One-way traffic: Black Bream passage through a storm surge barrier

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Natural Resource Management in Western Australia
Government of Western Australia

GeoCatch

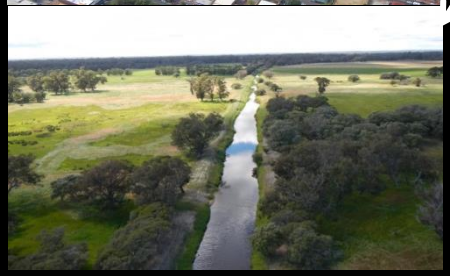
Department of Fisheries
Department of Water
Department of Parks and Wildlife
Government of Western Australia

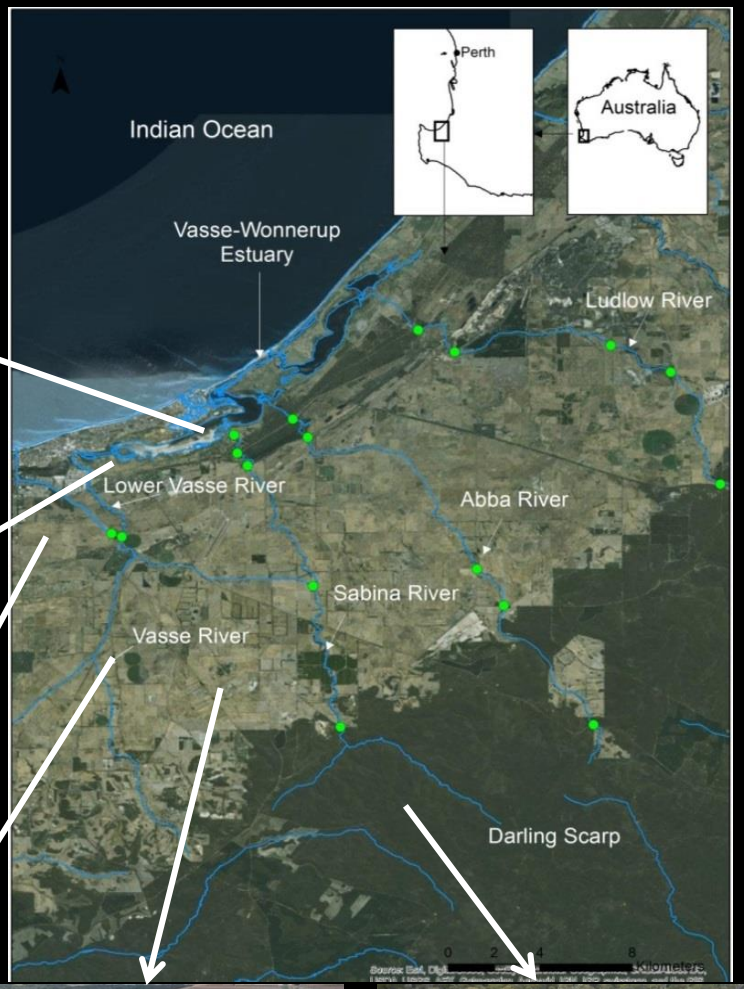
Overview

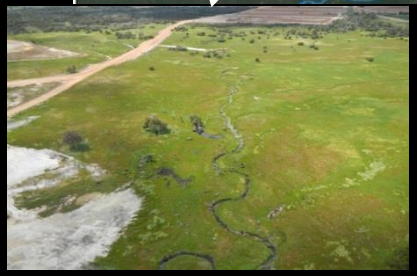
- Background
- Aims
- Methods
- Results
  - Environmental variables
  - Acoustic detection summary
  - Bream movement and key habitats
  - Conditions of Bream passage
- Summary and implications

Background

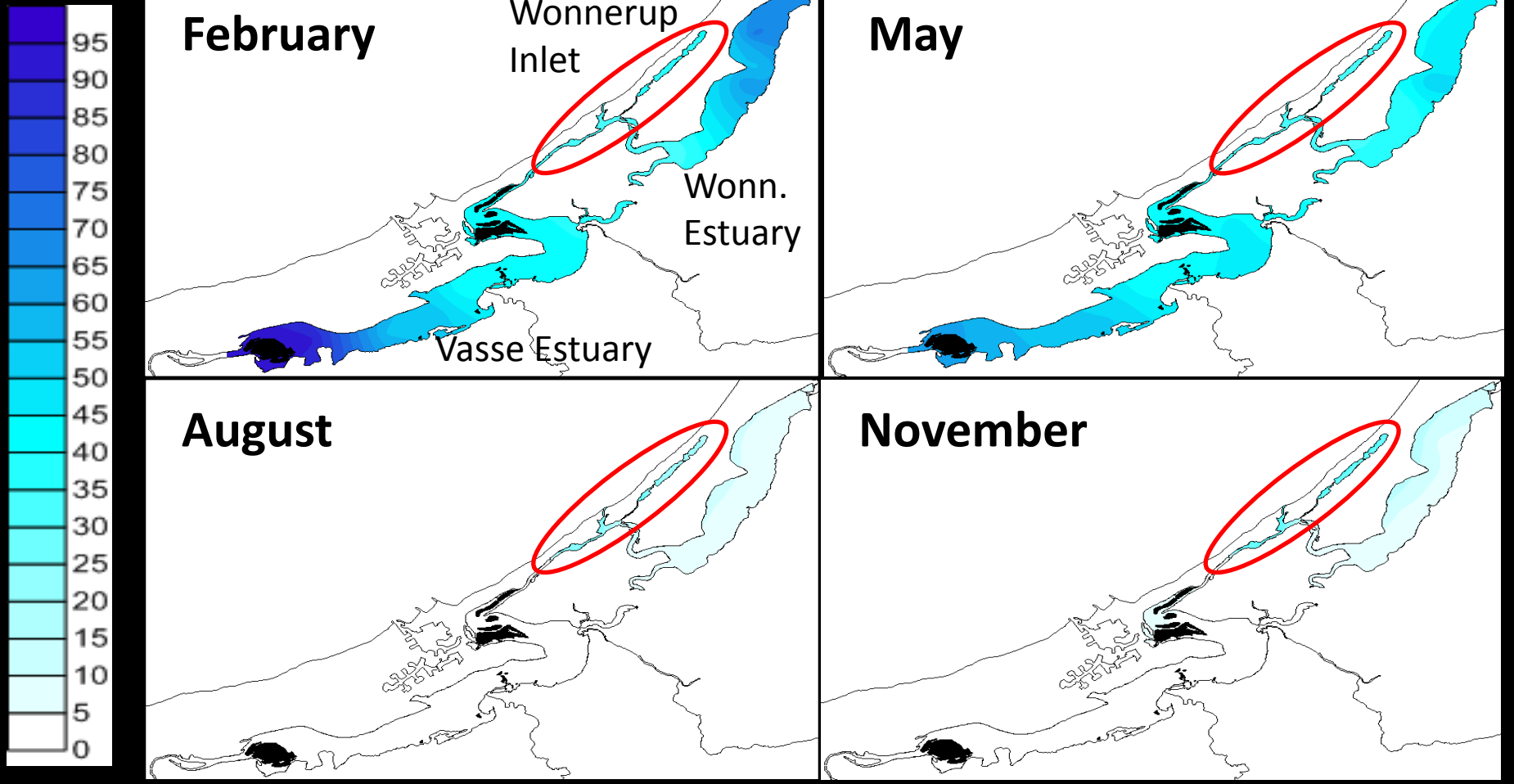
- Small (12 km^2) shallow <3m
- Intermittently-open to the ocean
- Ramsar listed (37k birds from 90 species)
- Highly regulated '*the most grossly enriched major wetland in WA*'
- Very little information on the fishes
- Two surge barriers (only three in WA)





