Tasmanian Salmonid Aquaculture: Physiology and Nutrition Research



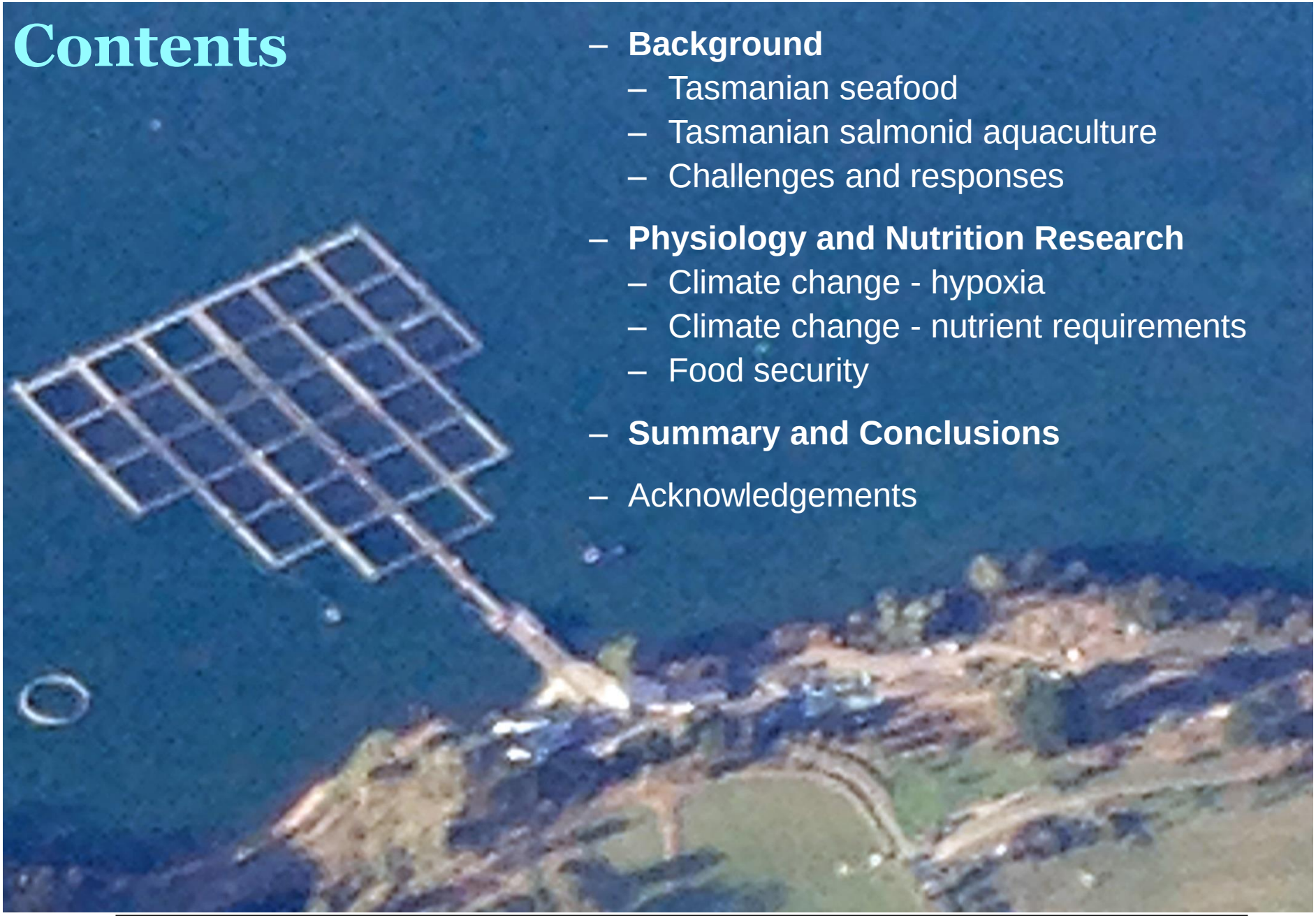
Prof Chris G. Carter

Aquaculture and Fisheries Conference, Brisbane
20 July 2015

UNIVERSITY of TASMANIA | IMAS INSTITUTE FOR MARINE AND ANTARCTIC STUDIES

Tasmanian Government

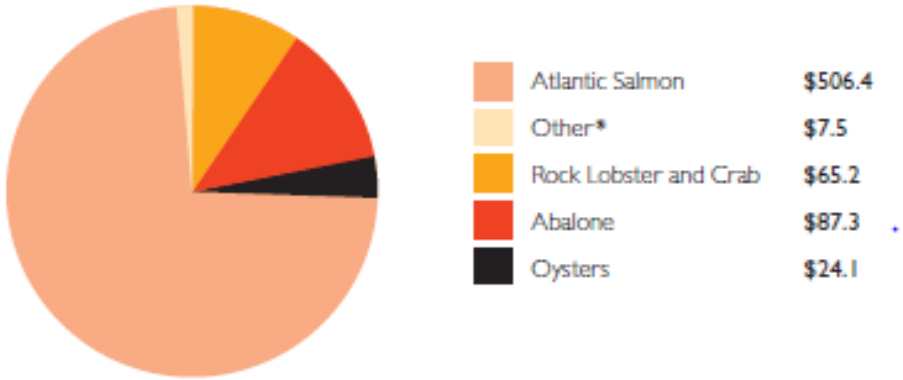
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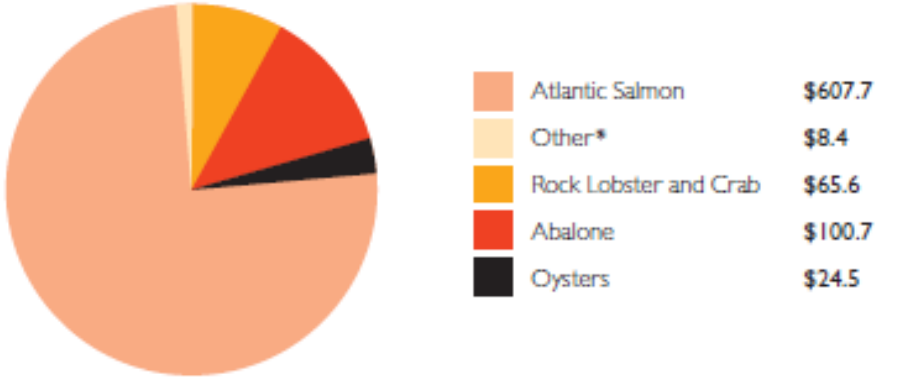
- **Background**
  - Tasmanian seafood
  - Tasmanian salmonid aquaculture
  - Challenges and responses
- **Physiology and Nutrition Research**
  - Climate change - hypoxia
  - Climate change - nutrient requirements
  - Food security
- **Summary and Conclusions**
- Acknowledgements

Tasmanian Seafood (2011-12)

Annual Gross Catch ($m)



Annual Processed Value ($m)



*Other includes scallops, octopus, squid, mussels and other marine fish.

Source: Tasmanian Seafood Industry ScoreCard 2011-12 – Department of Primary Industries, Parks, Water and Environment





Key Aquaculture Species:

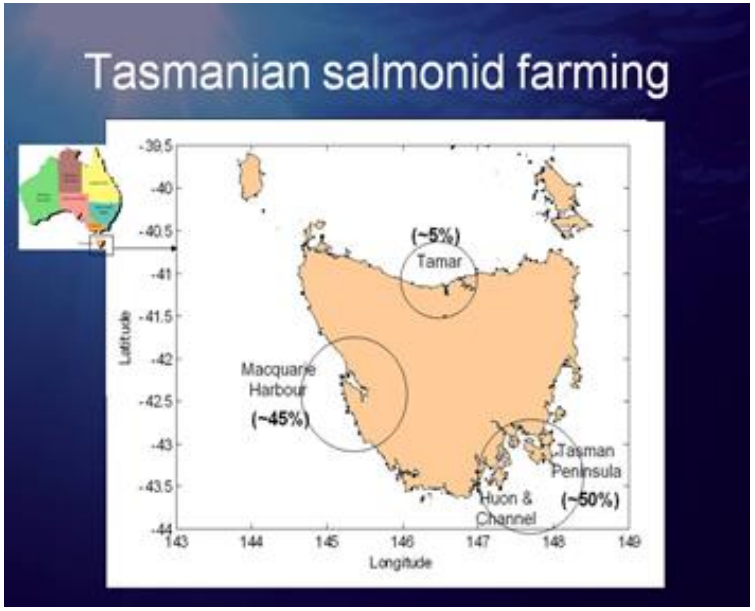
- Salmon (75%)
- Oysters (3%)
- Mussels (1%)
- Abalone (2%)

Tasmanian Salmonid Aquaculture

– Recreational fishing in 19th century hatchery raised from imported eggs.
– Atlantic salmon in 1980s from Canada via NSW (no further importation).
– Three companies: TASSAL, Huon Aquaculture; Petuna Seafoods.
– Employment: 1200 direct; 3500 indirect.
– Production: vertically integrated; 43000 Mt, A$506 Million; double by 2030;
– Product: >90% domestic markets; strong international certification;
