Use of otolith chemistry to trace life history variability in barramundi

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Background

Understanding the life history of fishes is fundamental to their conservation and management

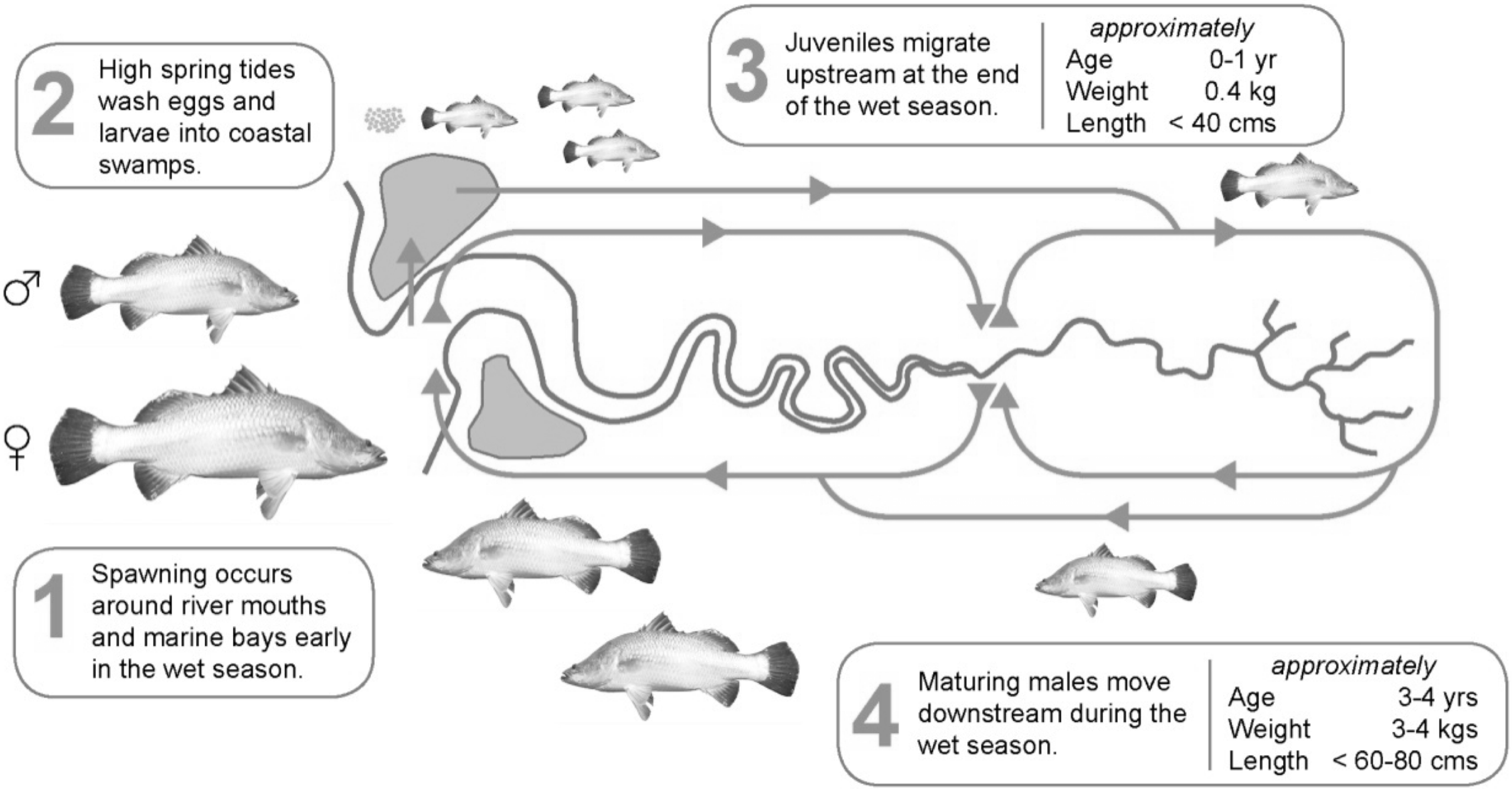
Movement is a key aspect of the life history and drives important ecological processes

Intra-specific variation in life history has important consequences for fish species and the fisheries they support (‘portfolio effect’, Schindler et al. 2010)

Barramundi *Lates calcarifer*

- High commercial, recreational and cultural importance
- Protandrous hermaphrodite
- Catadromous (spawns in salt water)
- Exhibits lots of intra-specific variation in behaviour

Barramundi life history model



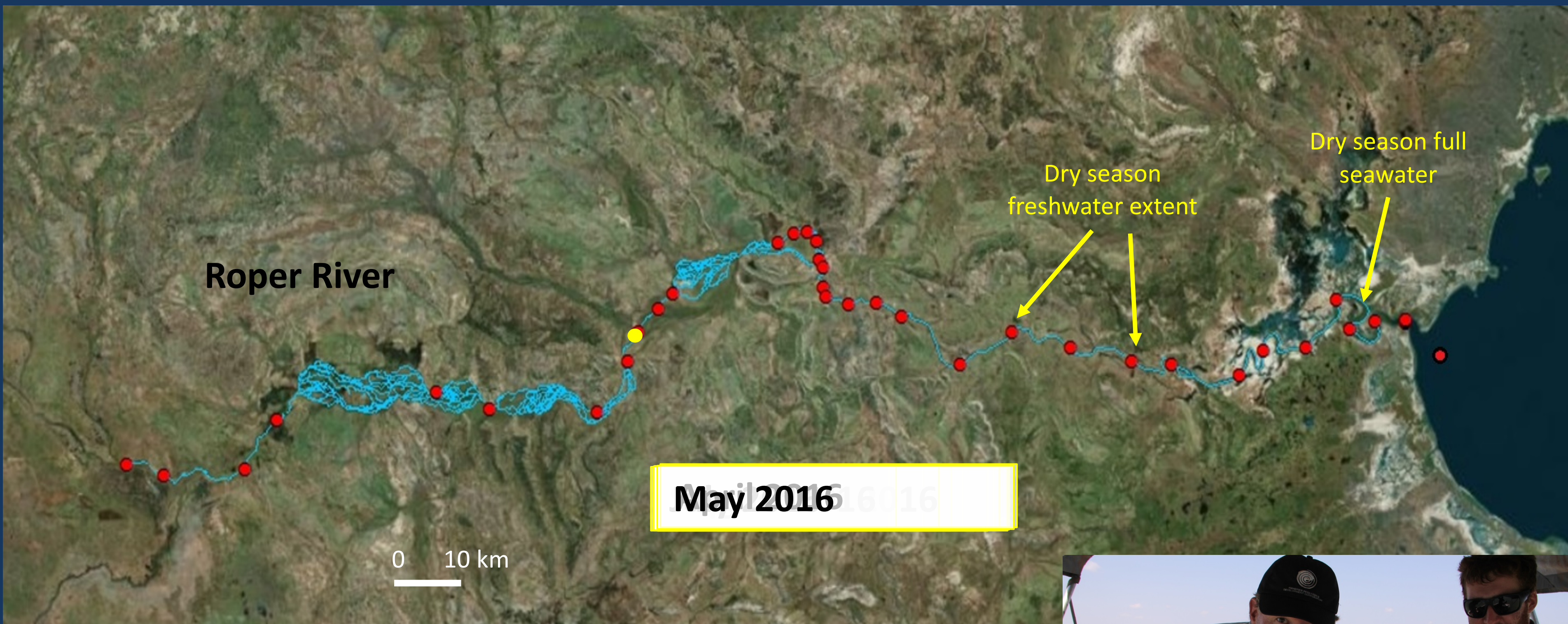
This presentation…

- Use otolith analysis to trace whole-of-lifetime salinity and growth histories of individual barramundi
- Revisit life history model and examine implications of movement behavior for food web and fishery productivity

- Crook et al. (2017). Use of otolith chemistry and acoustic telemetry to elucidate migratory contingents in barramundi *Lates calcarifer*. Marine and Freshwater Research 68, 1554-1566.
- Crook, et al. (2017). Temporal and spatial variation in strontium in a tropical river: implications for otolith chemistry analyses of fish migration. Canadian Journal of Fisheries and Aquatic Sciences 74, 533-545.
- Roberts et al. (in review). Migration to freshwater increases growth rates in a facultatively catadromous tropical fish.

