Dr John Taylor's Technical Visits to Tasmania

David Mitchell

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

Project No. 2012/755

PETUNA AQUACULTURE | 134 TARLETON ST, EAST DEVONPORT, TASMANIA, 7310 AUSTRALIA
www.petuna.com

PROUDLY TASMANIAN SINCE 1949

Dr. John Taylor
Reproduction & Genetics Department, Institute of Aquaculture, University of Stirling
Stirling FK9 4LA.

David Mitchell - Fish Performance Manager | Huon Aquaculture Group Pty Ltd
PO BOX 42, Dover, TAS 7117 | www.huonaqua.com.au
T: 03 6295 8109 M: 0427 353 334 | E: dmitchell@huonaqua.com.au

Richard Miller - General Manager – Farming, Petuna Aquaculture
Mob:0427039021 - Email: Richard.Miller@petuna.com

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Office Mark Oliphant Building, Laffer Drive, Bedford Park SA 5042
Postal Box 26, Mark Oliphant Building, Laffer Drive, Bedford Park SA 5042
Tollfree 1300 732 213 Phone 08 8201 7650 Facsimile 08 8201 7659
Website www.seafoodcrc.com ABN 51 126 074 048

Australian Government
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An Australian Government Initiative

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NON-TECHNICAL SUMMARY

PROJECT NO: Dr John Taylor's Technical Visits to Tasmania

PRINCIPAL INVESTIGATOR:

Dr. John Taylor
Reproduction & Genetics Department
Institute of Aquaculture
University of Stirling
Stirling FK9 4LA.
e-mail: jft2@stir.ac.uk
Tel: +44 (0) 1786 467929
Fax: +44 (0) 1786 472133

Web: http://www.aqua.stir.ac.uk/rep-gen/

(PROJECT) OBJECTIVES OF RESEARCH TRAVEL GRANT/ INDUSTRY BURSARY

To discuss the latest findings in the areas of:-

1. Performance improvement of Atlantic Salmon Triploids
2. Lighting regimes for Atlantic Salmon
3. Trout production
4. Rearing of Atlantic Salmon in sub optimal conditions

NON TECHNICAL SUMMARY:

Dr Taylor spent a week visiting marine sites and hatcheries where John presented his presentation and took questions followed by discussion. It provided a rare opportunity to have a lead researcher present and interact with on-site staff and was highly appreciated.

See attached itinerary and presentation.

OUTCOMES ACHIEVED TO DATE

- Growers have reviewed their early rearing temperatures and revised these downwards.
- Some growers have changed to a minerally enhanced diet.
- Current LED light development has moved away from single colour wavelengths back to white light
- Triploid deformity rates reduced by approximately a third

(PROJECT) OUTPUTS DEVELOPED AS RESULT OF TRAVEL GRANT/ INDUSTRY BURSARY:

- Changes to diet regimes
- Changes to hatchery manuals and SOPs
- Changes to lighting SOPs

ABOUT THE PROJECT/ACTIVITY

BACKGROUND AND NEED

It was hoped that the visit would lead to an exchange of information to between Europe and Tasmania on triploids with long term benefits in the outcomes. Tasmanian growers were keen to access the latest European research on triploidy in salmon. There is currently no research on triploidy in salmon being carried out in Australia

For Tasmanian growers triploids are one of the poorer performing stock types but a necessary part of the strategy for producing the right sized harvest fish all year round. The growers hope to achieve improved performance and quality of triploids through to harvest – lower FCR, faster growth, higher quality, lower deformities, higher survival, possibly enhanced breeding within the SBP.

In addition John's experience of lighting regimes of several species to maximise production will help to make sure Tasmanian growers are doing all they can to keep our fish healthy and productive. Tasmanian companies are currently looking at the use of LED lighting in sea cages which is one of John's areas of expertise.

His experience with the trout industry in Scotland will also be of benefit to Tasmanian companies who grow trout in Macquarie Harbour. This will be particularly important with a view to looking at female production as the industry is almost solely triploid trout. He has a long experience with feeding and lighting regimes with regard to Trout which Tasmanian growers can benefit from. It seems that the UK industry are experiencing similar problems with growth and survival of large trout, market acceptance of small trout and high maturation of females.

RESULTS

John presented a review of results from a variety of studies over the last few years, many of which are as yet unpublished. This has resulted in early access to research findings. In addition the question and answer sessions with staff were very wide ranging and gave the companies an overview of recent results of trials concerning improved salmon and trout production.

INDUSTRY IMPACT

PROJECT OUTCOMES (THAT INITIATED CHANGE IN INDUSTRY)

For improved triploidy production John highlighted the importance of lower rearing temperatures in the hatchery phase and the use of minerally enhanced diets as a way to help reduce triploid deformity rates. A reduction in deformity then gives better growth, conversion and quality.

For photoperiod control John highlighted the dangers of relying on specific wavelengths of light to have the desired affect.

SUMMARY OF CHANGE IN INDUSTRY

- The growers have reviewed their early rearing temperatures and revised these downwards.
- Some of the growers have changed to a minerally enhanced diet.
- Current LED light development has moved away from single colour wavelengths back to white light

WHAT FUTURE AND ONGOING CHANGES ARE EXPECTED?

Since John's visit we have implemented the above changes and there looks to be a reduction in triploid deformity rates by approximately a third. This will be economically significant in reducing the down grade % in triploids.

New powerful white light LED's have been developed this year between the growers and light manufacturers and initial results look promising.

WHAT BARRIERS ARE THERE FOR CHANGES TO OCCUR?

Reduction in early rearing temperatures also slows down growth so it needs to be trialled and senior management need convincing that it will reduce deformity rate. If not then the fish just end up smaller!!

The diet development has been with Biomar who do not have a mill in Tasmania. This means the feed needs to be imported which is no so easy but not insurmountable.

IF NOT ALREADY HAPPENING, WHEN WILL THE CHANGES OCCUR?

- Rearing temperatures have been changed by the growers in different cohorts and awaiting results but looks promising.

- One of the companies is already importing the feed so an avenue exists.

WHAT IS THE LIKELIHOOD THAT THESE CHANGES WILL OCCUR?
(e.g. 50% chance that four businesses will adopt project findings)?

Very high

WHAT BARRIERS ARE THERE TO ADOPTION OF THESE CHANGES AND WHAT ACTION COULD BE TAKEN TO OVERCOME THESE?

No insurmountable barriers

COMMUNICATION OF PROJECT/EXTENSION ACTIVITIES

WHAT IS THE OUTPUT THAT NEEDS TO BE COMMUNICATED?

The presentation was given to site staff and circulated to senior managers.

WHO IS/ARE THE TARGET AUDIENCE/S?

All site staff from husbandry personnel to technical and senior managers

WHAT ARE THE KEY MESSAGES?

How through husbandry can triploid performance be improved.

What direction show LED light technology follow top be most safe and effective

WHAT IS THE CALL TO ACTION?

Implement the recommendations, these have happened.

COMMUNICATION CHANNELS

(How can these messages be communicated and by who?):

Channel	*Who by*	*When*
Direct to Huon and Petuna Staff	Dave Mitchell	June 2014

LESSONS LEARNED AND RECOMMENDED IMPROVEMENTS

WHAT IS YOUR FEEDBACK?

This was a great visit much appreciated by all involved. It is very rare for an overseas researcher to openly present a review of their findings to site staff on Tasmanian salmon farms.

FURTHER ACTION REQUIRED IN REGARDS TO COMMERCIALISATION?

It has set up a good link between Tasmanian farmers and an applied research group at the Institute of Aquaculture, University of Stirling in Scotland. This is allowing exchange of information which helps both groups progress their knowledge at a faster pace.

ACKNOWLEDGEMENTS

- Dr J Taylor for being so generous with his precious time and information and his willingness to be so open to all for discussion
- Prof H Migaud from Stirling for allowing John to make the visit
- Dr M Porter from Petuna for facilitating contact
- Emily Mantilla for helping to make this happen

APPENDIX

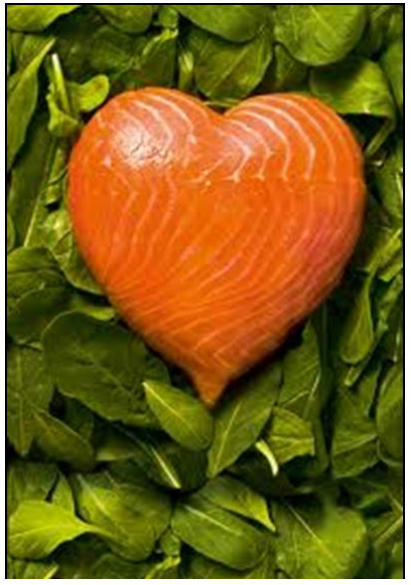
See attached itinerary, presentation and triploid induction protocols

ITINERARY – Dr John Taylor – Institute of Aquaculture, University of Stirling (Sun Mar 2nd to Fri Mar 7th)

Date	Activity	Where	Time	Other Information	Accommodation
Sun Mar 2	Arrive Hobart – HAC SE Open Day at Pt Huon – Visit SE sea sites in Huon/Channel	Pt Huon	10.00	Ross B (Taxi) -Arrive Pt Huon 12.00 Boat tour 2.00pm	Kermandie Hotel
Mon Mar 3	Presentation	Hideaway Boardroom	8:00 – 9:00	HB staff	
	Hatchery - Presentation	Lonnavale	11:00 – 13:00	Nath/Linz	
	Travel to Strahan(via Meadowbank)		13.30 – 18.30	Mike	Strahan Village
Tue Mar 4	MH Farm 1 - Presentation	Strahan	7:00 – 11.00	Rick	Devonport Gateway Dinner with M Thomsen
	MH Farm 2 - Presentation	Strahan	11:00 – 15:00	R Miller/ M O Malley	
	Travel to Launceston	Launceston	15:00 – 18:30		
Wed Mar 5	Factory 1	Devonport	8:30 – 10:30	Mike Thomsen	Launie country Club Dinner with M Porter, R Miller
	Factory 2	Paramatta Creek	11:00 – 13:00	Simon, Jeremiah	
	Hatchery - Presentation	Cressy	14:30 – 16:30	Richard, Shaun	
Thu Mar 6	Hatchery - Presentation	Bridport	10:00 – 11:00	Duncan	Woolstore Dinner DC, Ross B, Jonno
	Hatchery - Presentation	Springfield	11:30 – 13:00	Ian	
	Hatchery - Presentation	Millybrook	14:30 – 16:00	Matt	
Fri Mar 7	Hobart Offices	Hobart Offices	9:00 – 11:00	Review, prep,	TBA
	Presentation and discussion	Hobart Meetings Room	12:00 – 16:30	Senior management and Technical staff	

Overview: Ongoing Research at Institute of Aquaculture



Dr John Taylor

jft2@stir.ac.uk

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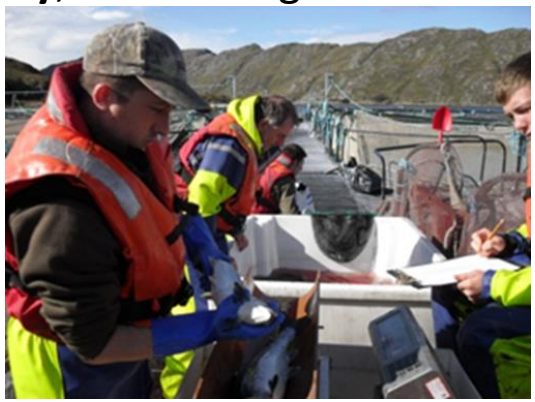
A bit about me

- Completed PhD in Dec 2004: "Photoperiod regulation of growth and reproduction in rainbow trout"

- Since 2005 I have held the position of **Research Fellow** in Genetics & Reproduction group

FP7: ARRAINA: *Advanced Research Initiatives for Nutrition & Aquaculture*
FP7: SALMOTRIP: *Triploid salmon feasibility study*
FP6: Cod-Light Tech: *Lighting technology for mariculture*
FP5: Pubertiming: *Regulation of puberty in farmed fish*

- **12 years direct working contact with academia and industry**, conducting research in the main farmed fish species in Europe and Internationally



- My research expertise is in the field of

  - **Environmental control of fish physiology**

  - **Nutritional regulation of deformity**

- My research is **industry driven** and **practically orientated** to ensure outputs are timely, current and with the **highest industrial application and impact**.

