



Factors influencing skeletal malformations in Australian cultured marine finfish

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Australian Government
Australian Research Council

TAFI is a joint venture between the State Government and the University of Tasmania

Outline

- Australian marine fish aquaculture industry
- Survey of hatcheries
- Species malformation case studies
- Future research direction



Australian Aquaculture

- **Total finfish industry value 2007-08**
AU\$546 million; 41,200 t *



Salmonids
AU\$299 million; >25,500 t



Southern Bluefin Tuna
AU\$187 million; 9,800 t

* ABARE, 2009



Australian Aquaculture

- Marine fish value (based on hatchery produced fry)
~AU\$57 million; ~ 5,600 t *
- Major species

Barramundi (*Lates calcarifer*)
AU\$34 million; 3,360 t



Yellowtail kingfish
(*Seriola lalandi*)



Mulloway
(*Argyrosomus japonicus*)



Australian bass
(*Maquaria novemaculeata*)

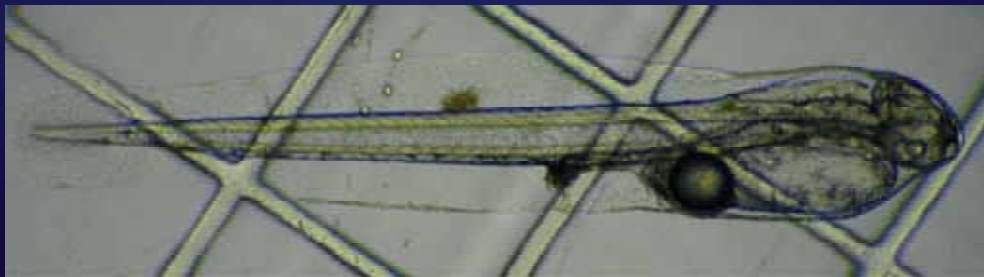
3 spp combined < AU\$23 million; 2,240 t

* ABARE, 2009



Australian Aquaculture

- **Species under development**
 - **Flowery grouper (*Epinephelus fuscoguttatus*)**
 - **Gold Spot grouper (*Epinephelus coioides*)**
 - **Cobia (*Rachycentron canadum*)**
 - **Striped trumpeter (*Latris lineata*)**
 - **Australian snapper (*Pagrus auratus*)**
 - **Southern bluefin tuna (*Thunnus maccoyii*)**



Images courtesy of L. Woolley and Clean Seas Tuna



Australian Aquaculture

- Target to increase finfish aquaculture production from 41,000 to 100,000 tonnes by 2015 *



Provision of sufficient numbers of high quality fry is a bottleneck to industry expansion

- **What are the issues at the hatchery level?**

* Hone, 2008 (FRDC Fish 16(2), 14-17)



Hatchery Survey

- Survey emailed to 26 marine fish hatcheries
- Follow-up with telephone interview
 - incidence and severity of skeletal malformations
 - perceived impact on hatchery production
 - techniques used to rear larvae
- Hatchery information kept confidential



Hatchery Survey

- Responses from 18 hatcheries (69%)

Species	Hatcheries surveyed No.	Fry production p.a. (1000's)	Malformation significant		Estimated proportion malformed		Hatcheries submitting samples
			No.	%	2008 range (%)	2005-2008 range (%)	
Barramundi	10	7,220	2	20	<1 to 5	<1 to 22	3
Yellowtail kingfish	6	1810	6	100	10 to 20	10 to 70	6
Grouper (x3)	2	>100	0	0	<5	<5	1
Cobia	2	>30	n.a.	n.a.	n.a.	<1	1
Striped trumpeter	1	*5	1	100	n.a.	10 to 95	1
Mulloway	4	*1,110	1	25	<1	<1 to 20	0
Snapper	3	*200	0	0	-	-	0
Australian Bass	3	500	0	0	-	-	0
Other species (x13)	8	>400	0	0	-	-	0
All hatcheries	18	>11,375	8	44		<1 to 95	9

* Minimal production 2008-2009

- Samples from 2 'no issue' hatcheries had >5% severe malformations (i.e. 56% hatcheries with an issue) – more work to be done

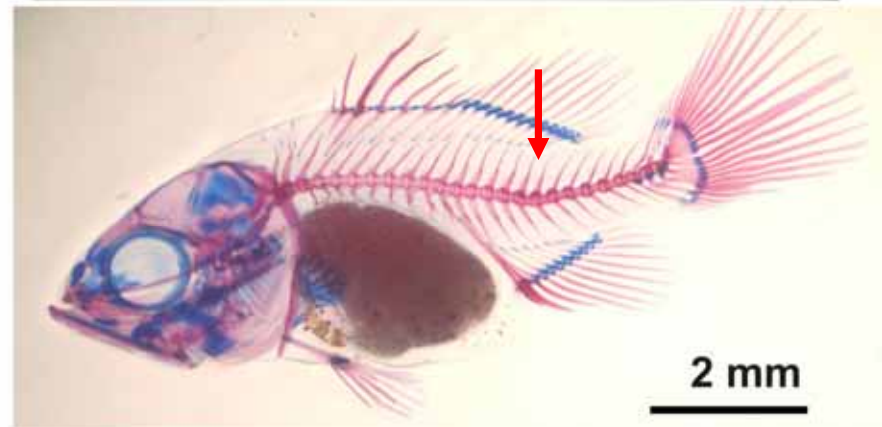
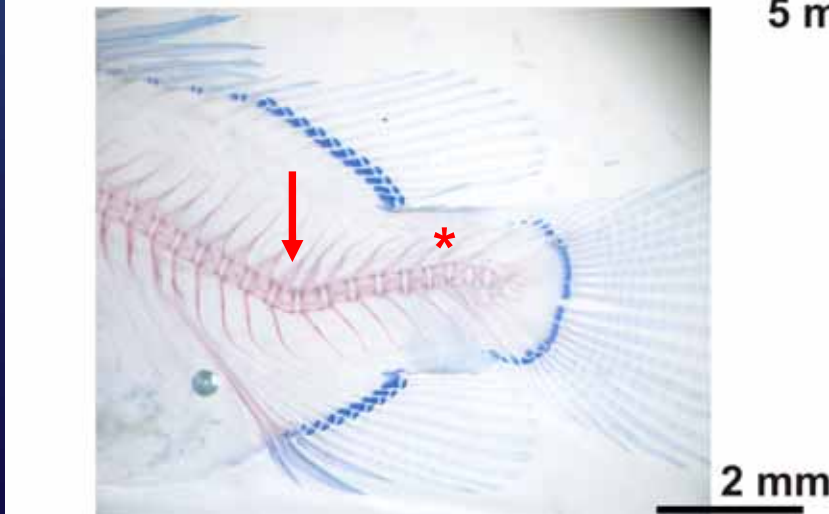


Barramundi

- Spinal

Normal

Short body



→ Lordosis

* Vertebral body – compression, dorsal or ventral shift in centre



Barramundi

- **Jaw - occasional**



Normal jaw



**Subtle deformed
jaw**



**Medium deformed
jaw**

Images provided
by Darwin
Aquaculture
Centre

Solved by changing
the commercial algae
pastes for rotifer and
larval culture *

* Bosmans personal communication; Schipp et al 2007



Barramundi

- **Jaw - occasional**

Normal



'Pinched' lower *



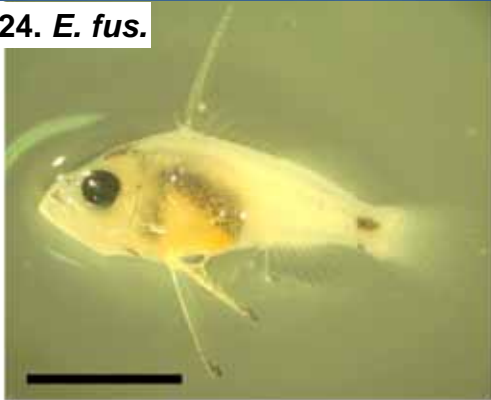
* Similar to the description of Fraser and de Nys, 2005