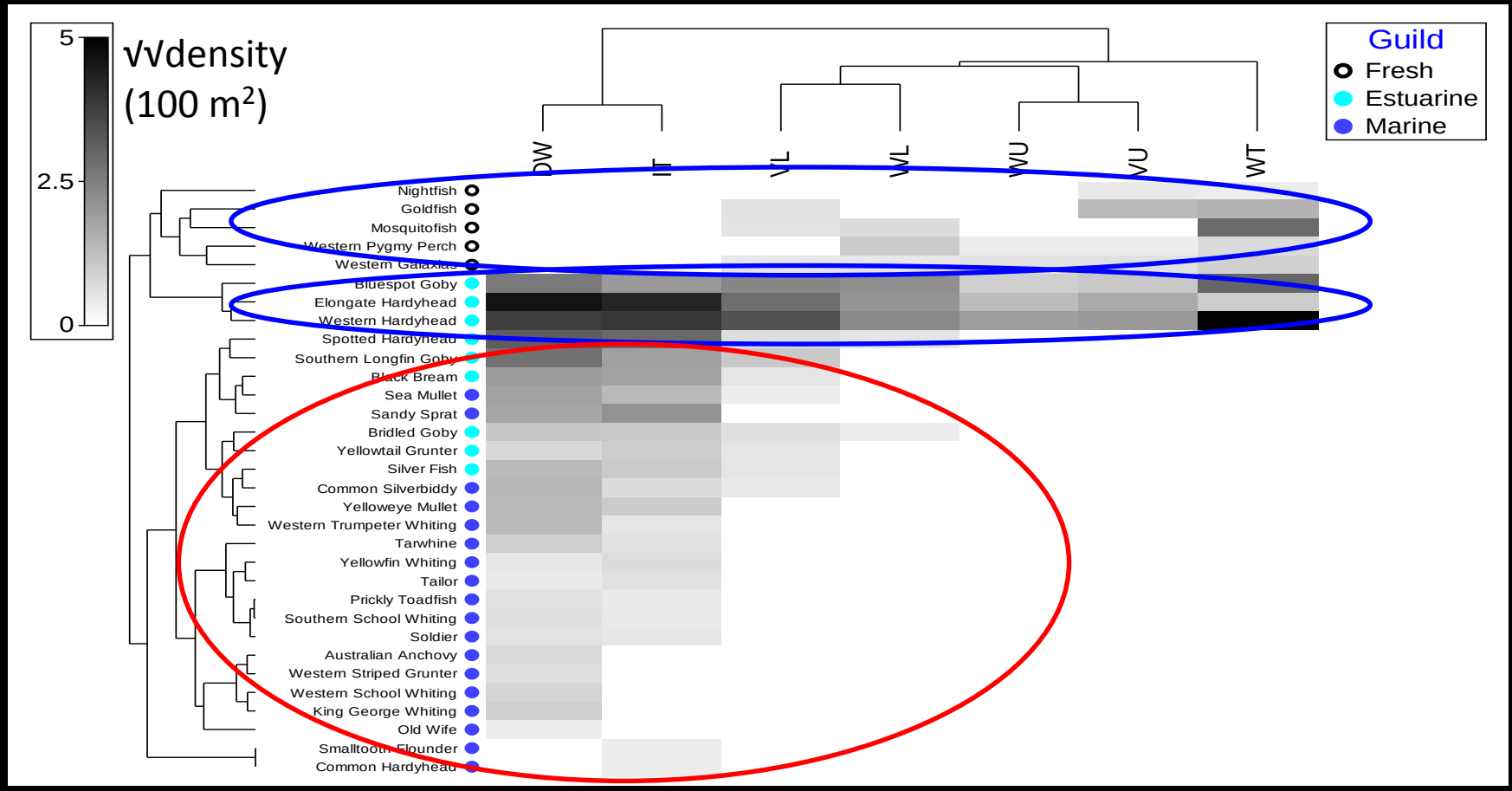


Extreme salinity variation



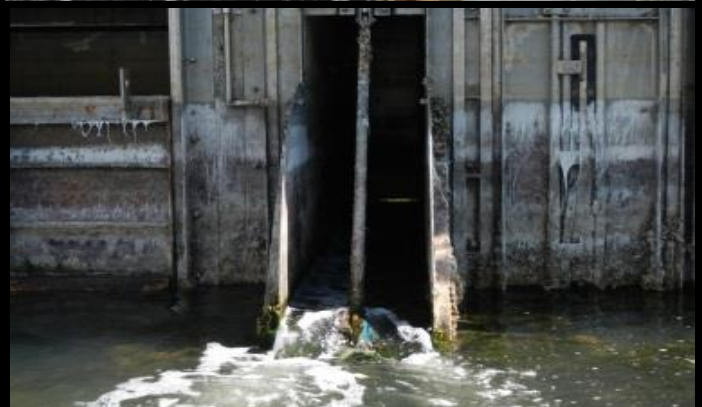
Vasse & Wonnerup estuaries

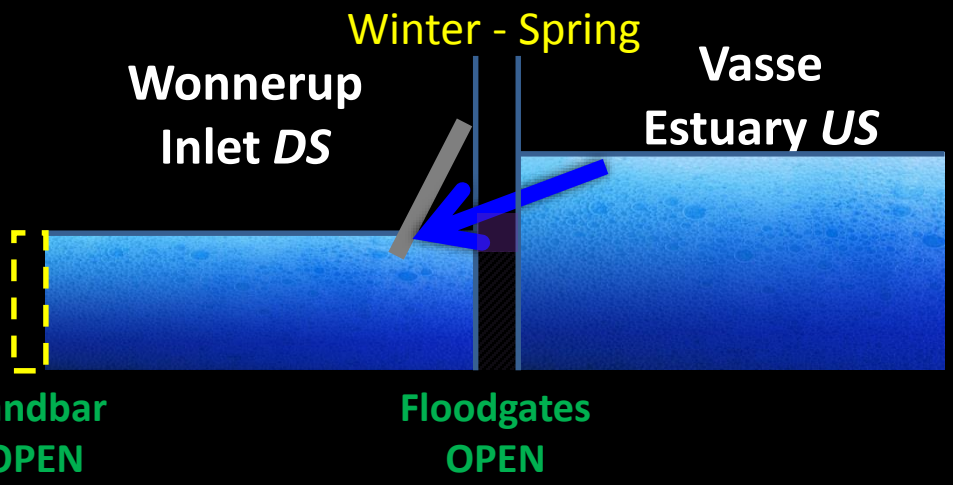
Diversity greatest in Wonnerup Inlet

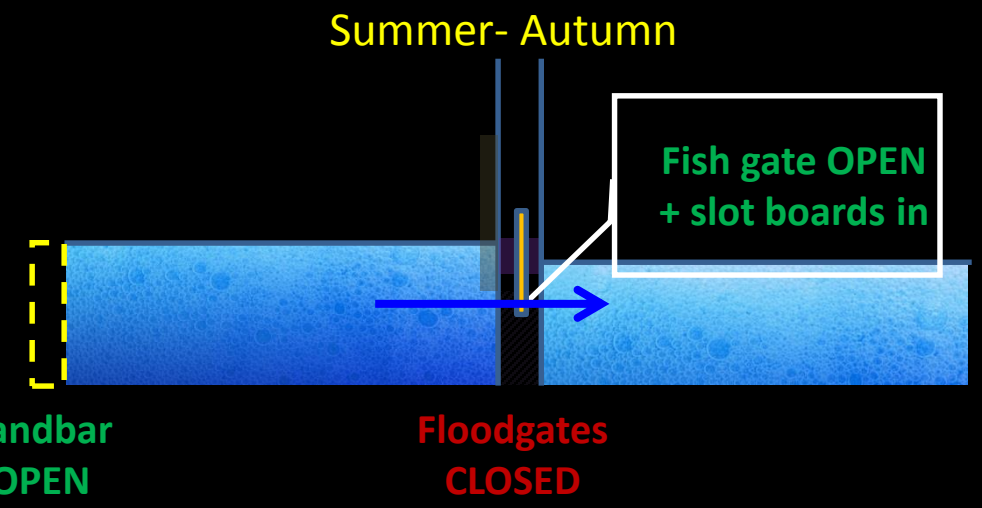


Inlet surge barriers

- Built in 1908 and replaced in 1928 and 2004
- Prevent saltwater intrusion into the estuaries in summer and storm surges in winter
- Supposed to enable fish passage







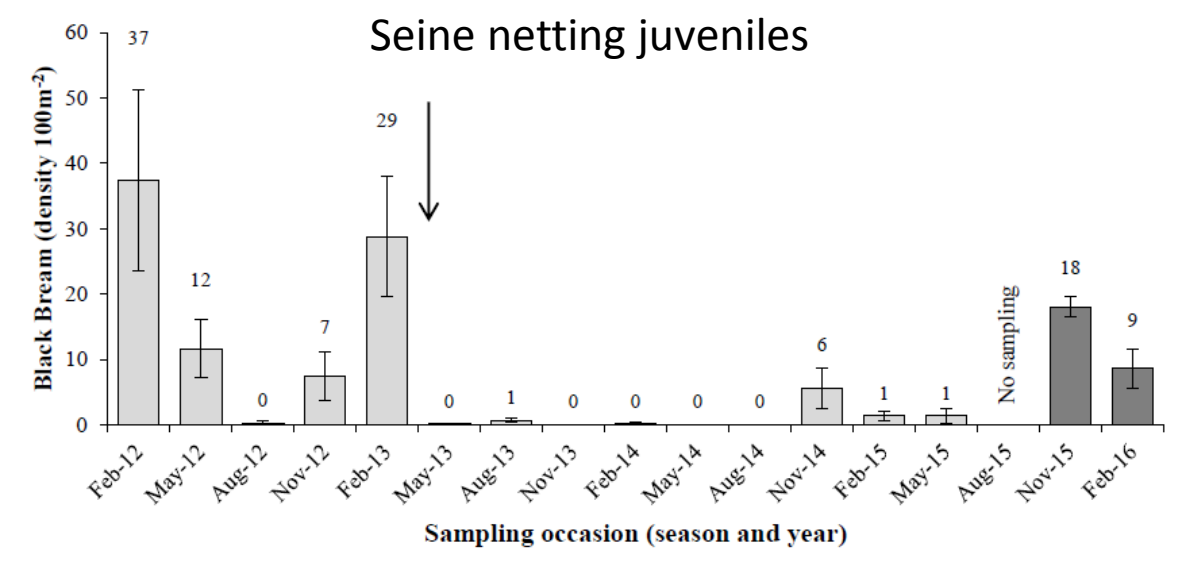
Fish Kills

- Long history
- Recent near floodgates
- 2013 major ~30000 fish Bream, Sea and Yelloweye Mullet

