How important are freshwater flows for Gulf estuaries? A study of the effect on fisheries & endangered species

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Australian Rivers Institute

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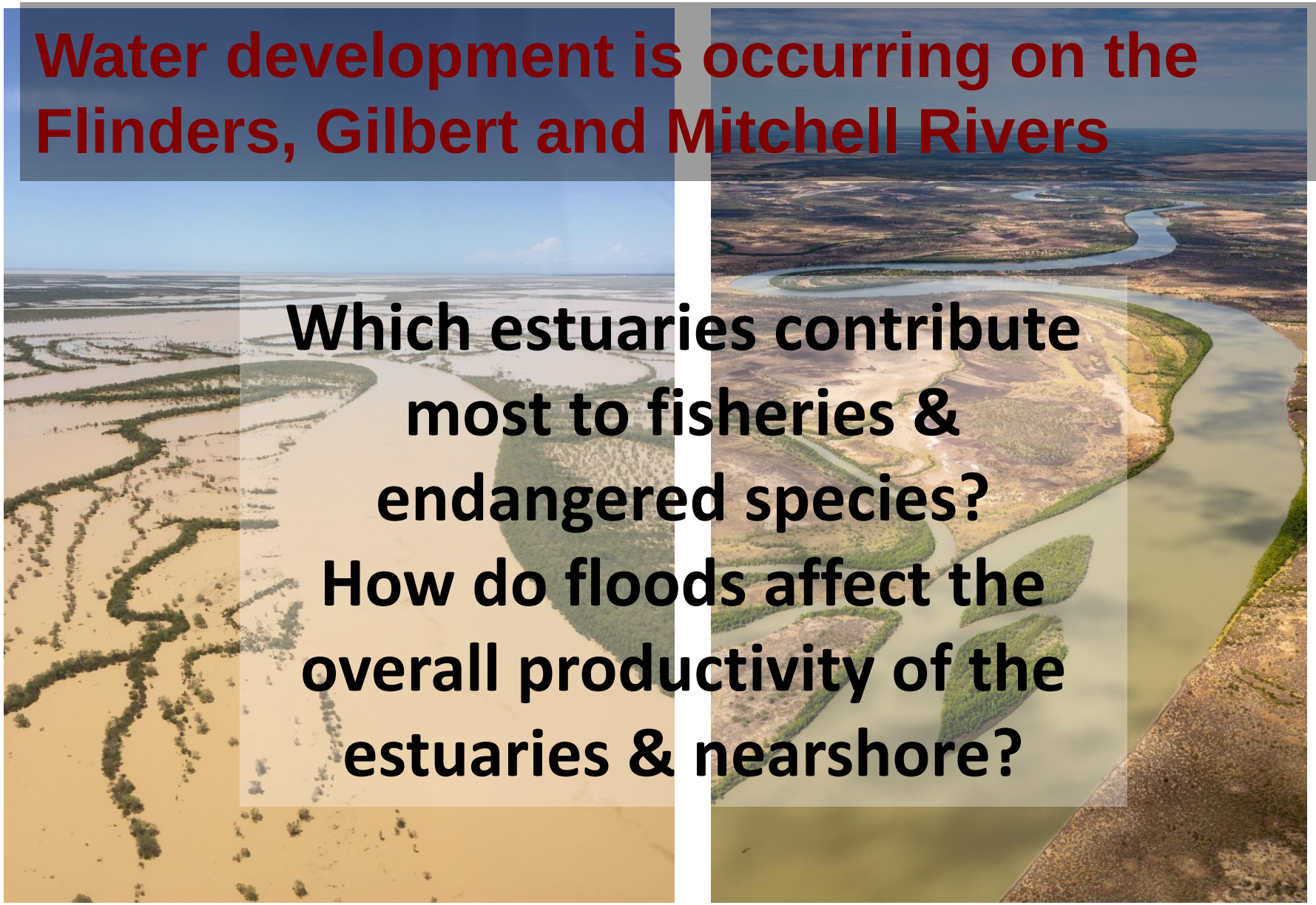
Northern Australia Environmental Resources Hub

National Environmental Science Programme

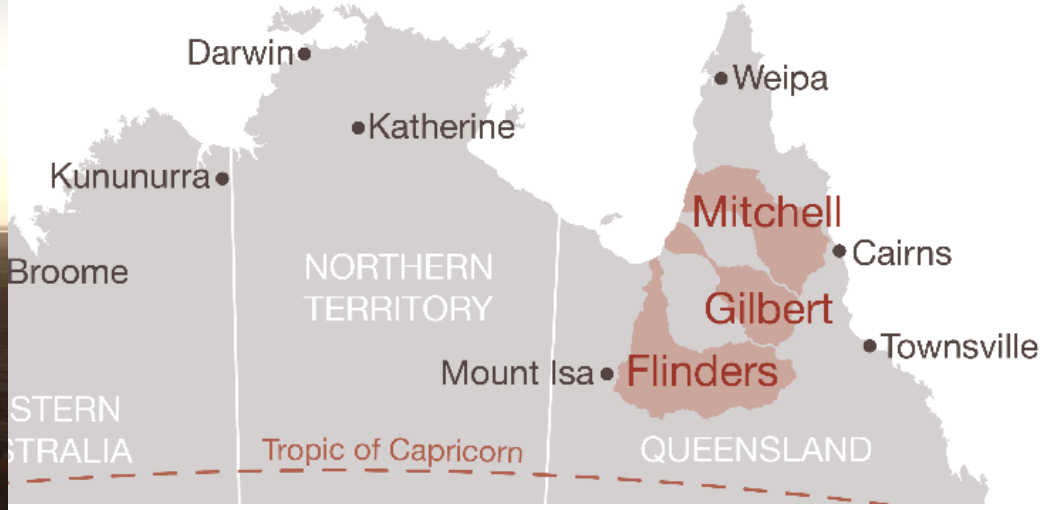
Water development is occurring on the Flinders, Gilbert and Mitchell Rivers



Which estuaries contribute most to fisheries & endangered species?

How do floods affect the overall productivity of the estuaries & nearshore?