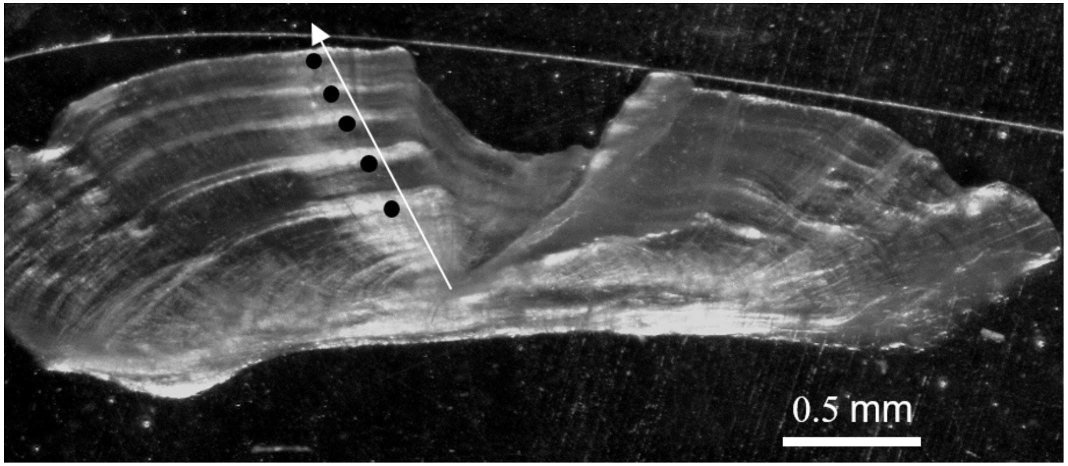
A year in the life of a barramundi

101cm fish, tracked by acoustic telemetry Sep 2015 to Nov 2016



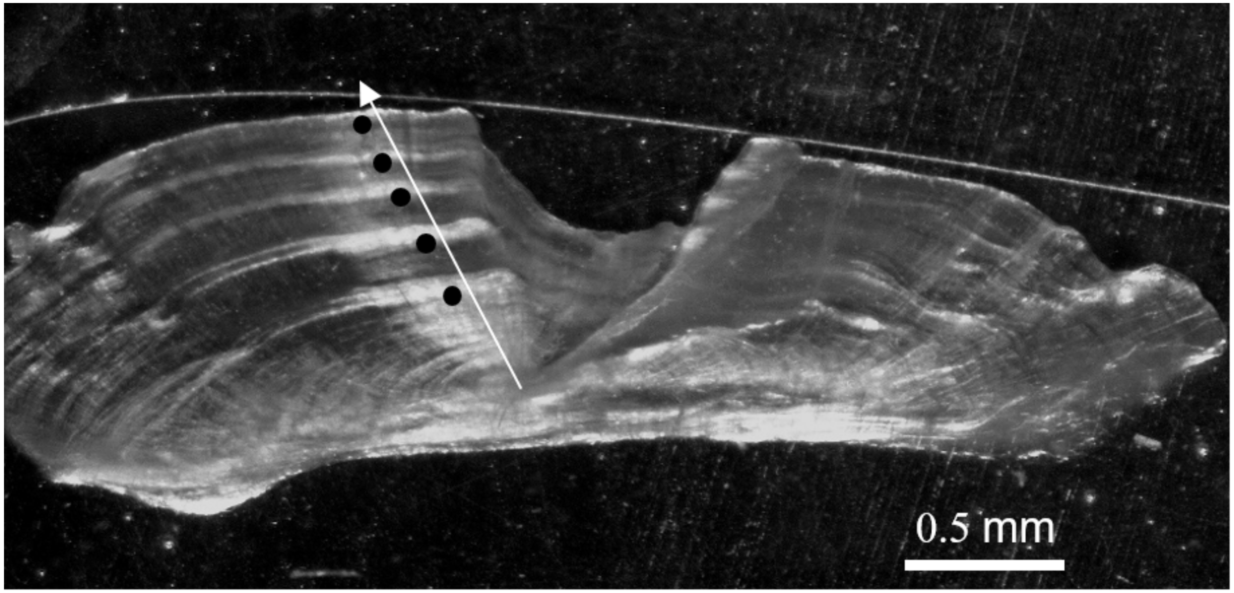
Otolith strontium isotope analysis

- Analysis of otolith $^{87}Sr/^{86}Sr$ allows us to hind-cast the entire salinity history of individuals
- $^{87}Sr/^{86}Sr$ is constant globally in marine waters (0.70916), but variable in freshwater
- Compare otolith and water $^{87}Sr/^{86}Sr$ to make inference about ambient salinity across life history
- Increment width is related to somatic growth rate
- We can align chemistry data with annual increments to examine effects of migratory strategies on growth rates



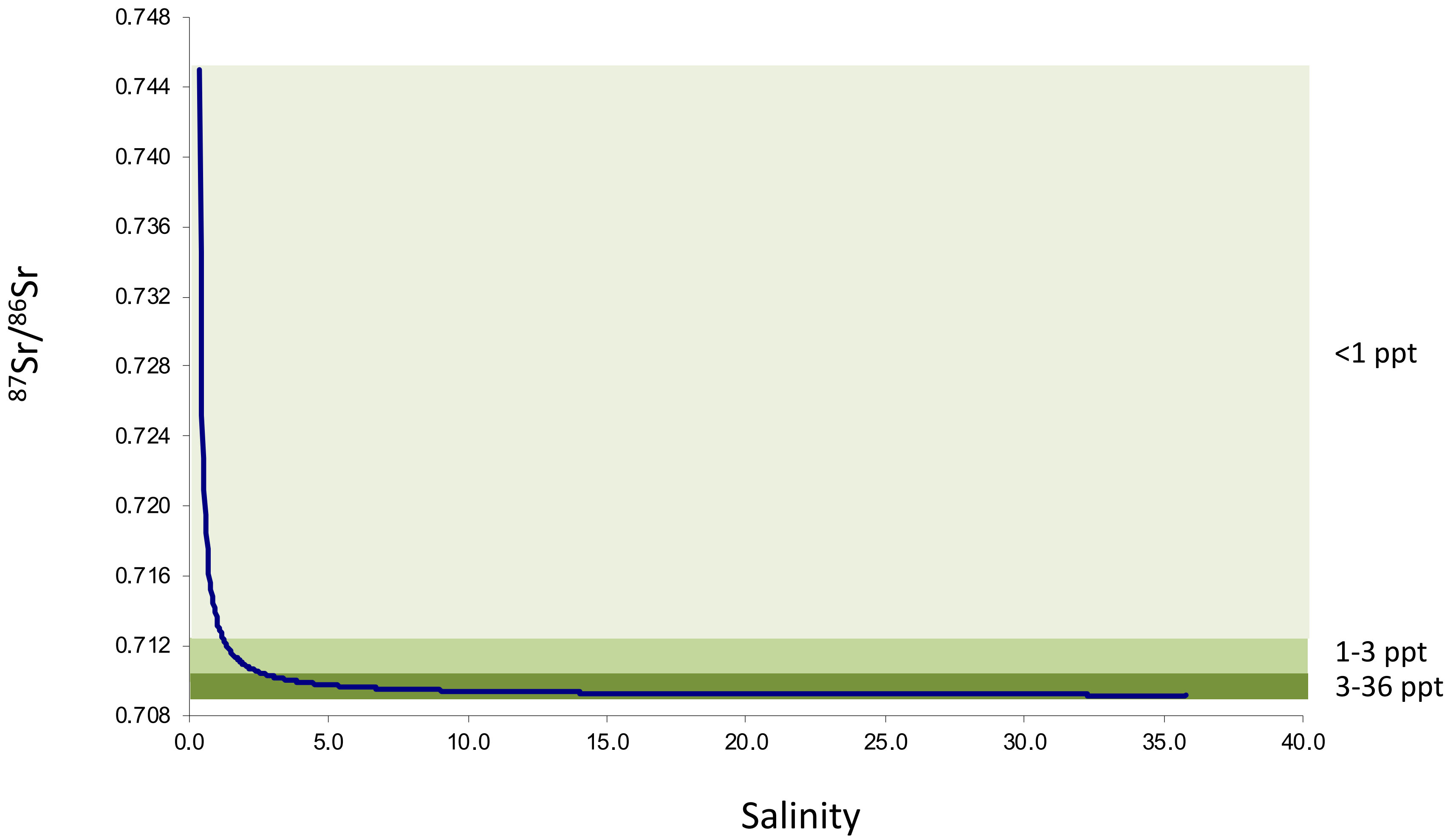
Methods

- Analysis of otolith $^{87}Sr/^{86}Sr$ conducted on >200 Barramundi otoliths from Daly, Mary, Roper, Sth Alligator, Macarthur and Fitzroy (WA) rivers
- Laser-ablation multi-collector inductively coupled plasma mass spectrometry (LA-MC-ICPMS) operated by University of Melbourne
- Core-to-edge $^{87}Sr/^{86}Sr$ transects, aligned with annual increments