Year	Month	Location	Estimated Number of Dead Fish	Suspected cause
1905	Jan	Lower reaches of Vasse estuary	1000's	Dead and stagnant water
Pre 1960	Summers	Vasse and Wonnerup estuaries	1000s	Fish "landlocked" by floodgates
1966	April	Wonnerup Inlet	4000	Low dissolved oxygen
1984	Feb	Vasse estuary channel	1000's	Low dissolved oxygen Heat wave
1988	Feb	Wonnerup Inlet	1000s	Low dissolved oxygen High temperatures
1989	Feb	Vasse estuary channel	1000	Poor water quality
1997	Feb	Vasse estuary channel	1000s	Low dissolved oxygen
1997	June	The deadwater	1000s	Sudden drop in salinity
2000	Dec	Vasse estuary and floodgates	1000	Low dissolved oxygen
2010	Feb	Vasse floodgates	2000	Low dissolved oxygen Fish gates malfunction
2012	Feb	Vasse floodgates	1000s small fish	Low dissolved oxygen
2013	April	Vasse estuary floodgates and Vasse exit channel	10-38,000	Possible toxin/irritant impact Low dissolved oxygen

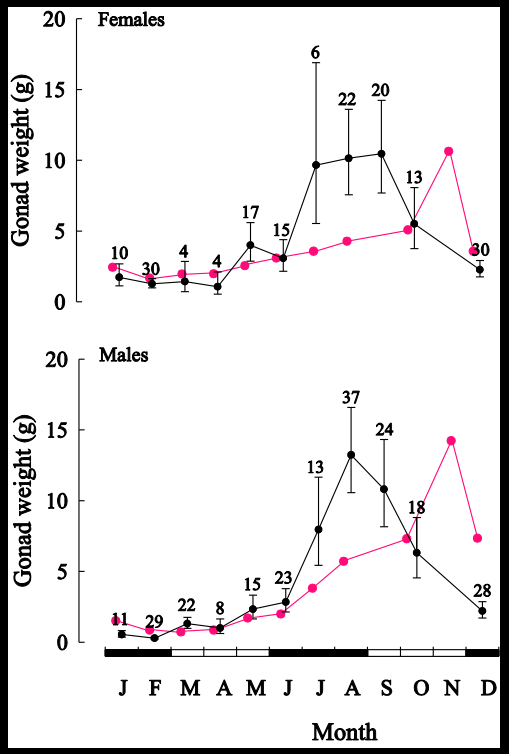
Black Bream

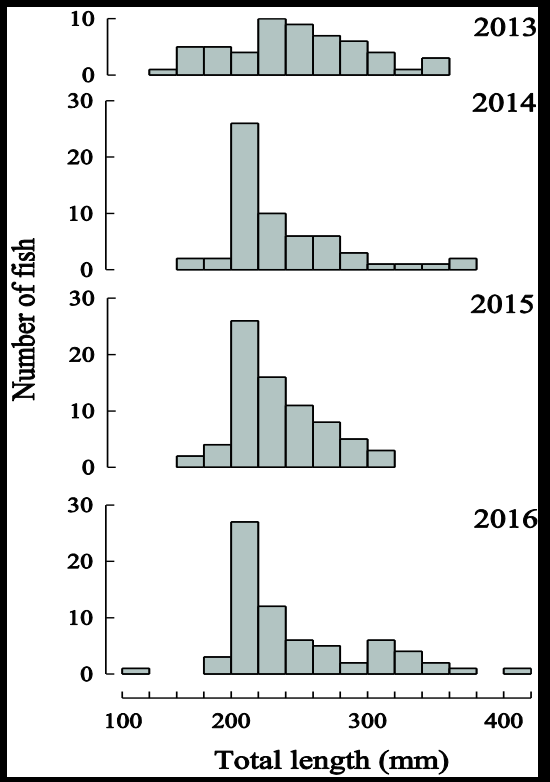
- Annual recruitment (since 1998)
- Reduced broodstock due to fish kill? – unlikely only factor as continued presence of large fish
- 2015, 2016 successful recruitment
- Resilient but fish kills not ideal



L50 = 163 (2.6 yrs), 147 (2.1 yrs) mm TL

Gill net adults





Tweedley et al. 2016, 2017

Aims

- Determine the movement patterns habitat use of Black Bream
  - Determine spatial/temporal mobility, habitat
  - Degree of passage through the Vasse barrier under range of operational / enviro scenarios
  - *How do movement patterns relate to fish kill risk (presence in the kill zones above and below barrier)?*

Methods

- V9 tag ~382 days
- Bream tagged = 41
- 11 receivers
- Continuous temperature / salinity loggers, sonar benthic habitat mapped for complexity, daily bar open/closure, binary and continuous gate variables
- Maximum monitoring period 3/4/2014 – 20/5/2015.

Wonnerup House

Tuart Drive

Receiver / water quality locations

Community involvement

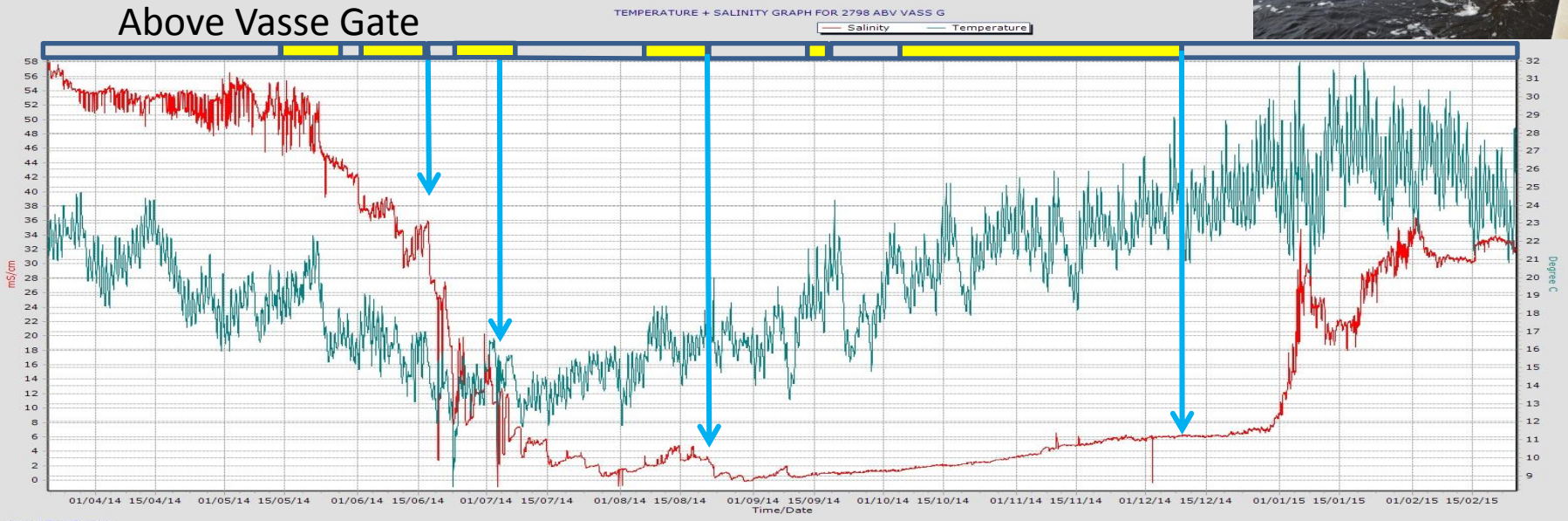
Analyses

- Passage conditions through the Vasse Gate (fish penstock, surge barrier)
- GAM/Ms for spatial/temporal distribution (#fish/day) and daily distances moved
- Predictor variables:
- Fixed: bar open/closed, surge barrier open/closed, proximity to artificial structure (bridges, gates)
- Smoothed continuous: temperature, salinity, time (day of experiment), tide range, rainfall, distance from ocean, mean depths