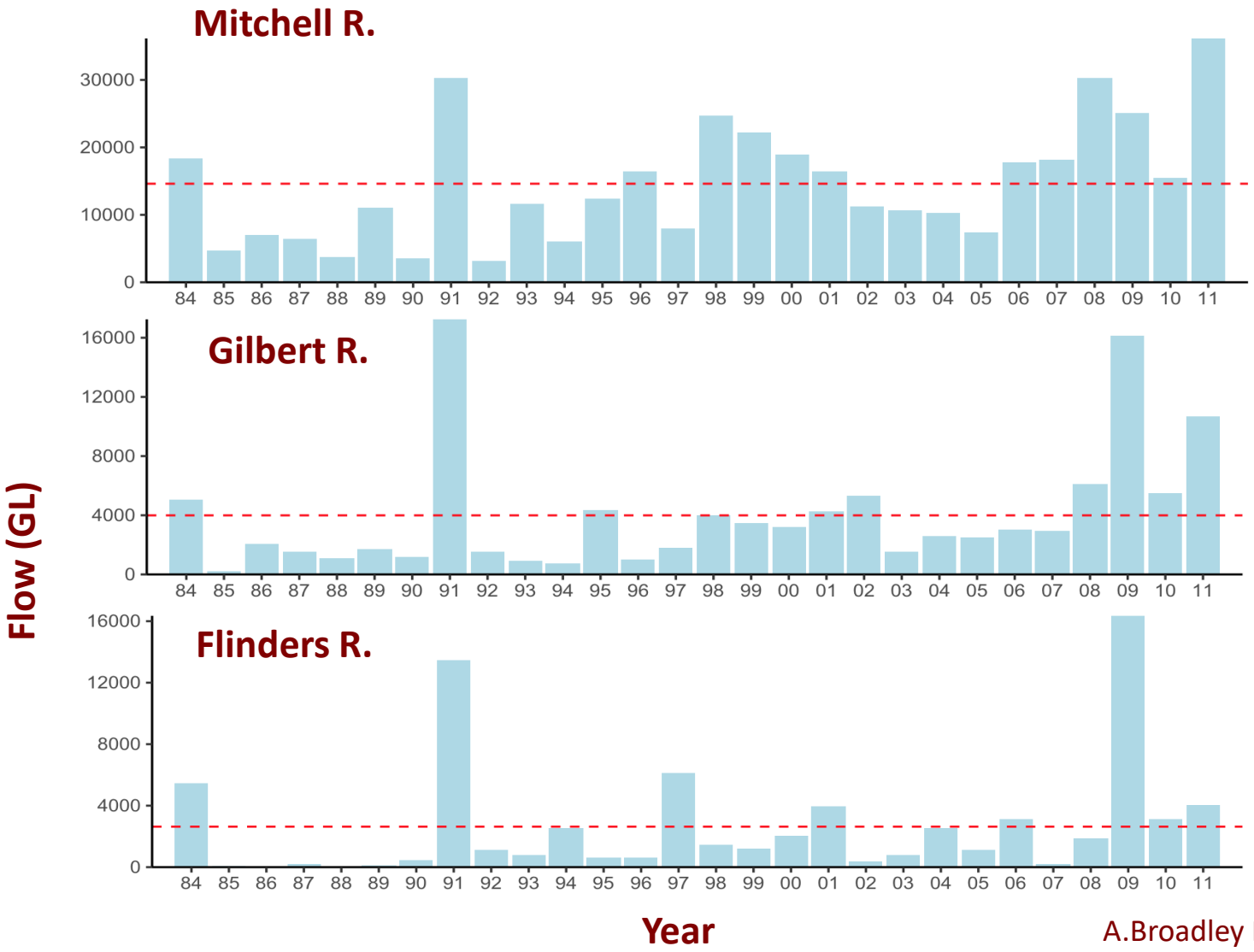

Mitchell River


Darwin
Katherine
Kununurra
Broome
NORTHERN TERRITORY
Weipa
Mitchell
Cairns
Gilbert
Townsville
Mount Isa
Flinders
Tropic of Capricorn
QUEENSLAND