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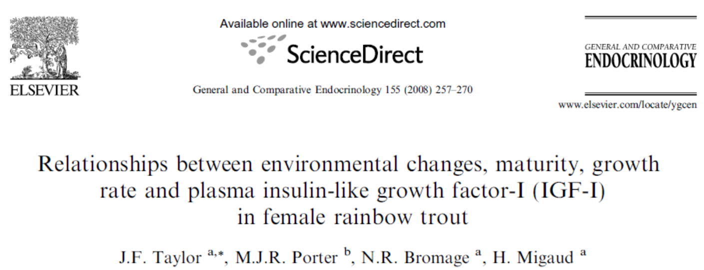
Environmental Endocrinology & Physiology

- **Environmental entrainment**: principally photoperiod and temperature
- **Biomarkers** of growth and reproductive function: somatotropic – reproductive axis cross-talk
- **Manipulation of farmed stocks**:
    - out-of season production
    - enhanced broodstock management
    - arrest pre-harvest maturation
- Relevant for culture requirements in face of **climatic change**

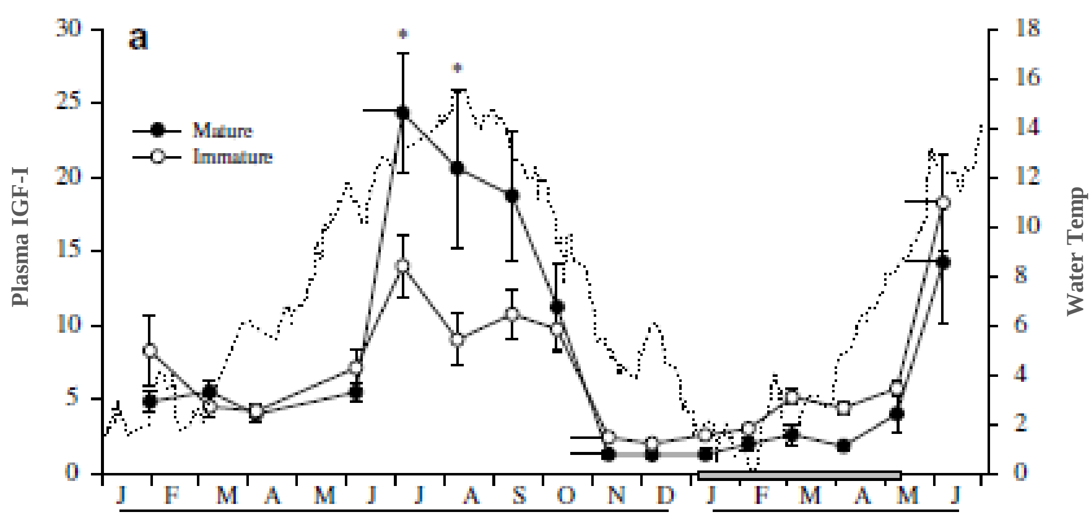

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
General and Comparative Endocrinology 155 (2008) 257–270
GENERAL AND COMPARATIVE ENDOCRINOLOGY
www.elsevier.com/locate/ygcen

Relationships between environmental changes, maturity, growth rate and plasma insulin-like growth factor-I (IGF-I) in female rainbow trout

J.F. Taylor [a,*], M.J.R. Porter [b], N.R. Bromage [a], H. Migaud [a]

FP5 Pubertiming

FP6 codlight-tech.com



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Alternative Stock Management Strategies - Sterile Fish

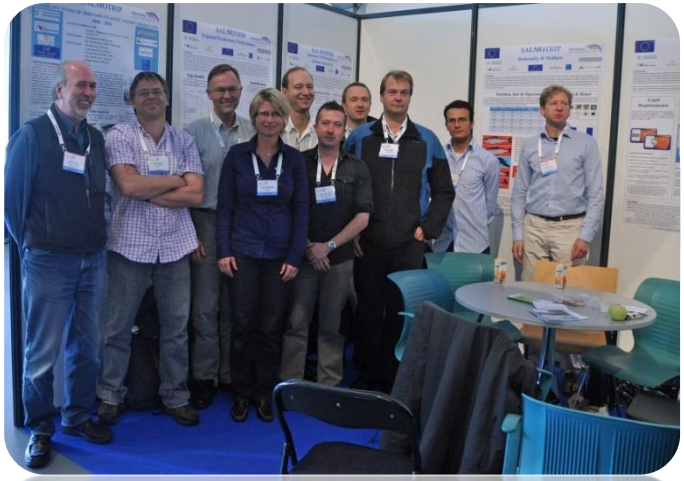
A sterile animal directs **energy towards muscle growth** and not reproduction

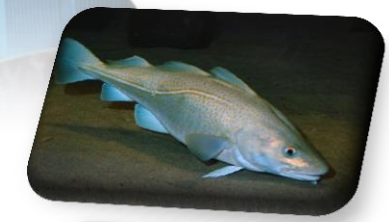
Salmotrip
Study of Triploid Atlantic Salmon Production

FP7 SALMOTRIP: Feasibility study of commercial triploid Atlantic salmon production (€1.2 M)
An international RTD & industrial collaboration

Key Results:

- **Growth enhancement of 25-30%**
- **More efficient resource utilisation**
- **"Green" farming credentials**
- **Knowledge based consumer acceptance**
- **Application in other species**





Contents lists available at ScienceDirect
Aquaculture
journal homepage: www.elsevier.com/locate/aqua-online

Parr–smolt transformation in out-of-season triploid Atlantic salmon (*Salmo salar* L.)

J.F. Taylor [a], E. Leclercq [a], A.C. Preston [a], D. Guy [b], H. Migaud [a,*]
[a] Institute of Aquaculture, University of Stirling, Stirling, Scotland, UK
[b] Landcatch Natural Selection, Alloa, Scotland, UK

Contents lists available at ScienceDirect
Comparative Biochemistry and Physiology, Part A
journal homepage: www.elsevier.com/locate/cbpa

Comparative seawater performance and deformity prevalence in out-of-season diploid and triploid Atlantic salmon (*Salmo salar*) post-smolts

E. Leclercq [a], J.F. Taylor [a], D. Fison [a], P.G. Fjelldal [b], M. Diez-Padrisa [a], T. Hansen [b], H. Migaud [a,*]
[a] Institute of Aquaculture, University of Stirling, Stirling, Scotland, UK
[b] Institute of Marine Research, Matre Research Station, Norway

Malformation Monitoring & Mitigation

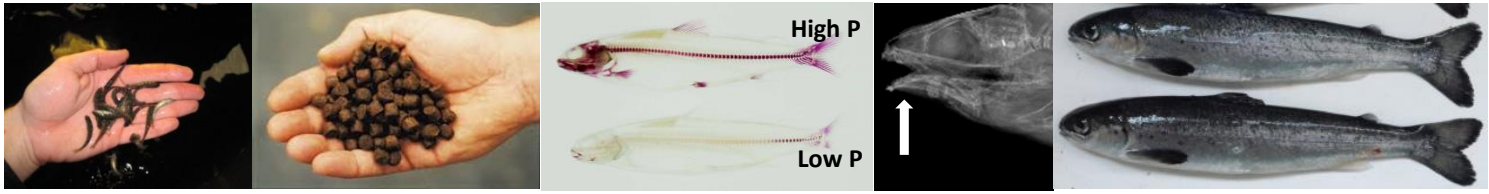
- Understanding **nutritional regulation of deformity**

Past

Future

- **Integrated Life Cycle Management : Interactions** between **life stage & micronutrients**

"Because we see the problem in one place does not mean it did not start elsewhere"



Freshwater

?

Seawater

- **Complementarity** between research disciplines
- **Central management role** of long-term feeding trials

ARRAINA
Advanced Research Initiatives for Nutrition & Aquaculture

Translation of Research into Application

- **Application of technology innovation to support industrial evolution**





Available online at www.sciencedirect.com
SCIENCE DIRECT
Aquaculture 256 (2006) 216–234
Aquaculture
www.elsevier.com/locate/aqua-online

Photoperiod can be used to enhance growth and improve feeding efficiency in farmed rainbow trout, *Oncorhynchus mykiss*

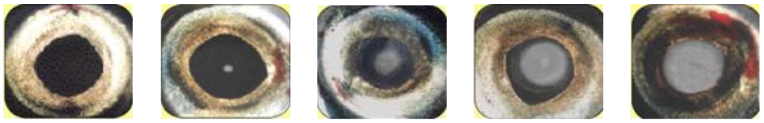
J.F. Taylor [a,*], B.P. North [a], M.J.R. Porter [b], N.R. Bromage [a], H. Migaud [a]
[a] Institute of Aquaculture, University of Stirling, Stirling, Scotland, FK9 4LA, UK
[b] Tasmanian Aquaculture and Fisheries Institute, School of Aquaculture, Tasmania, Australia

Contents lists available at ScienceDirect
Aquacultural Engineering
journal homepage: www.elsevier.com/locate/aqua-online

The potential of alternative lighting-systems to suppress pre-harvest sexual maturation of 1+ Atlantic salmon (*Salmo salar*) post-smolts reared in commercial sea-cages

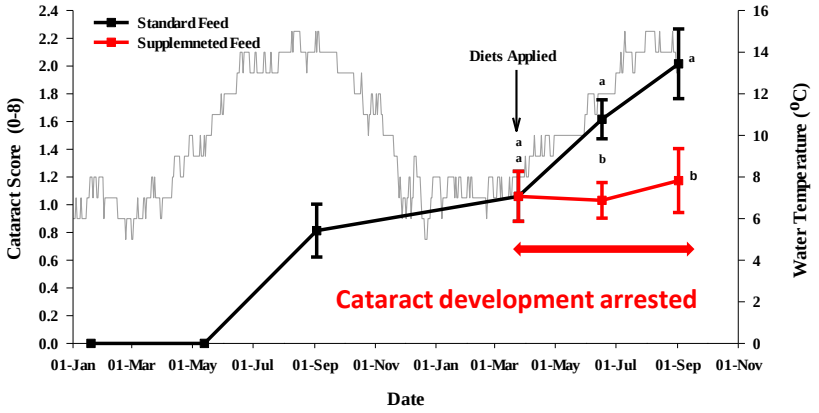
E. Leclercq, J.F. Taylor, M. Sprague, H. Migaud*

- **Anti-malformation diets**



Covering of lens diameter

0 %	< 10 %	10 – 50 %	50 – 75 %	> 75 %
Cataract score				
0	1	2	3	4



Taylor et al.,(2014) *Aquaculture Nutrition*

Salmotrip

Study of Triploid Atlantic Salmon Production

Triploid salmon: What did we learn?