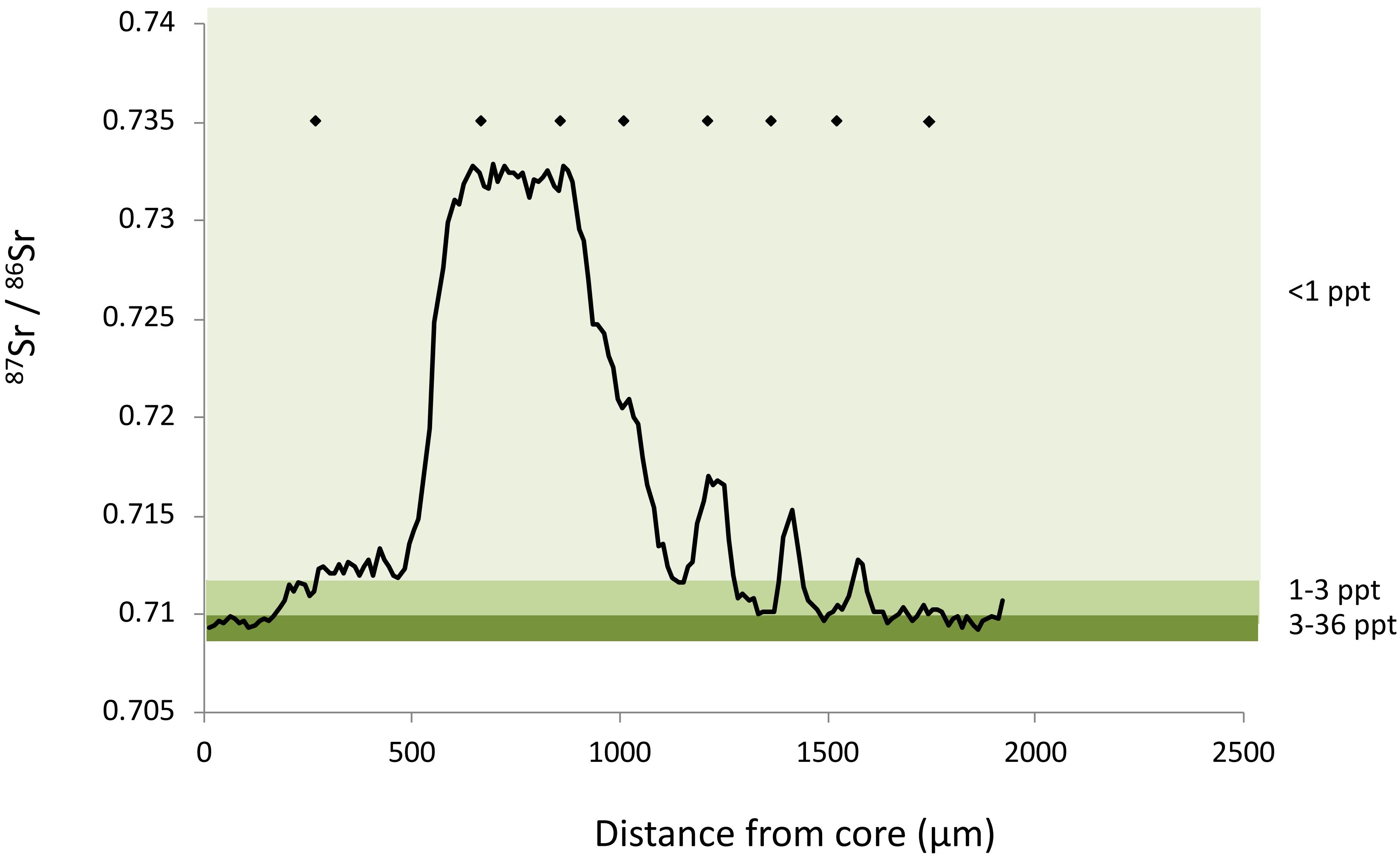
Results – migration history

Water mixing model – South Alligator River



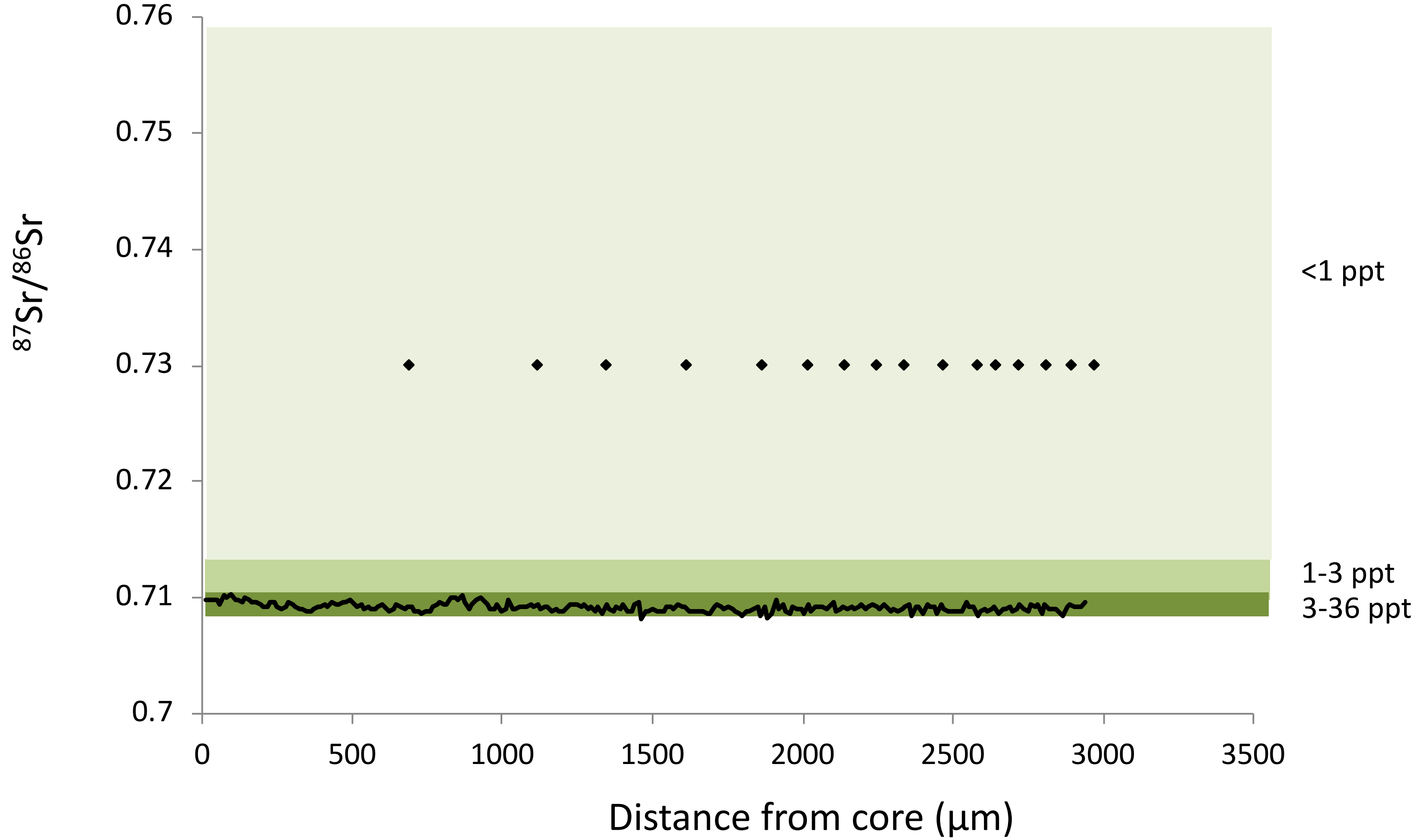
Results – migration history

Barramundi (89 cm TL), Mary River estuary



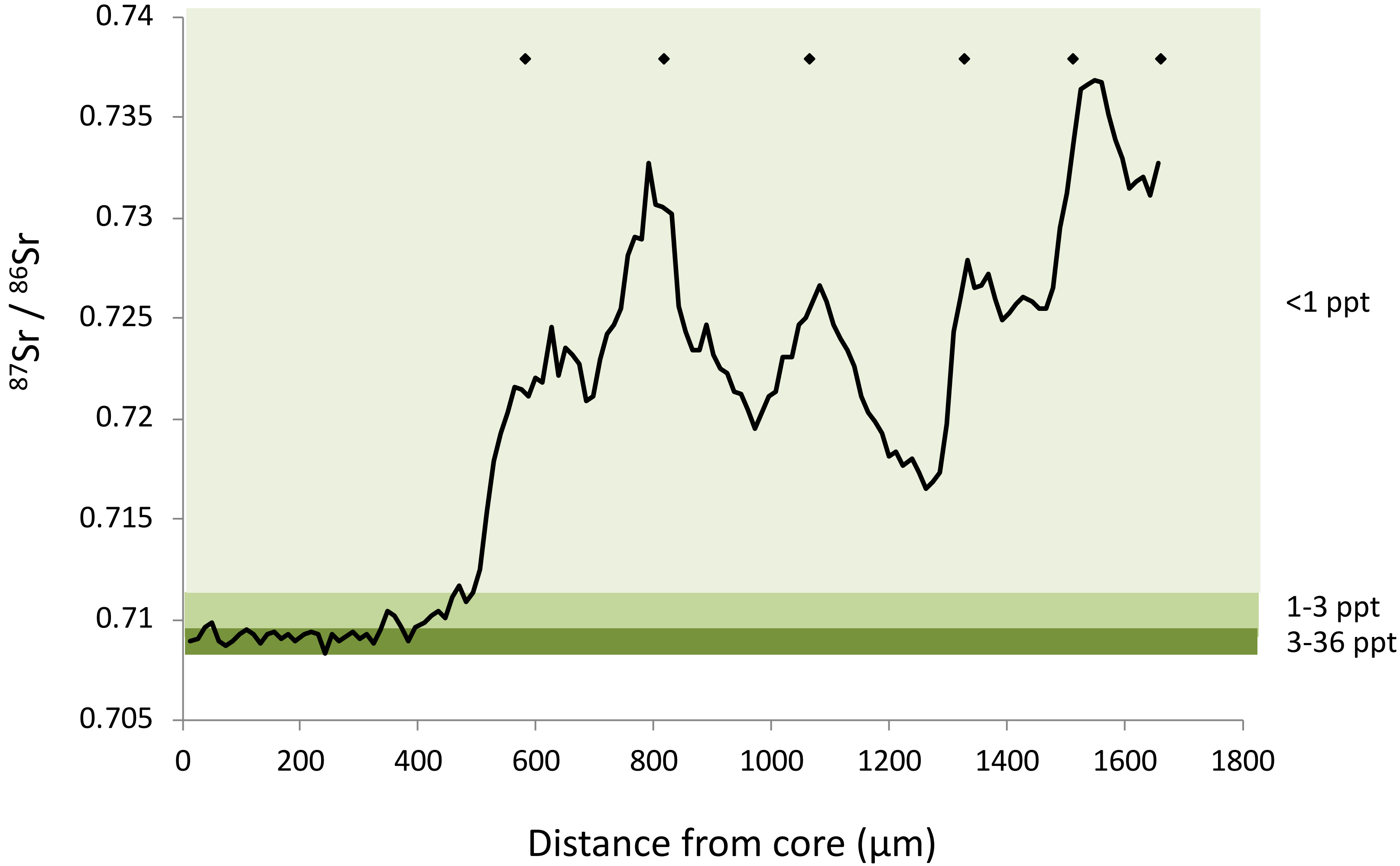
Results – migration history

Barramundi (122 cm TL), Mary River estuary