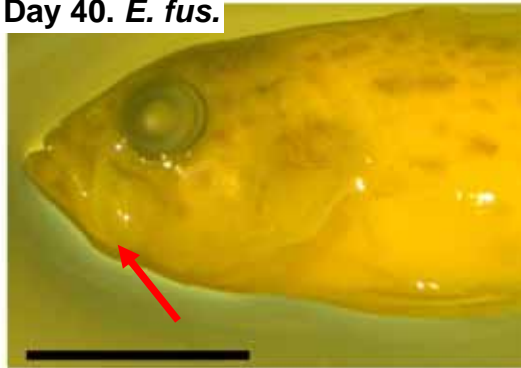
Grouper

- *Epinephelus fuscoguttatus* and *Epinephelus coioides*
- Jaw (maxilla, dentary) and some spinal

Day 24. *E. fus.*



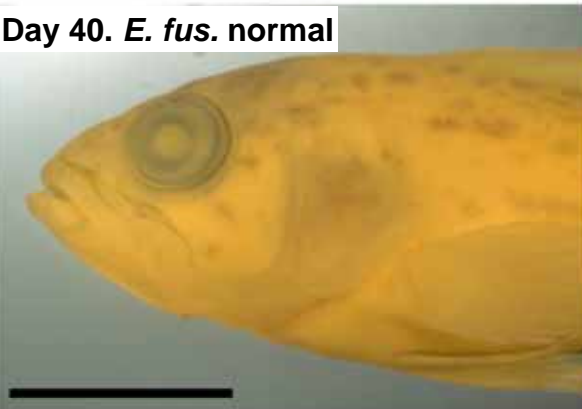
Day 40. *E. fus.*



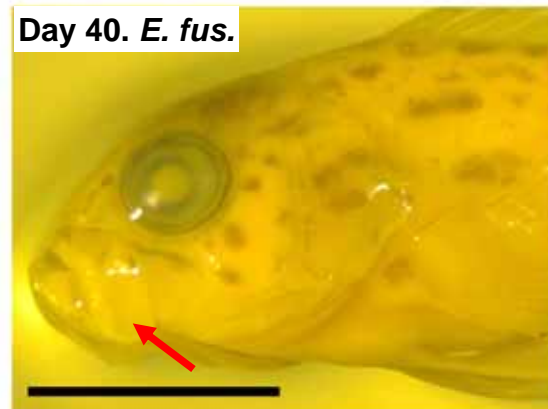
Day 40. *E. fus.*



Day 40. *E. fus.* normal



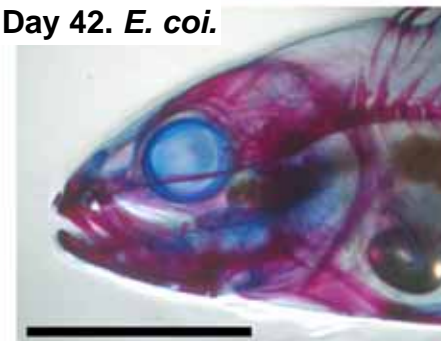
Day 40. *E. fus.*



Day 32. *E. fus.*



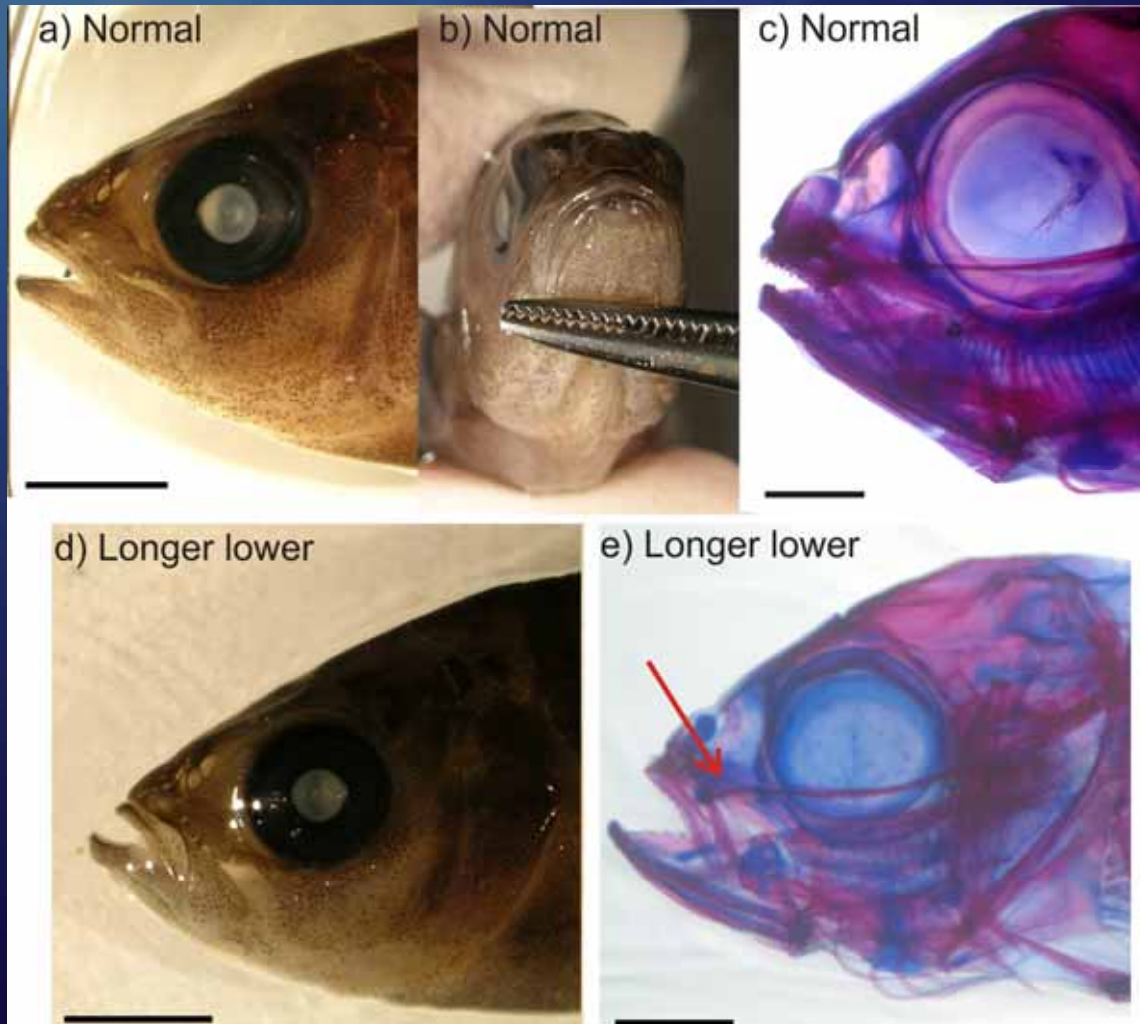