John Taylor*, P.G. Fjelldal, T. Hansen, A. Kole, A. Storset, D.R. Guy, O. Breck, T. Danielson, G. Moss, D. Hunter, P. Campbell, J. Walton & H. Migaud**

* **jft2@stir.ac.uk,** Institute of Aquaculture, University of Stirling, Scotland

**hm7@stir.ac.uk, Institute of Aquaculture, University of Stirling, Scotland

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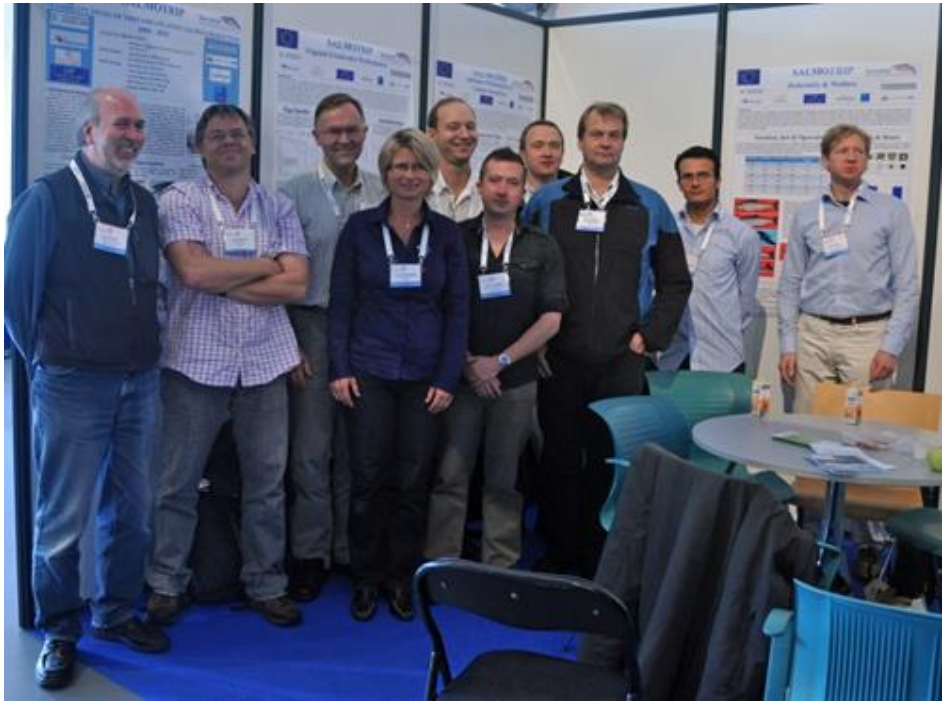
Salmotrip

Study of Triploid Atlantic Salmon Production

CAPACITIES

This project was supported by the EUROPEAN UNION (FP7, project 222115)

June 2008 to June 2011



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INSTITUTE OF MARINE RESEARCH
HAVFORSKNINGSINSTITUTTET

WAGENINGEN UR
For quality of life

Landcatch
A Hendrix Genetics Company

AquaGen

AquaGen

marineharvest

SAUMON
DE FRANCE

CAC
CENTRE FOR AQUACULTURE COMPETENCE AS

Research has since continued within Scotland

Salmotrip
Study of Triploid Atlantic Salmon Production

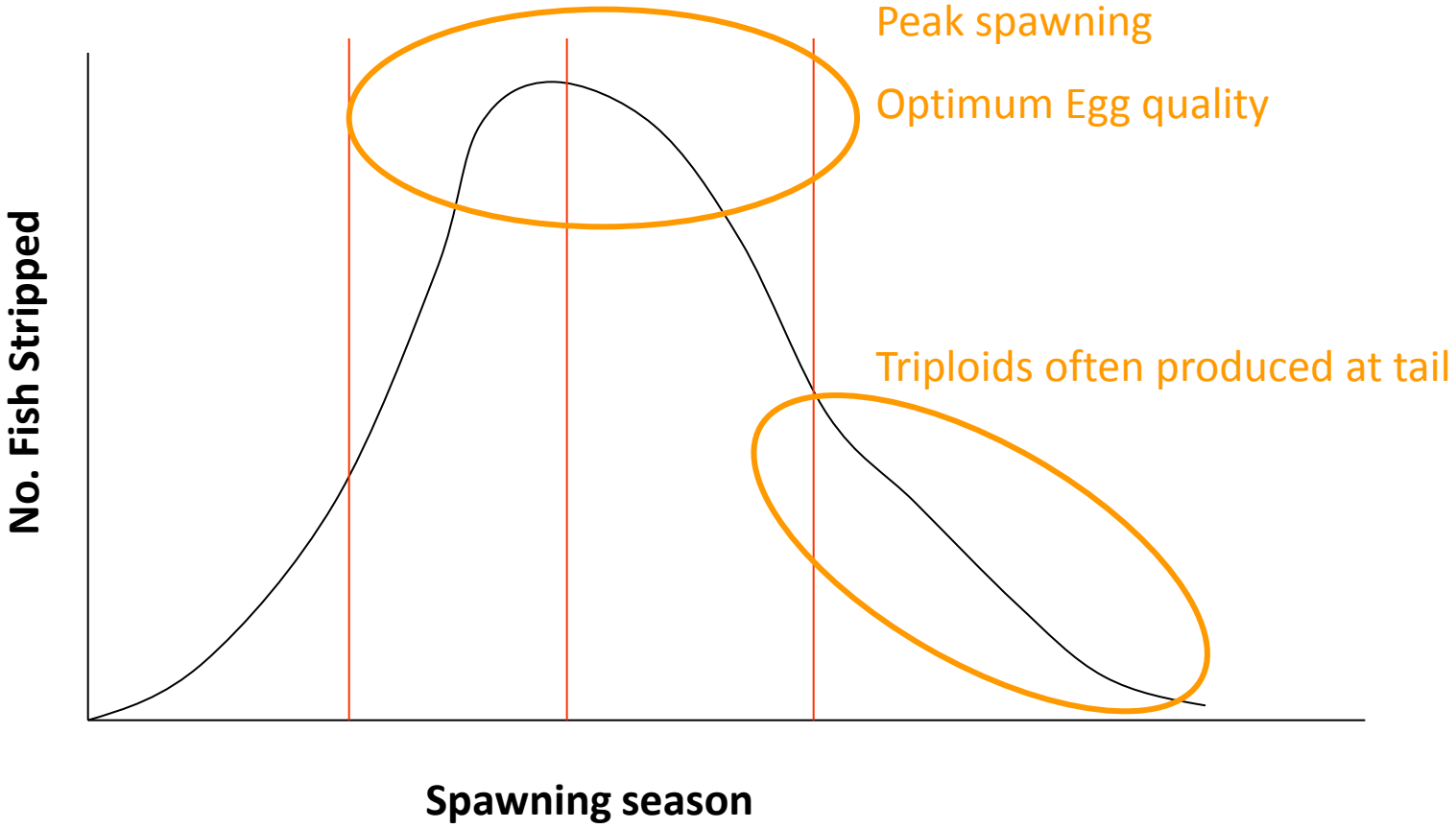
Improved Survival

- **Assumption: Triploids have poorer survival**
  - **Higher between eyeing to hatch, thereafter 3N = 2N**
  - **Timing of stripping crucial**
  - **50% reduction in yield if inferior quality eggs are used**
  - **Handling procedures majorly affect yield**
  - **Commercial up-scaling**