Results – migration history

Barramundi (103 cm TL, 6 years old), Yellow Water



Results – migration history

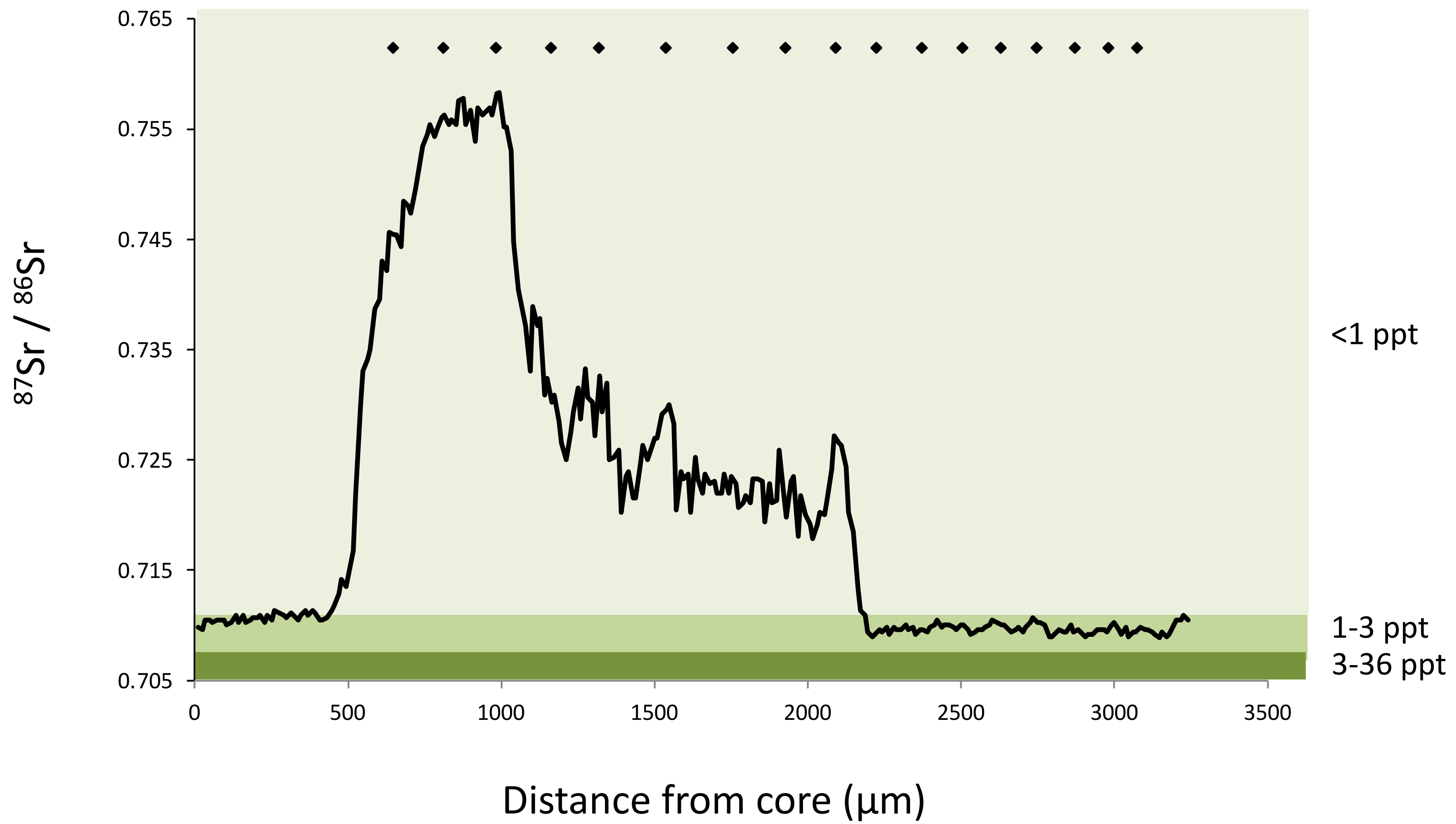
Barramundi (103 cm TL, 6 years old), Yellow Water, Sth Alligator River

Mature female

Results – migration history

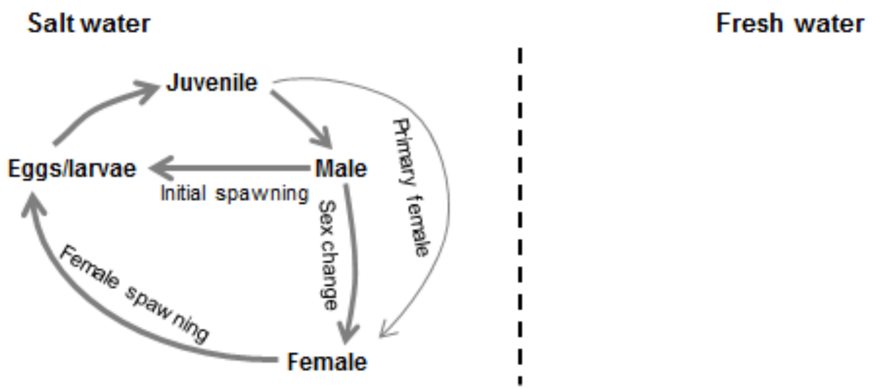
Barramundi (109 cm TL, 17 years old), Daly River