– Globally small but economically viable and important regional industry: innovative and educated workforce; supportive State government; local state of the art feed mill and other support industries; large network of research providers.











Challenges and Responses

Challenges

- Climate change
- Food security
- **Fish health:Amoebic gill disease**
- Space and water
- Increasing public awareness

Responses

- Technology (inc. offshore, onshore)
- Biotechnology (inc. vaccines)
- Selective breeding programs
- Public engagement, local community support, international certification (inc. WWF, GAA)
- Increase research capability and partnerships











Local Research Capability: IMAS

Fisheries → Disciplines ← Aquaculture







- Animal Performance:
- Aquaculture Innovation:
- Aquatic Animal Health, Biosecurity, and Welfare:
- Ecosystem Effects and Interactions:
- Global Seafood Trends:
- Management Systems:
- Recreational and Traditional Fisheries:
- Recruitment Dynamics:



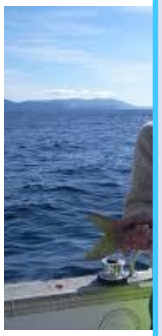




Sustainable Fisheries and Aquaculture

IMAS Research Disciplines





•**Animal Performance = Physiology and Nutrition: climate change effects; elevated water temperature; decreased dissolved oxygen; offshore environments; RAS; growth efficiency; non-infectious disease; fishmeal and fish oil replacement; product quality**

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•Aquaculture Innovation:

•Aquatic Animal Health, Biosecurity, and Welfare:

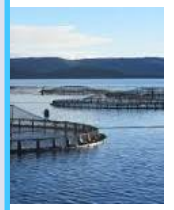
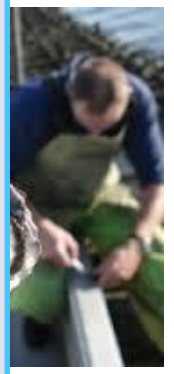
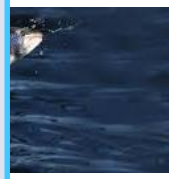
•Ecosystem Effects and Interactions:

•Global Seafood Trends:

•Management Systems:

•Recreational and Traditional Fisheries:

•Recruitment Dynamics:

Sustainable Fisheries and Aquaculture

Climate Change

Changes

- Extreme weather: increase
- Air & water temperature: increase
- Dissolved oxygen: decrease
- pH seawater: decrease
- Rainfall and freshwater: decrease

Tasmania as research resource

- Changes occurring at a faster rate than global average (x4)
- Elevated summer temperatures have been managed for many years on Tasmanian salmon farms
- State is a centre of temperate marine research
- Good integration and structures across multiple users, industries, Government and trans-discipline research







Climate Change

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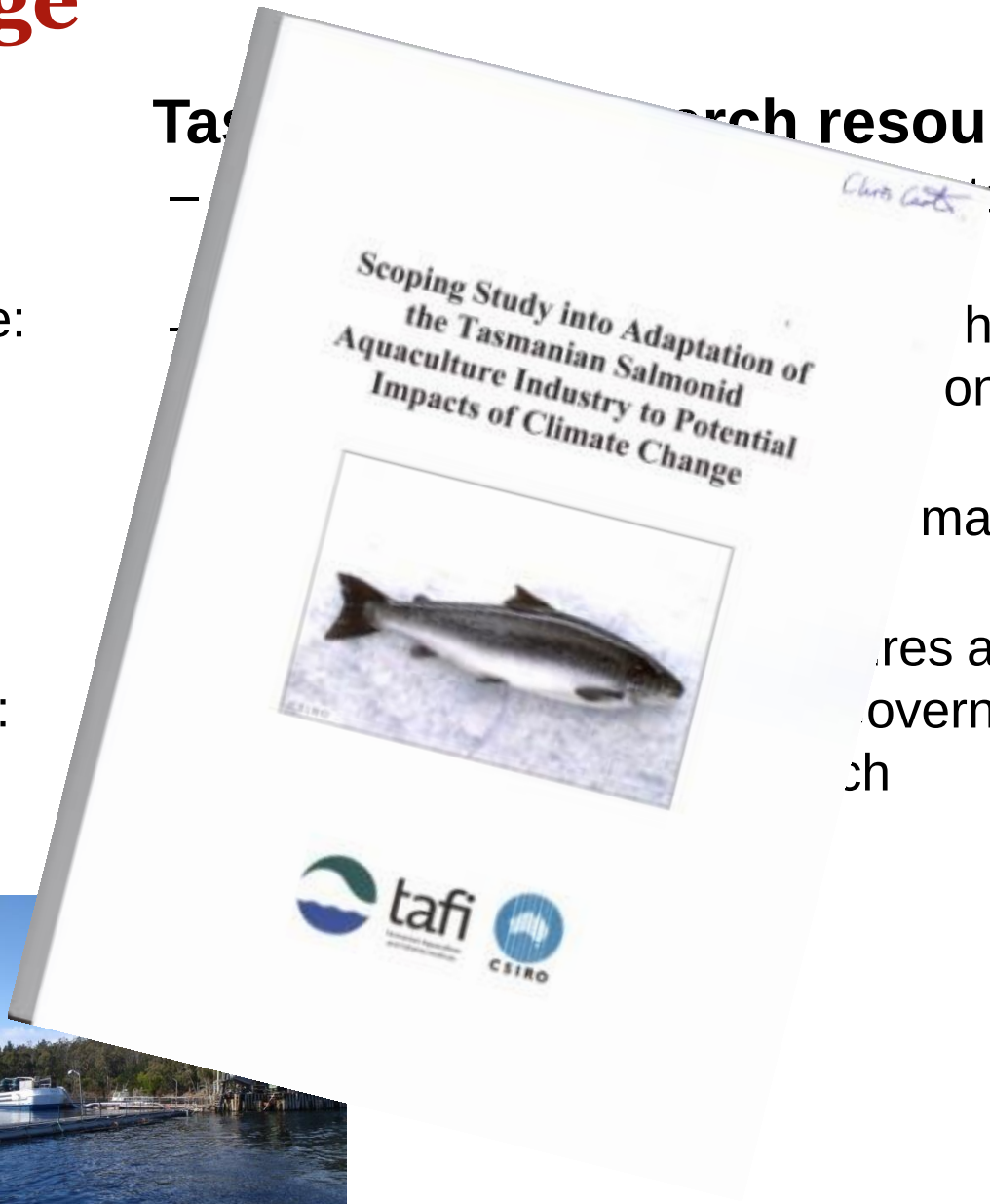
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Hypoxia

- Temperature effect
  - DO decreases with increasing temperature
- **Freshwater hatchery**
  - High summer temperatures
  - High oxygen demand from animals
  - Low summer water volumes
  - Recirculation systems
- **Seawater cages**
  - High summer temperatures
  - High oxygen demand from animals
  - Water circulation through cages
  - Freshwater bathing for AGD