Gilbert River

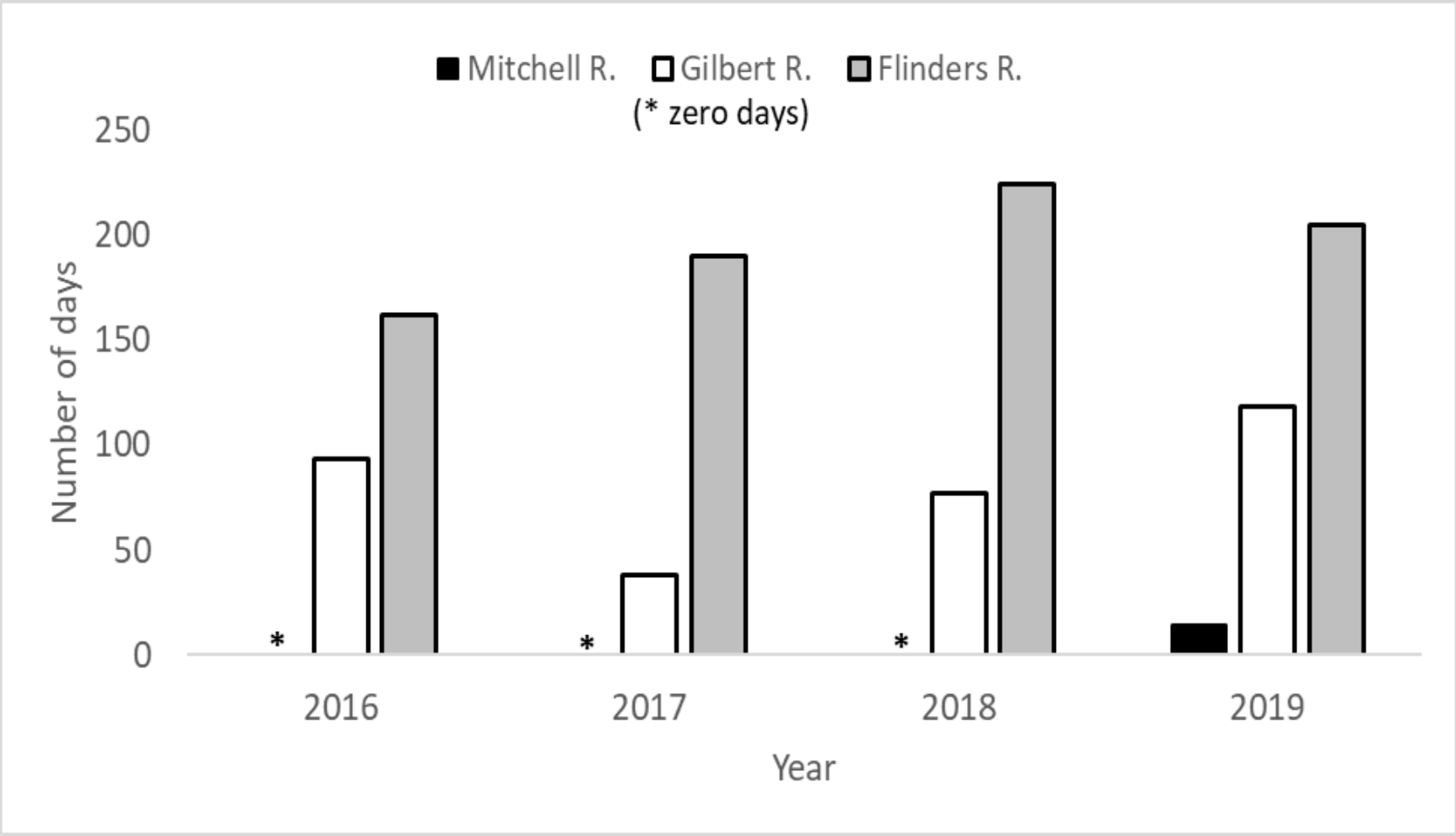

Flinders River

Annual flow



A.Broadley PhD student
CSIRO data

Number of cease-to-flow days



Importance of southern Gulf for shorebirds

2nd most important shorebird site of International importance in Australia

50% (ca. 2,000,000) use Gulf from Oct-March

Endangered & critically endangered species

East-Asian Australasian Flyway

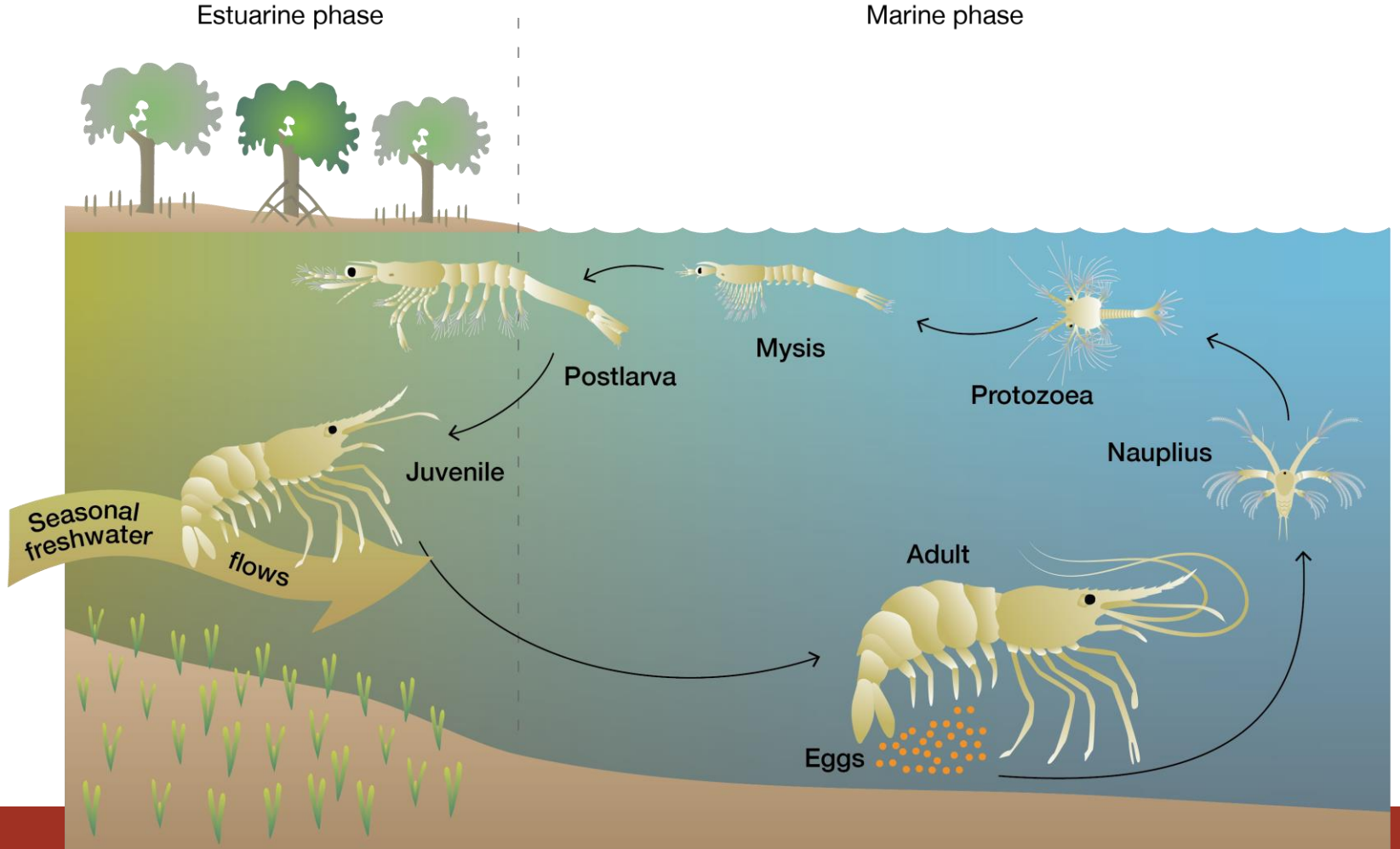
Bamford et al. 2008

Commercial barramundi fishery

$15 million catch revenue in 2017 (Qld DAF)

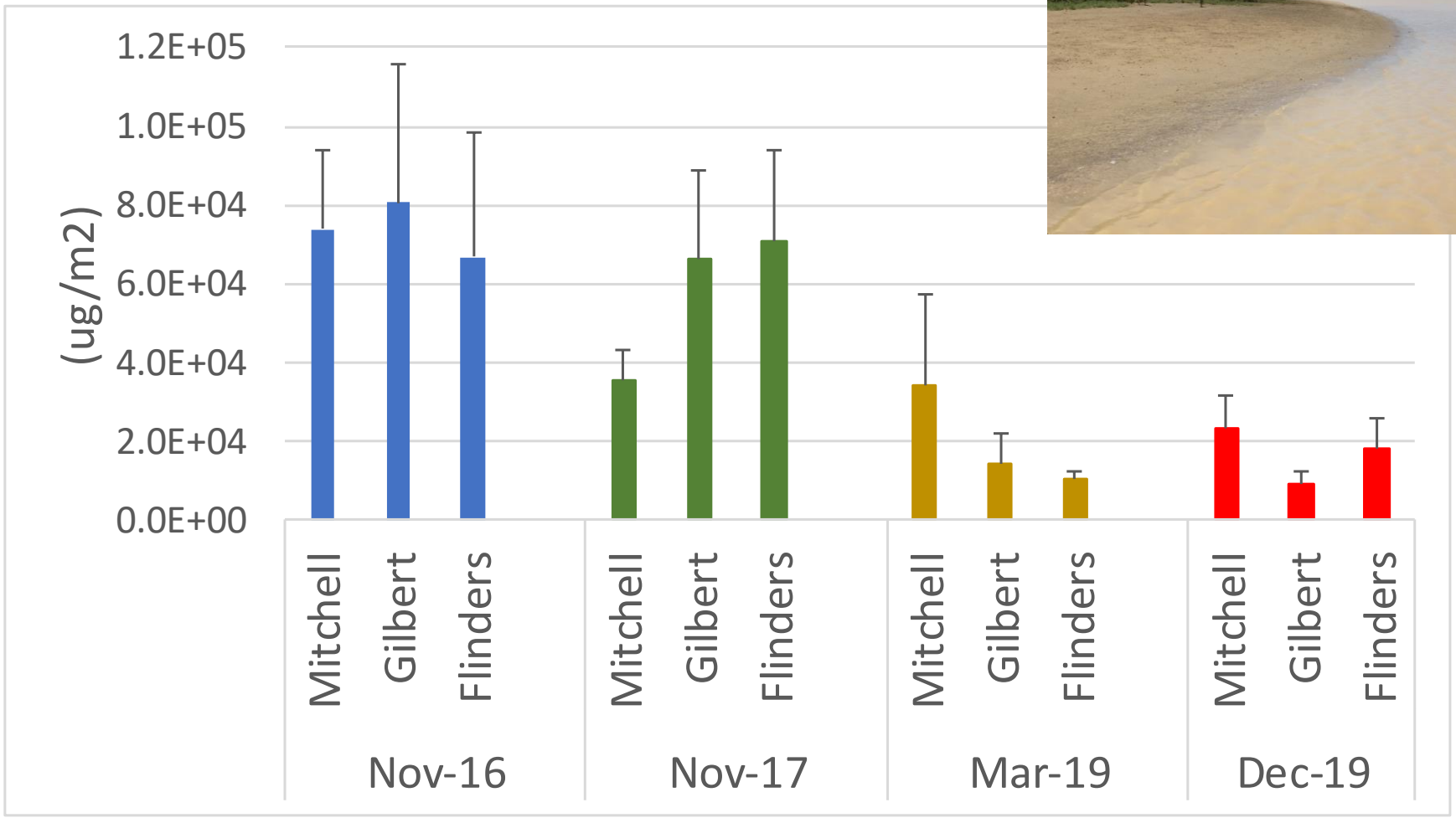
Banana prawn fishery is major industry in Gulf

$217 million catch revenue in 2017 (AFMA)

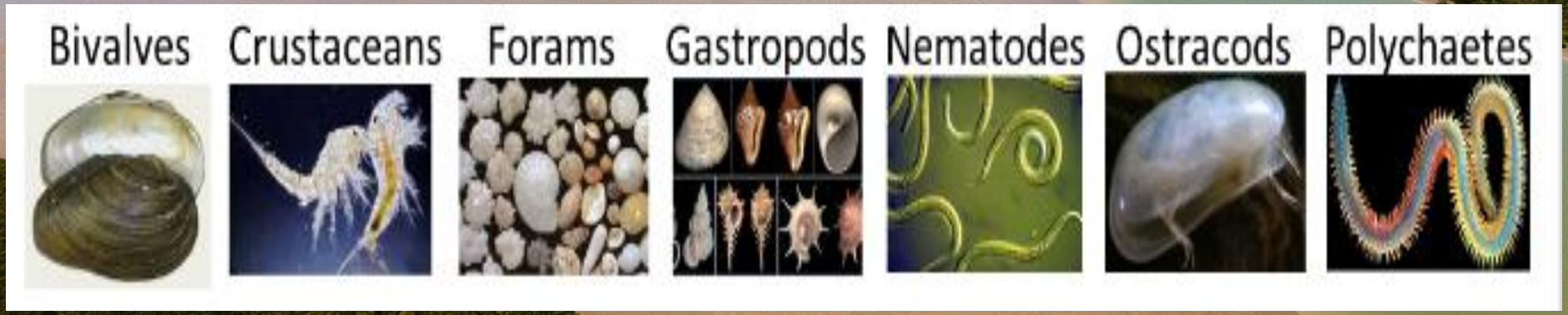


How does flow affect food supply?