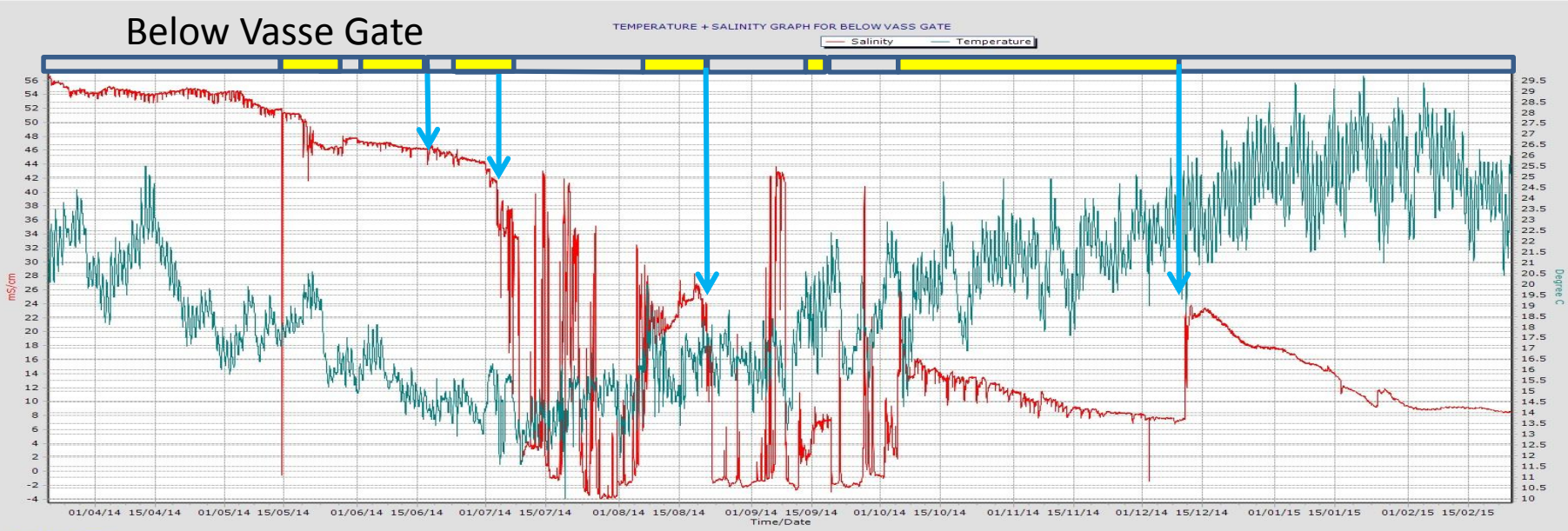
Results

Surge barriers prevent tide and smooth salinity

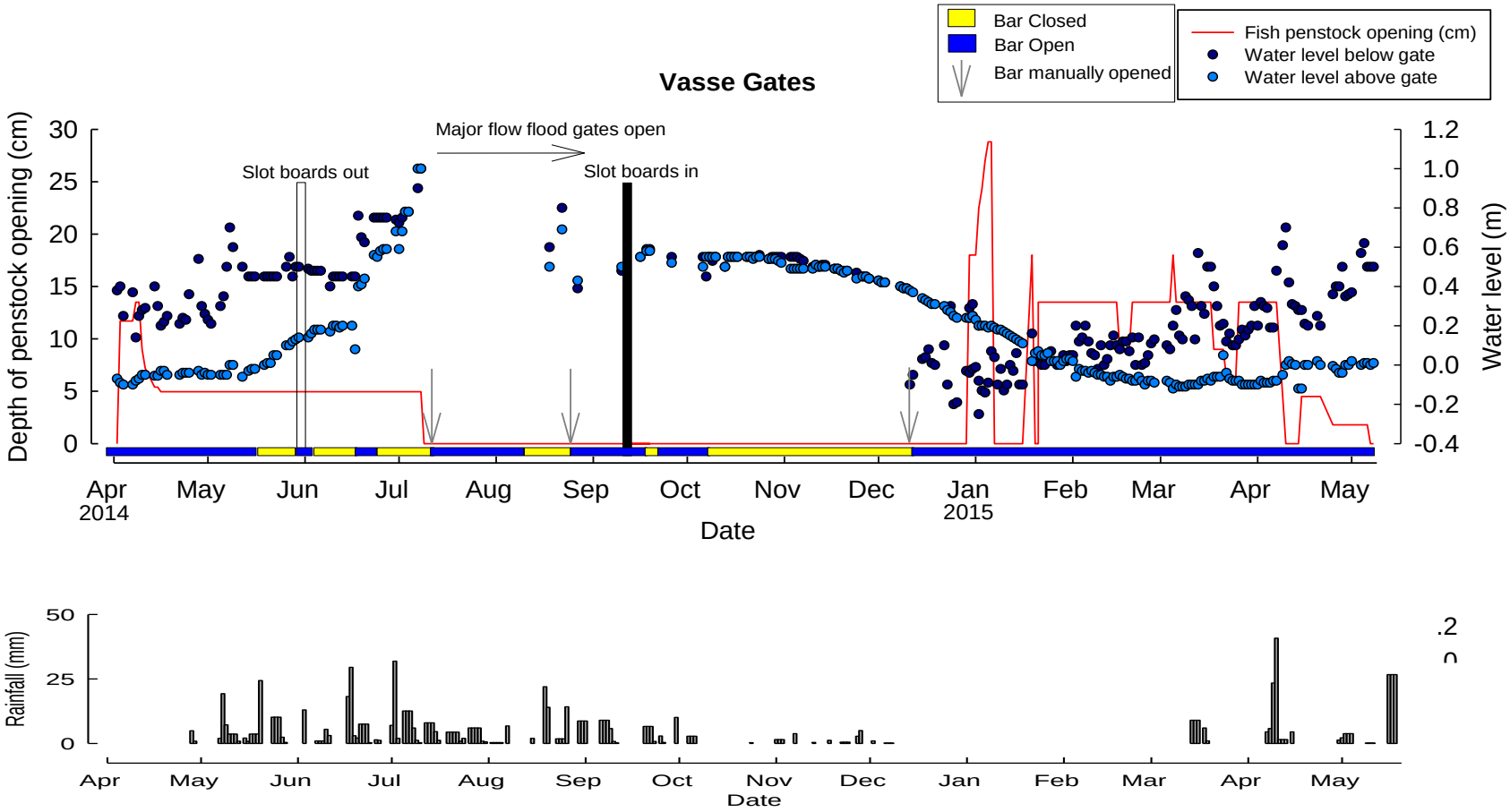
Above Vasse Gate



Below Vasse Gate



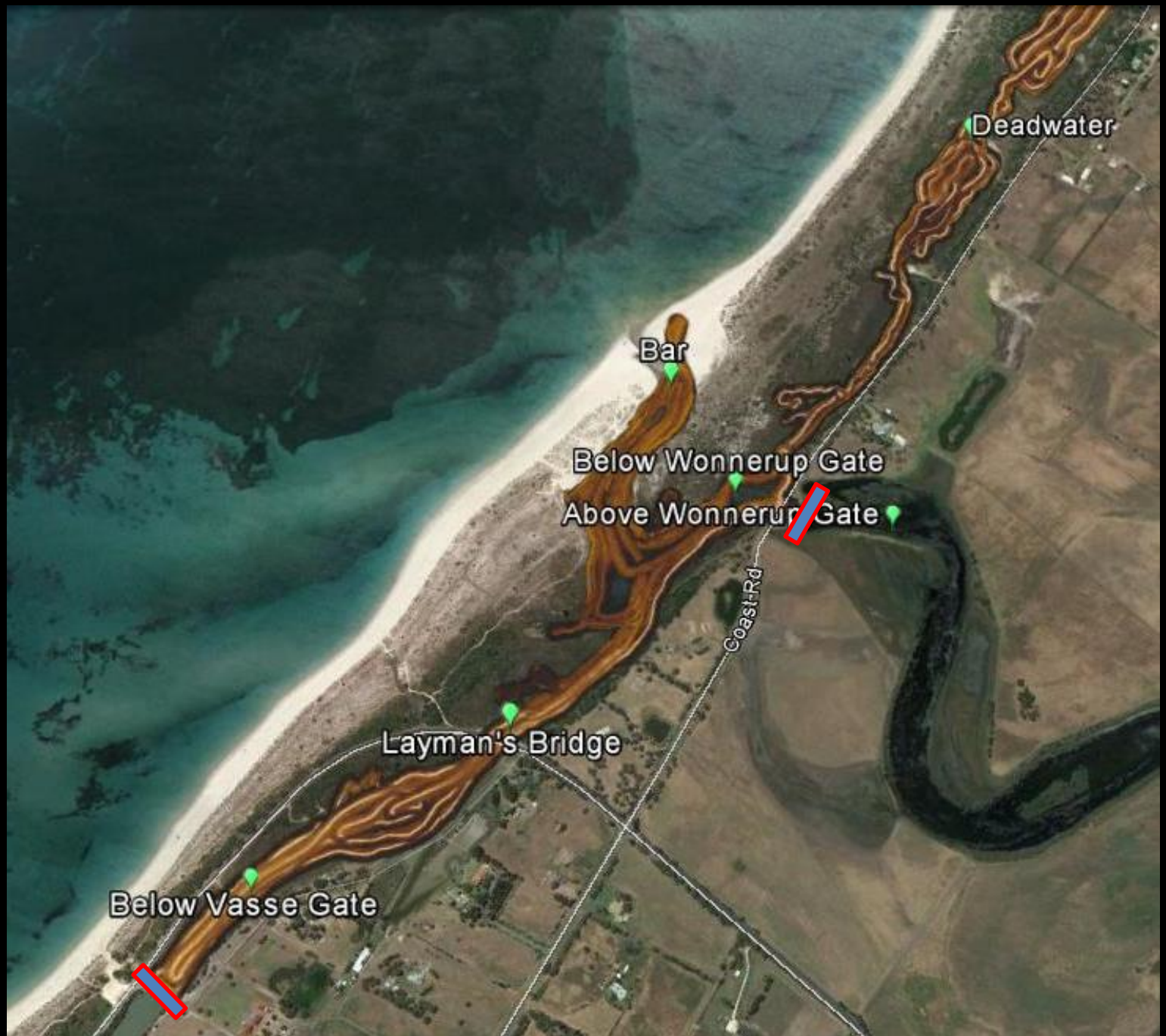
Its complex…



…but key things to note:

- Bar opens and shuts a lot
- Flow period July - Sept = big surge gates open
- Slot boards in Sept – June = fish penstock operates (red line = gap height)
- Water level greater below gate Feb-onwards

Almost no (natural) complex structure




Deadwater
Bar
Below Wonnerup Gate
Above Wonnerup Gate
Layman's Bridge
Below Vasse Gate
Below Vasse Gate
Layman Rd
© 2017 Google
2005
Imagery Date: 11/16/2015 lat -33.619226° lon 115.414174° elev


Deadwater
Bar
Below Wonnerup Gate
Above Wonnerup Gate
Layman's Bridge
Below Vasse Gate
Deadwater
© 2017 Google
Google
2005
Imagery Date: 11/16/2015 lat -33.607562° lon 115.430712° elev 1 m

Acoustic detections summary

- Total of 2,307,576 detections (28 fish) 22nd May 2014 - 20th May 2015
- Survival rates:

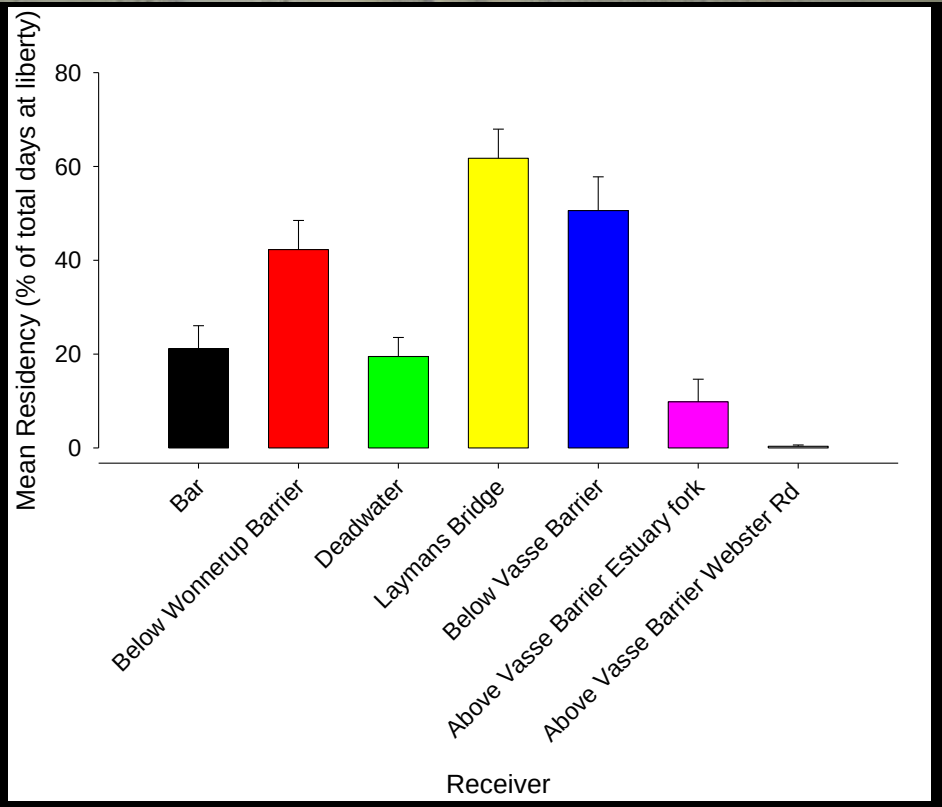
  30 (73%) >July 2014

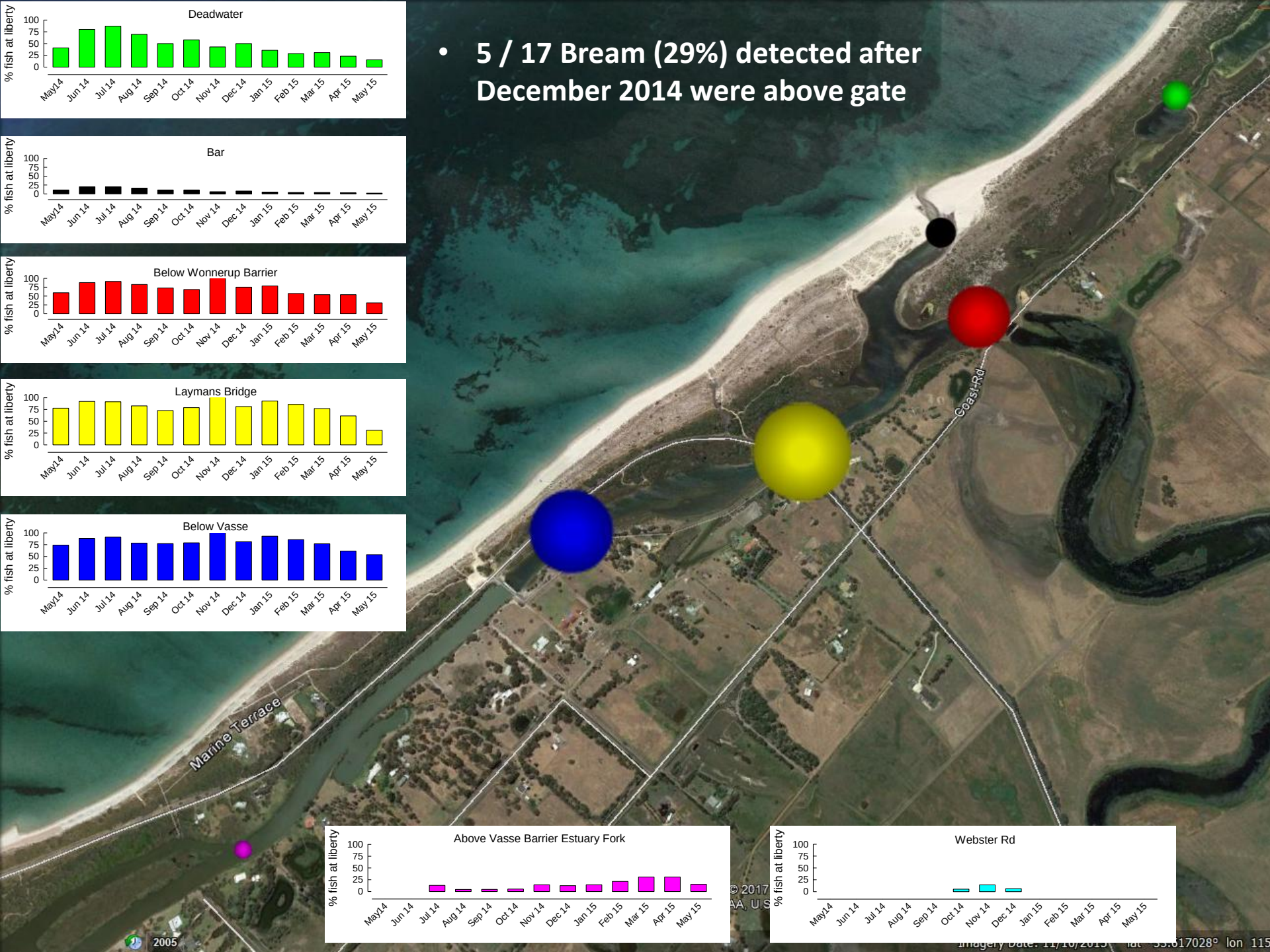