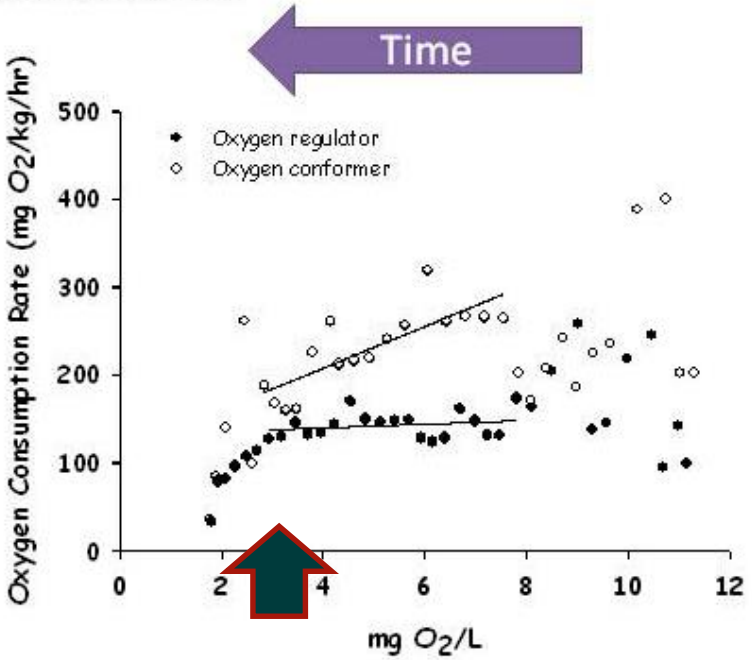


Salmon Response to Hypoxia

Salmon were considered the **classic oxygen conformer**, the ability to oxygen regulate was rarely documented.

- **Oxygen conformer** (○)
  - Linear decline in oxygen consumption with decreasing DO
- **Oxygen regulator** (●)
  - Significant piece-wise regression (breakpoint) and clear Pcrit
  - Plateau was at least 3 h
  - Linear decrease below Pcrit
- Pcrit = DO where regulation stops

Atlantic salmon parr. Change in oxygen consumption as dissolved oxygen decreases. Pattern for regulator and conformer.



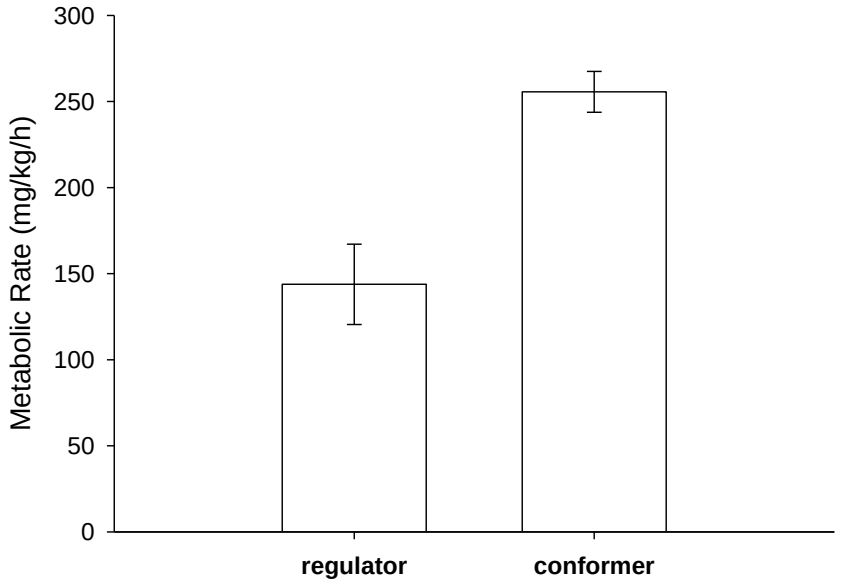
[Barnes et al. 2011]

Regulators and Conformers

- Regulators have significantly lower metabolic rates at normal DO.
- Lower metabolic rates suggests lower energy expenditure, greater potential for higher growth efficiency and greater “robustness”.



- Metabolic rate for regulators and conformers at near saturation DO (> 80% saturation) (P<0.002)