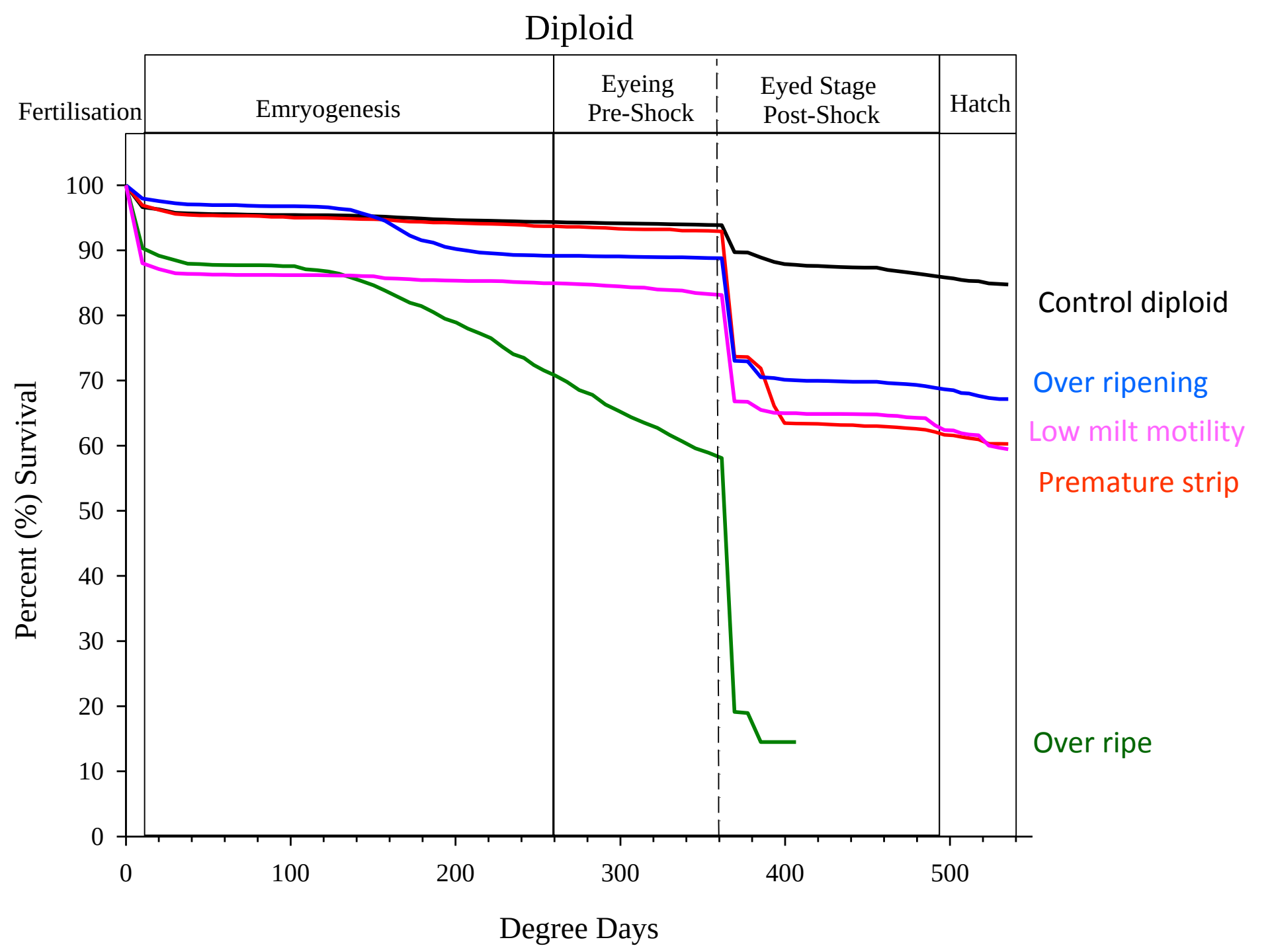
Good Eggs

“Bad” Eggs

Time of stripping



ALSO IMPORTANT TO CONDISER TIME OF OVULATION-INSPECTION-STRIPPING


Diploid
Fertilisation
Emryogenesis
Eyeing
Pre-Shock
Eyed Stage
Post-Shock
Hatch
Percent (%) Survival
100
90
80
70
60
50
40
30
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10
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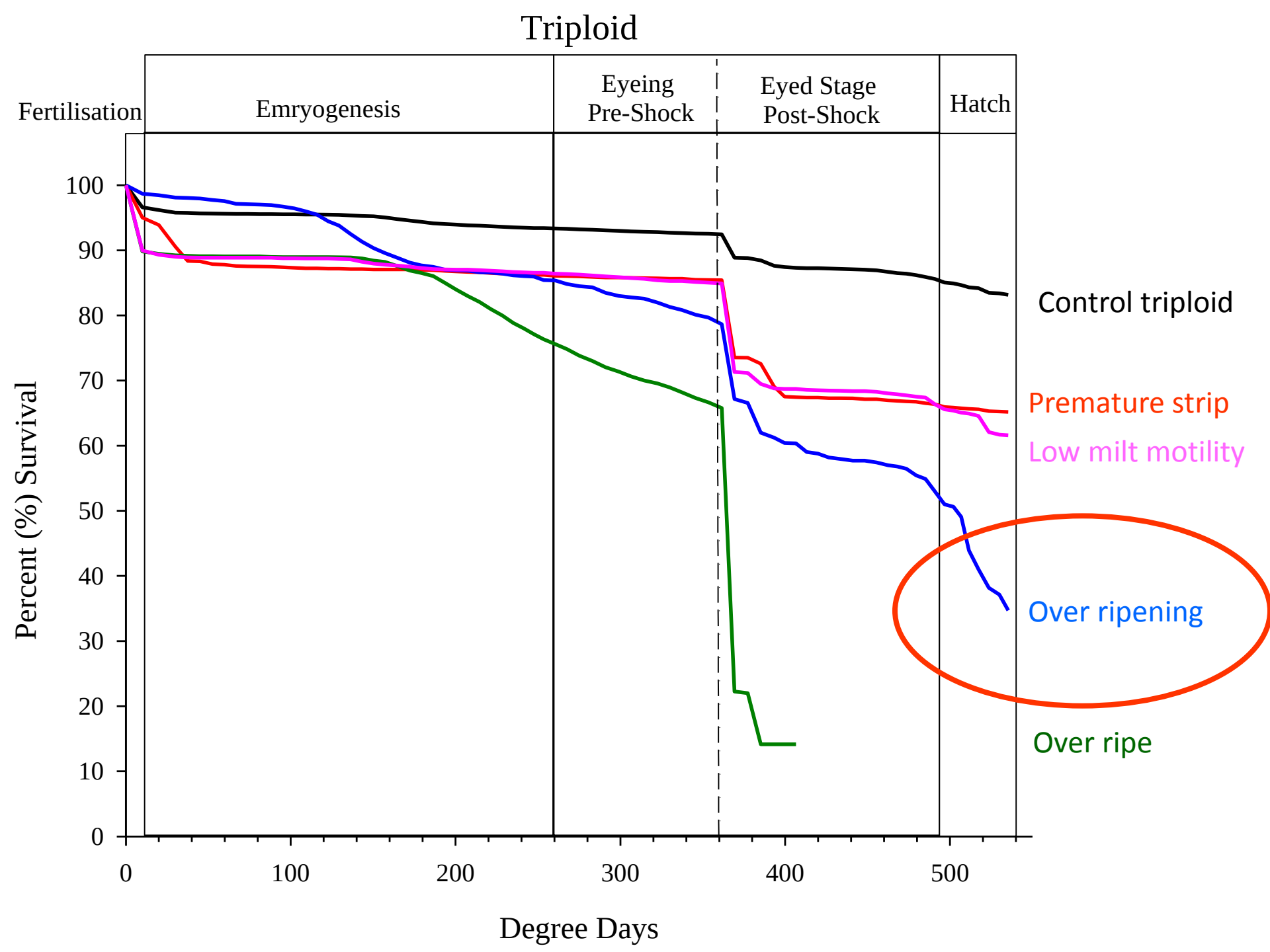
200
300
400
500
Degree Days
Control diploid
Over ripening
Low milt motility
Premature strip
Over ripe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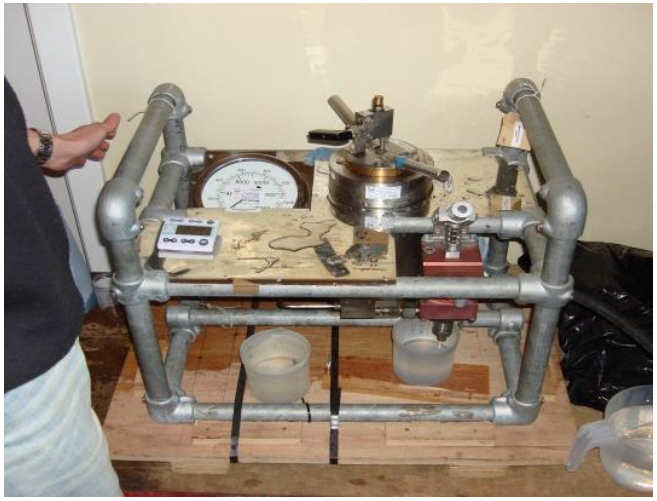
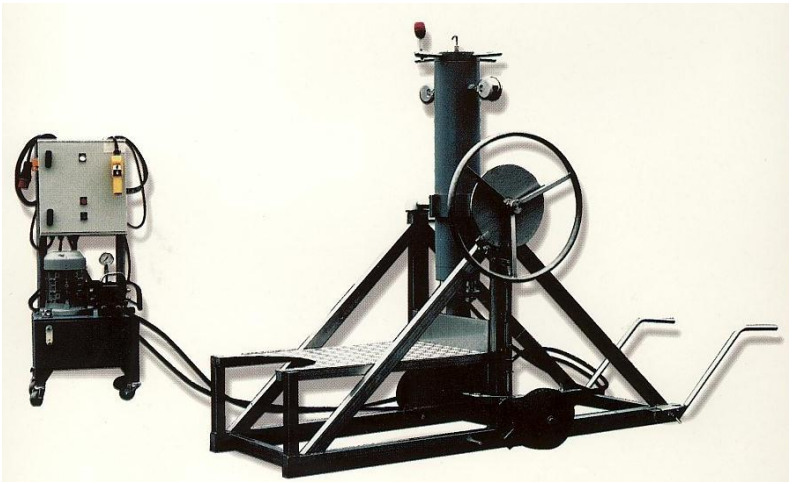
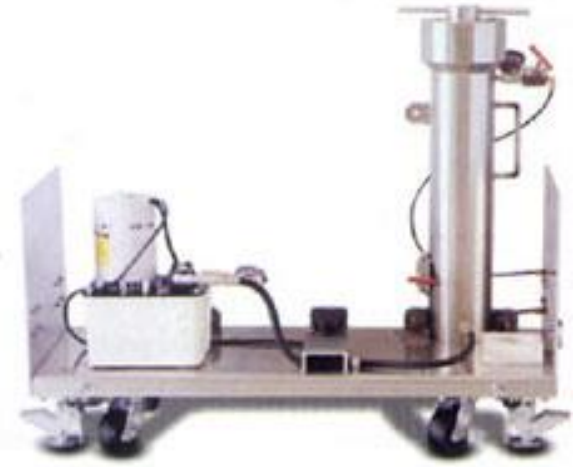
Pressure Vessels



Air driven: custom build



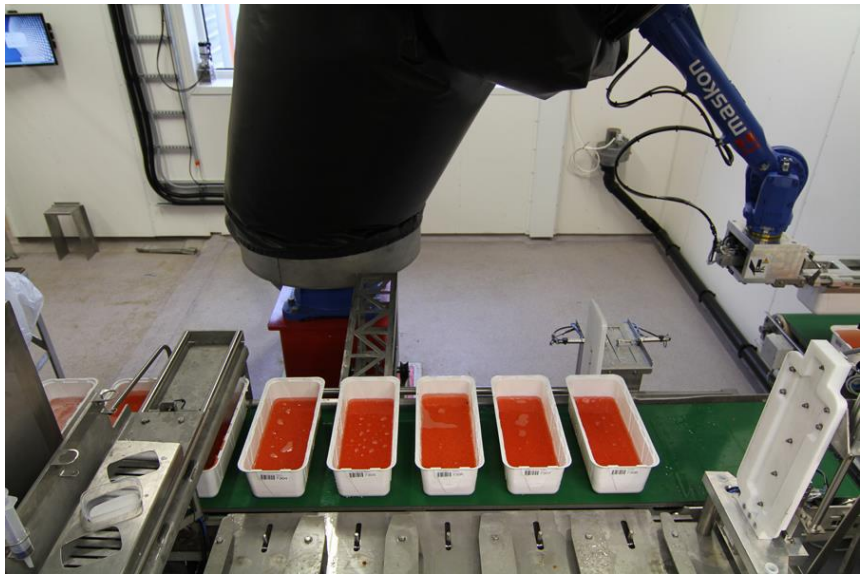
MegaPascal – France (10L capacity)

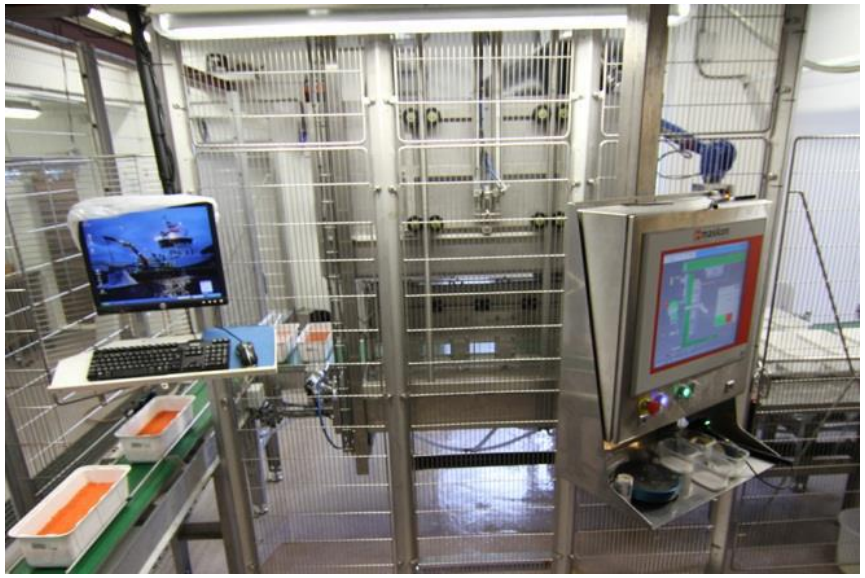


TRC-APV – Canada (3L capacity)