  17 (41%) >December 2014

  13 (32%) whole period
- 5 Bream (12%) possibly left to ocean

Bream movement and key habitats

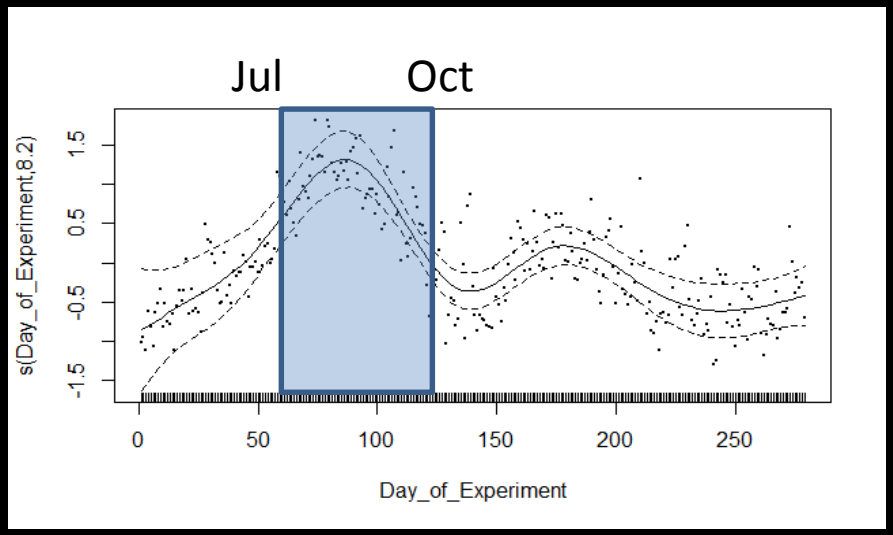
- Most stayed within the array
- Overall mean daily movement fish at liberty = 2.73 km ± 0.06 km, Max 45 km
- No passage detected upstream of Wonnerup Gate
- No fish as far as Vasse River (Butter)
- 19 of the 21 Bream (90%) detected during the breeding period Deadwater
- The other two fish were above Vasse Gate at the time

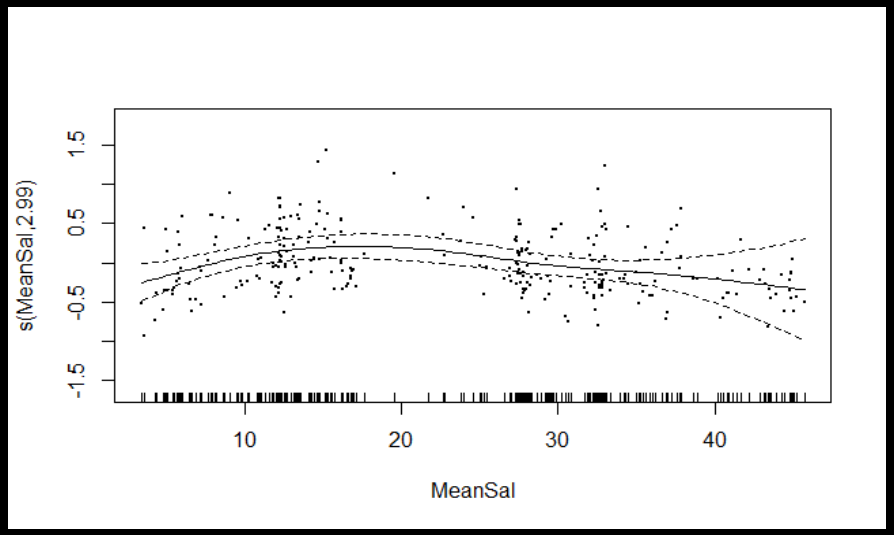




- **5 / 17 Bream (29%) detected after December 2014 were above gate**

Daily distance
Signif effect of surge barrier open
Smoothed day and salinity

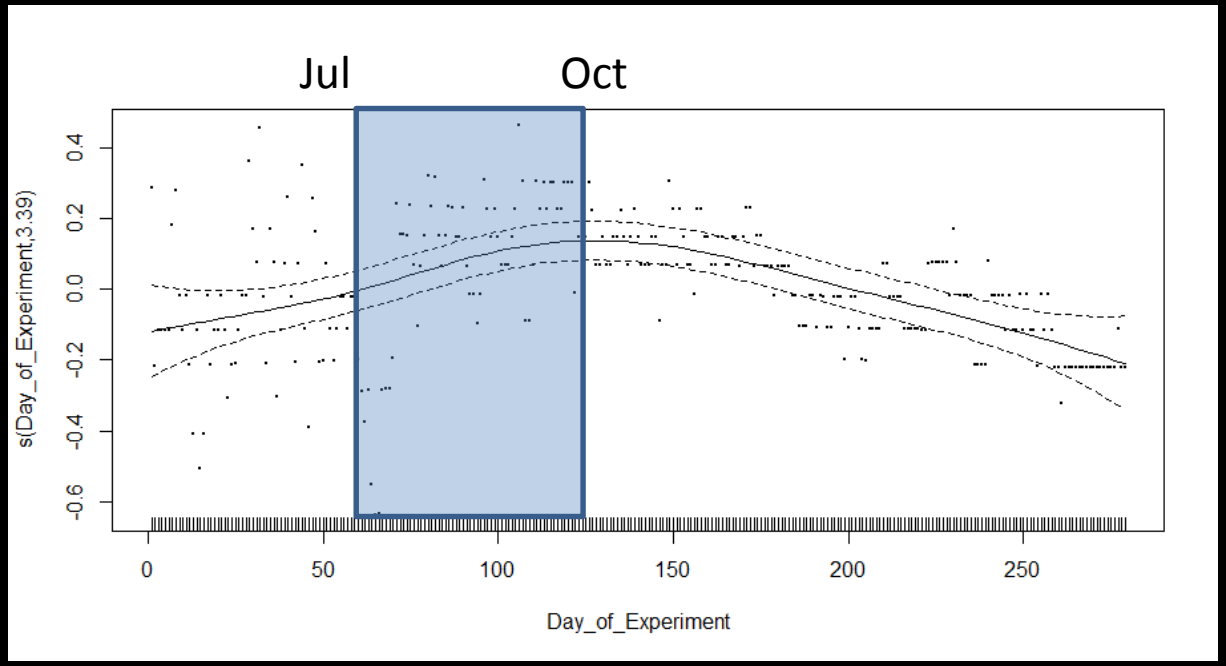




~coincides with spawning period

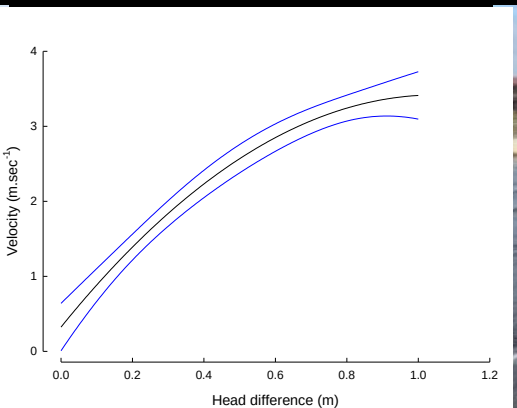
Number of fish / day below Vasse barrier