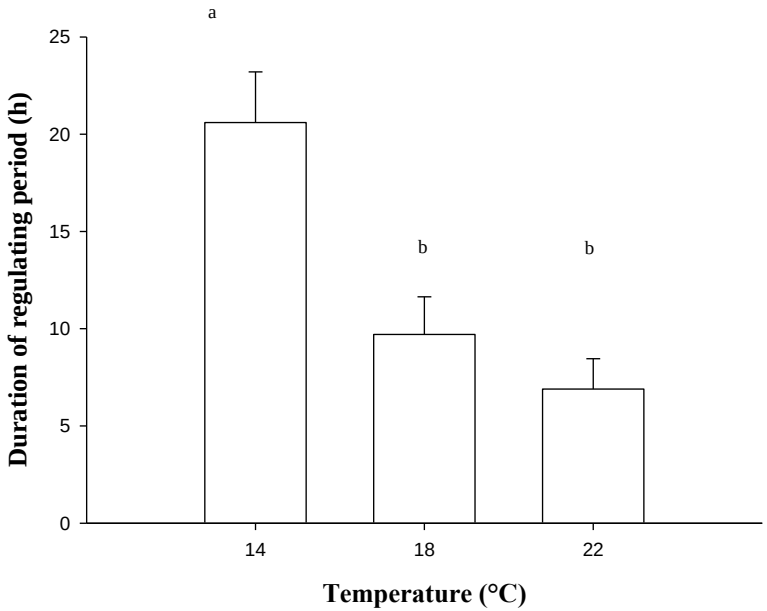


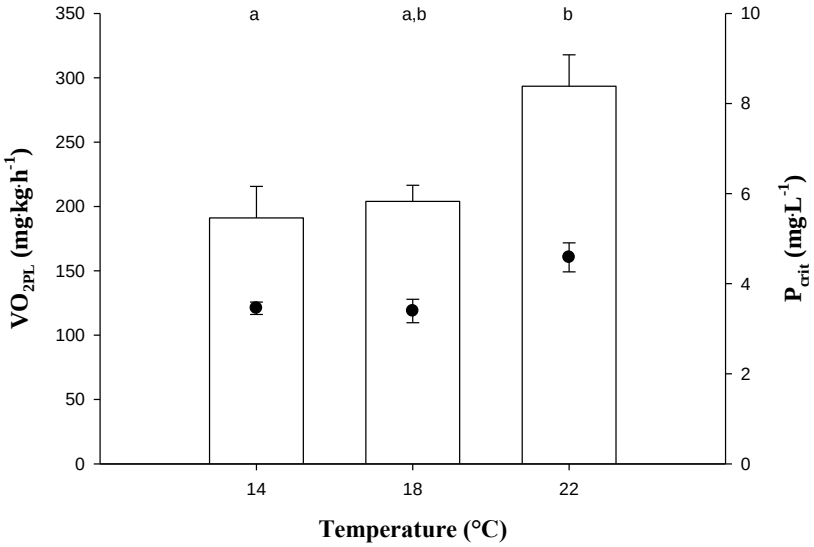
[Barnes et al. 2011]

Hypoxia and Temperature

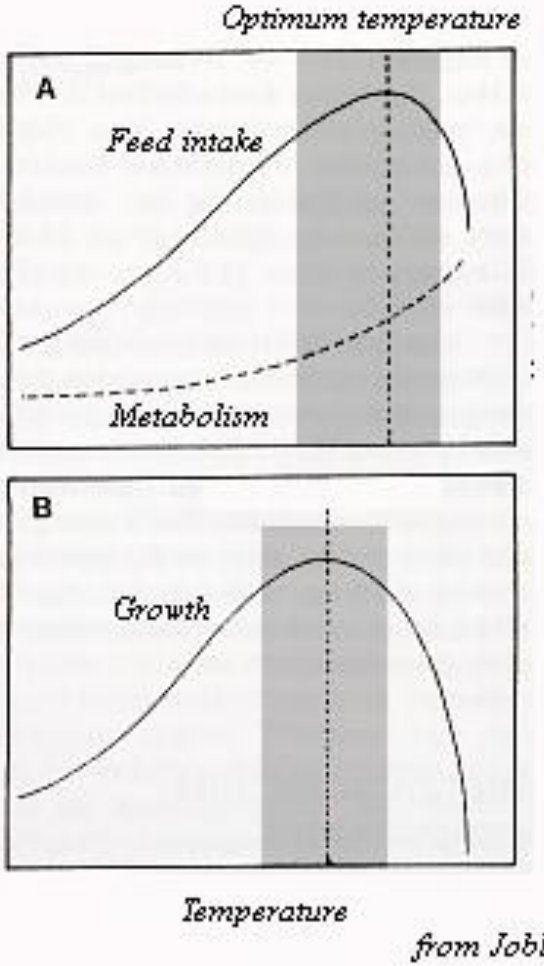
– The effect of temperature on the mean duration of the regulating period (h).

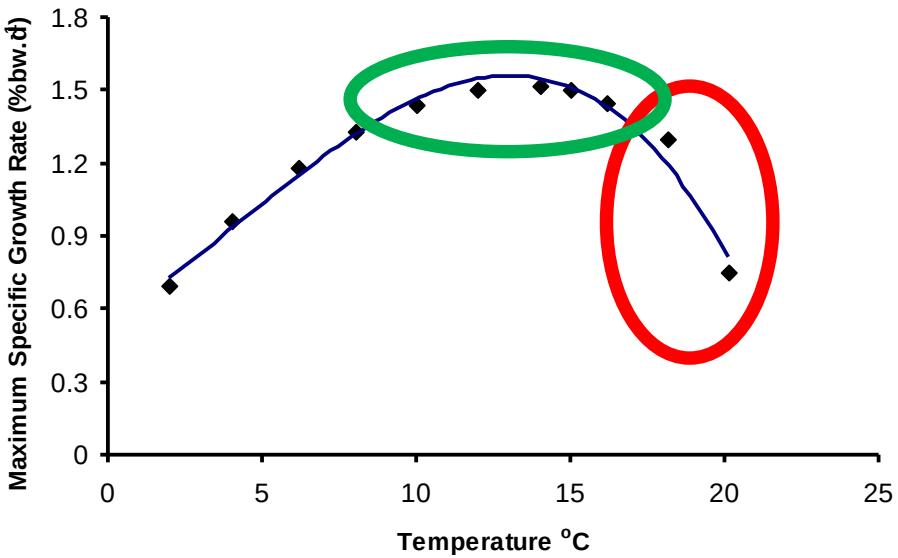
– The effect of temperature on the plateau metabolic rate (VO_{2PL}, $mg \cdot kg \cdot h^{-1}$, bars) and the critical oxygen threshold (P_{crit}, $mg \cdot L^{-1}$,)