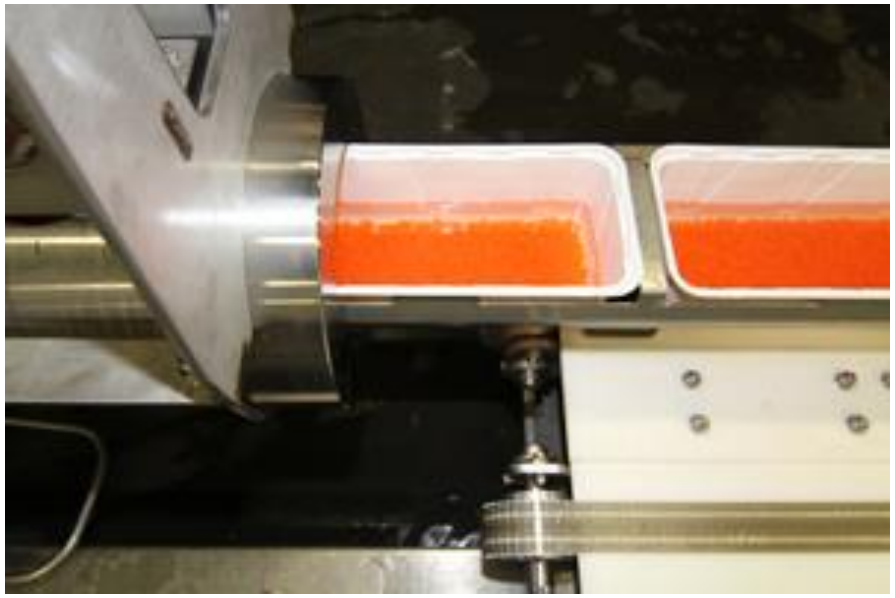
Handling – Survival?

Robotic Induction





Horizontal Chamber



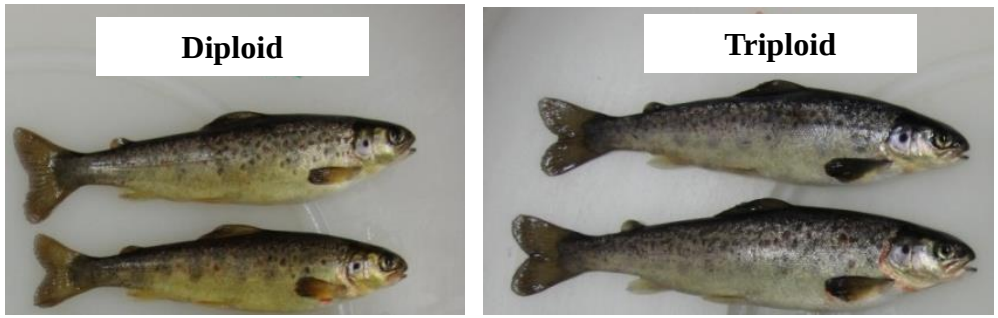
Salmotrip
Study of Triploid Atlantic Salmon Production

Smoltification

- **Assumption: Triploids poorer survival at sea transfer**

- **Clear demonstration:**
  - **Response to photoperiod the same = Out-of-season smolt**
  - **20-30% larger triploid smolt (in 12 trials: expt. & comm.)**
  - **SW transfer survival comparable**
  - **Pattern of smoltification may be different ~ growth & adiposity**
    - **Possible implications for vaccination and sea transfer**

Same Stage of Development



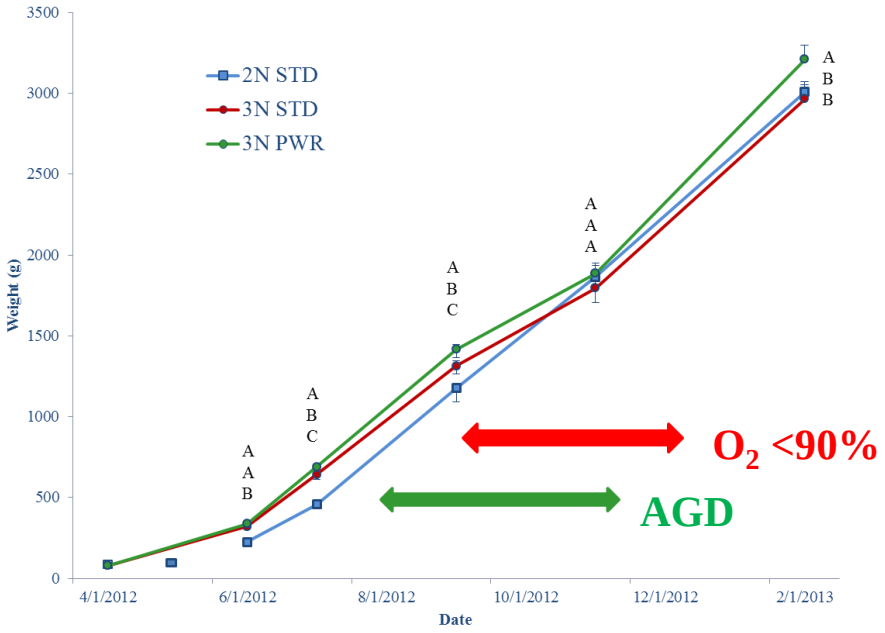
Final Smolt

Taylor et al. (2012) *Aquaculture*

Salmotrip
Study of Triploid Atlantic Salmon Production

Growth

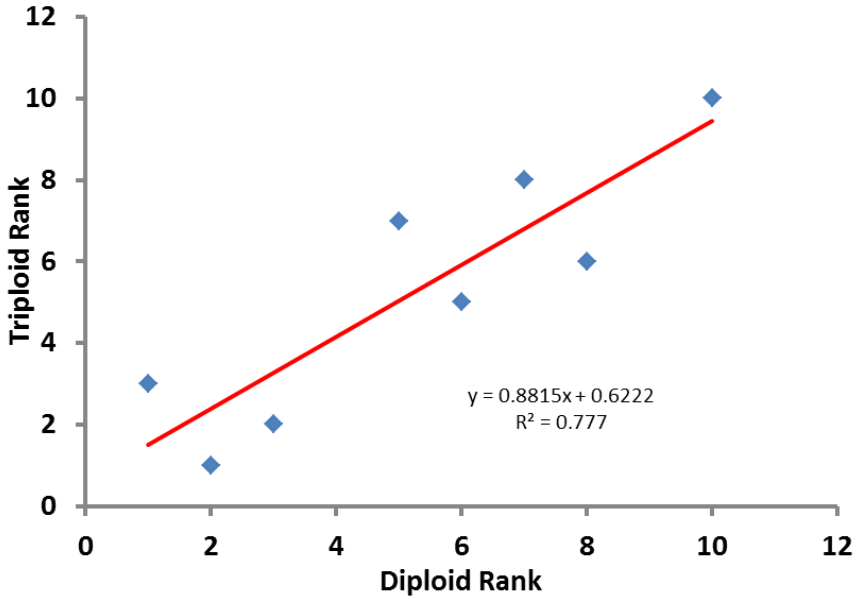
- **Assumption: Triploids have lower growth**
- **Triploids grow faster than diploids in FW (+30% FW)**
- **Generally, lost growth at sea (-10%)**
- **Reasons:**
  - **Environment**
  - **Nutrition-deformity**



- **2012-2013, +10% in 3N using specialist diets**

Selection

- **Assumption: Triploids perform differently to diploids**
- **Growth traits 3N = 2N**
- **Selection for deformity more challenging ~ low prevalence in 2N**
- **May be more fundamentally linked to nutrition than ploidy alone**



- **Heritability estimates? - Maternal vs. Paternal inheritance**

Taylor et al 2013

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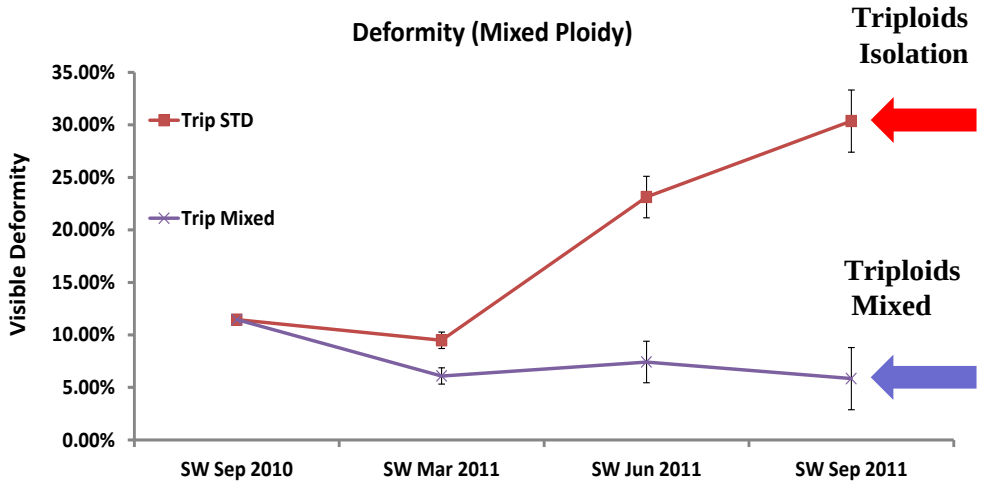
Study of Triploid Atlantic Salmon Production

Growth Rate & Deformity

- Siblings groups grown Isolated vs. Mixed ploidy
- Triploid growth compromised by mixed ploidy rearing
- HOWEVER, slower growth = less deformity



DIPLOID DIETS ARE

NUTRITIONALLY DEFICIENT FOR TRIPLOIDS?