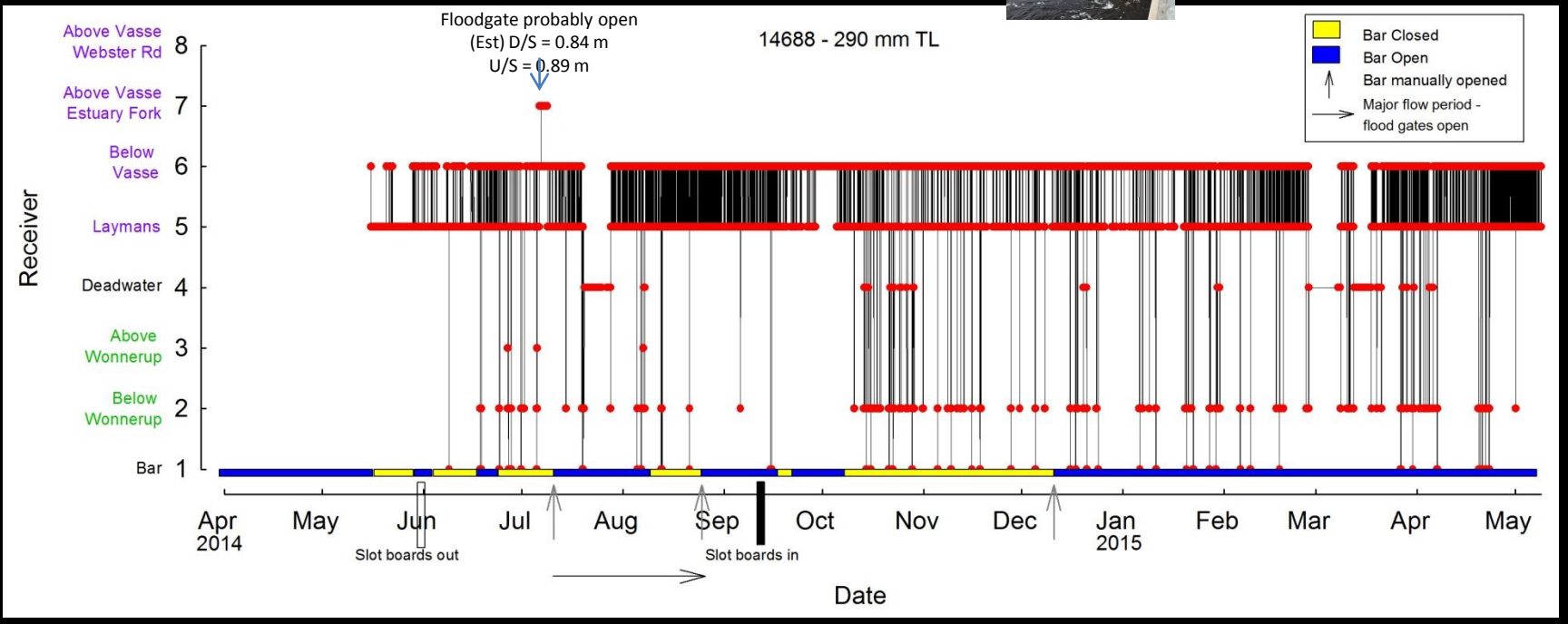
~coincides with spawning period

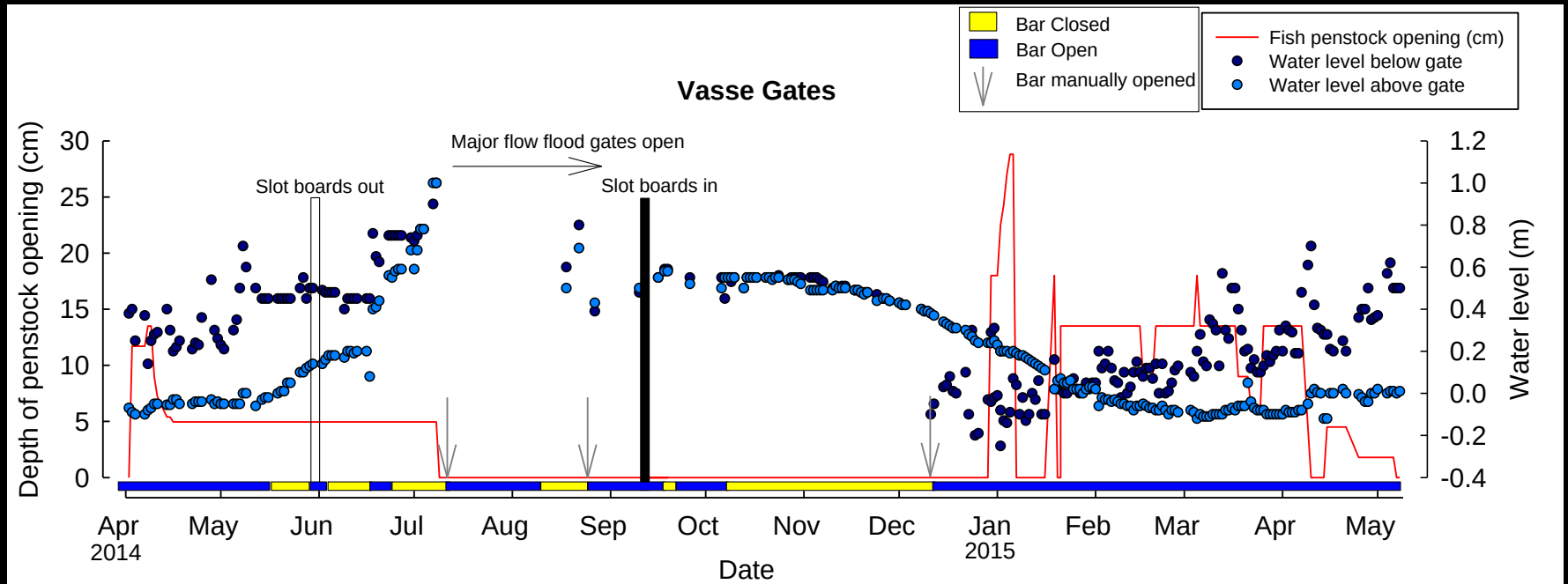


Passage through the surge barrier

Fish ID	TL (mm)	Date first above Vasse	Date last above Vasse	Floodgate open?	Δ D/S to U/S (m) (potential passage day range)	Penstock gap (cm)	Date last detected
14688	290	6/7/14	8/7/14	Yes	-0.05	4.95	20/5/15
14726	370	7/7/14	29/12/14	Yes	-0.10	4.95	29/12/14
14690	287	12/11/14	20/5/15	No?	0.00	0.00	20/5/15
14701	269	3/2/15	20/5/15	No	0.06 – 0.76	13.50	20/5/15
14709	305	28/3/15	27/4/15	No	0.00 – 0.51	13.50	27/4/15
14715	393	7/4/14	6/10/14	No	0.30 – 0.76	11.70	6/10/14
14729	360	28/1/15	30/4/15	No	-0.05 - 0.48	13.50	30/4/15




Floodgate probably open
(Est) D/S = 0.84 m
U/S = 0.89 m
14688 - 290 mm TL
Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open
Receiver
Above Vasse Webster Rd 8
Above Vasse Estuary Fork 7
Below Vasse 6
Laymans 5
Deadwater 4
Above Wonnerup 3
Below Wonnerup 2
Bar 1
Apr 2014
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2015
Feb
Mar
Apr
May
Slot boards out
Slot boards in
Date


Vasse Gates
Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate
Major flow flood gates open
Slot boards out
Slot boards in
Depth of penstock opening (cm)
30
25
20
15
10
5
0
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Water level (m)
Apr 2014
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2015
Feb
Mar
Apr
May
Date

Floodgate open

7/7/14
Penstock 4.95cm
and floodgate open
D/S = 0.9 m
U/S = 1.0 m

14726 - 370 mm TL

Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open

Receiver
Above Vasse Webster Rd 8
Above Vasse Estuary Fork 7
Below Vasse 6
Laymans 5
Deadwater 4
Above Wonnerup 3
Below Wonnerup 2
Bar 1

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May
Slot boards out
Slot boards in
Date