Stayed in freshwater until 10 years of age

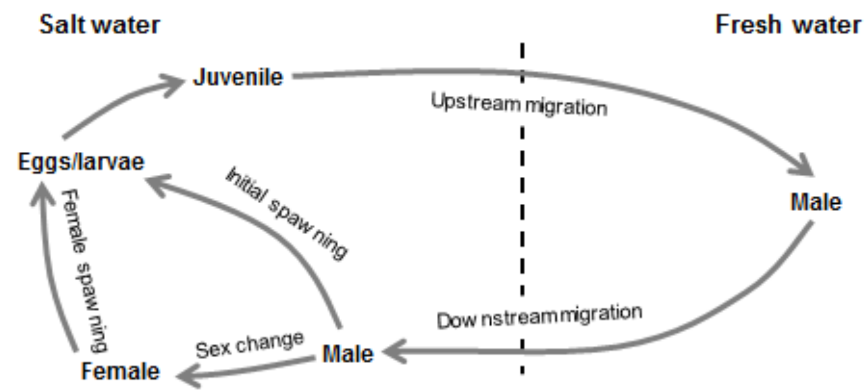


Conclusions – migration history

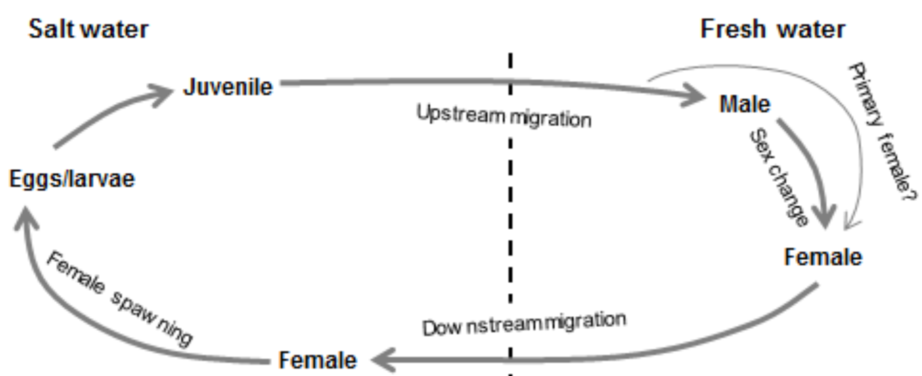
1) Estuarine



2) Catadromy, sequential hermaphrodism

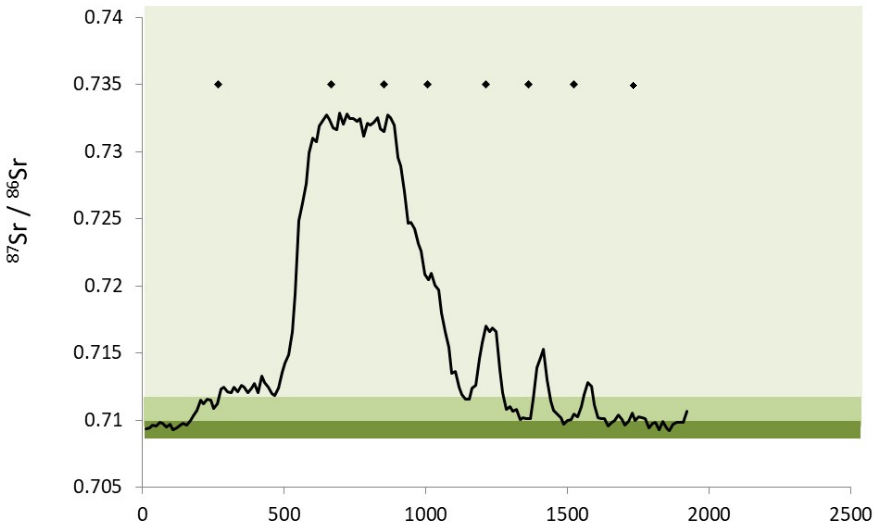


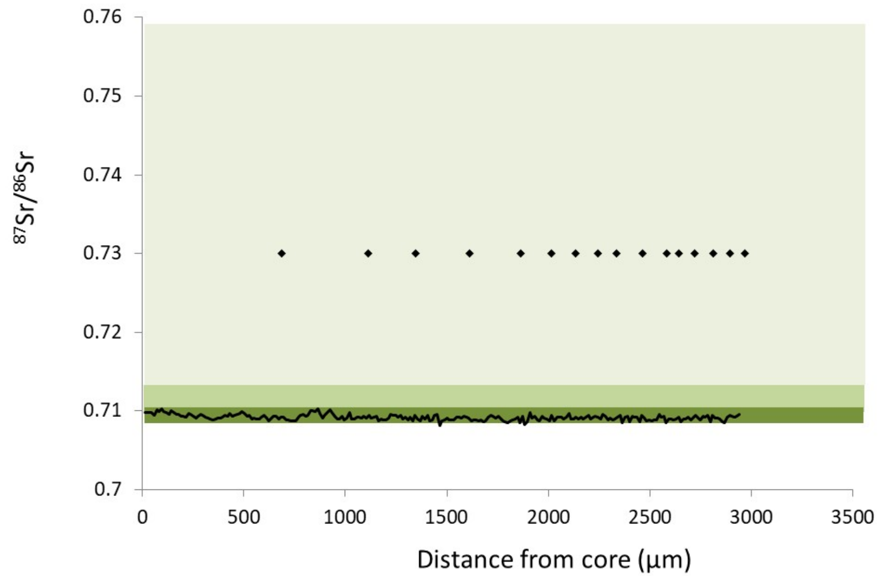
3) Catadromy, delayed female spawning



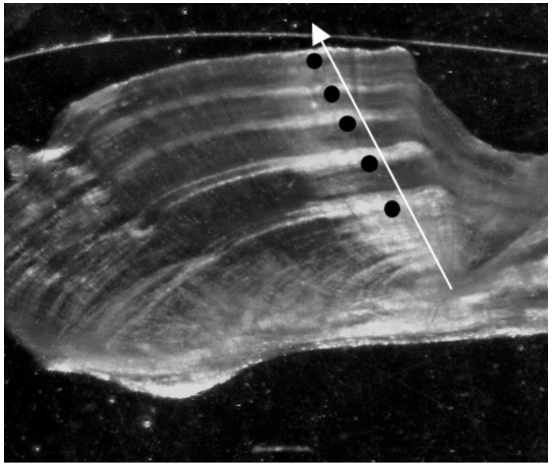
From Crook et al. (2017)