Taylor et al 2013 (in review)

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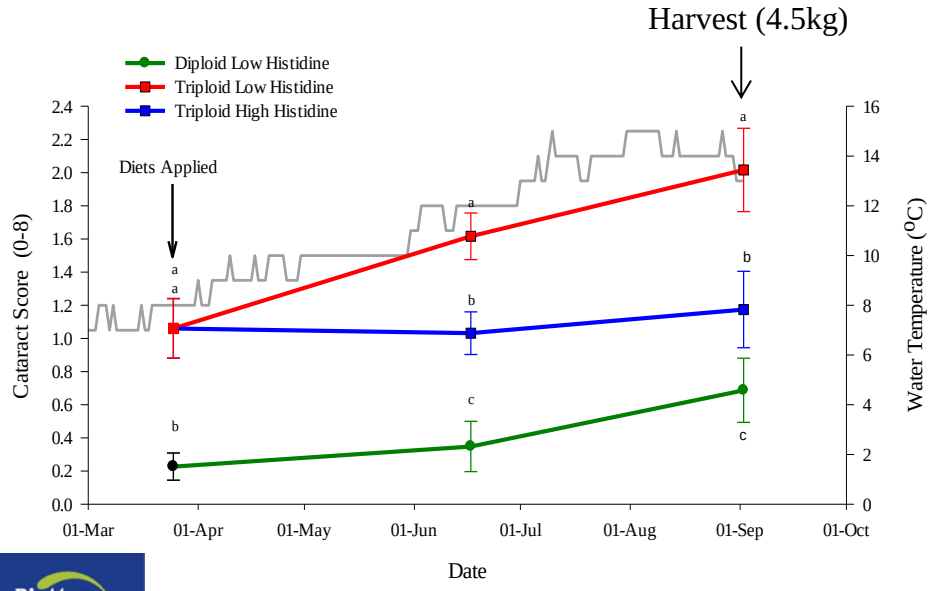
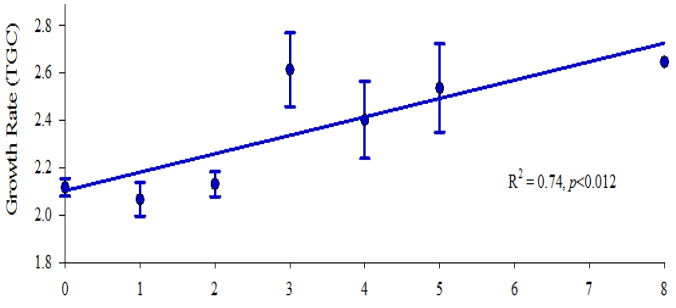
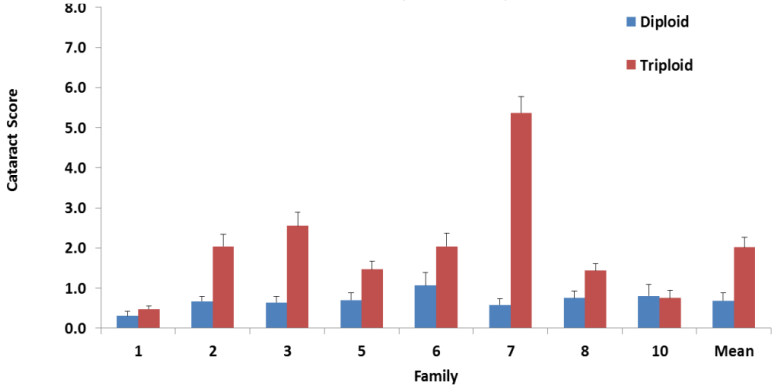
Cataract & Nutrition

- **Assumption: Triploids are more prone to cataracts**
  - **Risk periods: Increasing Temp & High SGR in SW**
  - **Histidine requirement is higher in triploids (2011-2013)**
  - **Strong genotype effect on cataract prevalence**







Taylor et al 2014. Aquaculture Nutrition

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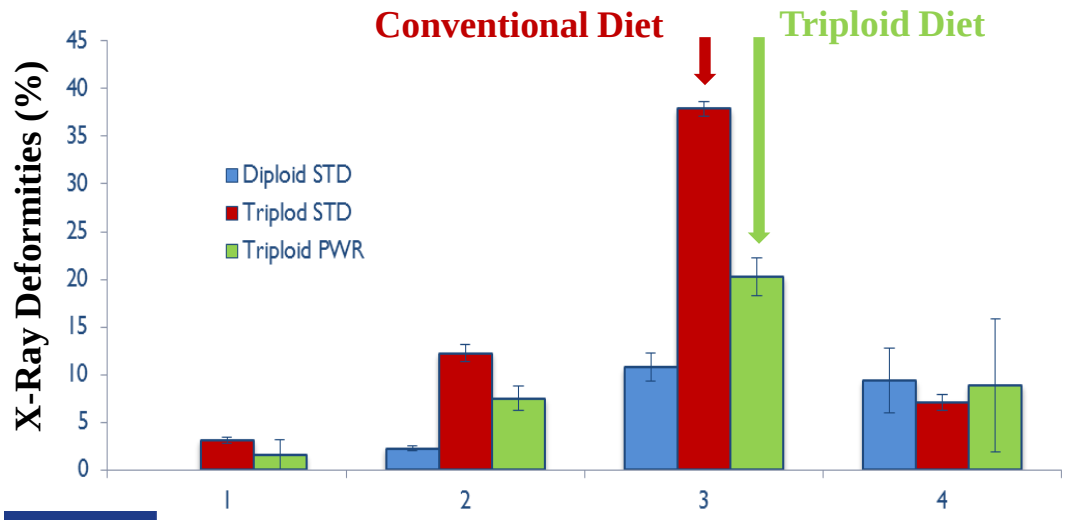
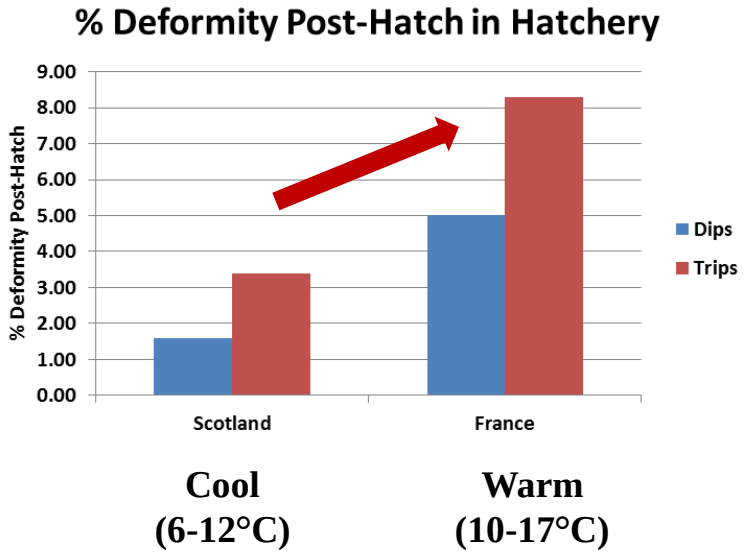
Deformity

- **Assumption: Triploids are more prone to deformity**
- **But, Risk Factors identified:**

Nutrition – Triploid Specific Saltwater diets (BIOMAR 2012-2013)

Rearing Temperature – Lower egg incubation temp
– Periods fast growth





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Incubation
Temperature Effect on Deformity

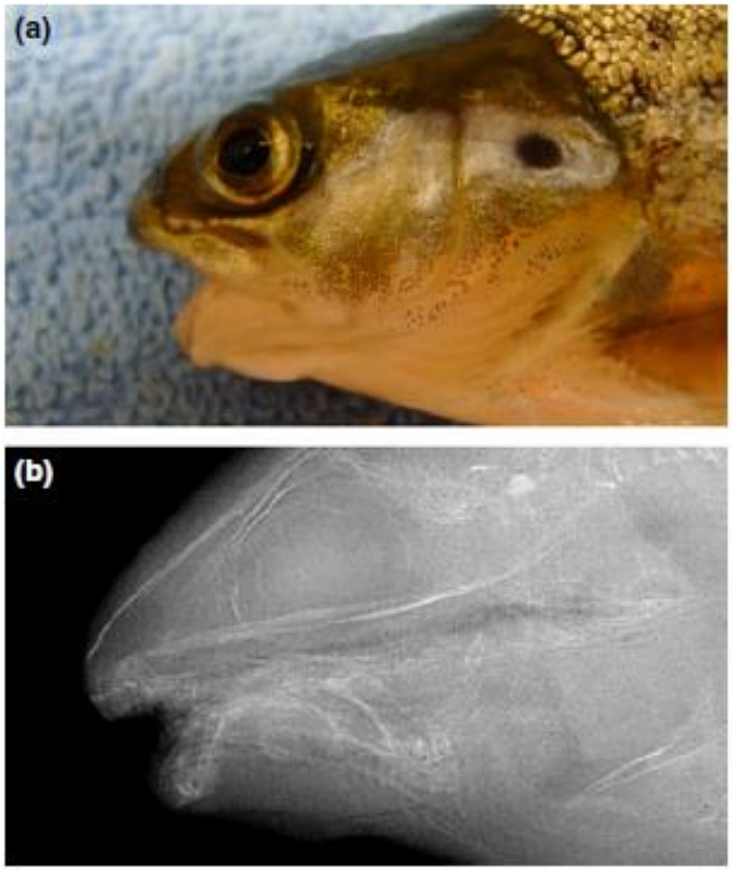

Figure 1 Lower jaw deformity in triploid Atlantic salmon as seen by (a) eye and (b) radiograph.

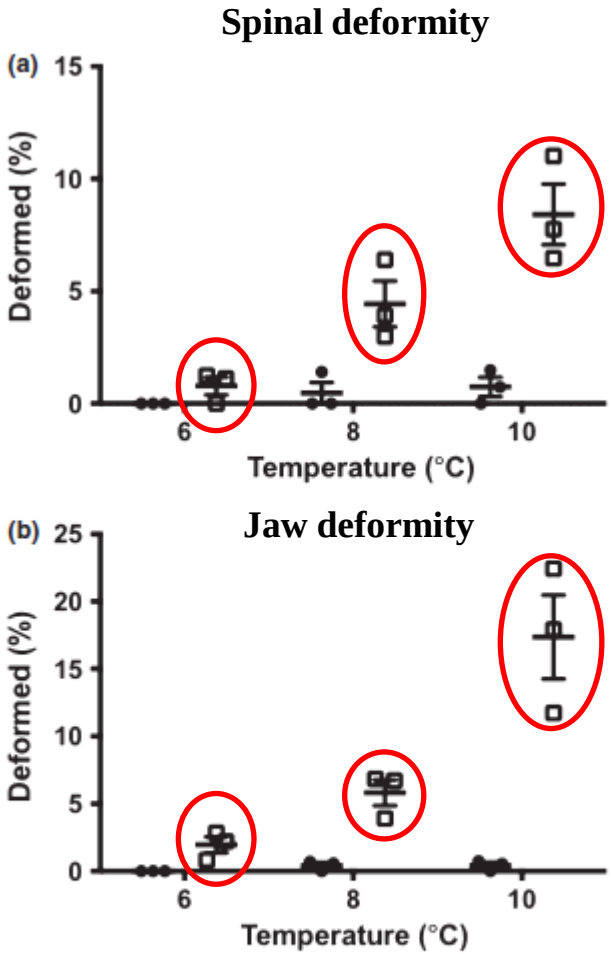

Figure 2 Interleaved scatterplot with mean (SE) percentage of diploid (circle) and triploid (square) Atlantic salmon parr incubated at one of three temperatures with externally detectable (a) spinal deformities and (b) jaw deformities. $n = 3$ per ploidy per incubation temperature.