Benthic algae - no difference in biomass between estuaries



Food for prawns and shorebirds



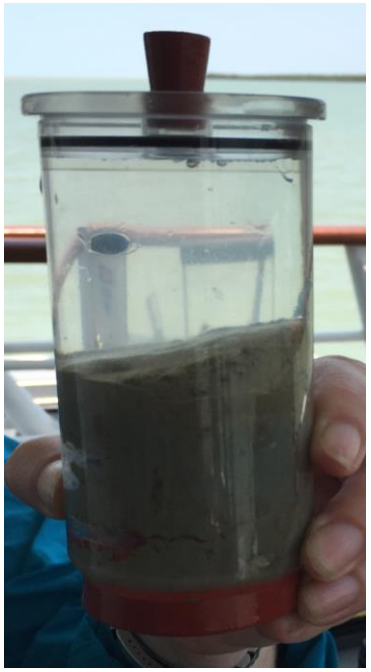
High abundance of benthic animals – polychaetes dominate

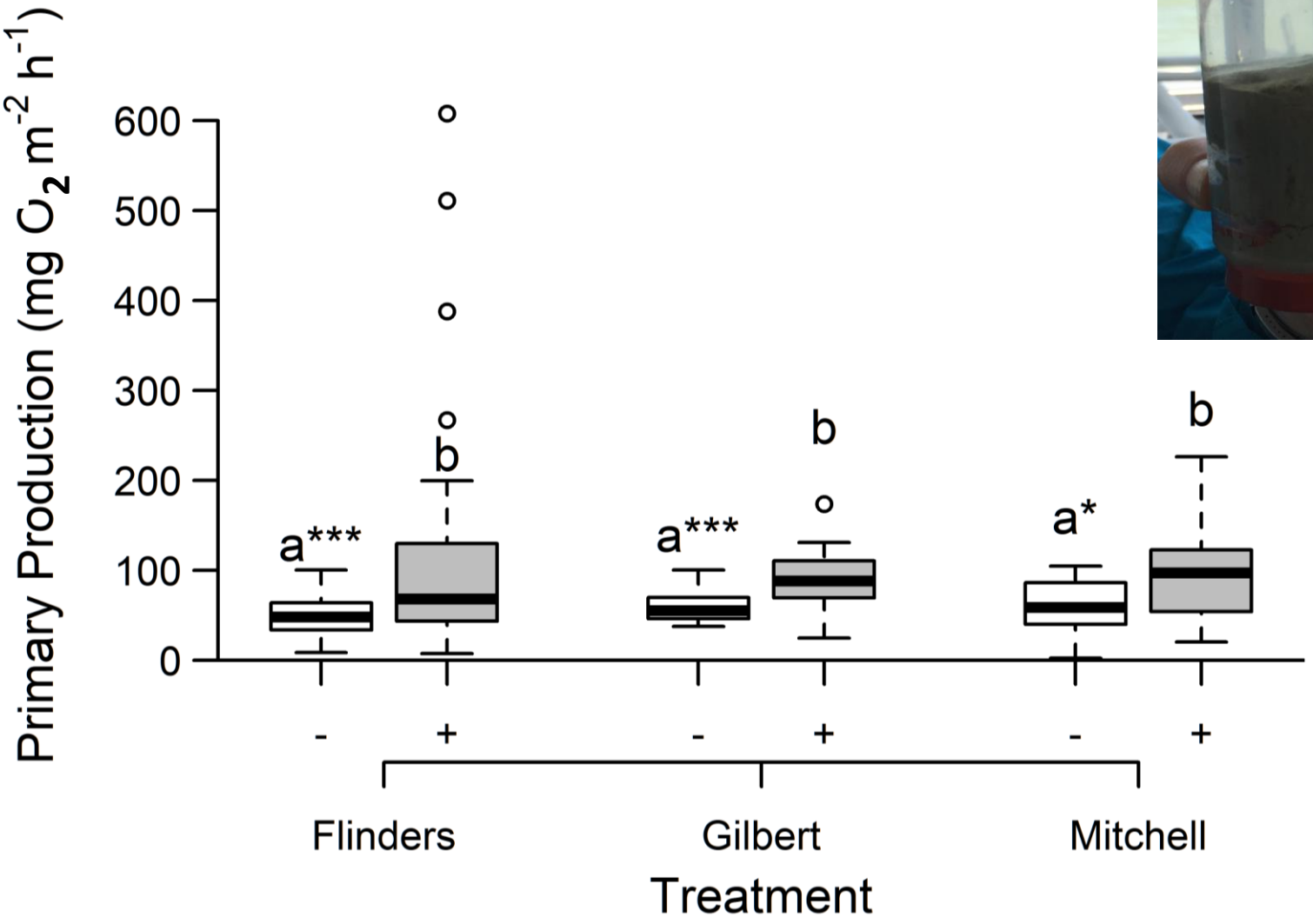
No differences in numbers between estuaries

Numbers drop in floods

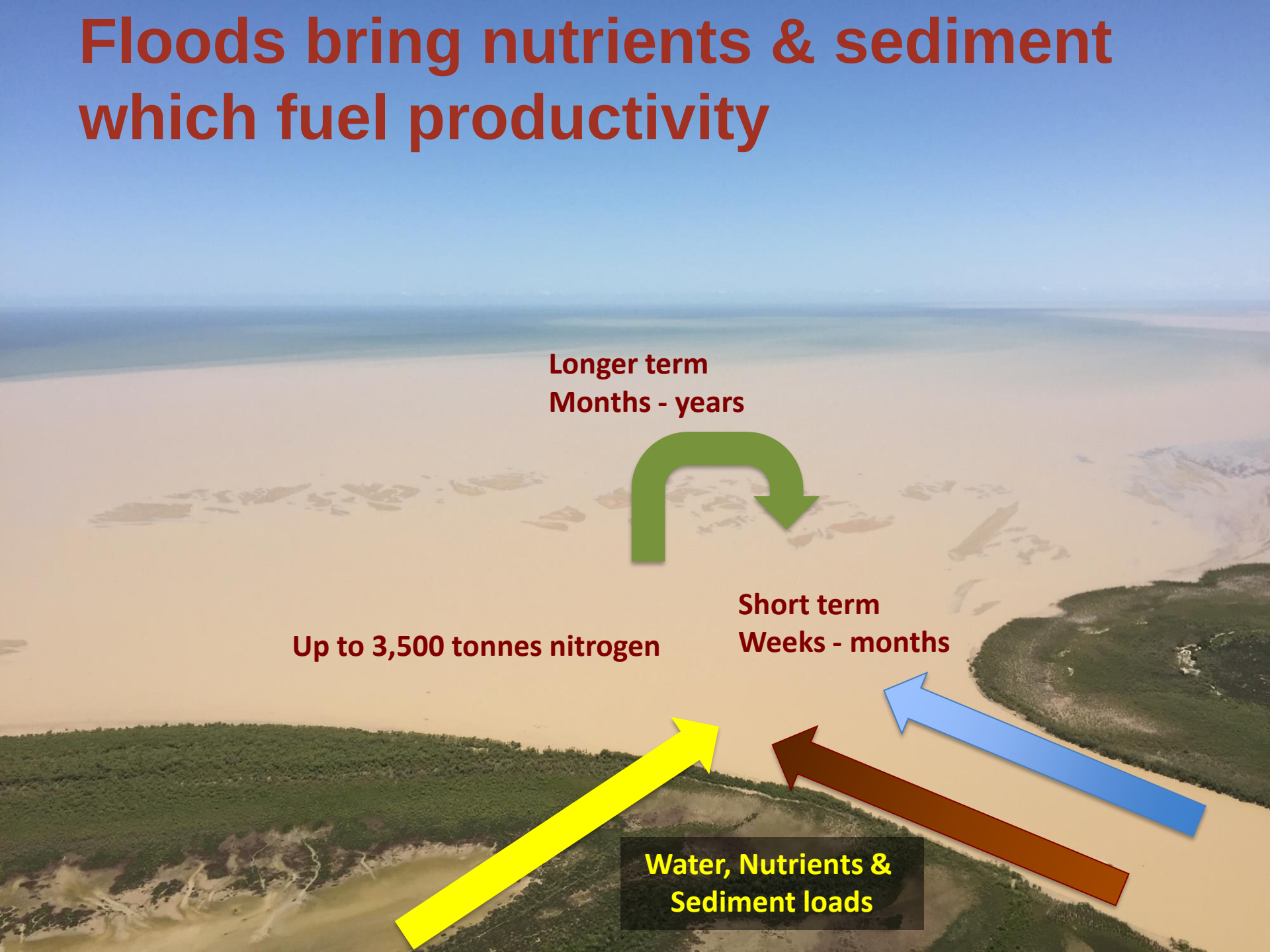
Vikki Lowe, honours student

Nutrients critical for algae to grow





Floods bring nutrients & sediment which fuel productivity



Why are estuaries so productive?