Day 42. *E. coi.*



All scale bars 5 mm

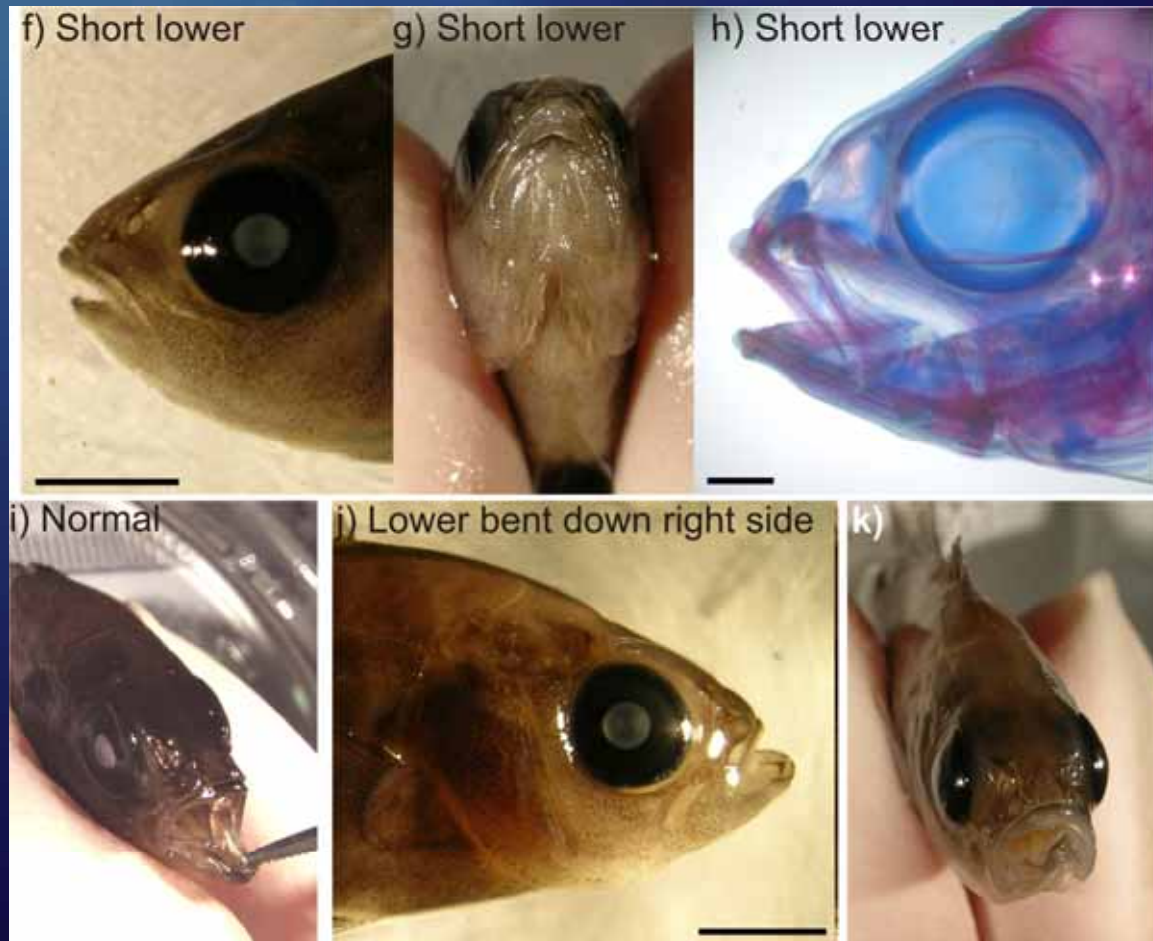
Yellowtail kingfish

- **Jaw – several malformation types**



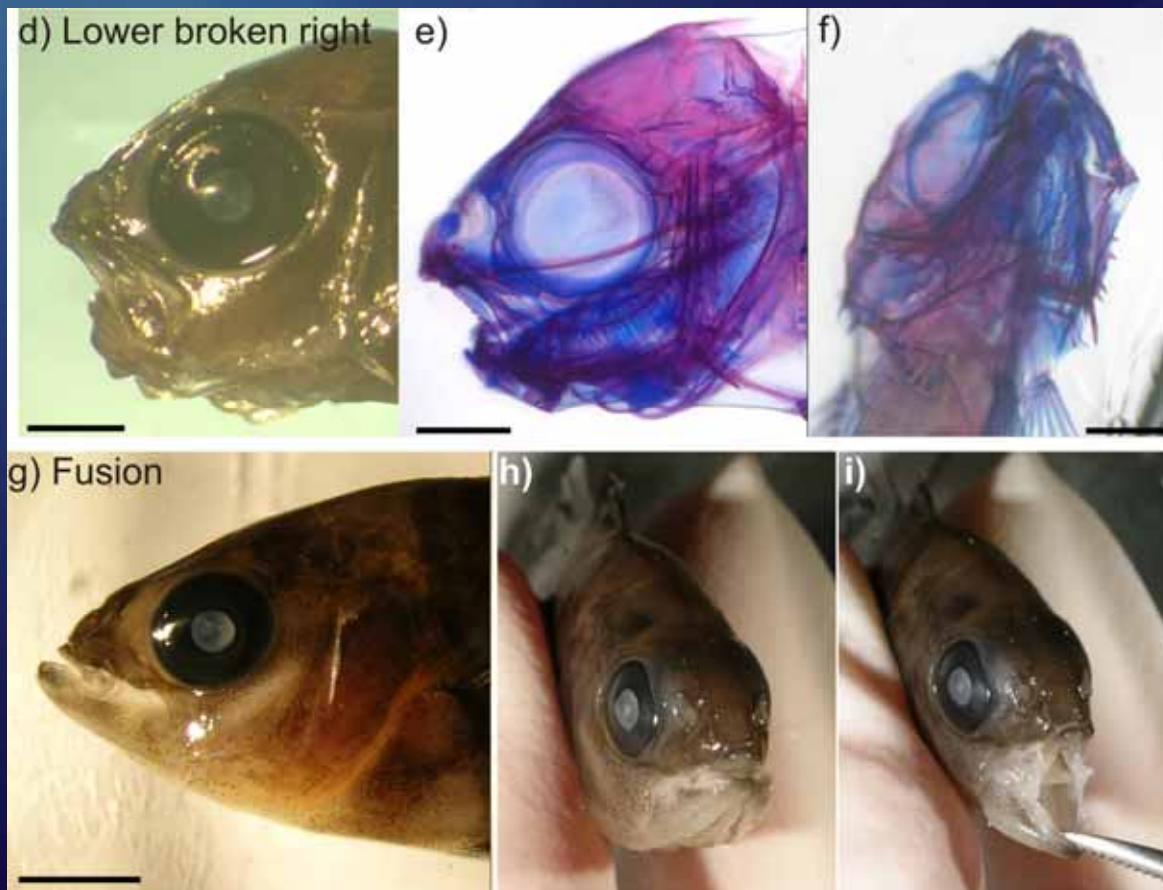
Yellowtail kingfish

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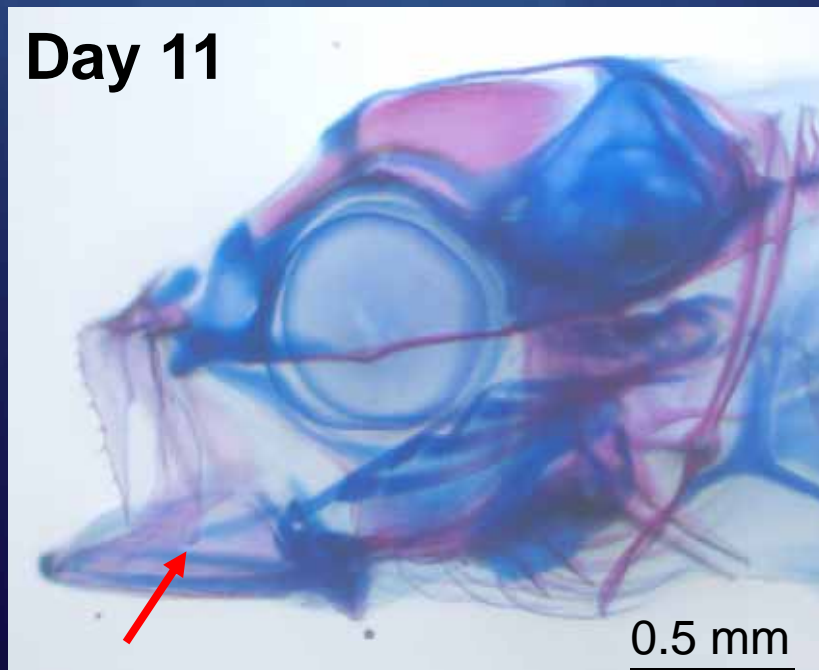
Yellowtail kingfish

- **Jaw – several malformation types**

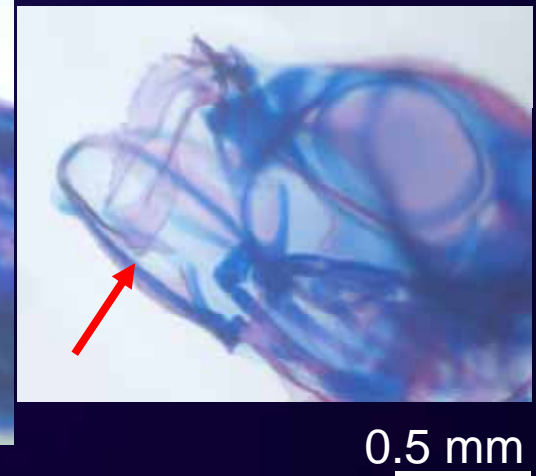
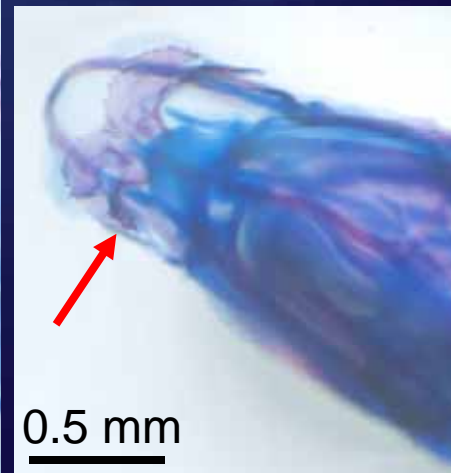