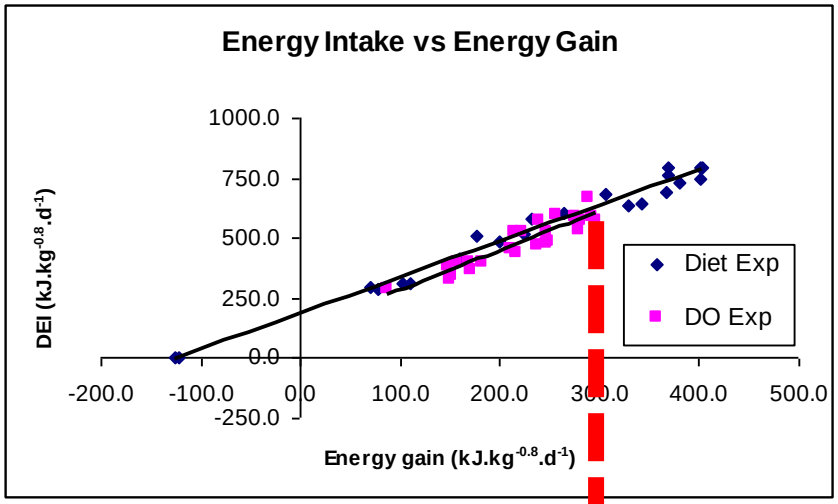
Climate change and nutrient requirements

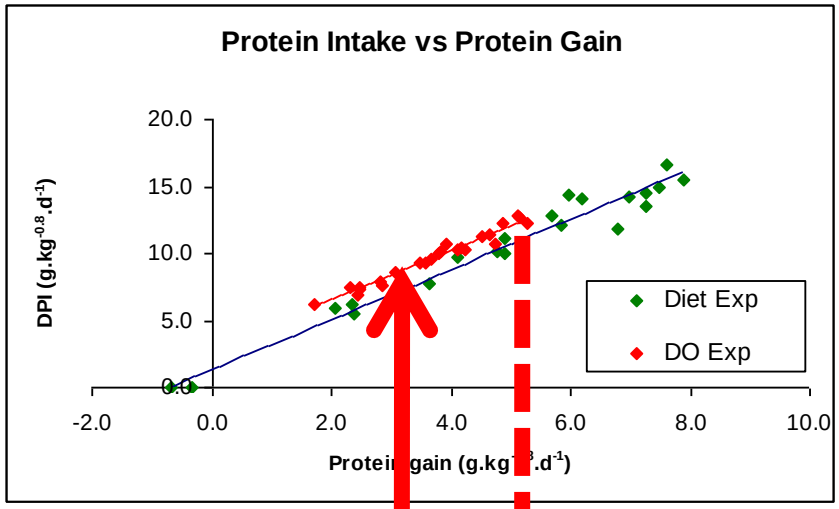




➔Good performance over wide temperature range
➔Sub-optimum elevated temperature > 15-18°C
➔Investigate protein energy requirements at 19°C