Harsh environment, dry most of the year with little flow

Lacks extensive mangrove areas

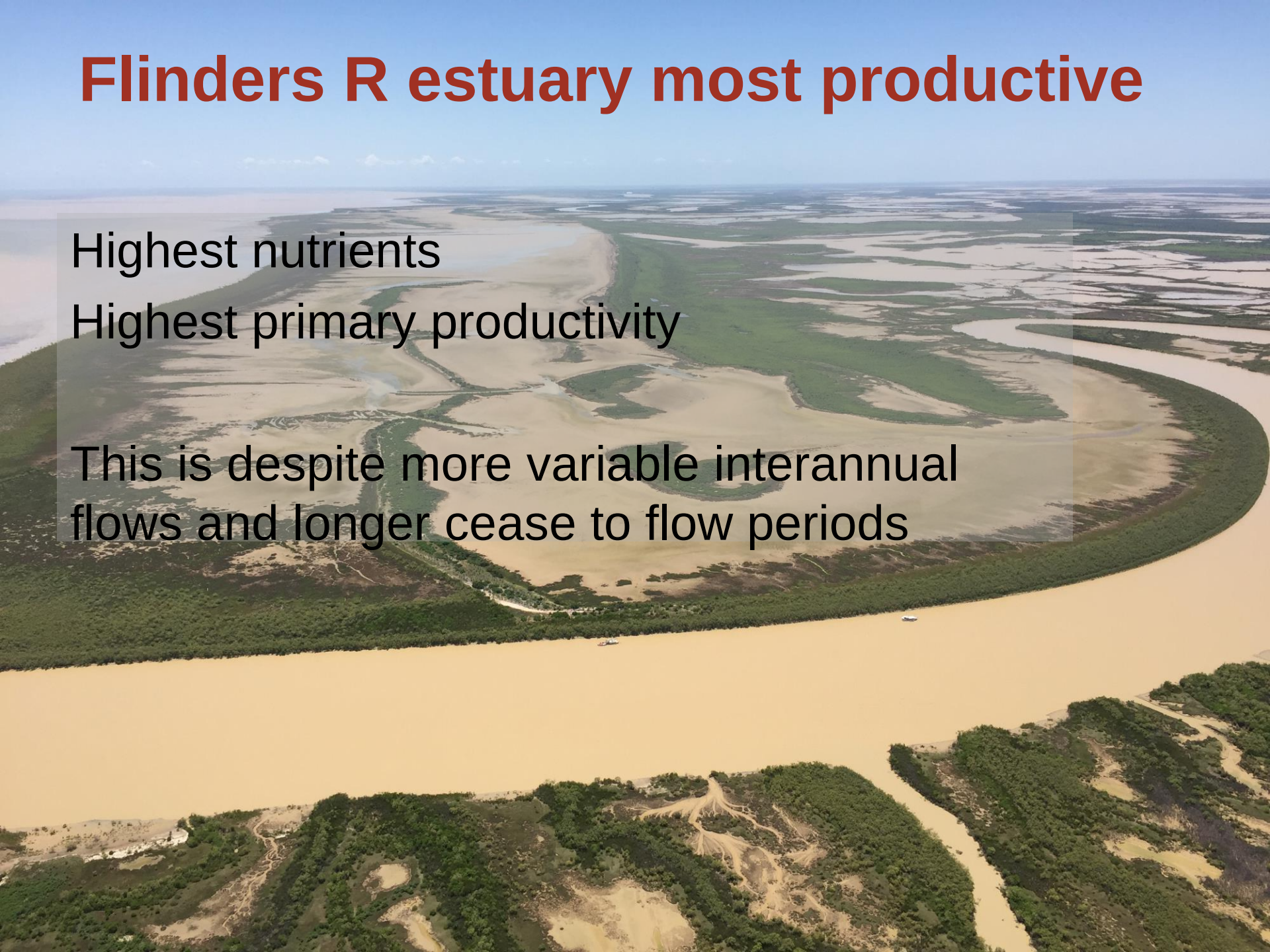
Coastal waters are low in nutrients

Rivers have massive catchments

Significant loads of sediment and nutrients enter estuaries and nearshore in floods

Saltflats are an important source of nutrients

Flinders R estuary most productive



Highest nutrients

Highest primary productivity

This is despite more variable interannual flows and longer cease to flow periods

Gilbert & Mitchell R
Low tide feeding sites

Internationally significant (>1%)

- Black-tailed Godwit

Nationally significant (>0.1%)

- Red Neck Stint
- Bar-Tailed Godwit
- Greater Sandplover
- Lesser Sandplover
- Sharp-tailed Sandpiper
- Whimbrel
- Eastern Curlew

Hansen et al. 2016

Queensland Wader Study Group

Carpentaria Land Council Aboriginal Corporation – Flinders shorebird counts

January 2019

15,090

March 2019

2513

September 2019

12,591

April 2020

1,130*

***COVID-19 restrictions**

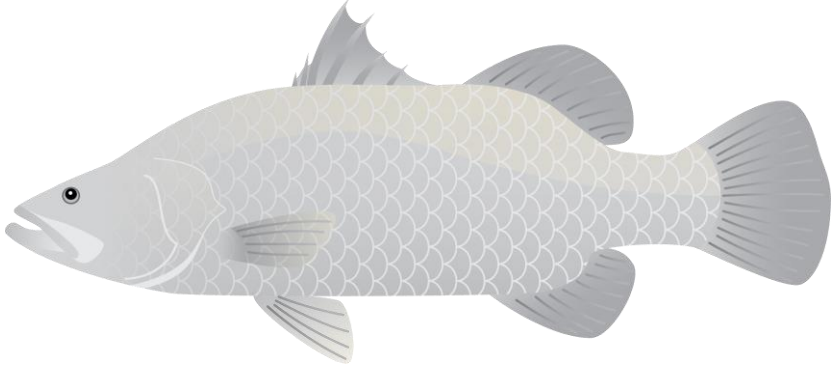
Flinders R
High tide roost sites

Internationally significant

- **Great Knot**
- **Red Knot**
- **Black tailed Godwit**
- Bar Tailed Godwit
- Curlew sandpiper
- Eastern Curlew
- Greater & Lesser Sand Plovers