Results - migration and growth rate

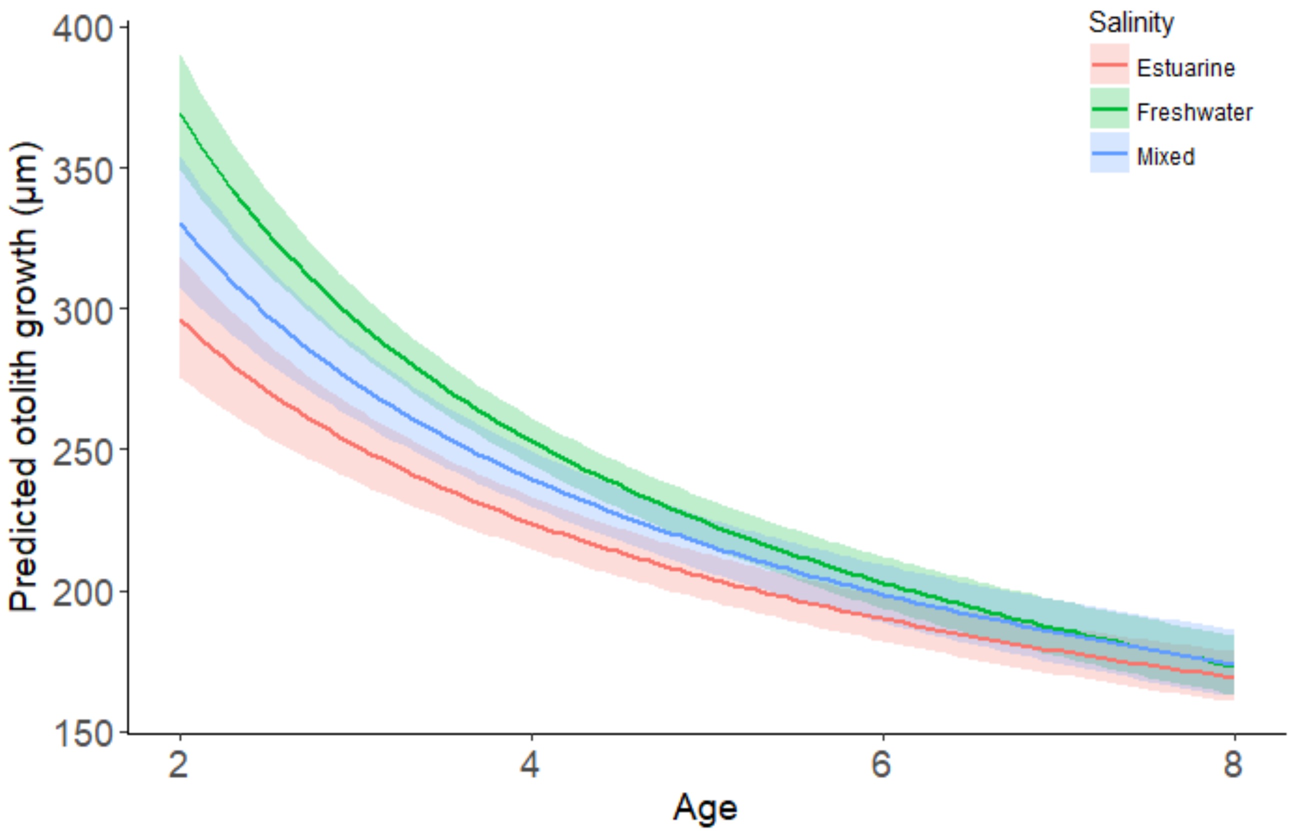




Daly, Mary, Sth Alligator, Roper, Macarthur



Migration and growth rate



Advantage versus estuarine/marine residence

Age	2	3	4	5	6	7	8
Freshwater	+24.17%	+17.26%	+12.59%	+9.10%	+6.33%	+4.04%	+2.09%
Mixed	+11.18%	+8.63%	+6.86%	+5.50%	+4.41%	+3.49%	+2.71%

Roberts et al. (in review)

Conclusions – migration and growth rate

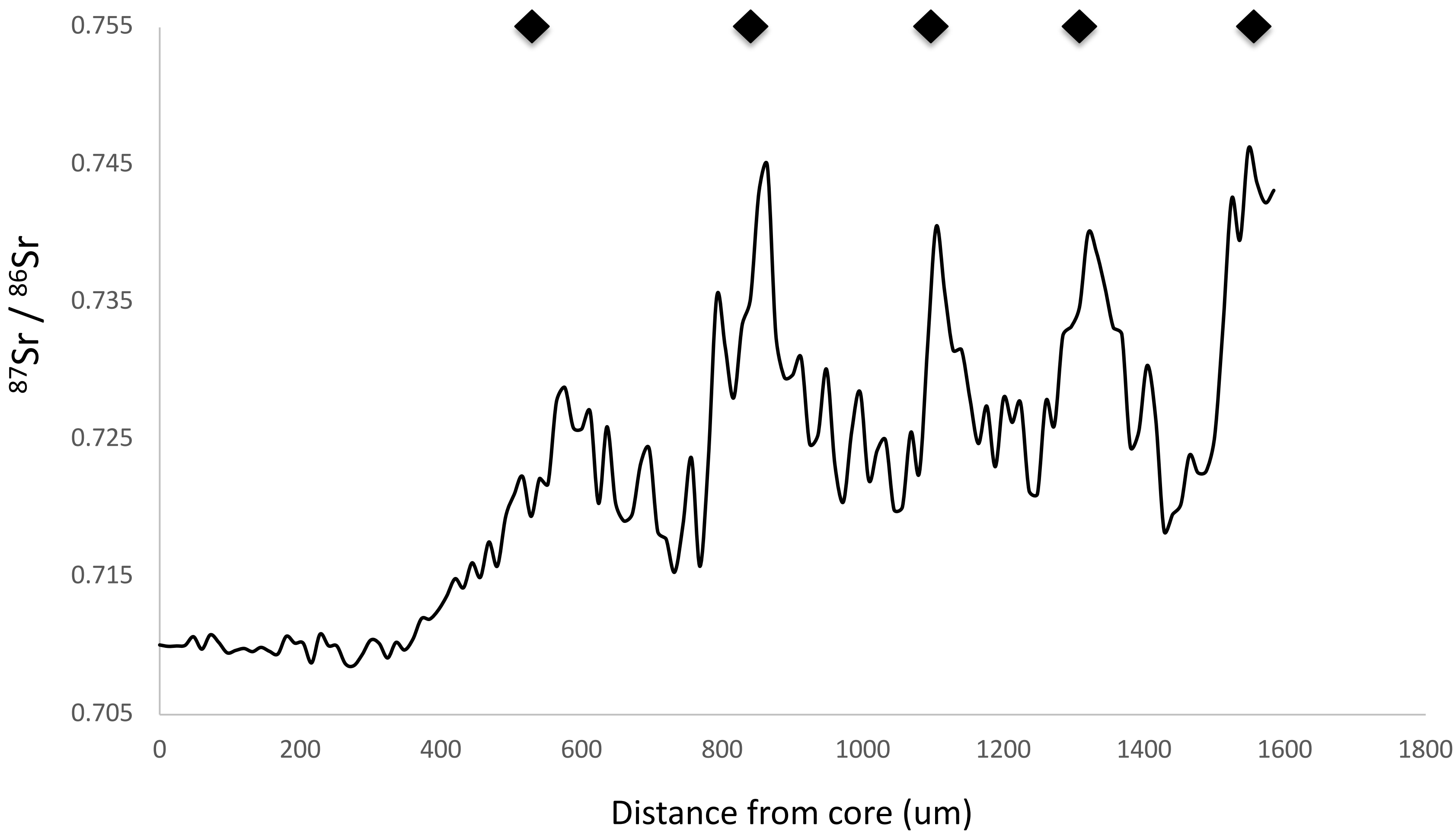
- Growth rates of barramundi tend to be greater when they are living in fresh water (access to productive floodplains)
- This is the opposite pattern to temperate anadromous fish (e.g., salmonids)
- Consistent with the 'productivity hypothesis' (Gross et al. 1988, Science)
    - Diadromy driven by productivity differentials between fresh and marine waters
    - This hypothesis suggests that diadromy is an intermediate evolutionary step between marine and freshwater residence
- If there's such a big advantage, why don't they all migrate?
- Environmental variability may allow different phenotypes to co-exist
- Demonstrates the importance of undisturbed floodplains for fishery productivity

Temporal stability of water Sr signatures

- Marine $^{87}Sr/^{86}Sr$ is temporally stable at a global scale over millennia
- Freshwater $^{87}Sr/^{86}Sr$ is determined by catchment geology
- It is often assumed that $^{87}Sr/^{86}Sr$ in rivers is stable because underlying geology is invariant
- However, surface run-off and groundwater hydrology potentially interact with geology to influence local patterns of $^{87}Sr/^{86}Sr$
- Temporal variation in freshwater $^{87}Sr/^{86}Sr$ has the potential to confound interpretation of otolith chemistry data

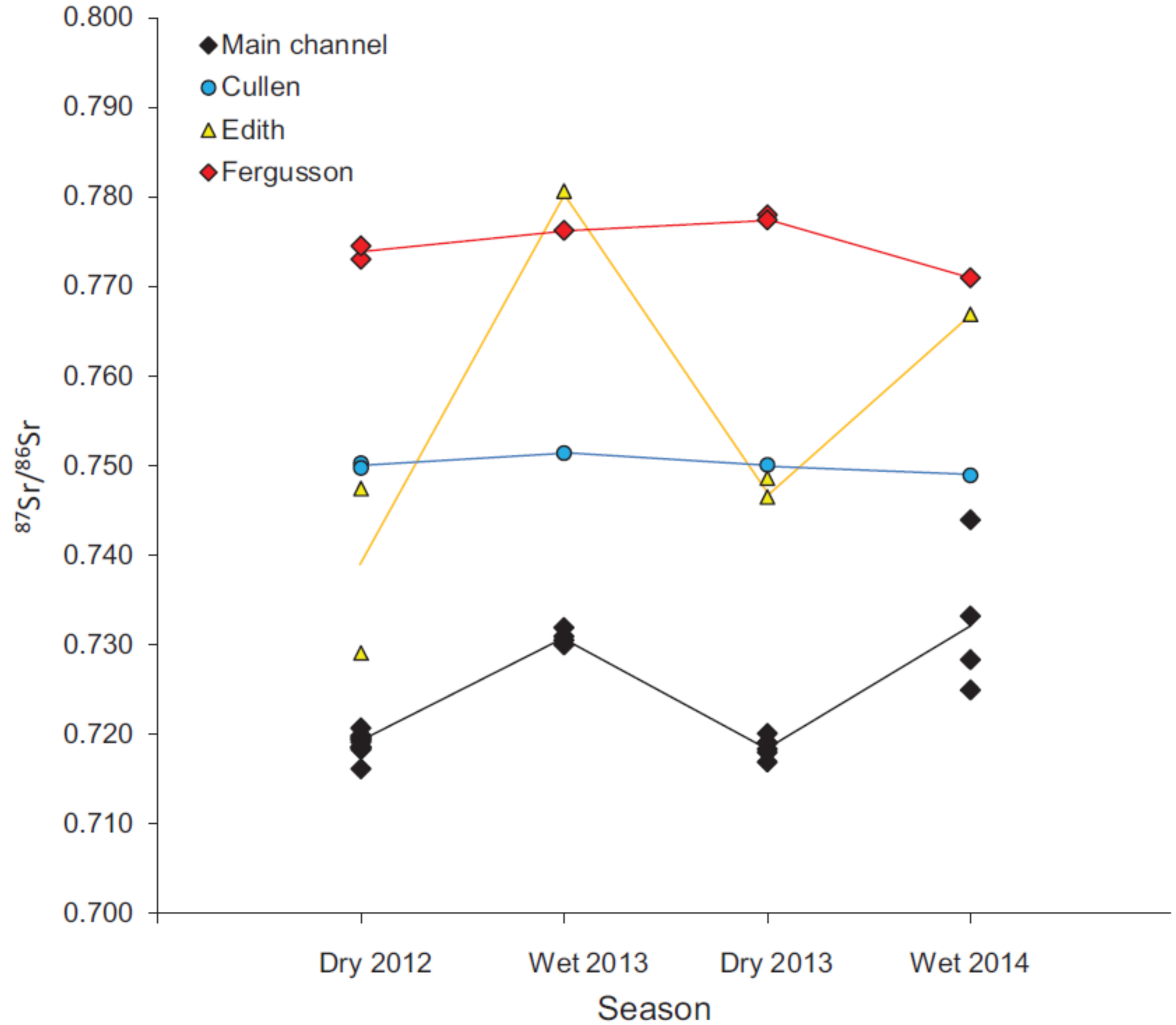
Temporal stability of water Sr signatures