Protein energy at low DO (70%) and elevated temperature 19°C



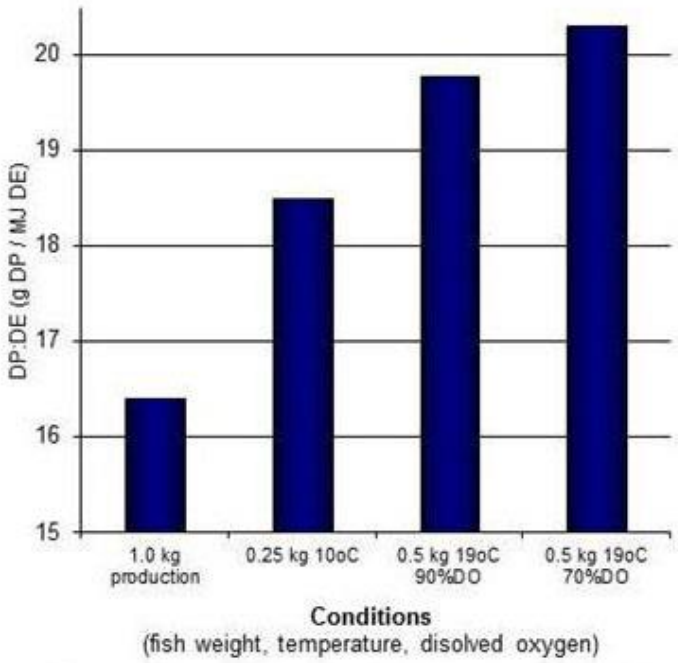


2. Increase in protein intake for same protein gain

1. Maximum Feed Intake restricted by low dissolved oxygen

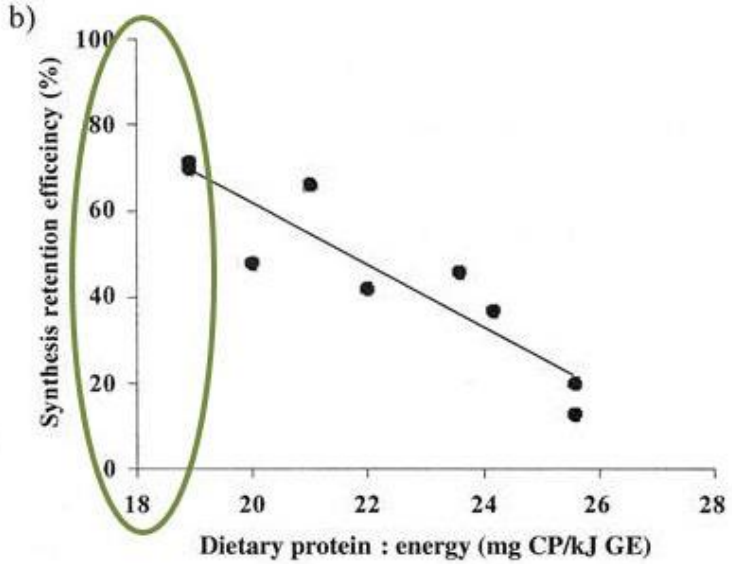
Dietary Protein Energy - Fish

Optimum dietary protein:energy for salmon



[Einem & Roem 97, Helland et al 10, Carter et al 2008]

Effect of dietary protein:energy on salmonid Synthesis Retention Efficiency (%)



[Carter & Houlihan 2001]

- Optimum dietary protein energy in salmonids 16-19 mg CP / kJ GE
- Synthesis retention efficiency increases towards the optimum dietary protein energy

More dietary protein under more stressful environmental conditions (optimum shifts)

Elevated temperature and pigmentation

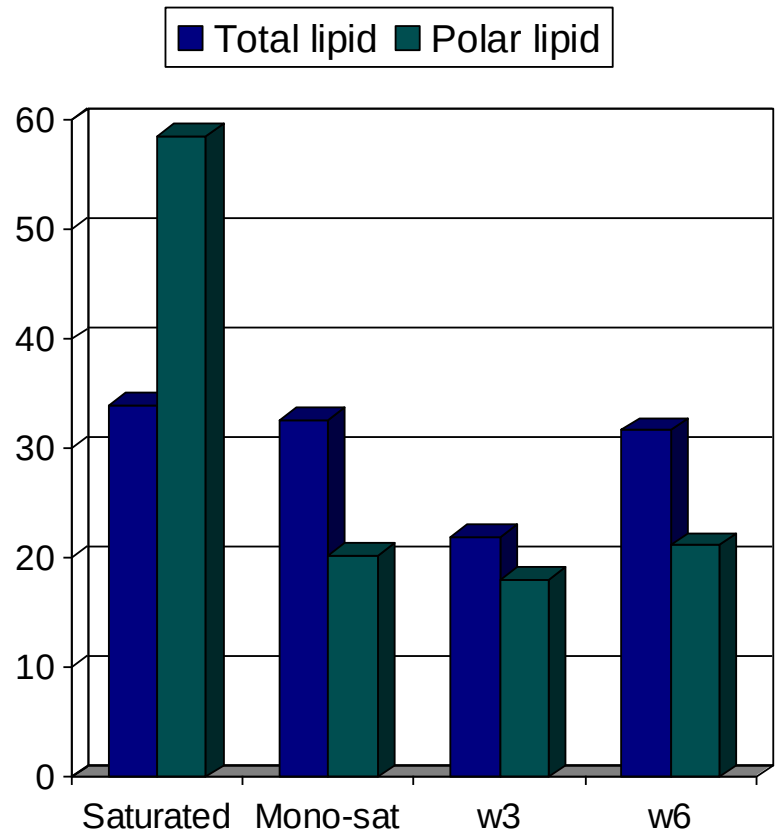




Fillets from salmon weights 2–3 Kg

- **Impaired pigmentation**
- **High variation in pigmentation among individuals**
- **“Banded” fillets of salmon at harvest size in the summer period and a few weeks after**

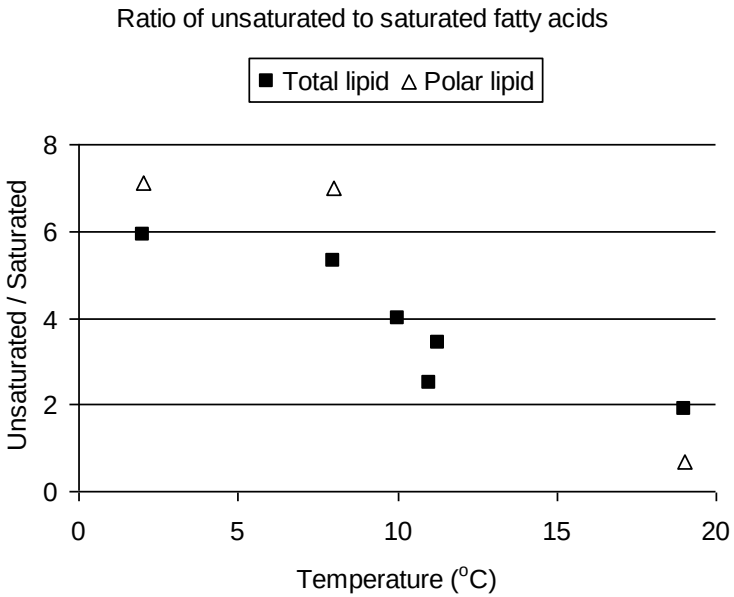
Elevated temperature and fatty acid profile



[Miller et al. 2006]