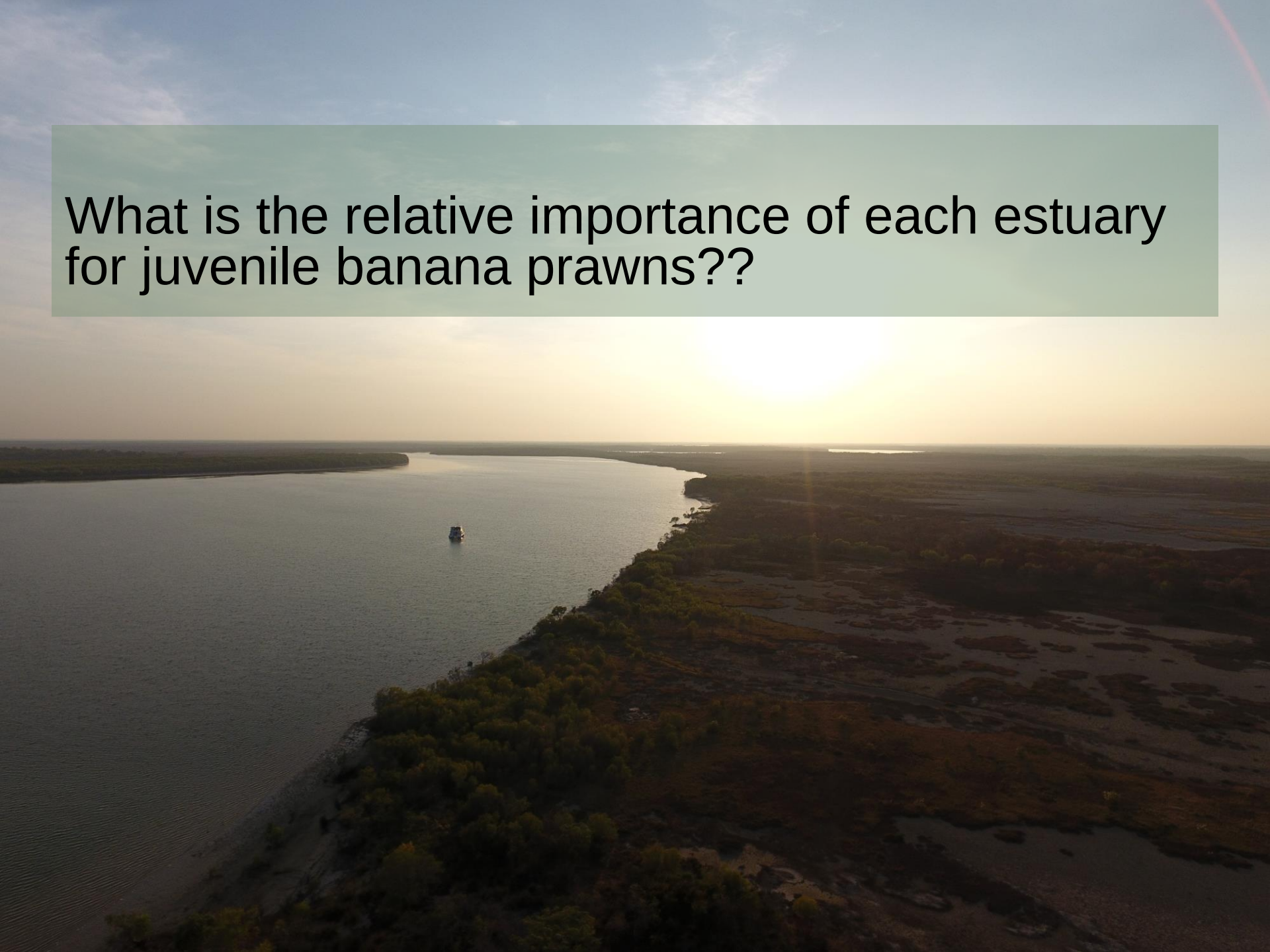
Carpentaria Land Council Aboriginal Corporation

Barramundi findings



- Sequential pattern of river flow over multiple years is an important driver of barramundi population dynamics
- Therefore long term effects of extraction important
- Growth rates linked to flow. More extraction equals smaller fish
- All rivers important to barramundi stocks
- Economic modelling shows that water extraction will affect profitability of fishery

McMahon et al. 2020 NESP report
Robins et al. 2020 NESP report



What is the relative importance of each estuary for juvenile banana prawns??

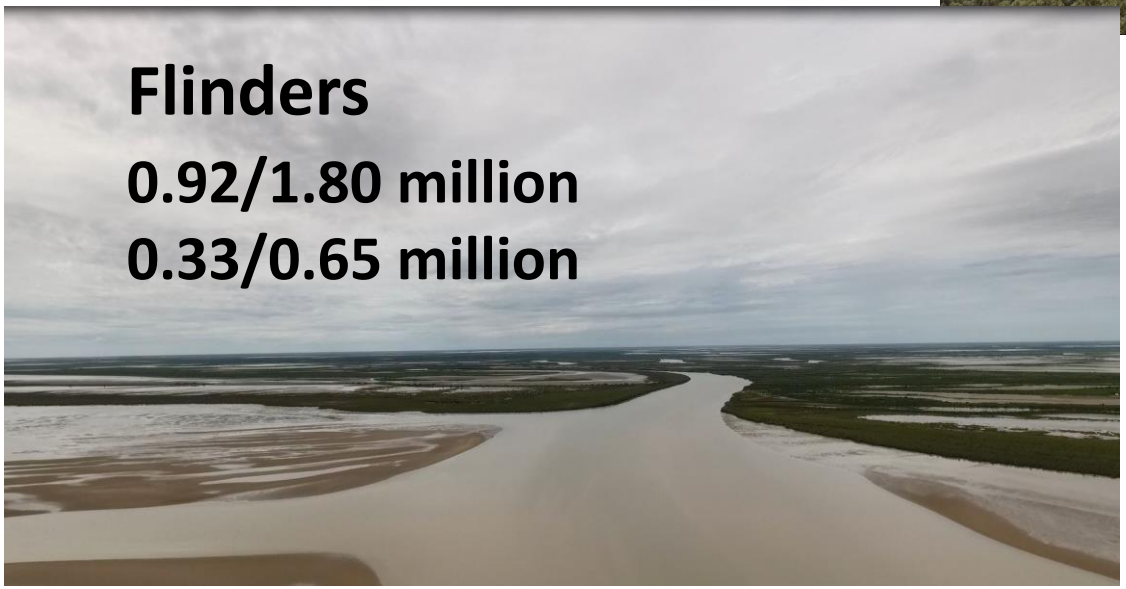
World-class research to support sustainable development in northern Australia

How many prawns in each estuary in Nov 2016?

Rob Kenyon
CSIRO

Stephen Faggotter
Griffith Uni

How many prawns in each estuary in Nov 2017?

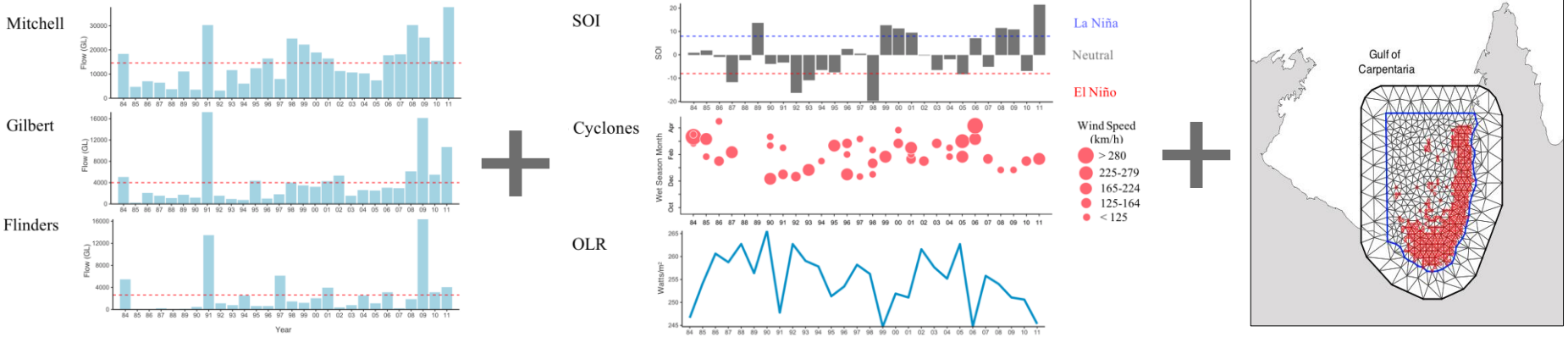


Modelled drivers of banana prawn catch

River flows

Climate indices

Spatial effect



- Used to predict reported weekly banana prawn catches at
- 6 n.m. resolution over period 1984 – 2011
- Calibrated against log book data; checked using cross-validation

Predicting impacts of extractions

- Used EOS flow data from 1900 to 2011 to categorise flow into low, med, high scenarios