Fraser et al (2013)

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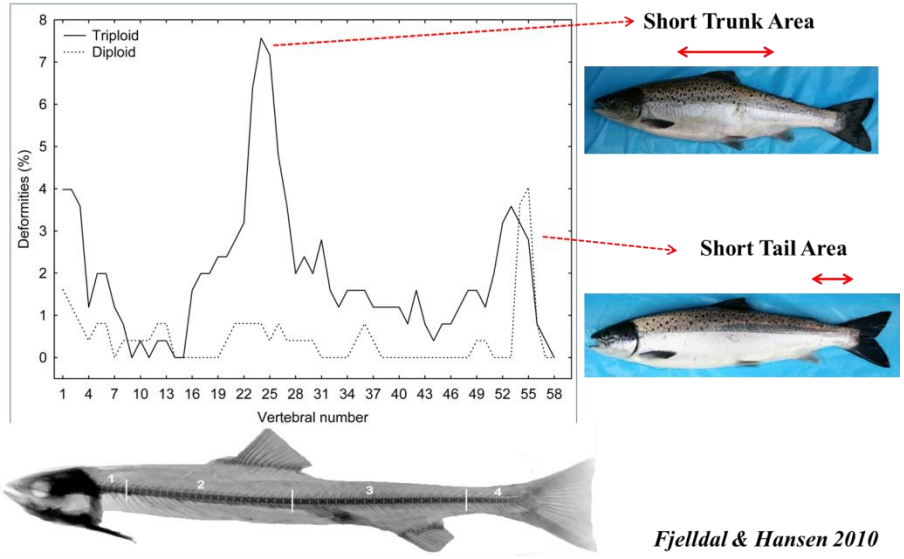
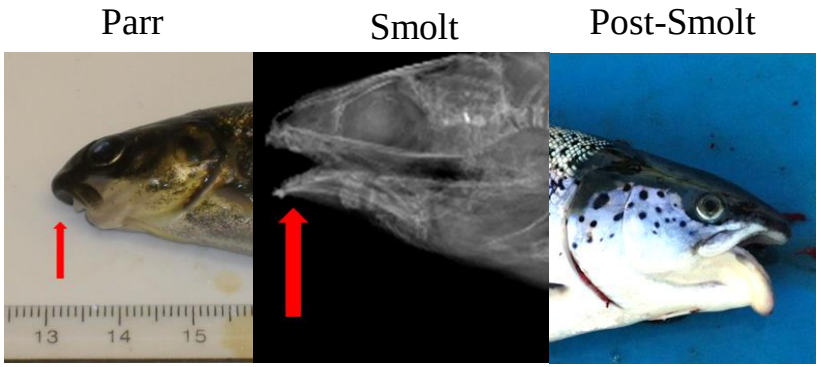
Deformity – Life Stage Specific?

- **Assumption: deformity is a saltwater problem**
- **Not Necessarily**
  - **Externally visible in SW**
  - **Radiologically detectable in FW**



Fjelldal & Hansen 2010

"Screamers" in FW ~ also Diet?



Taylor et al, unpublished

- **Deformity in SW in part related to FW dietary history**

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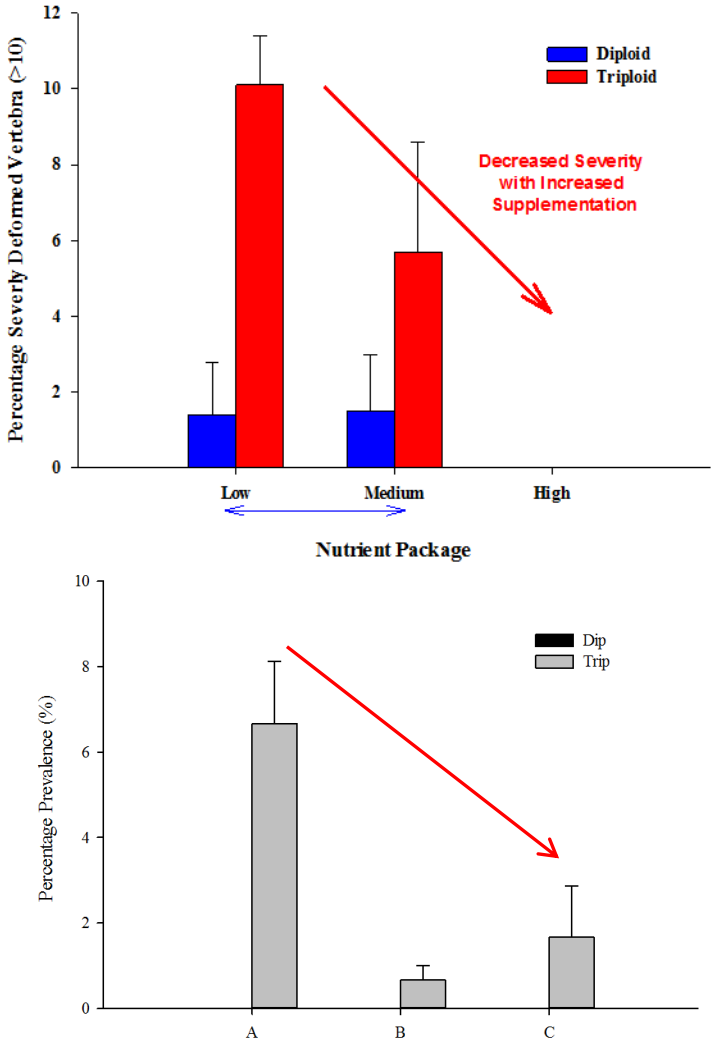
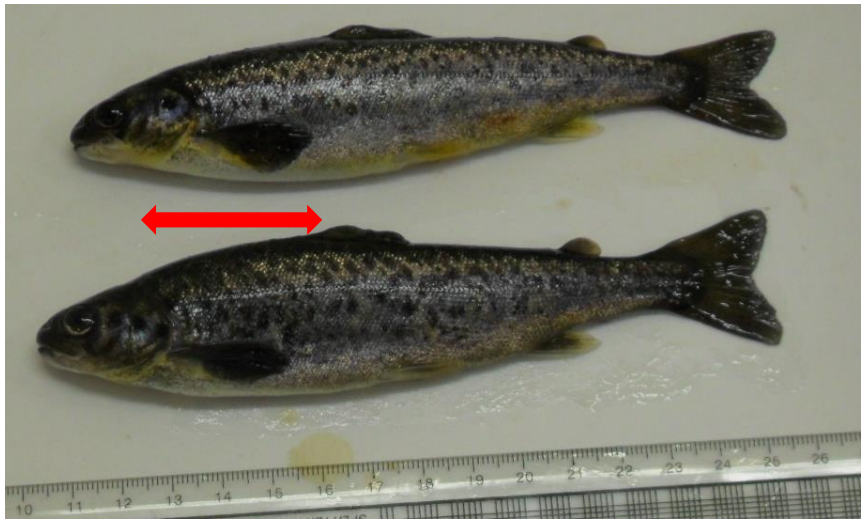
FW Diet Effect on Deformity





Smedley et al (in prep)

BioMar

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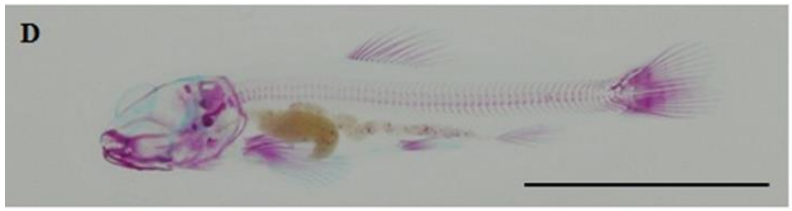
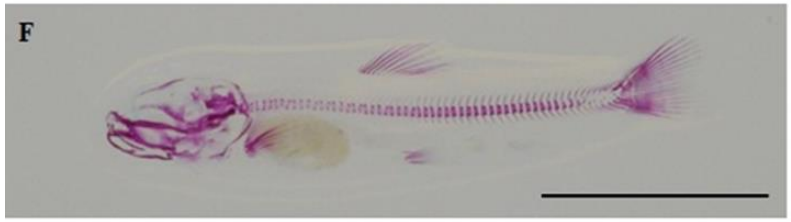
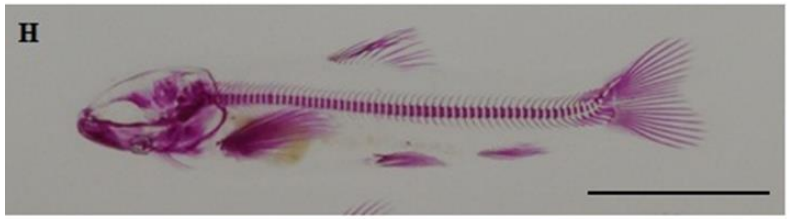
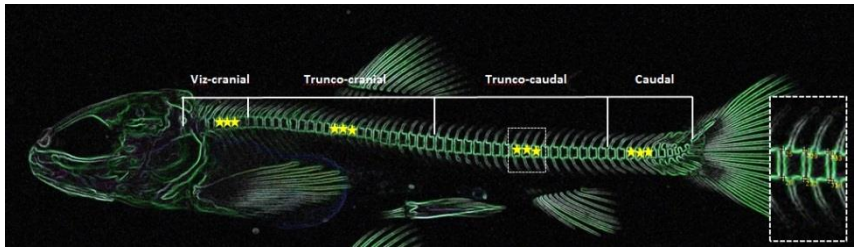
Imaging Fry









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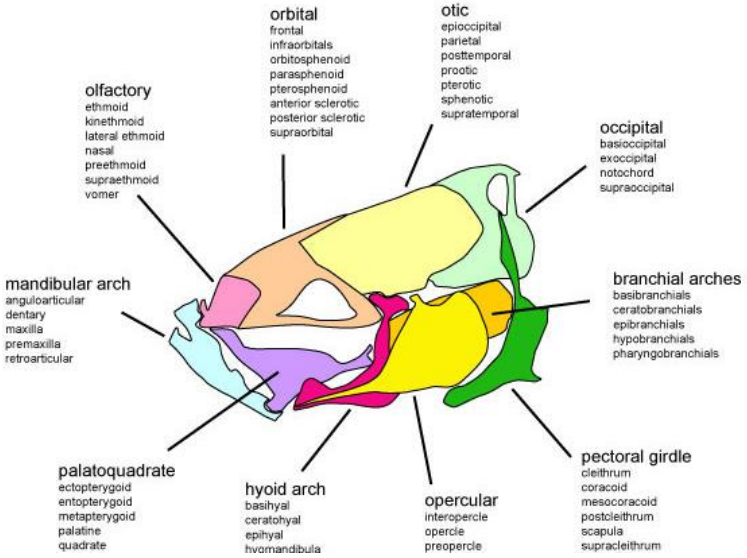
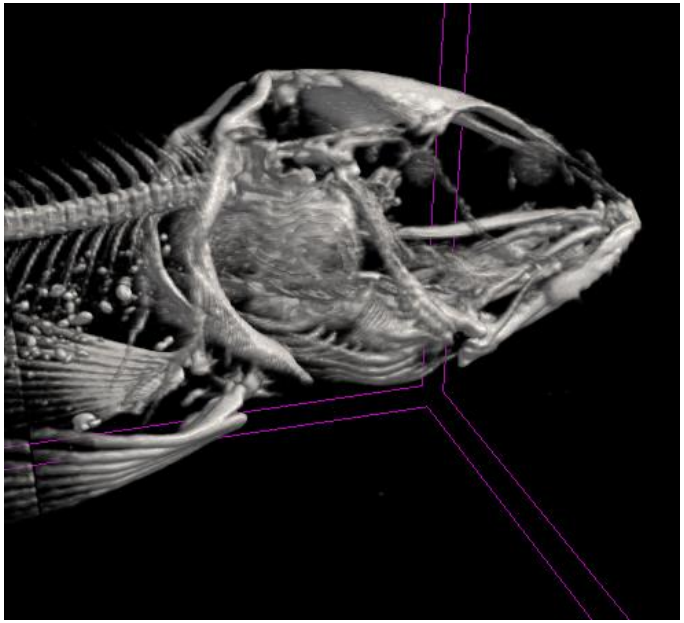
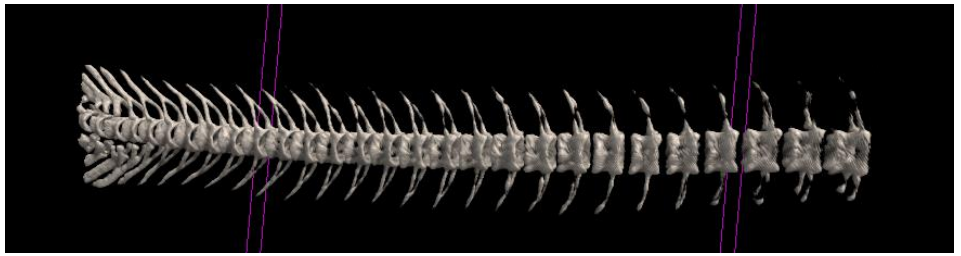
Imaging Fry