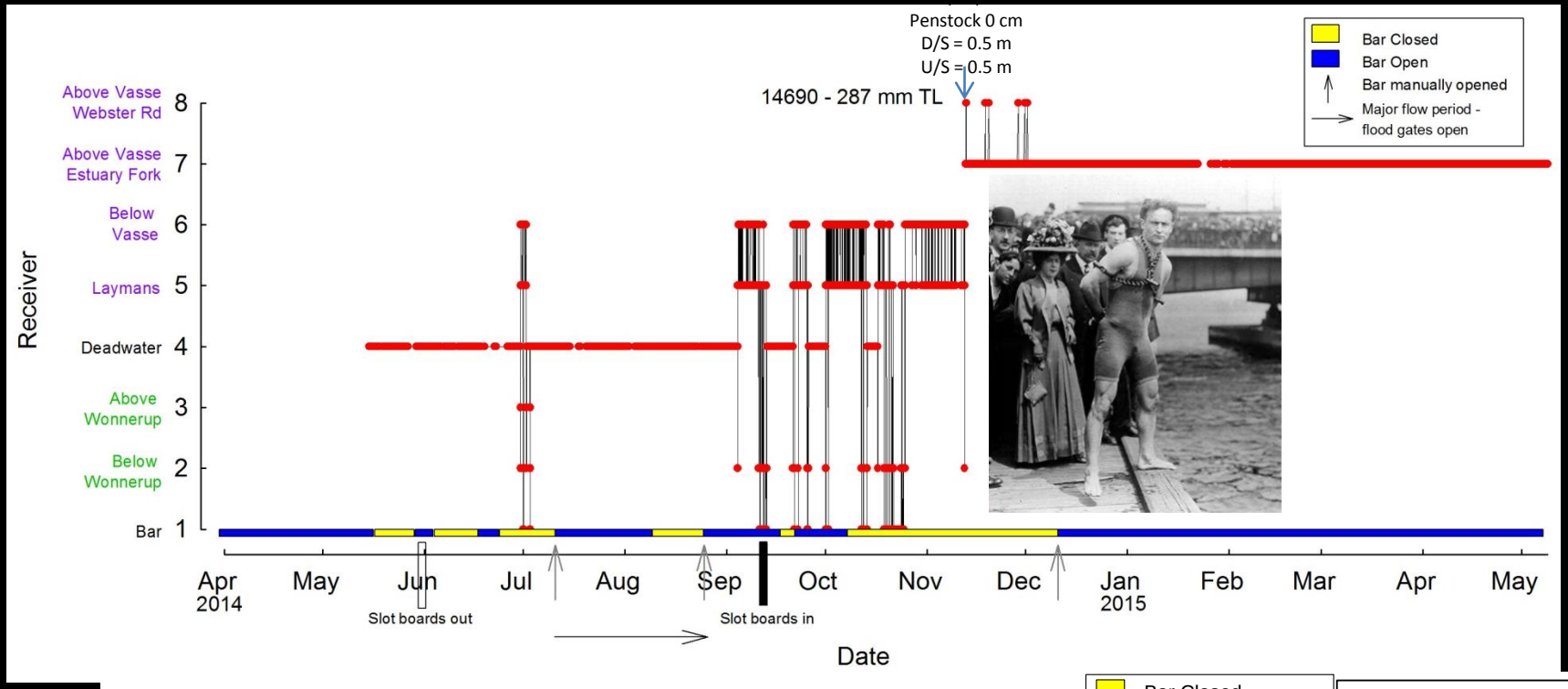
Vasse Gates

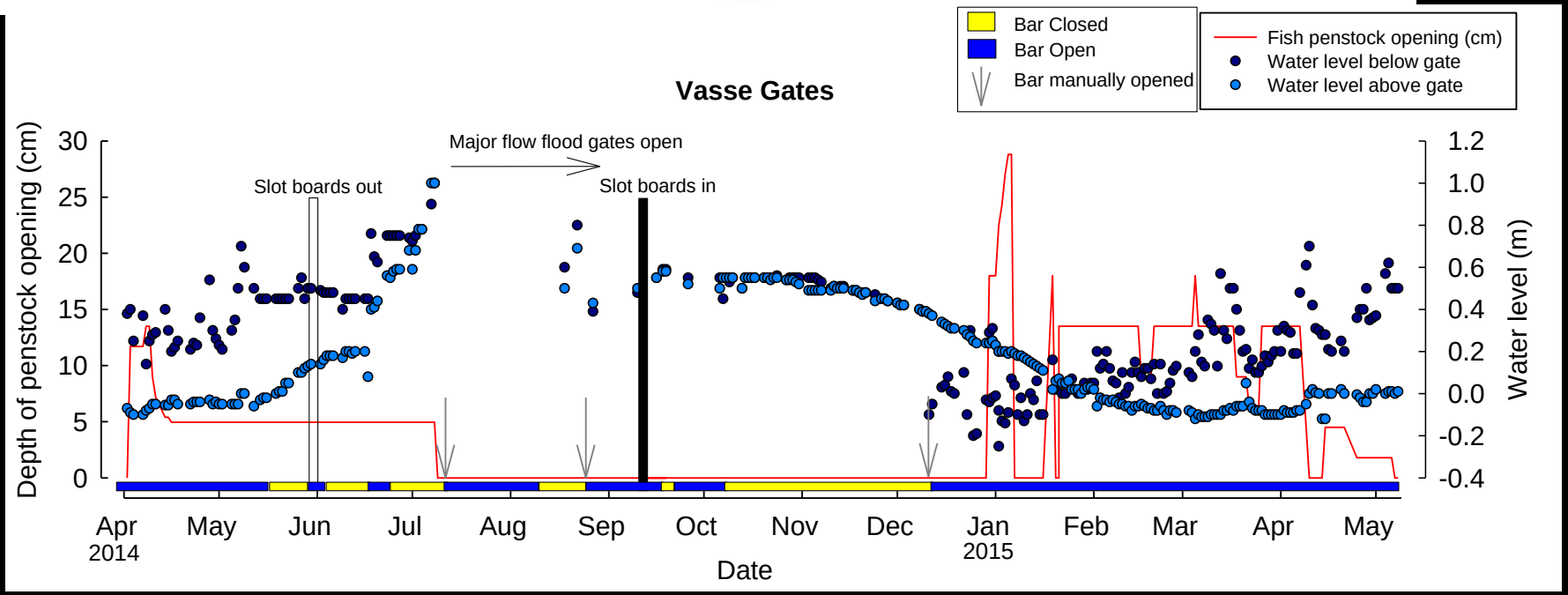
Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate

Major flow flood gates open
Slot boards out
Slot boards in

Depth of penstock opening (cm) 30 25 20 15 10 5 0
Water level (m) 1.2 1.0 0.8 0.6 0.4 0.2 0.0 -0.2 -0.4

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May
Date


Penstock 0 cm
D/S = 0.5 m
U/S = 0.5 m
14690 - 287 mm TL
Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open
Receiver
Above Vasse Webster Rd
Above Vasse Estuary Fork
Below Vasse
Laymans
Deadwater
Above Wonnerup
Below Wonnerup
Bar
8
7
6
5
4
3
2
1
Apr 2014
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2015
Feb
Mar
Apr
May
Slot boards out
Slot boards in
Date


Vasse Gates
Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate
Major flow flood gates open
Slot boards out
Slot boards in
Depth of penstock opening (cm)
Water level (m)
30
25
20
15
10
5
0
1.2
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
Apr 2014
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan 2015
Feb
Mar
Apr
May
Date

Used Penstock

14701 - 269 mm TL

3/2/15
Penstock 13.5 cm
D/S = 0.12 m
U/S = -0.02 m

Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open

Receiver
8 Above Vasse Webster Rd
7 Above Vasse Estuary Fork
6 Below Vasse
5 Laymans
4 Deadwater
3 Above Wonnerup
2 Below Wonnerup
1 Bar

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May

Slot boards out
Slot boards in

Date

Vasse Gates

Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate

Major flow flood gates open
Slot boards out
Slot boards in

Depth of penstock opening (cm)
30 25 20 15 10 5 0

Water level (m)
1.2 1.0 0.8 0.6 0.4 0.2 0.0 -0.2 -0.4

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May

Date

Used Penstock

14709 - 305 mm TL

Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open

28/3/15
Penstock 13.5 cm
D/S = 0.15 m
U/S = -0.1 m

Receiver

Above Vasse Webster Rd 8
Above Vasse Estuary Fork 7
Below Vasse 6
Laymans 5
Deadwater 4
Above Wonnerup 3
Below Wonnerup 2
Bar 1

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May

Slot boards out
Slot boards in

Date

Bar Closed
Bar Open
Bar manually opened

Fish penstock opening (cm)
Water level below gate
Water level above gate

Vasse Gates

Major flow flood gates open
Slot boards out
Slot boards in

Depth of penstock opening (cm)
30 25 20 15 10 5 0

Water level (m)
1.2 1.0 0.8 0.6 0.4 0.2 0.0 -0.2 -0.4

Apr 2014 May Jun Jul Aug Sep Oct Nov Dec Jan 2015 Feb Mar Apr May

Date

Used Penstock

14715 - 393 mm TL

7/4/14
Penstock 11.7 cm
D/S = 0.37 m
U/S = -0.10 m

Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open

Receiver

Above Vasse Webster Rd 8
Above Vasse Estuary Fork 7
Below Vasse 6
Laymans 5
Deadwater 4
Above Wonnerup 3
Below Wonnerup 2
Bar 1

Apr 2014 | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan 2015 | Feb | Mar | Apr | May

Slot boards out
Slot boards in

Date

Vasse Gates

Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate

Depth of penstock opening (cm)

30 25 20 15 10 5 0

Major flow flood gates open
Slot boards out
Slot boards in

1.2 1.0 0.8 0.6 0.4 0.2 0.0 -0.2 -0.4

Water level (m)

Apr 2014 | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan 2015 | Feb | Mar | Apr | May

Date

Used Penstock

14729 - 360 mm TL

28/1/15
Penstock 13.5 cm
D/S = 0.02 m
U/S = 0.0 m

Bar Closed
Bar Open
Bar manually opened
Major flow period - flood gates open

Receiver
Above Vasse Webster Rd 8
Above Vasse Estuary Fork 7
Below Vasse 6
Laymans 5
Deadwater 4
Above Wonnerup 3
Below Wonnerup 2
Bar 1

Apr 2014 | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan 2015 | Feb | Mar | Apr | May

Slot boards out
Slot boards in

Date

Vasse Gates

Bar Closed
Bar Open
Bar manually opened
Fish penstock opening (cm)
Water level below gate
Water level above gate

Major flow flood gates open
Slot boards out
Slot boards in

Depth of penstock opening (cm)
30 25 20 15 10 5 0

Water level (m)
1.2 1.0 0.8 0.6 0.4 0.2 0.0 -0.2 -0.4

Apr 2014 | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan 2015 | Feb | Mar | Apr | May

Date

Summary

- Broad-scale movement greatest in winter/spring (spawning period)
- More fish detected below Vasse barrier winter/spring, but Deadwater likely spawning
- Non-tidal habitats upstream of Wonnerup and Vasse Gates are not utilised (much)……but
- 5 / 17 Bream (29%) detected after December 2014 were above barrier
- Fish passed 13.5cm and none passed <11.7 cm – 15 cm seems a reasonable criteria…but….
- Bream passaged with the ‘flow’ and seemed to be ‘stuck’ – suggests a trap
- Recommended that Bream be prevented from passaging (pre 1988 conditions)
- Oxygenation plant installed, sustainable solutions required
- PIT study underway

Special thanks to….

- *Dep. Fisheries:* Alicia Reagan for her exceptional coordination of community events
- *Busselton SHS: Year 9 students and Renay Down*
- *Georgiana Molloy SHS:* Hamish Gibson, Rebecca Teale
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- Kath Lynch (GeoCatch/Dep. Water)
- Clive Piggott (Water Corporation)

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