Daly River barramundi



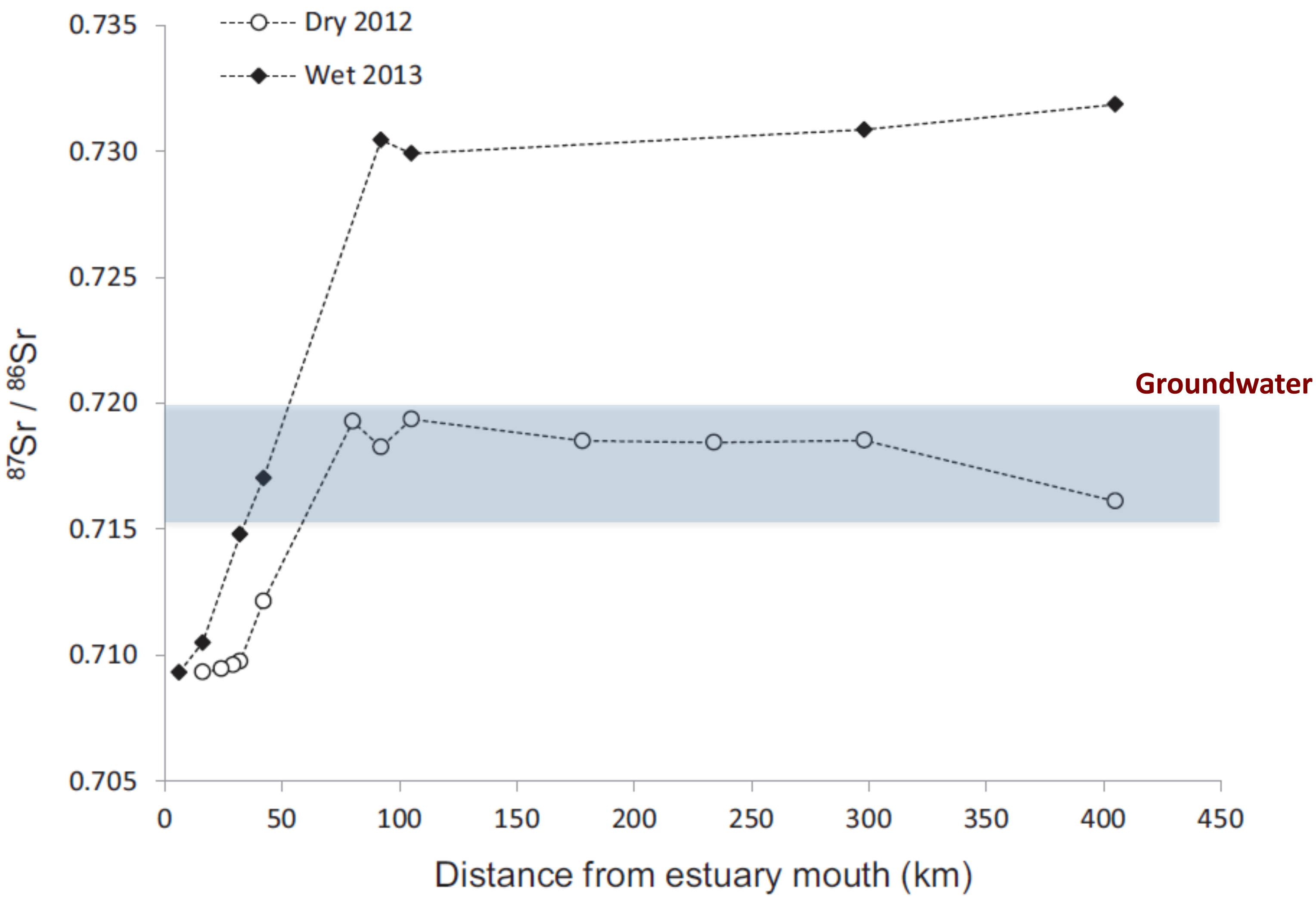
Temporal stability of water Sr signatures

$^{87}Sr/^{86}Sr$



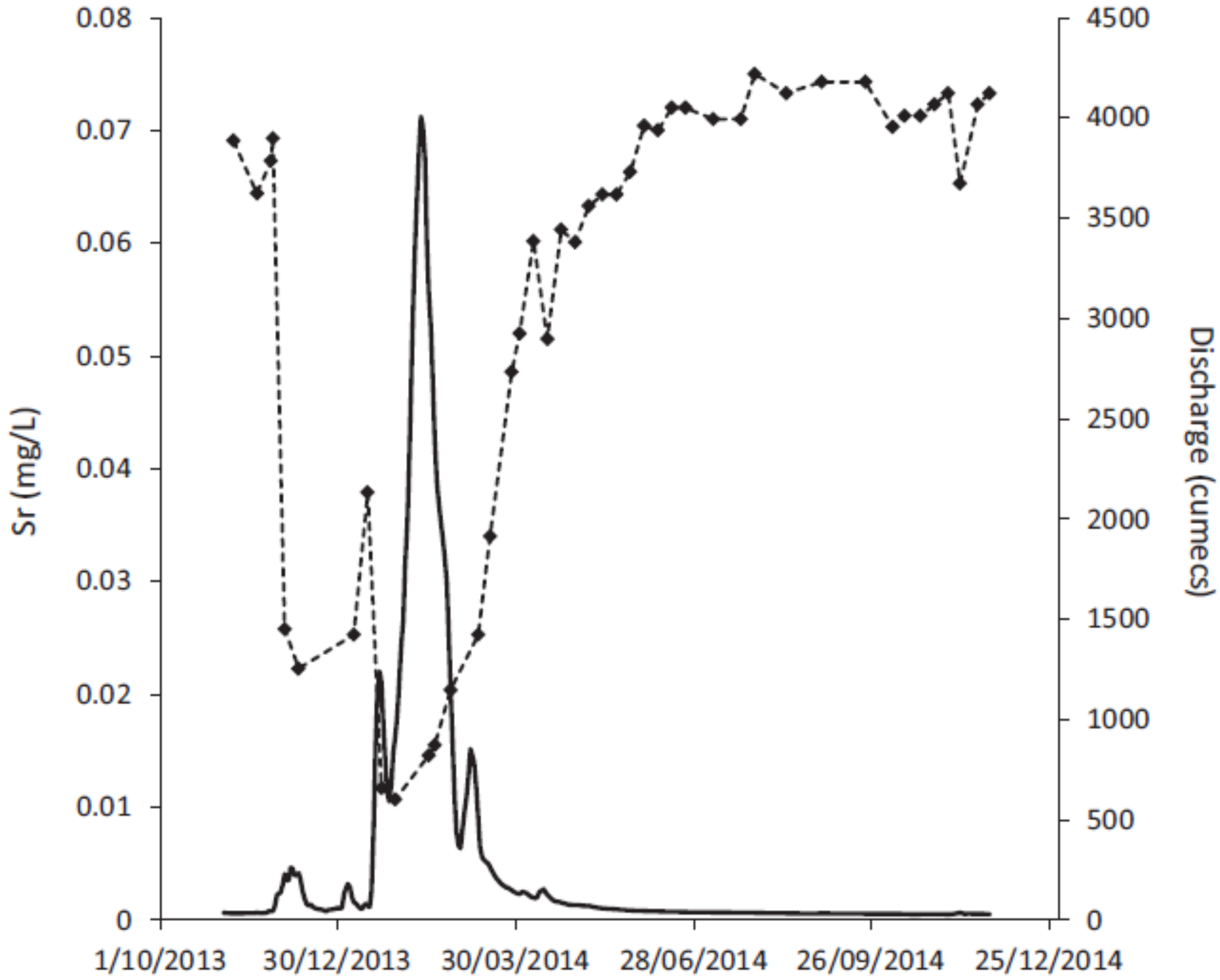
Temporal stability of water Sr signatures