Craniofacial structure in fish



MicroCT - (Skyscan)
(45mins + processing)





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Environmental Tolerance

Assumption: Triploids are less tolerant of sub-optimal environments

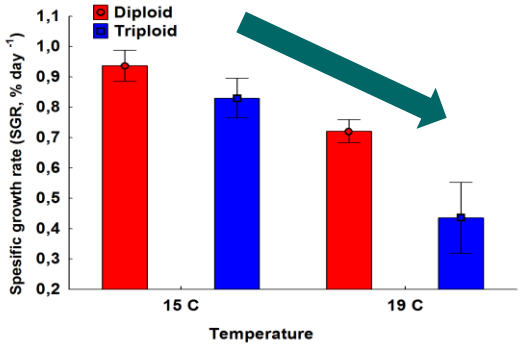
Triploids are:

- Sensitive to higher temp.
- When O_2 saturation is low
- Reduced SGR
- Increased mortality
- Reduced feed intake

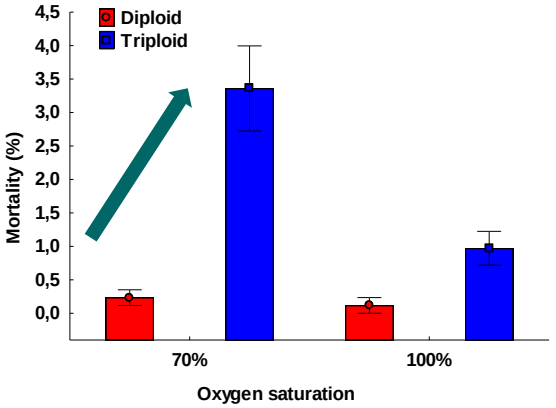
Consideration for:

- Site selection
- Grading & handling/crowding

Growth & Temp

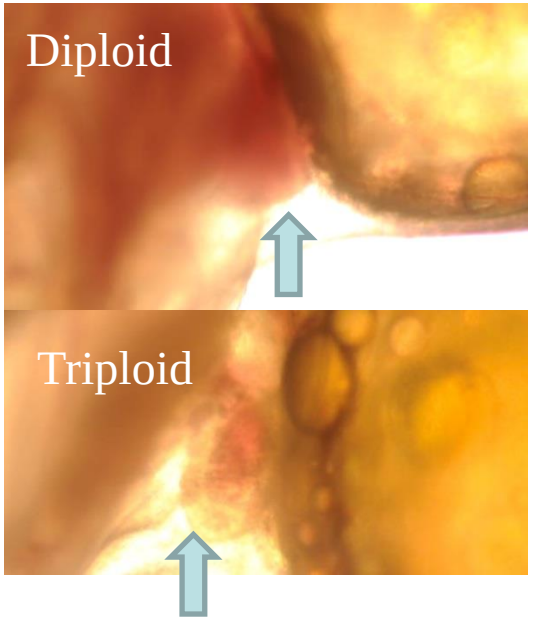


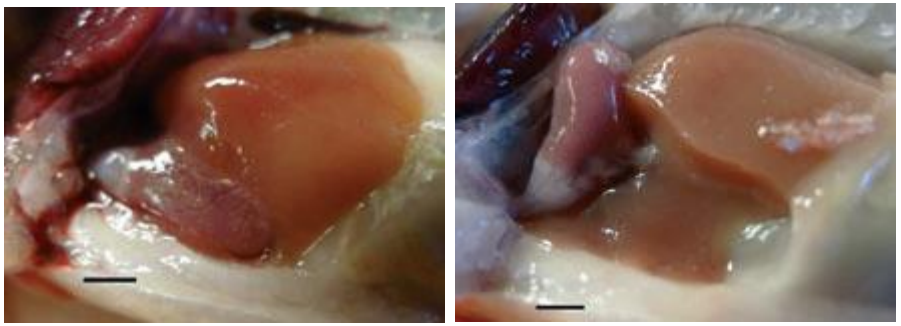
Mortality & O_2



Fjelldal & Hansen

Incubation Temp Effect on Heart Function





Aplasia of *septum transevrsum* @ 10ºC
(Fraser et al 2013)

linked to high levels of mortality, especially during stressful procedures that put an increased demand on the heart

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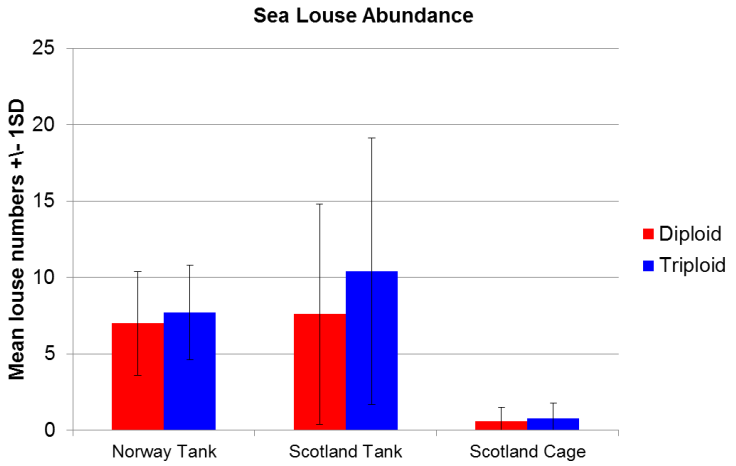
Health & Disease

- **Assumption: Triploids are less disease tolerant**
- **On Farm Challenges faced during SALMOTRIP**

Furunculosis in FW
Sea Lice
AGD
IPN in SW



- **No differences in survival between ploidy**

Frenzl et al., 2014

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Harvest Quality

- **Quality Grading**
  - **Increased discard/rebate ~ deformity**
  - **Screamers reduce harvest weight**
  - **Excluding deformities 3N ≥ 2N weight**

- **Flesh Quality Comparable:**
  - **Texture properties similar**
  - **May have higher DHA:EPA in 3N**
  - **Lower Pigment retention**

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Conclusions

Triploids:

- Superior growth
- Selection according to diploids
- Deformity can be tackled with diet
- Risk factors identified
- Disease tolerance comparable
- Flesh quality comparable

Knowledge Gaps:

- Specific nutritional requirements
- Immune function
- Environmental tolerance

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Current Research Scotland

Nutritional trials (2013-2016)

- Nutrient packages to combat deformity
- Feeding windows
- FM/FO replacement (FP7 EC ARRAINA)

Harvest Quality

- Pigment retention
- Reducing rebate

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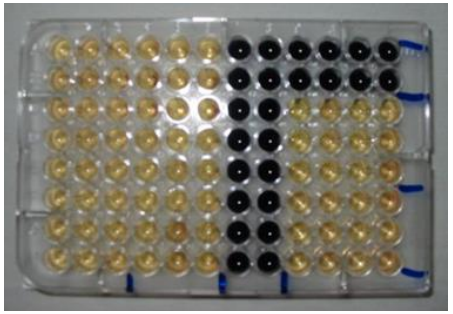
Current Research Scotland

Health & Robustness (2013-2016)

- Disease challenges
- Innate & Adaptive responses
- Vaccination

Genetics

- Selection criteria
- Gene regulation



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AquaGen

AquaGen

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Triploid Induction Protocols

Table 1. Shock timings for different temperature regimes.

Pressure (PSI / BAR)	Temperature (˚C)	Time Post-Fertilisation (min)	Duration of Pressure (min)
9500 / 655	10	30min	5min
9500 / 655	9.5	31min 35sec	5min 16sec
9500 / 655	9	33min 20sec	5min 33sec
9500 / 655	8.5	35min 18sec	5min 53 sec
9500 / 655	8	37min 30sec	6min 15 sec
9500 / 655	7.5	40min	6min 40sec
9500 / 655	7	42min 51sec	7min 9sec
9500 / 655	6.5	46min 9sec	7min 42sec
9500 / 655	6	50min	8min 20sec

Table 2. Procedure for triploid induction at 8˚C

Time (min)	Process
0	dry fertilise eggs (bucket placed in water bath at appropriate temp)
+1	add water of appropriate temp to eggs
+2	rinse off eggs in appropriate temp water, add clean water of appropriate temp.
+3	Leave to water harden in water bath
+35	fill pressure vessel with water of 8 degrees
+36	load eggs into pressure vessel & screw down lid
+37	begin raising pressure over 30secs
+37m 30sec	full pressure achieved (9500 PSI/655 BAR)
+43m 45sec	begin raising releasing pressure
+44	remove eggs & water harden eggs for 1 hour

Table 3. Procedure for triploid induction at 10˚C

Time (min)	Process
0	dry fertilise eggs (bucket placed in water bath at appropriate temp)
+1	add water of appropriate temp to eggs
+2	rinse off eggs in appropriate temp water, add clean water of appropriate temp.
+3	Leave to water harden in water bath
+27m 30sec	fill pressure vessel with water of 10 degrees
+28	load eggs into pressure vessel & screw down lid
+29m 30sec	begin raising pressure over 30secs
+30	full pressure achieved (9500 PSI/655 BAR)
+35	begin raising releasing pressure
+36	remove eggs & water harden eggs for 1 hour

Example of water bath set up using a trough for egg incubation prior to triploid shock. Appropriate temperature dialled into digital thermostat on heater (Model: Grant T100 Heating Circulator)

Eggs in incubation prior to triploid induction