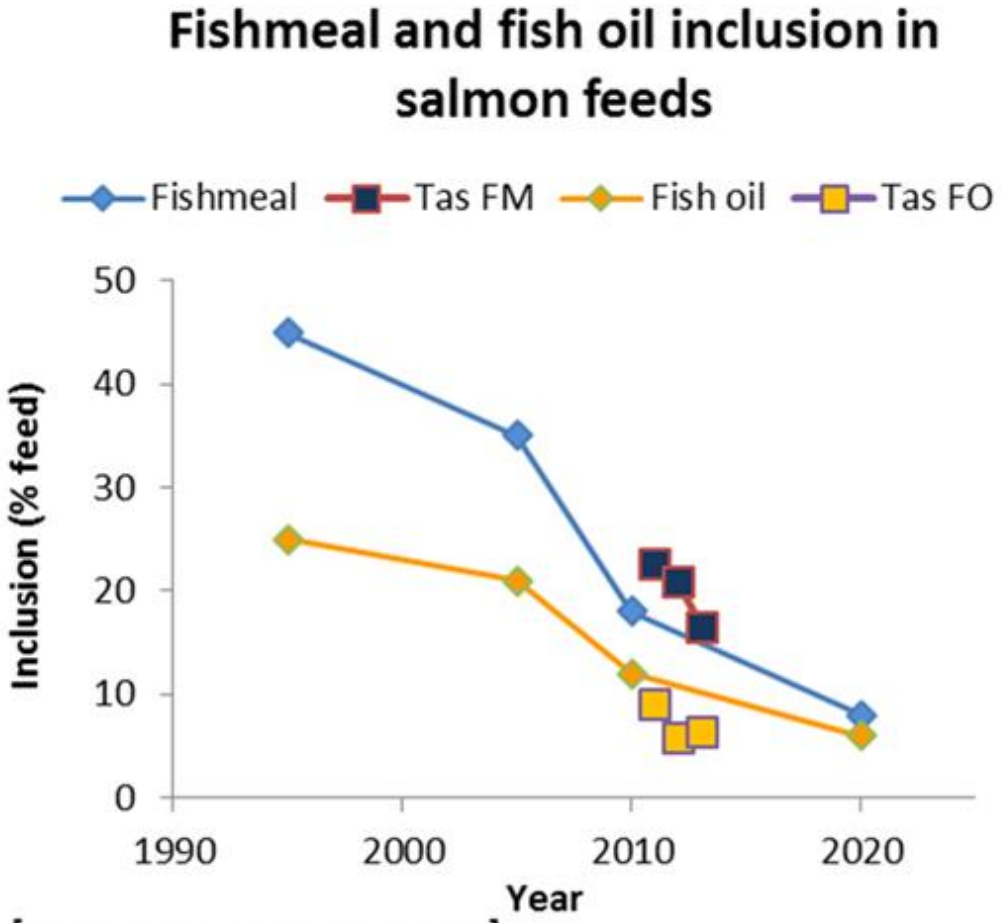
Atlantic salmon (500 g) at 19°C fed commercial feed

Food security issue



Food Security – Fishmeal and Fish oil replacement

- Commercial: Reduction in fishmeal and fish oil to at least world standard
- Research: optimising the use of marine and terrestrial protein and oil sources for aquafeeds
- Research: investigate potential for local ingredients



[Tacon & Metian 2008, Tassal 2014]

Fish oil replacement

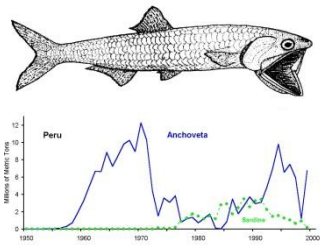
Worldwide Issues

- Increase sources of fish oil
  - **Improve extraction** from whole fish, FM still contains 6-9% oil
  - **Increase** oil by-products from fish processing
  - **Develop** alternative oils: standard vegetable oils, single cell oils, oil blends,
- Manage use of oils
  - Only use at key times in production: broodstock, hatchery and finishing feeds
  - Improve use of Fish Oil Finishing Feeds

Tasmanian Issues

- Increasing water temperatures lead to reduction in long chain omega-3 fatty acids; Tasmania may or may not be GMO free; local industrial fisheries and by-catch.





Salmon Feeds in Tasmania

What do salmon aquafeeds contain?

- 14% Marine (protein and oil)
- 28% Terrestrial animal (protein and oil)
- 30% Terrestrial plant (protein, oil, carbohydrate)
- *39% protein, 34% oil, 10% carbohydrate (2-3kg fish, 2014)*



Average inclusion rate of feed ingredients (%) at Skretting Australia

Marine Proteins	
Fish meal (reduction fisheries)	8.0%
Fish meal (by-products)	6.2%
Land-animal Proteins	
Poultry meal	16.0%
Feather meal	9.6%
Meat meal	3.2%
Blood meal	1.7%
Vegetable Proteins	
Lupin	6.1%
Wheat gluten	3.8%
Soy protein concentrate	2.0%
Marine oils	
Fish oil	6.5%
Land-animal Oils	
Poultry oil	12.8%
Vegetable Oils	
Canola oil	2.2%
Carbohydrate	
Wheat	11.1%
Faba bean	5.6%
Starch	1.1%
Other	4.1%
	100.0

SKRETTING

Summary and Conclusions

- Tasmania offers an excellent research-resource to study key global concerns related to aquaculture including effects of climate change and food security.
- Climate change and food security are future drivers for research in physiology and nutrition including:
  - Water quality (DO, pH, temperature)
  - Interactions between water quality and nutrition
  - Interactions between water quality, nutrition and product quality

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