Yellowtail kingfish

- Jaw – onset of fusion from day 11

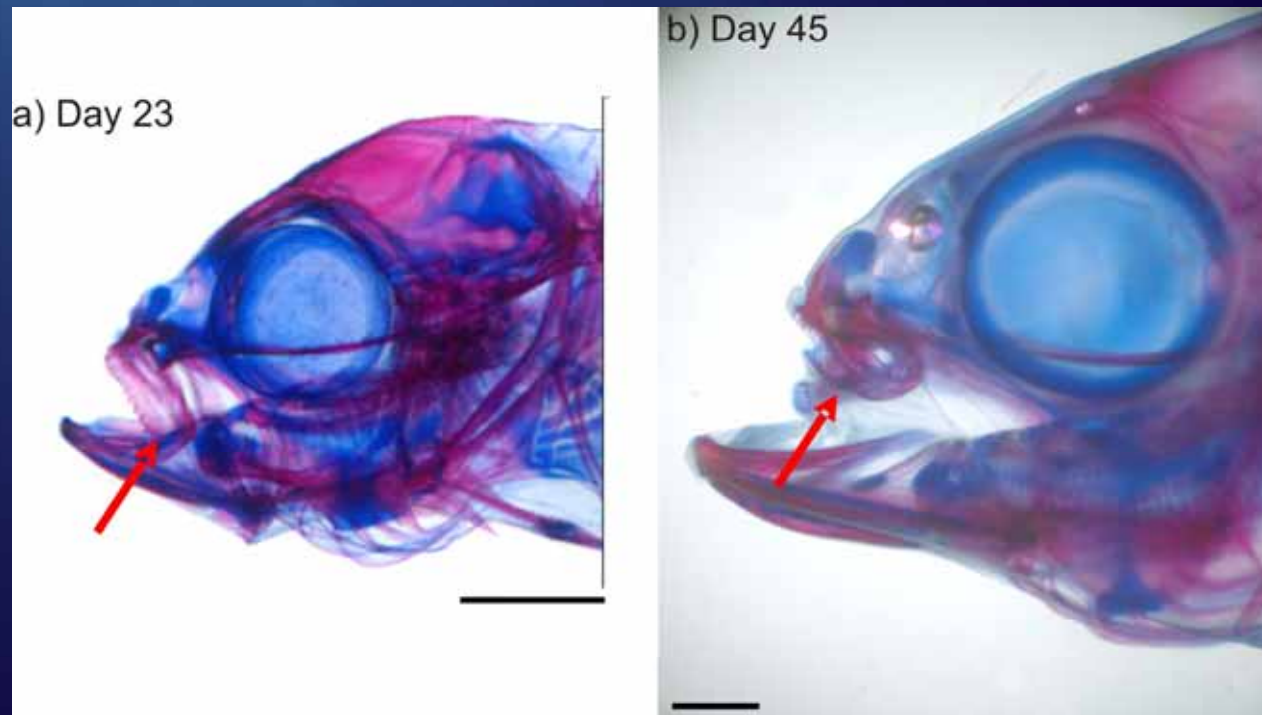


Maxilla located inside lower jaw



Yellowtail kingfish

- **Jaw – onset of fusion, force exerted on maxilla and premaxilla by lower jaw movement**



Striped trumpeter

- Occasional spinal



Striped trumpeter

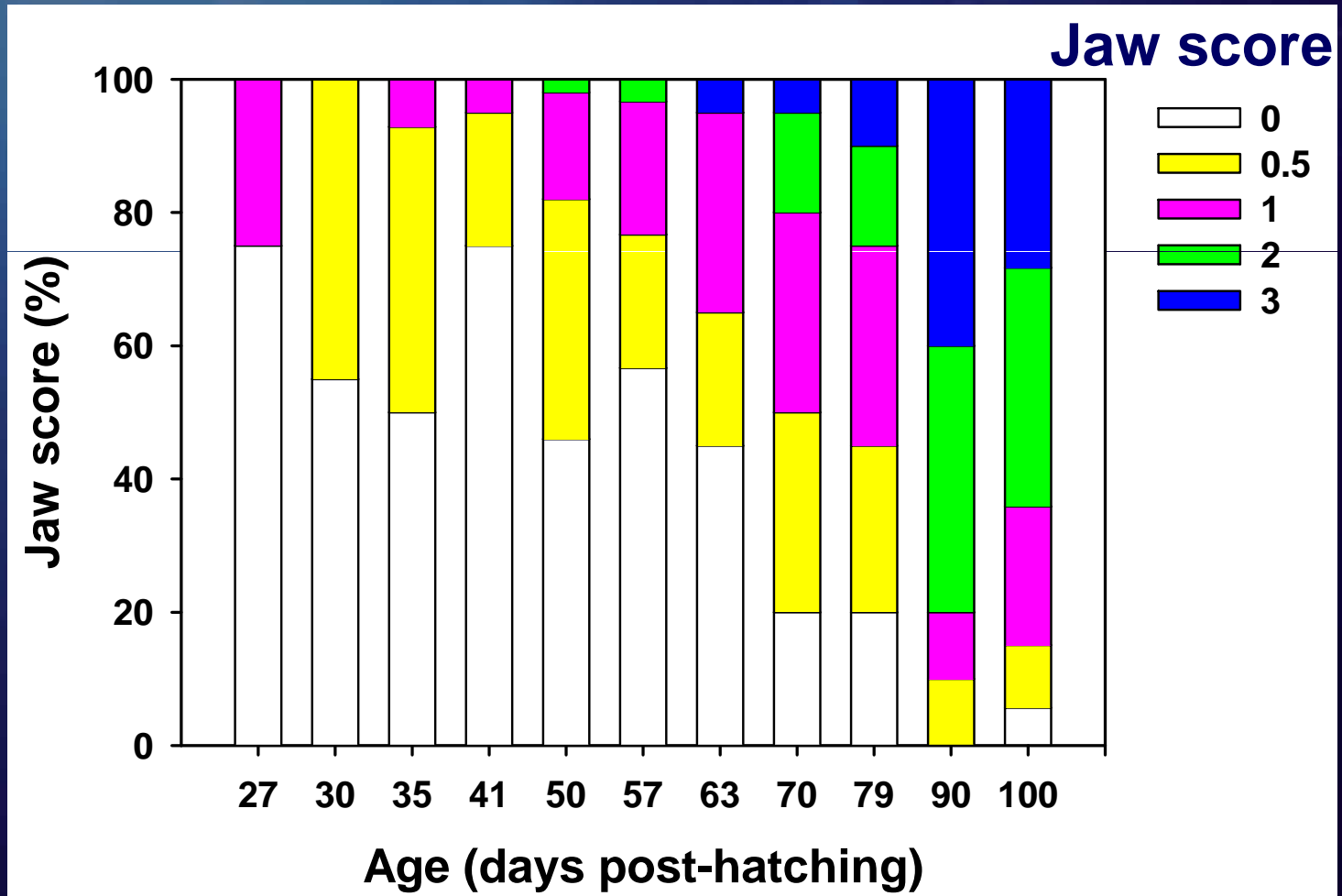
Jaw
malformation
index

Day 44



Striped trumpeter

Onset of jaw malformation



Striped trumpeter

- **Conducted a series of experiments (dietary and environmental factors)**
- **Experimental system – 24 x 300 L tanks**
- **Controlled photoperiod, temperature**
- **Flow through, recirculation or both**
- **Ozonated seawater**