$^{87}Sr/^{86}Sr$ – longitudinal main channel



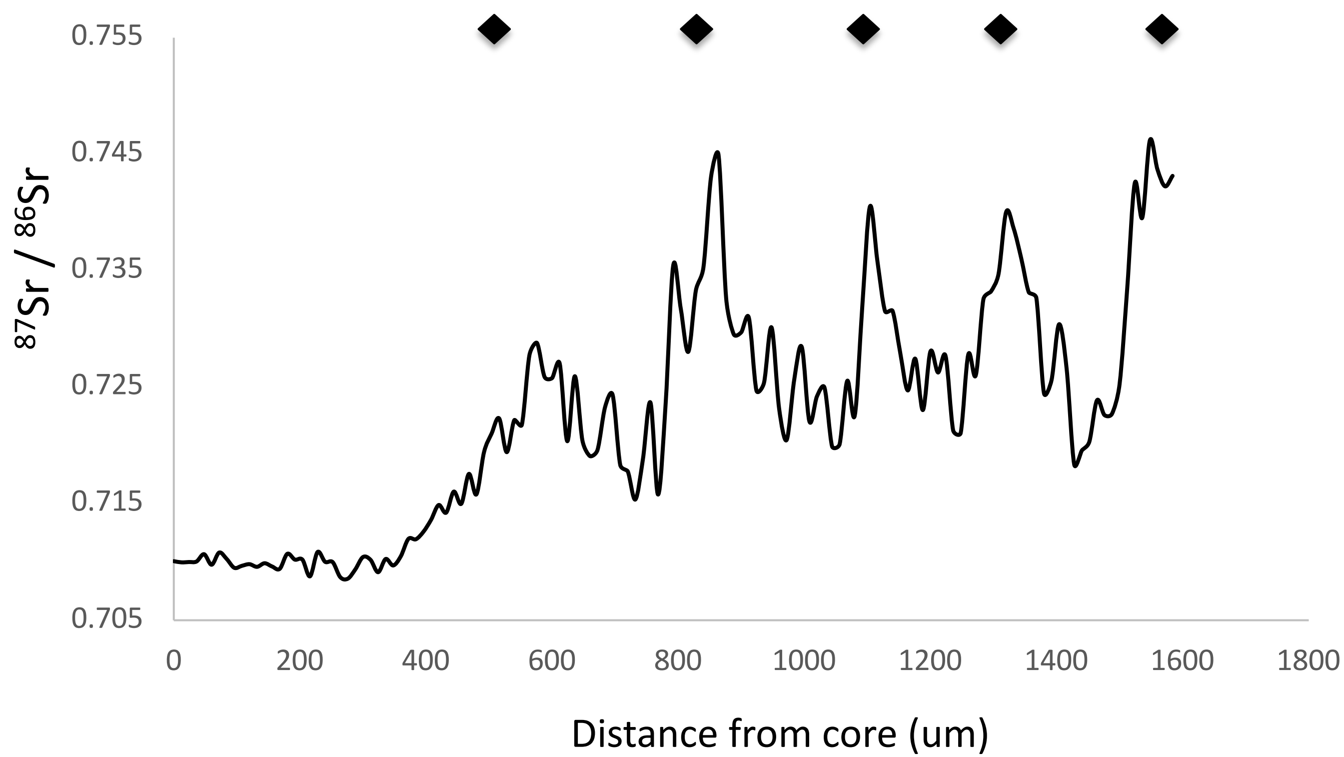
Temporal stability of water Sr signatures

Sr concentration



Temporal stability of water Sr signatures

- There is potential for strong temporal variation in water Sr signatures, especially where there is significant groundwater input
- Caution is needed when interpreting otolith chemistry data
- Need data on water chemistry over time



Acknowledgments

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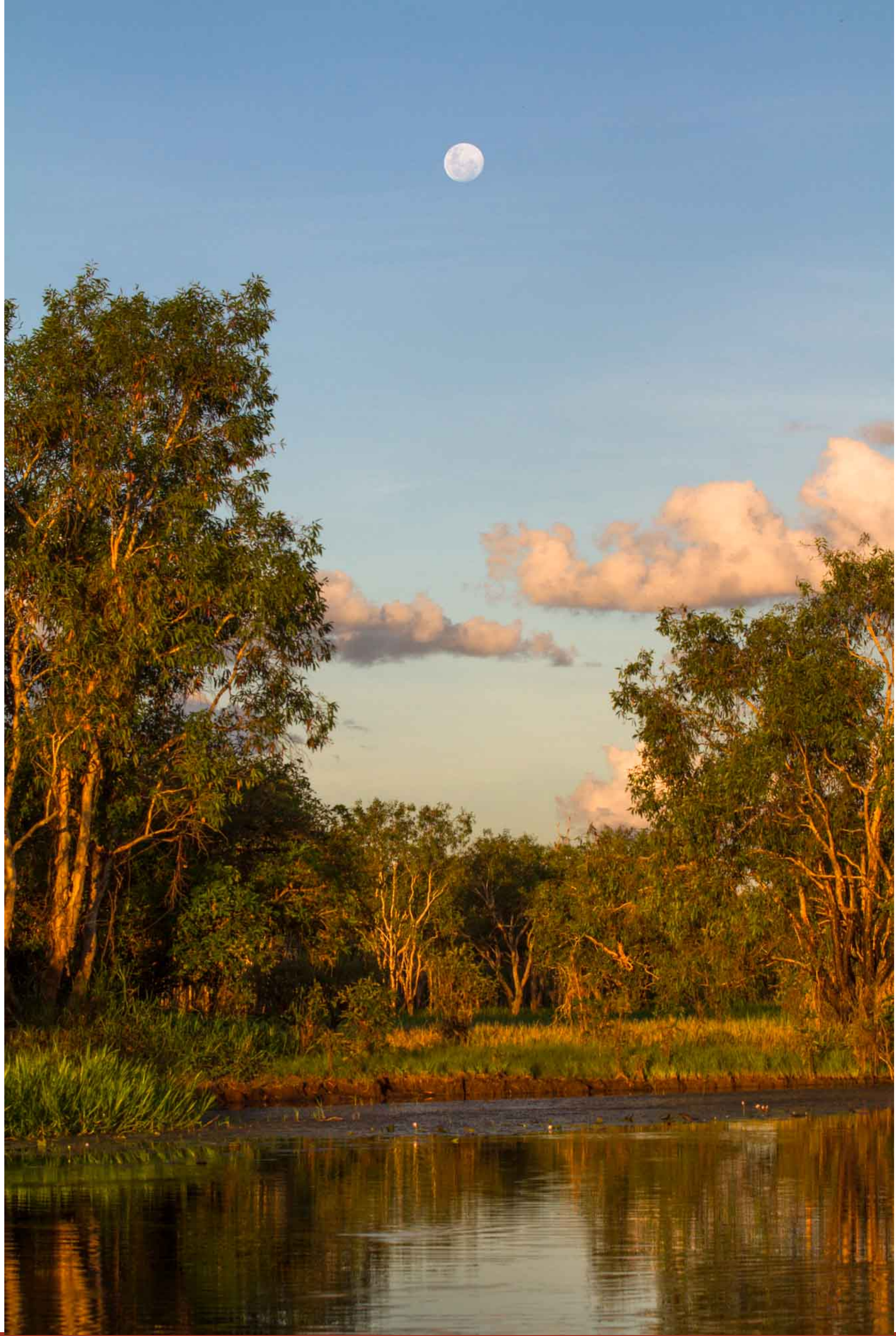

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