Scenario	Flinders	Gilbert	Mitchell	1900-2011	%	1984-2011	%
1	low	low	low	25	22	5	18
2	low	low	medium	11	10	4	14
3	high	high	high	10	9	3	11
4	low	medium	high	7	6	3	11
5	medium	medium	medium	13	12	2	7
6	low	medium	low	6	5	2	7
7	medium	high	high	6	5	2	7
8	medium	medium	high	5	4	2	7
				83	74	23	85

Extraction scenarios modelled

Impact of three extraction scenarios on banana prawn catch were modelled:

Scenario A: Granted entitlements

Scenario B: Planned allocations + Granted entitlements

Scenario C: Mitchell in-stream dams + Planned allocations + Granted entitlements

Predicted declines in catch: Scenario A Granted entitlements

Low-low-low
18% of the time

Flow pattern	Flinders		Gilbert		Mitchell		Decline in catch	
	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	%	Tonnes (CI 95%)
1	**Low**	**540-334**	**Low**	**1,221-1,100**	**Low**	**4,975-4,955**	**4.9**	**52.2 (45.3-59.9)**
2	Low	540-334	Low	1,221-1,100	Medium	12,946-12,926	2.7	34.7 (30.4-39.5)
3	Low	540-334	Medium	3,734-3,613	High	21,022-21,002	1.9	51.6 (44.7-59.1)
4	Medium	2,883-2,677	Medium	3,734-3,613	Medium	12,946-12,926	3.7	72.7 (51.1-102.0)
8	High	7,113-6,907	High	8,231-8,110	High	21,022-21,002	0.7	22.5 (16.7-35.4)
10	Very high	18,234-18,028	Very high	22,716-22,595	Very high	38,467-38,447	0.1	5.2 (3.4 -15.9)

Broadley, A., Stewart-Koster, B., Kenyon, R.A., Burford, M.A., Brown, C.J. 2020. *Ecosphere,* 11, e03194

Predicted declines in catch: Scenario B Planned allocations + Granted entitlements

Flow pattern	Flinders		Gilbert		Mitchell		Decline in catch	
	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	%	Tonnes (CI 95%)
1	**Low**	**540-274**	**Low**	**1,221-732**	**Low**	**4,975-4,905**	**17.3**	**184.5 (161.7-209.9)**
2	Low	540-274	Low	1,221-732	Medium	12,946-12,876	13.8	178.9 (155.2-206.0)
3	Low	540-274	Medium	3,734-3,245	High	21,022-20,952	12.4	197.5 (169.2-228.9)
4	Medium	2,883-2,617	Medium	3,734-3,245	Medium	12,946-12,876	14.3	226.3 (199.4-256.9)
8	High	7,113-6,847	High	8,231-7,742	High	21,022-20,952	1.2	38.8 (22.6-62.0)
10	Very high	18,234-17,968	Very high	22,716-22,227	Very high	38,467-38,397	0.7	26.1 (9.8-51.8)

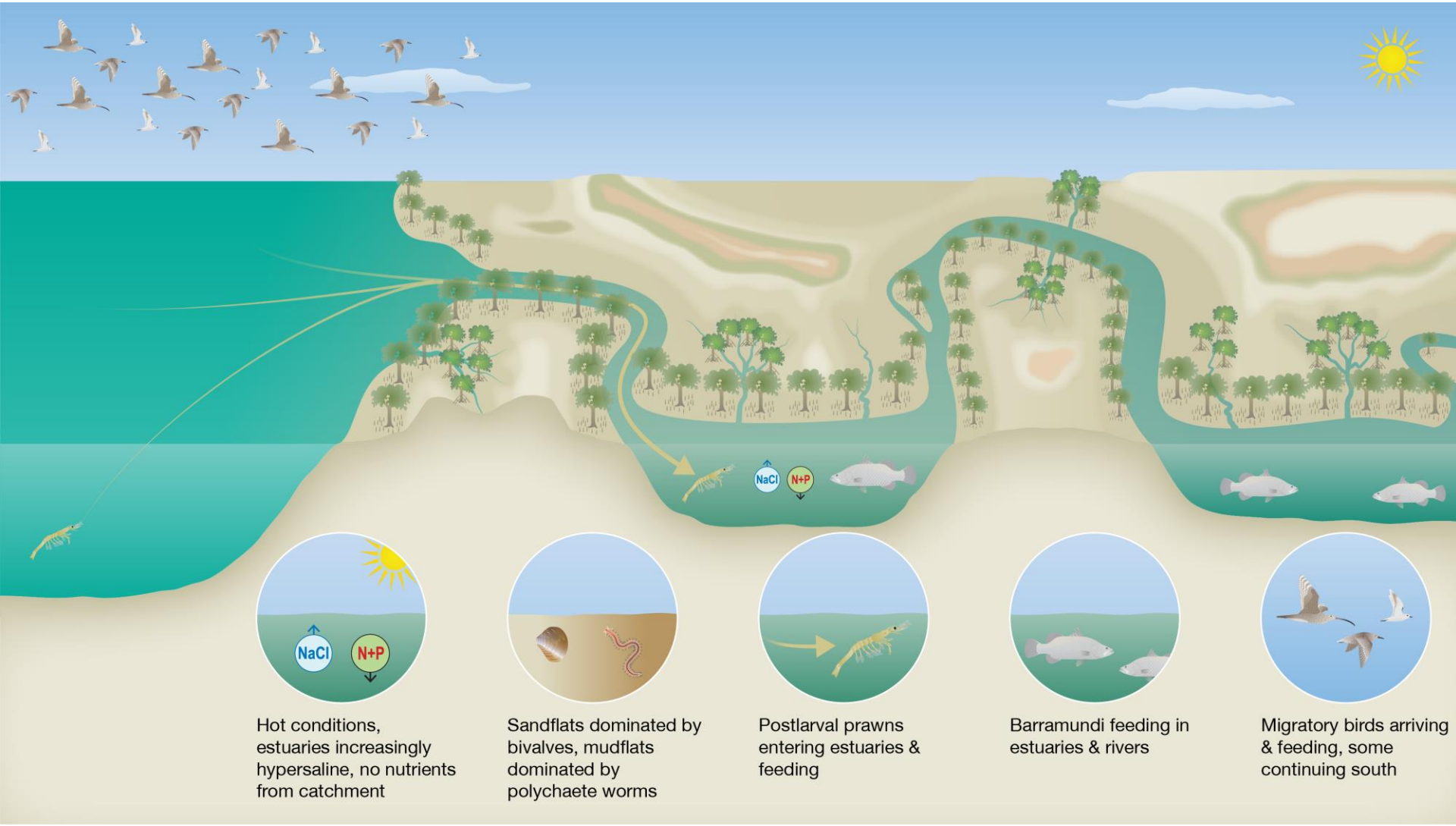
Predicted declines in catch: Scenario C Mitchell dams + Planned allocations + Granted Entitlements

Flow pattern	Flinders		Gilbert		Mitchell		Decline in catch	
	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	Flow	Change in mean flow (GL)	%	Tonnes (CI 95%)
1	**Low**	**540-274**	**Low**	**1,221-732**	**Low**	**4,975-1,550**	**53.2**	**568.5 (498.8-646.3)**
2	Low	540-274	Low	1,221-732	Medium	12,946-9,521	28.8	373.5 (323.8-430.1)
3	Low	540-274	Medium	3,734-3,245	High	21,022-17,597	23.4	371.4 (313.3-436.8)
4	Medium	2,883-2,617	Medium	3,734-3,245	Medium	12,946-9,521	27.0	425.7 (376.1-482.0)
8	High	7,113-6,847	High	8,231-7,742	High	21,022-17,597	9.4	305.3 (223.3-414.4)
10	Very high	18,234-17,968	Very high	22,716-22,227	Very high	38,467-35,042	9.0	348.7 (227.2-524.2)