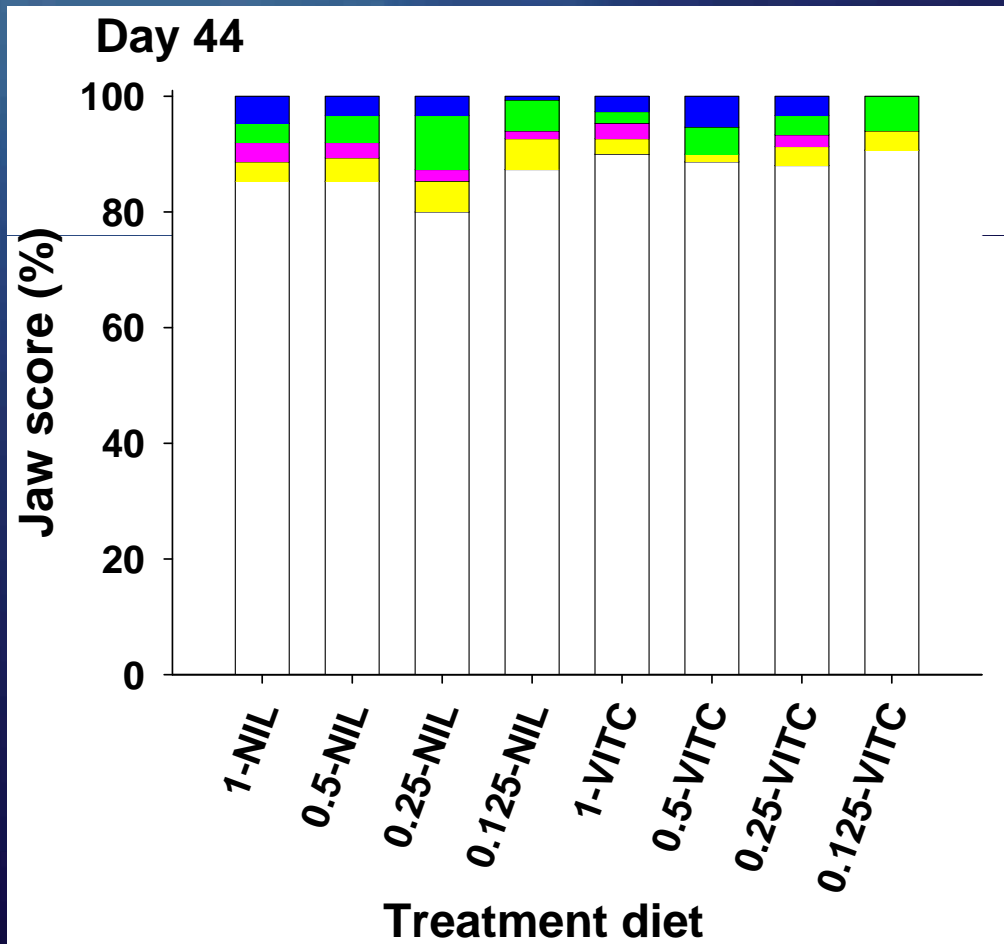
Striped trumpeter

- **Live feed - *Artemia* enrichment with Vitamin C**
 - Larvae fed *Artemia* Day 17 to Day 44
 - Multifactor experiment (Vit C and prey density)
 - *Artemia* with Vitamin C enrichment (ascorbic acid, aa, 7,900 $\mu\text{g g}^{-1}$) and without (aa 640 $\mu\text{g g}^{-1}$)
 - 4 *Artemia* densities (0.125, 0.25, 0.5 and 1.0 mL^{-1}), fed 4x daily



Striped trumpeter

- Live feed - Artemia enrichment with Vitamin C



Lower incidence with Vitamin C (8%) enrichment than without (11%)



Striped trumpeter

- **Tank colour, enrichment & water type**
 - Tank colour (black & white)
 - Diet (enriched & non-enriched)
 - Water type (green & clear)



- **Larvae cultured Day 1 to Day 29**
- **Rotifers Day 6 – Day 19**
- ***Artemia* Day 18 – Day 29**
- **Assessed growth, survival, jaw malformation**
- **Daily assessment of larval walling behaviour**



