitment failure from recent spawning seasons.

There was a significant difference in the CPUE of gill net effort between day and evening catches. EP were more mobile in the shallows during the evening, making them susceptible to gill net capture. The habitats targeted for sampling included rocky shorelines, areas with fallen timber/logs and areas fringed with reeds. Only two gill net sets with catches of more than 10 fish occurred during the day. A study on EP movement in a Victorian river found that during the day, the fish associated with structure in deeper sections of the river and spent most time in one location for the whole day (Douglas 2010). However, at night, the fish became mobile and began to move away from structure and throughout the estuary (Douglas 2010). Therefore, it is likely the higher catch rates observed during the evening in this survey were due to increased movement with the onset of night.

On closer examination of the sex ratios from gill net sets that caught over 10 individuals, it was found that some schools were significantly dominated by either males or females, although three schools had a relatively even split of sexes. Sex segregation has been observed in marine fish, reptiles, birds, and mammals however, the underlying cause/s is not well understood (Wearmouth and Sims 2008). Sex specific schooling in EP may have implications when undertaking further surveys, where if the sample size collected is not large enough, catches may be biased towards one sex. The overall ratio of sexes for the total number of EP caught during this survey was not significantly different.

Diet analysis

Only a small proportion of EP stomachs examined (N= 7, 23 per cent) contained prey items. The prey items consisted of small shrimps, crabs, and unidentified fish. The high occurrence of empty stomachs may be due to the regurgitation of stomach contents during stressful events, ie. when they are entangled in a gill net (Sutton et al. 2004). Or may be due to increased digestion rates (Baker et al. 2014). The Arthur River appears to be a highly productive system, supporting a range of small teleost fish species (DPIPWE 2014). During the survey numerous crab and fish species were also caught, which could all be potential prey for EP, both adults and juveniles (McCarraher and Mckenzie 1986, McDowall 1996). As a result, prey availability is unlikely to be a limiting factor for the EP population within the Arthur River.

Summary

Over the five days of this survey, a total of 378 EP were captured. Although the population appeared to be robust with at least two strong young cohorts evident, there was highly variable recruitment across many years. A dominant older cohort that was identified during the Van Wyk (2015) survey, was still present in the population, at 23 years old. Numerous weak and missing cohorts were apparent; however, this could be due to the small sample size of fish retained for aging. The high rate and multiple recaptures of tagged EP from the Van Wyk (2015) survey suggests the population remains relatively small. Overall, growth rates of recaptured tagged fish were slow and are likely to be representative of the population. Slow growth is linked to low water temperatures, as well as the life history traits of EP.

Targeting EP in the evening with trammel gill nets was found to be highly effective, and based on the maturity stages observed, the fish were spawning or preparing to spawn at the time of the survey. This suggests the timing of the survey was ideal and further supported that EP in the Arthur River have a delayed spawning period in comparison to mainland populations, as first observed by Van Wyk (2015).

EP are highly fecund, opportunistic spawners and given their longevity they can potentially endure numerous seasons that are unfavourable for reproduction. The population in the Arthur River is self-sustaining, however due to their highly restricted distribution, variable recruitment and small population size, further efforts to conserve the population are warranted.

Recommendations

- Maintain EP status as a "Protected Fish" under the *Inland Fisheries Act 1995*.
- Publish survey results of EP in the Arthur River (2015 and 2023 survey combined) in a scientific peer review journal.
- Better define the Arthur River seaward limit and adjustment of the indigenous fish boundary under Inland Fisheries legislation, to improve protection of EP and provide clarity to anglers targeting other indigenous fish species in the lower reaches of the river.
- Undertake an educational campaign to inform the public/fishers of the status of EP in Tasmania.
- Seek additional external resources and funding to investigate and research knowledge gaps relating to EP in the Arthur River, and progress the development of a recovery plan for the species within Tasmania.

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