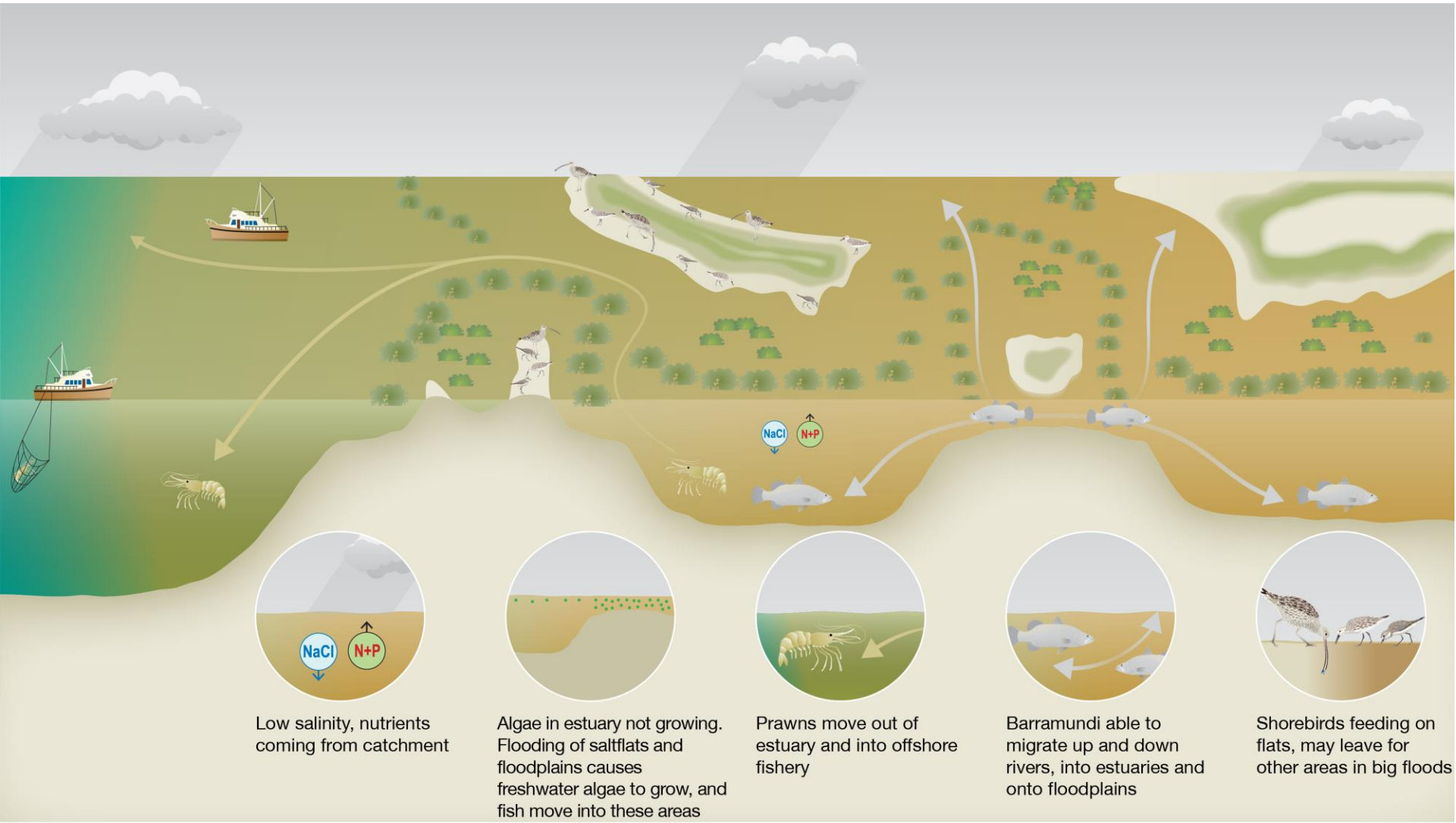
Summary – modelling fishery effects

- Years of low flow in all three rivers lead to greatest impact on catch
- Highlights importance of multiple rivers to support fishery
- Key knowledge gap on actual end of system flows (and limited gauging throughout these rivers)

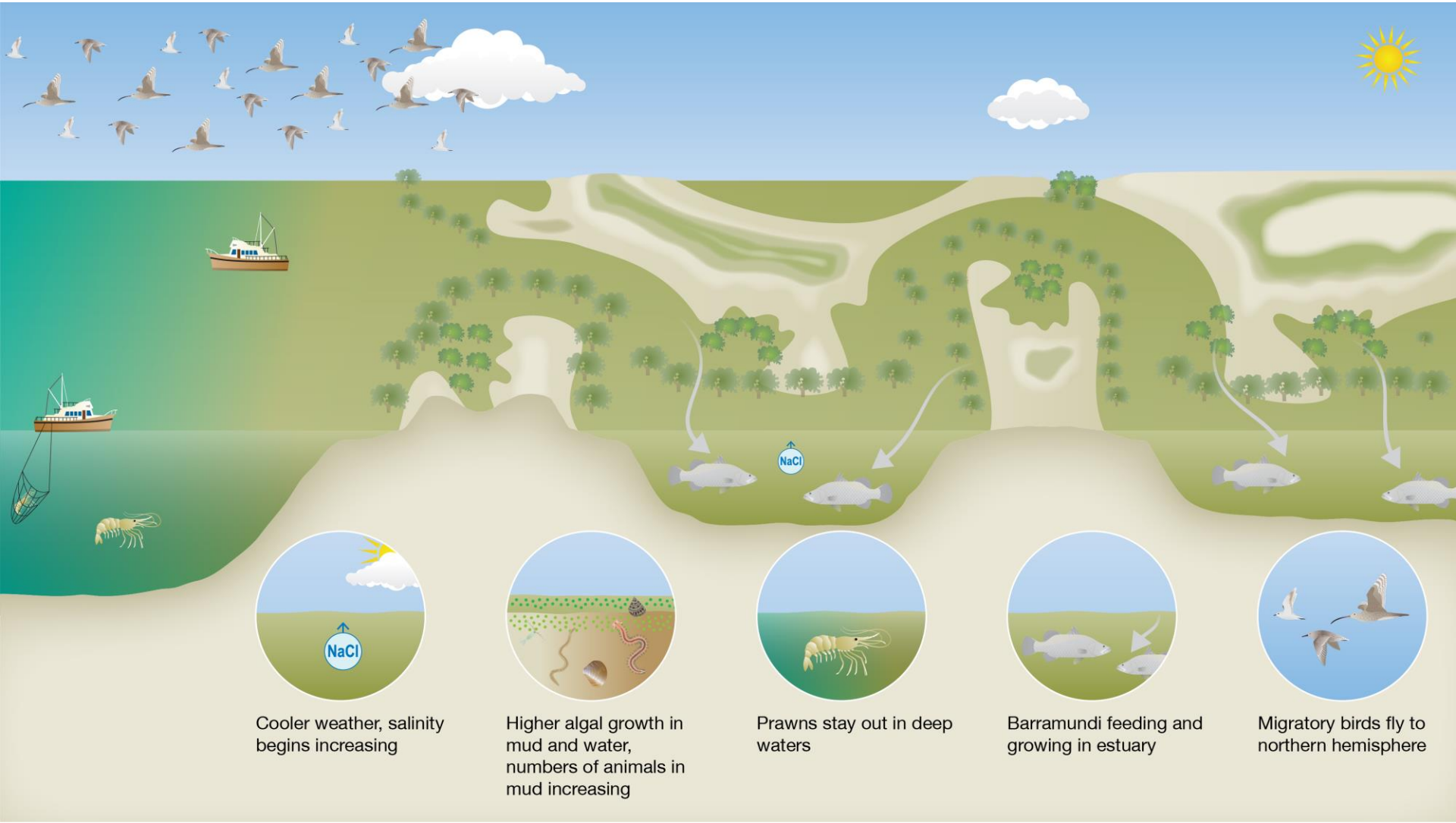
Late dry season



Wet season


NaCl
N+P
NaCl
N+P
Low salinity, nutrients coming from catchment
Algae in estuary not growing. Flooding of saltflats and floodplains causes freshwater algae to grow, and fish move into these areas
Prawns move out of estuary and into offshore fishery
Barramundi able to migrate up and down rivers, into estuaries and onto floodplains
Shorebirds feeding on flats, may leave for other areas in big floods

Post wet season



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CSIRO

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