Striped trumpeter



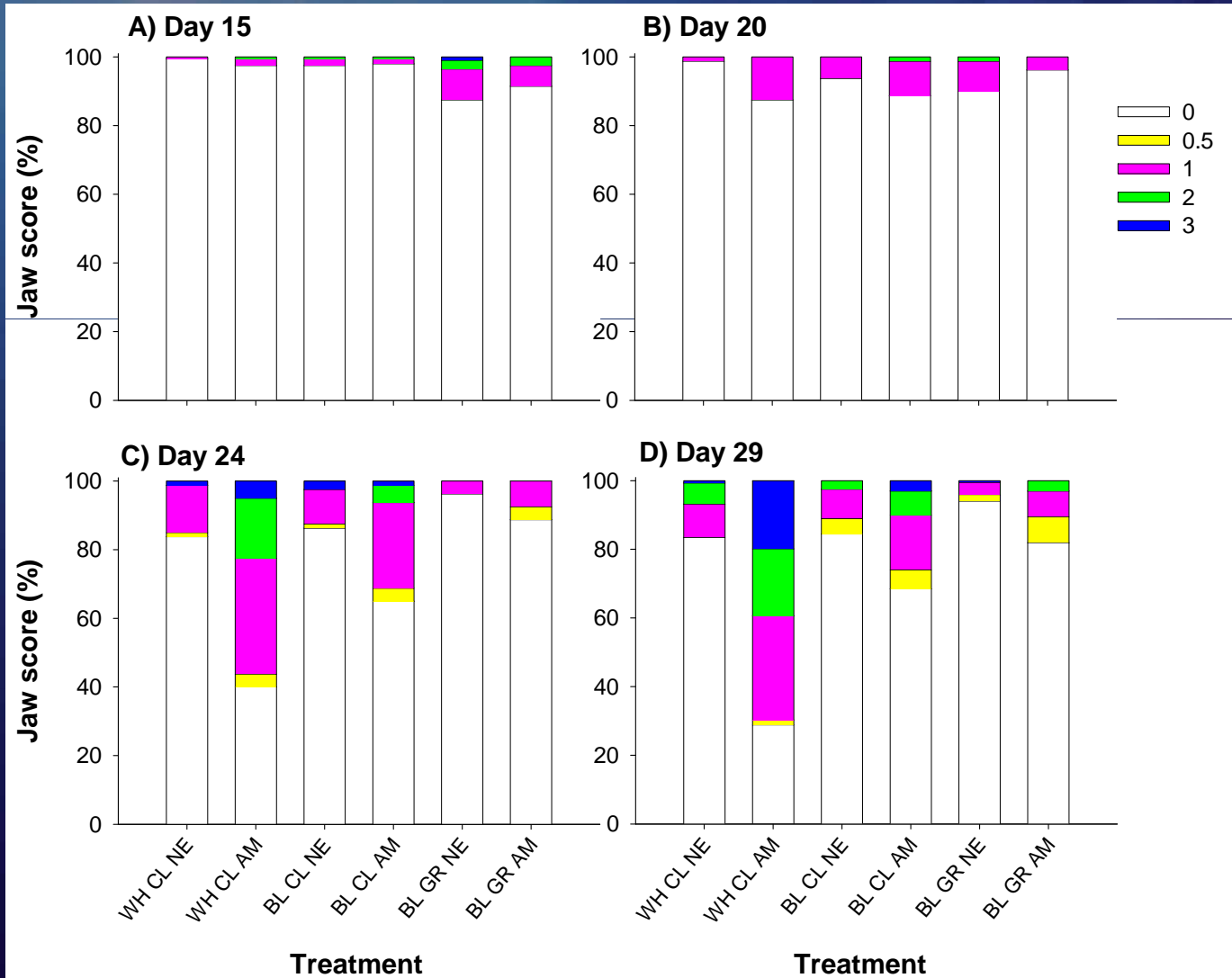
Away from wall



Walling behaviour



Results – jaw malformation



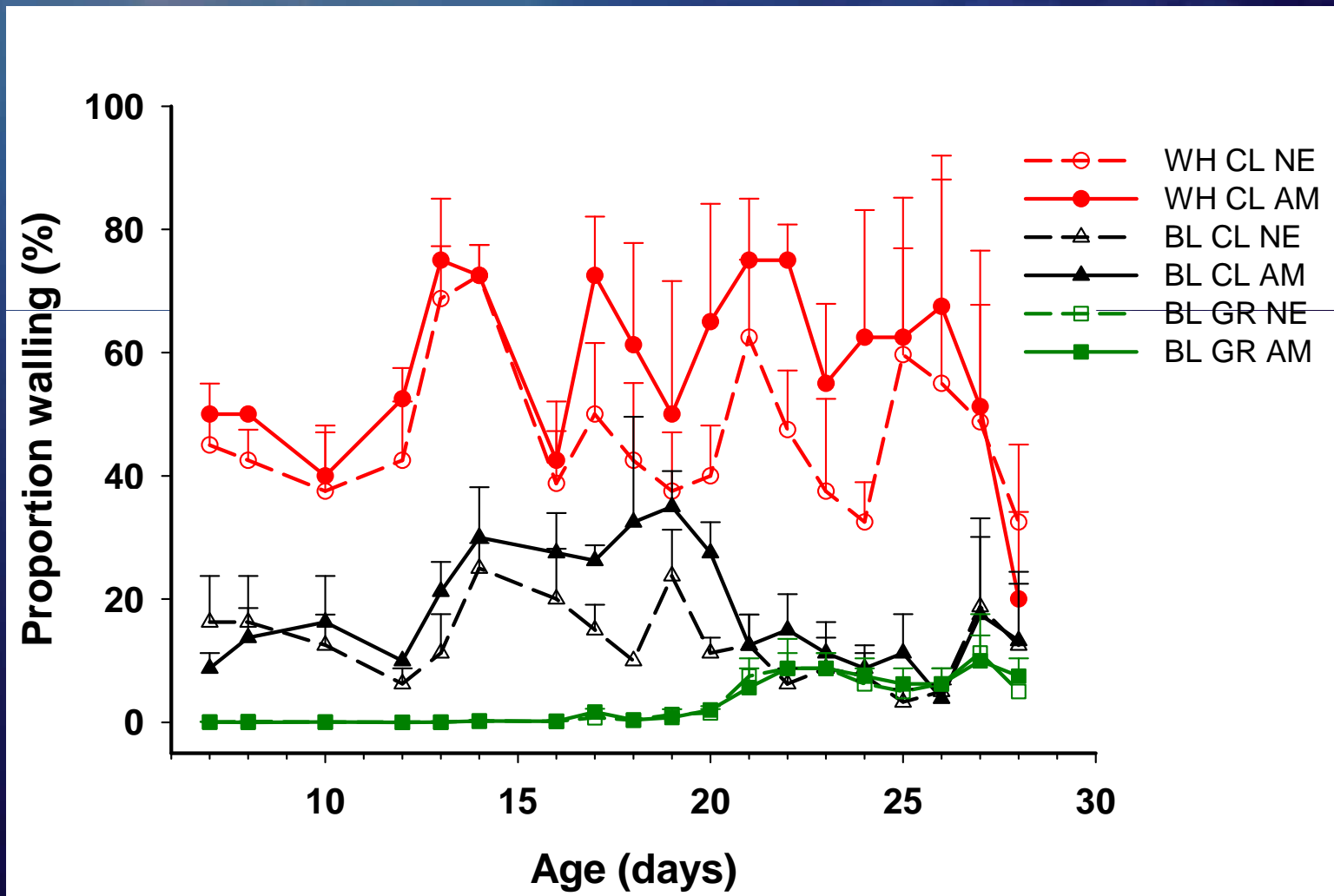
7.5 mm when malformation first observed

Day 29
In clearwater treatments
WH CL AM
70 ± 15%
> all others

In black tanks
CW > GW
AM > NE



Results – walling behaviour



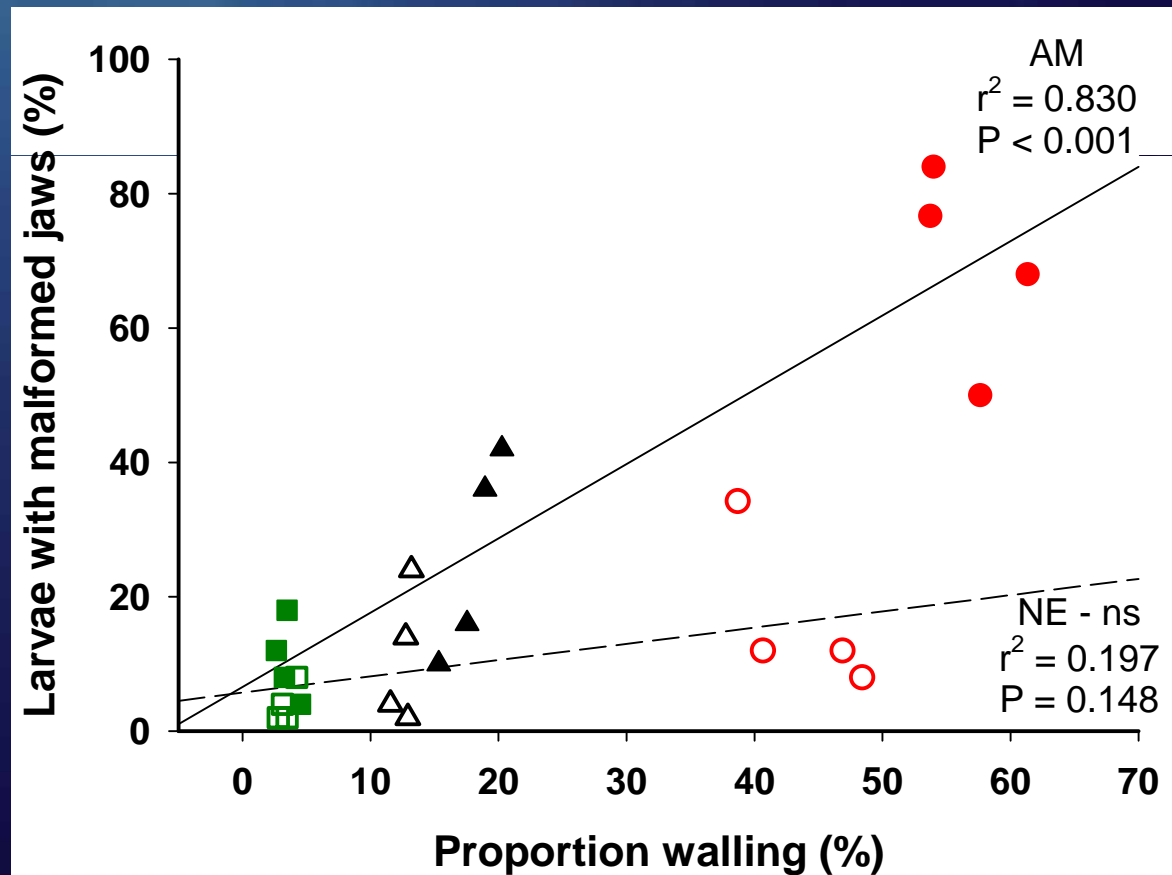
Mean + SD



Results

- jaw malformation vs walling

Correlation between jaw malformation and walling



Cobcroft et al, unpublished data



Comparison with tank colour

Tank colour

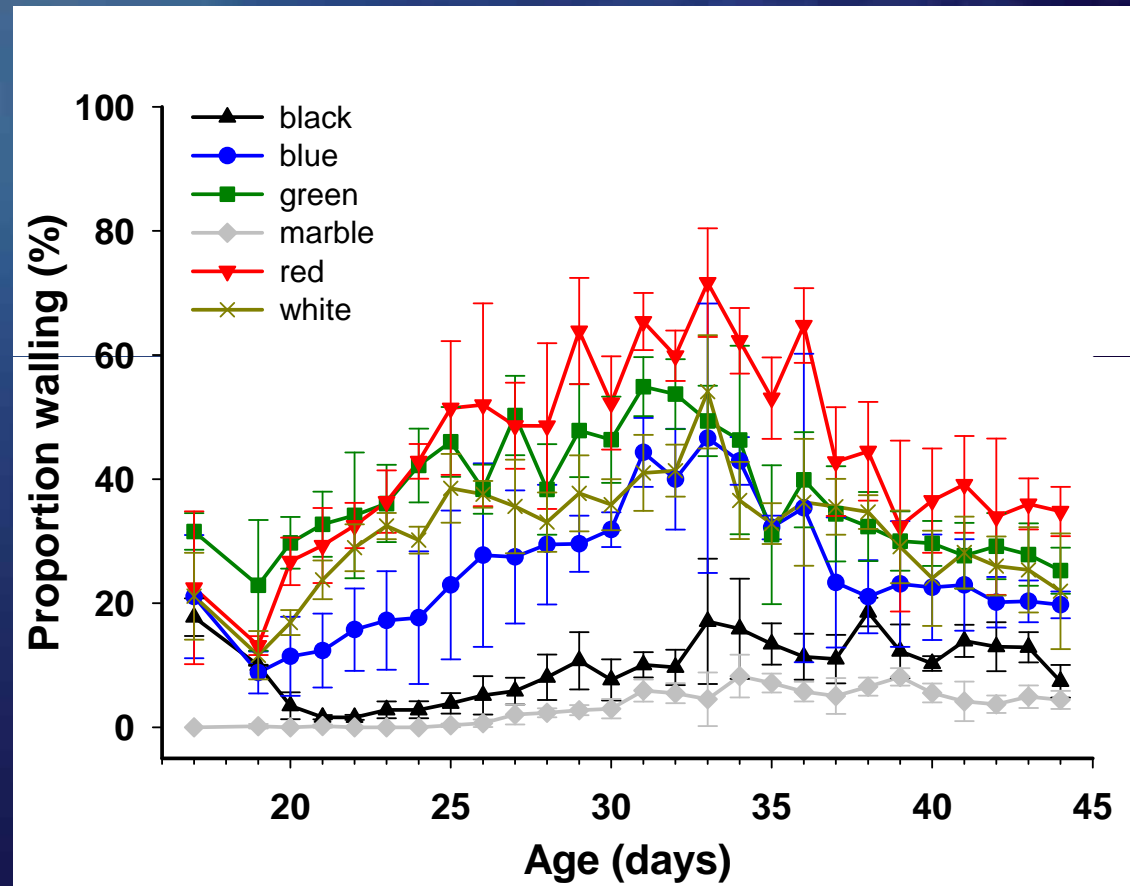
- Design: 6 tank colours, 4 reps
- Larvae cultured Day 16 to Day 44
- Daily assessment of larval walling



Comparison with tank colour

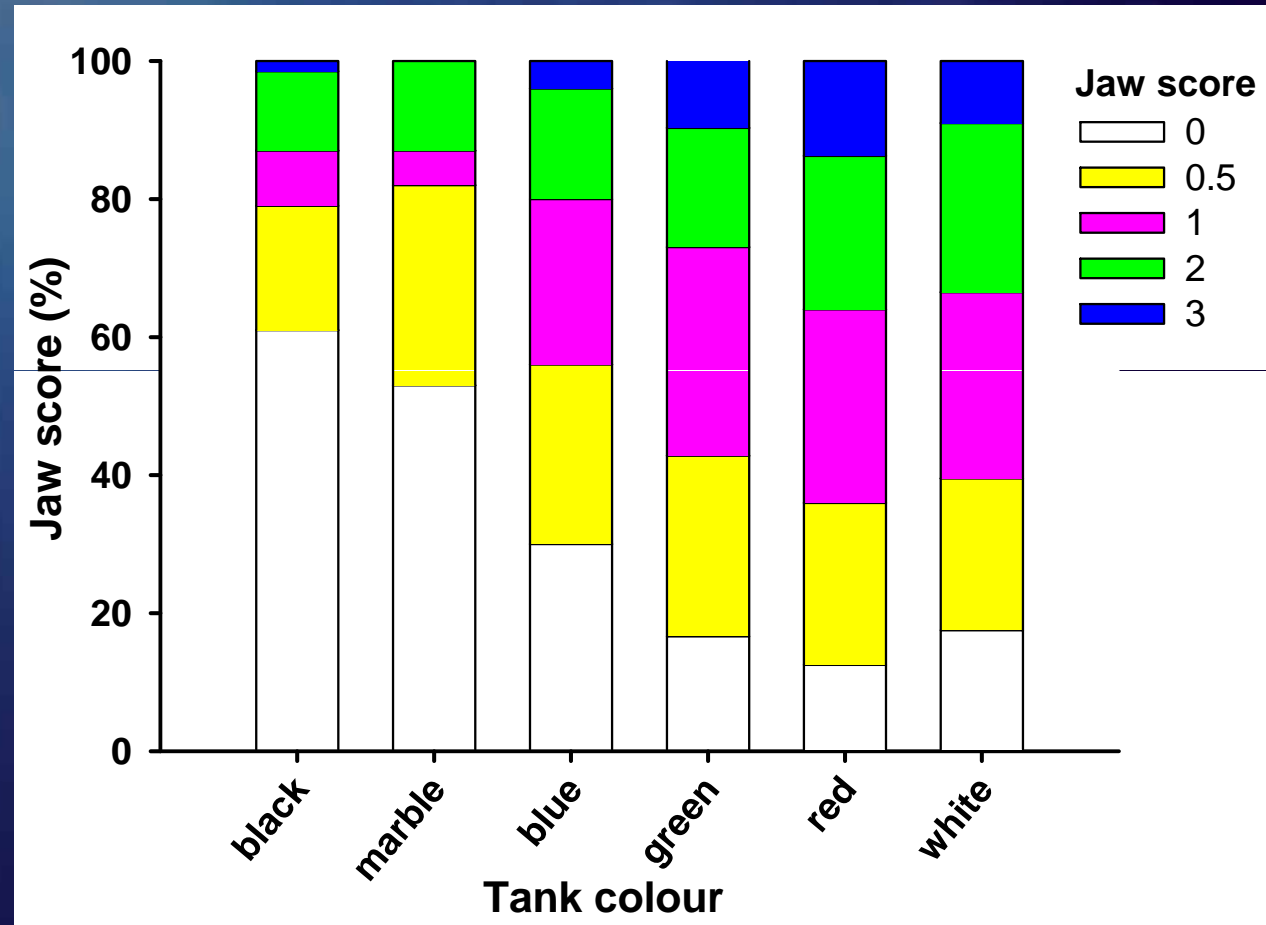
Walling behaviour

Mean \pm SD



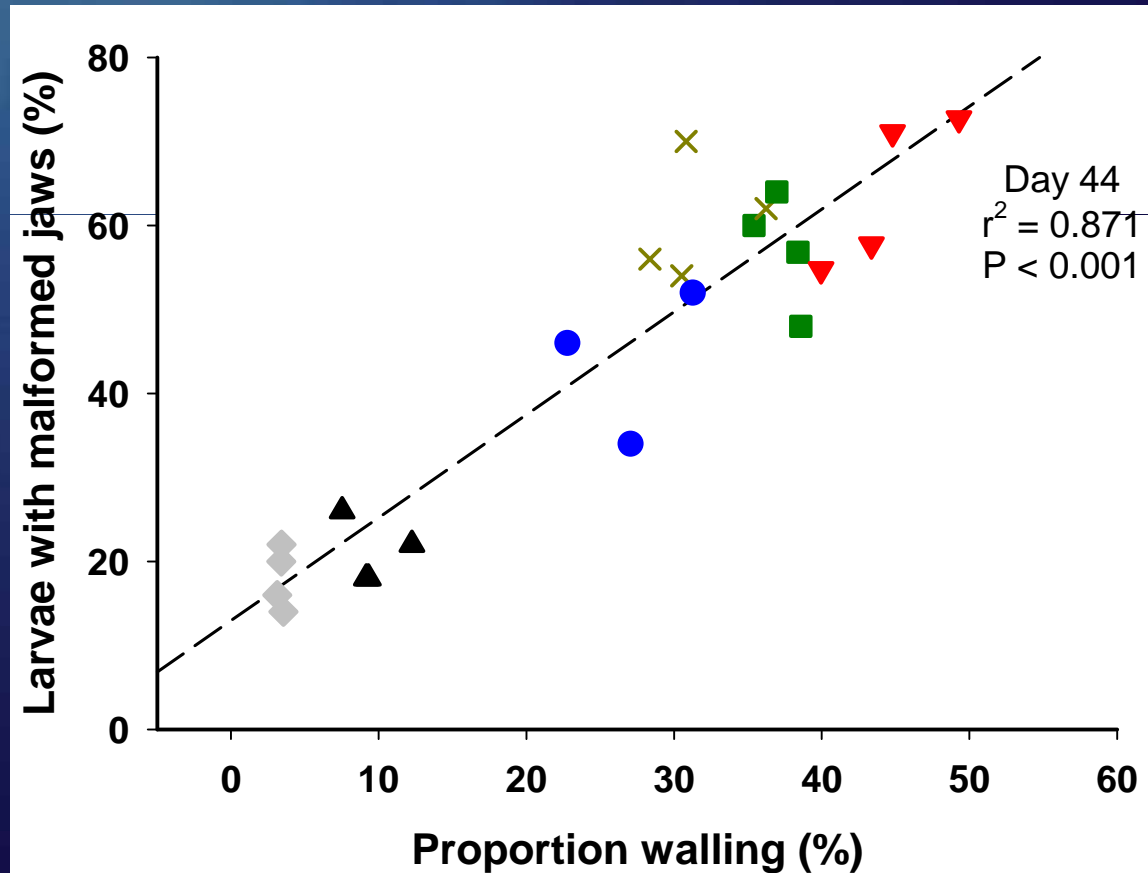
Comparison with tank colour

Jaw
malformation
Day 44





Correlation between jaw malformation and walling



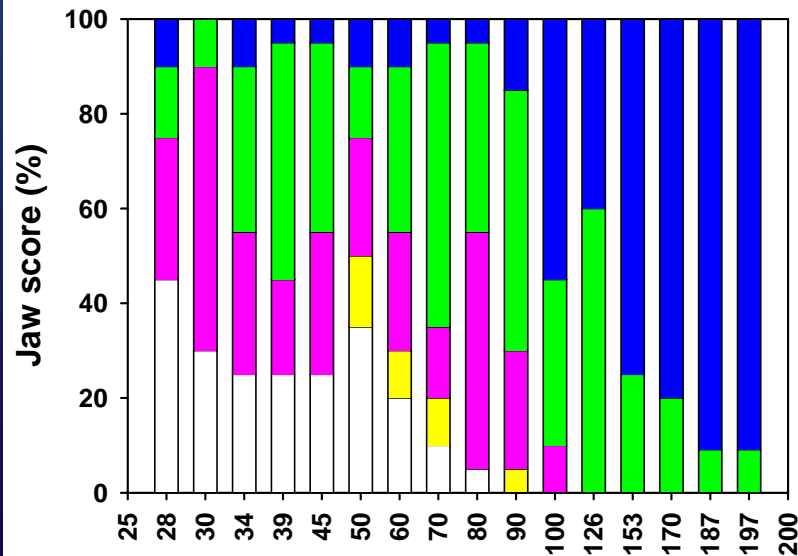
Day 44



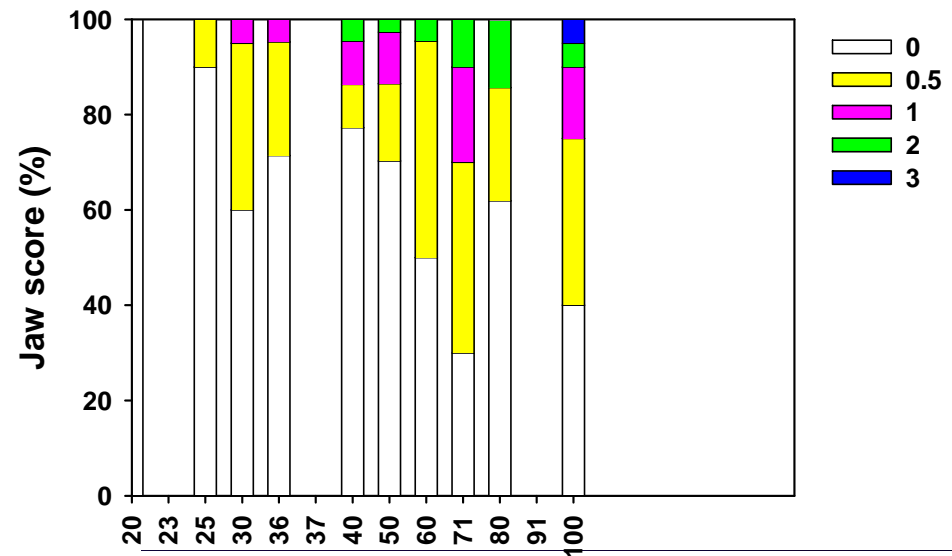
Striped trumpeter

- Improvement in quality of larvae from production trials
- 75% fish with normal & minor malformations at Day 100 in 2 trials in 2006 & 2007

2005
STT1-05



2007
STT2-07 Tank 2



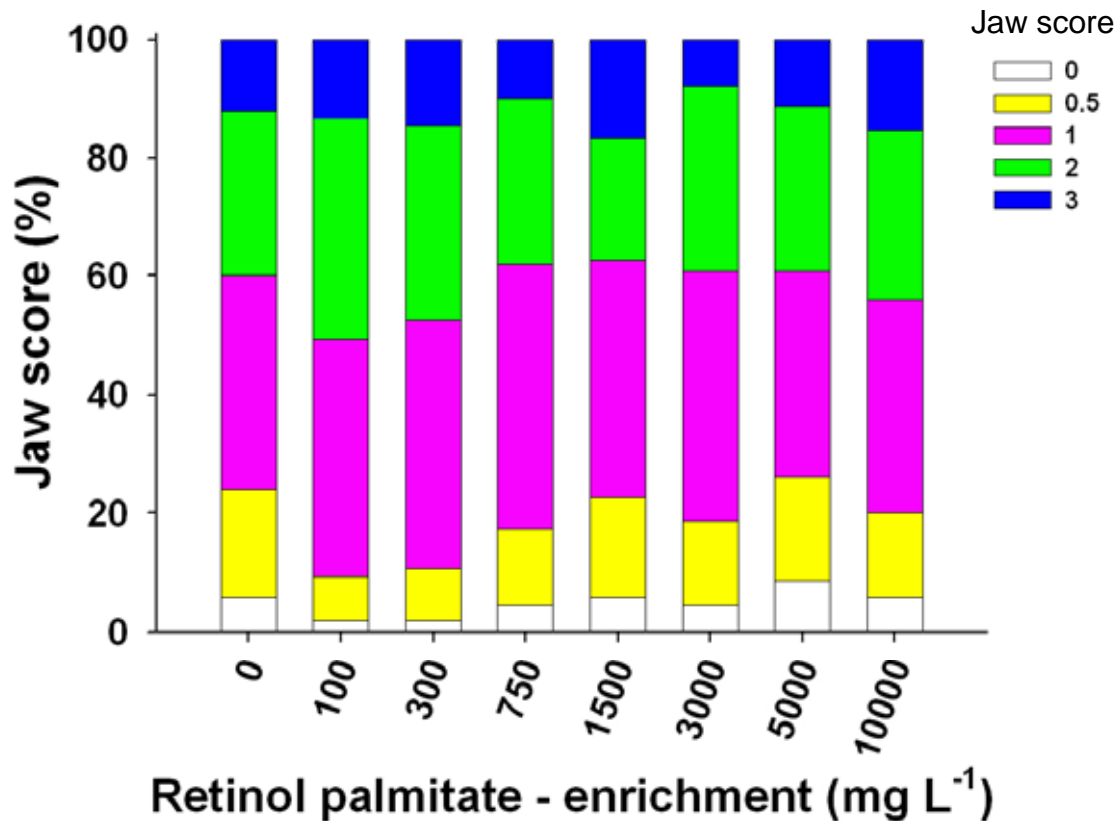
Striped trumpeter

- **Live feed - *rotifer* enrichment with Vitamin A (retinol palmitate)**
 - Larvae stocked at day 1
 - Rotifers enriched with 8 different retinol palmitate levels (enrichments contained: 0, 100, 300, 750, 1500, 3000, 5000, 10000 mg L⁻¹; NutraKol)
 - Rotifers fed day 6 to 18
 - *Artemia* (all AlgaMac 3050 enriched) fed day 17 to 43



Striped trumpeter

Day 43



Slightly higher at lower VA doses 100 and 300 mg L⁻¹.

Overall, jaw malformation higher than tank colour experiment.

Analysis of live feed VA profile and other malformations are underway.



Future Research

- Striped trumpeter (ARC Linkage) - vitamin A in live feeds on malformation and gene expression and tank system design
- Yellowtail kingfish (Seafood CRC)
- Southern bluefin tuna (Seafood CRC, CST)
- Communication with industry & identification of target areas (e.g. barramundi)
- International collaboration



Acknowledgements

TAFI – MRL Research team

Staff

Stephen Battaglione
Alan Beech
Jenny Cobcroft
Melanie Evans
Ross Goldsmid
Tanaz Jungalwalla
Tom Litjens
Anna Overweter
Gavin Shaw
Bill Wilkinson

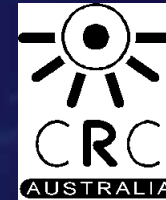
PhD Candidate

Reham Negm



Acknowledgements

Hatchery and Research staff of
Clean Seas Tuna



Darwin Aquaculture Centre – NT DRDPIFR
Northern Fisheries Centre – QDPI



Huon Aquaculture Company
NutraKol
Skretting
Clean Seas Tuna
Tasmanian Government