Factors controlling common smelt abundance and rainbow trout growth in the Rotorua Lakes, New Zealand

PhD Thesis Overview

Jennifer Blair

Thesis overview

- 1) Comparison of smelt sampling methods
- 2) Seasonal patterns in the relative abundance and diet of smelt
- 3) Diet of rainbow trout
- 4) Factors influencing rainbow trout growth in lakes with varying characteristics
- 5) Bioenergetic assessment of the influence of stocking practices on rainbow trout growth and consumption

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Electrofishing surveys

Smelt sampling methods and dynamics

- Sampling methods:
  - Boat-mounted nets most effective
  - Need to sample pelagic and littoral zones to sample adults and juveniles
  - Night sampling best
- Dynamics:
  - Autumn: peak spawning and abundance in littoral zone
  - Diet: zooplankton, benthic invertebrates, smelt eggs

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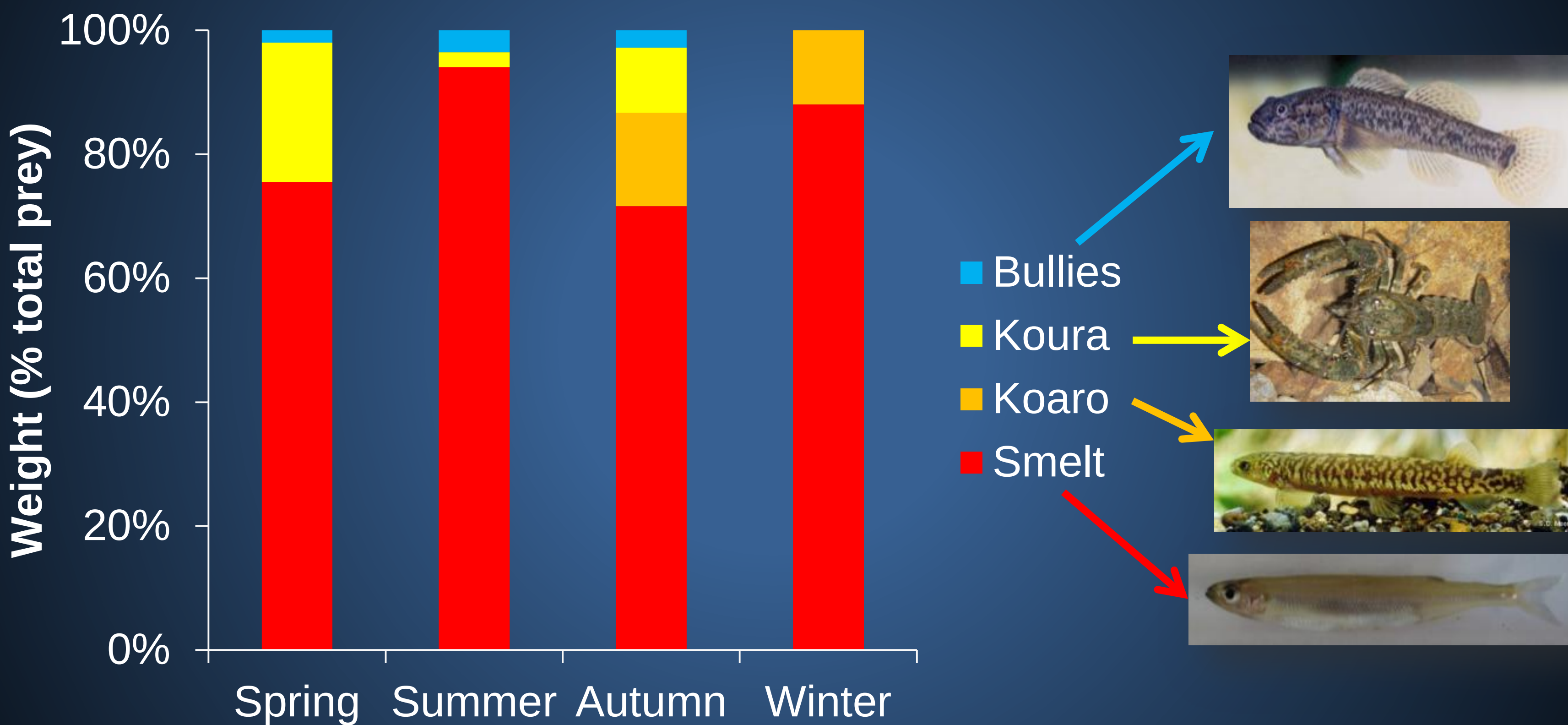
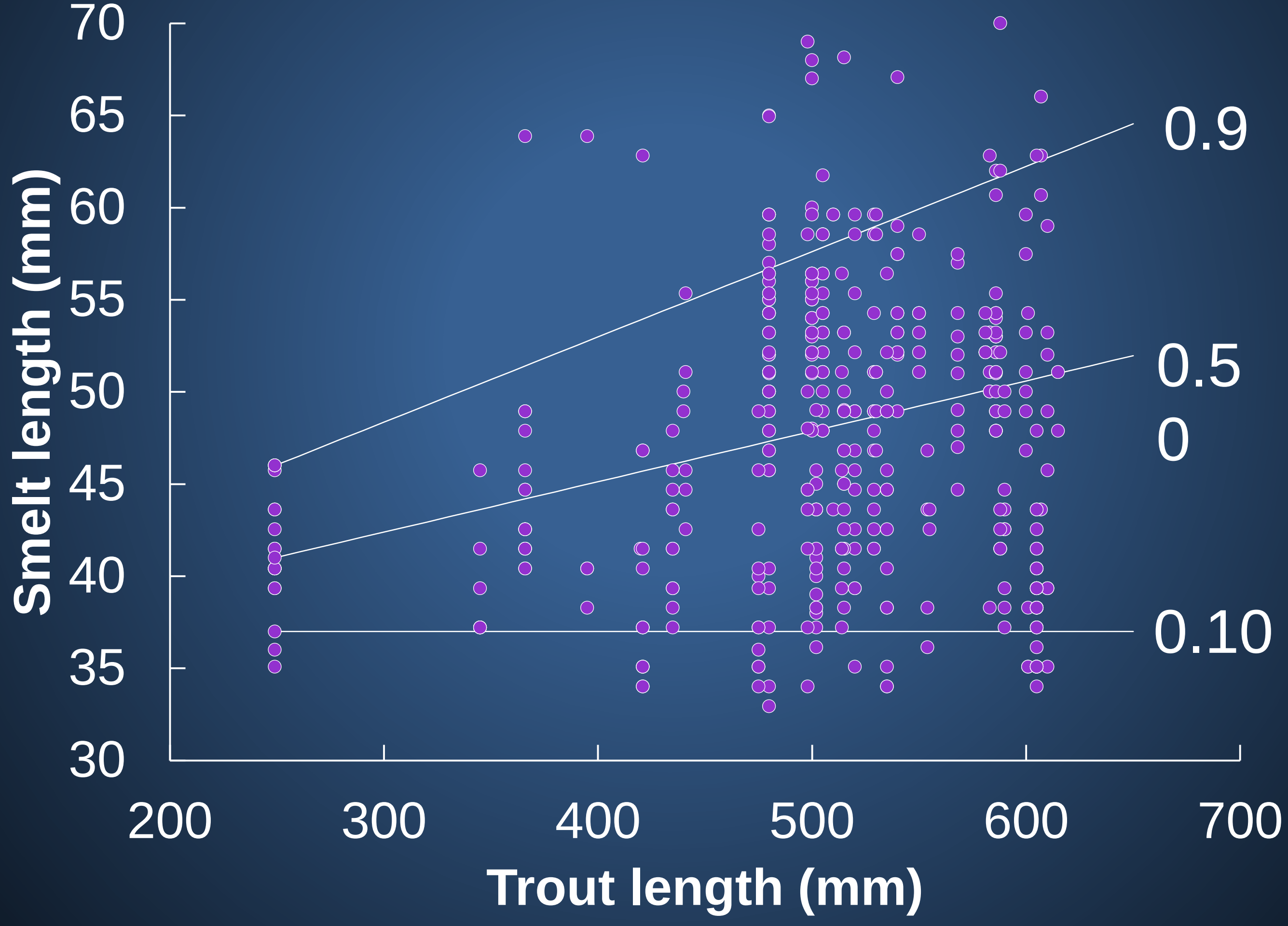
Diet of rainbow trout



Blair, J. M., Hicks, B. J., Pitkethley, R., and Ling, N. (In press) Diet of rainbow trout in Lake Rotoiti: an energetic perspective. New Zealand Journal of Marine & Freshwater Research. doi: 10.1080/00288330.2012.707660.

Sizes of smelt consumed by trout



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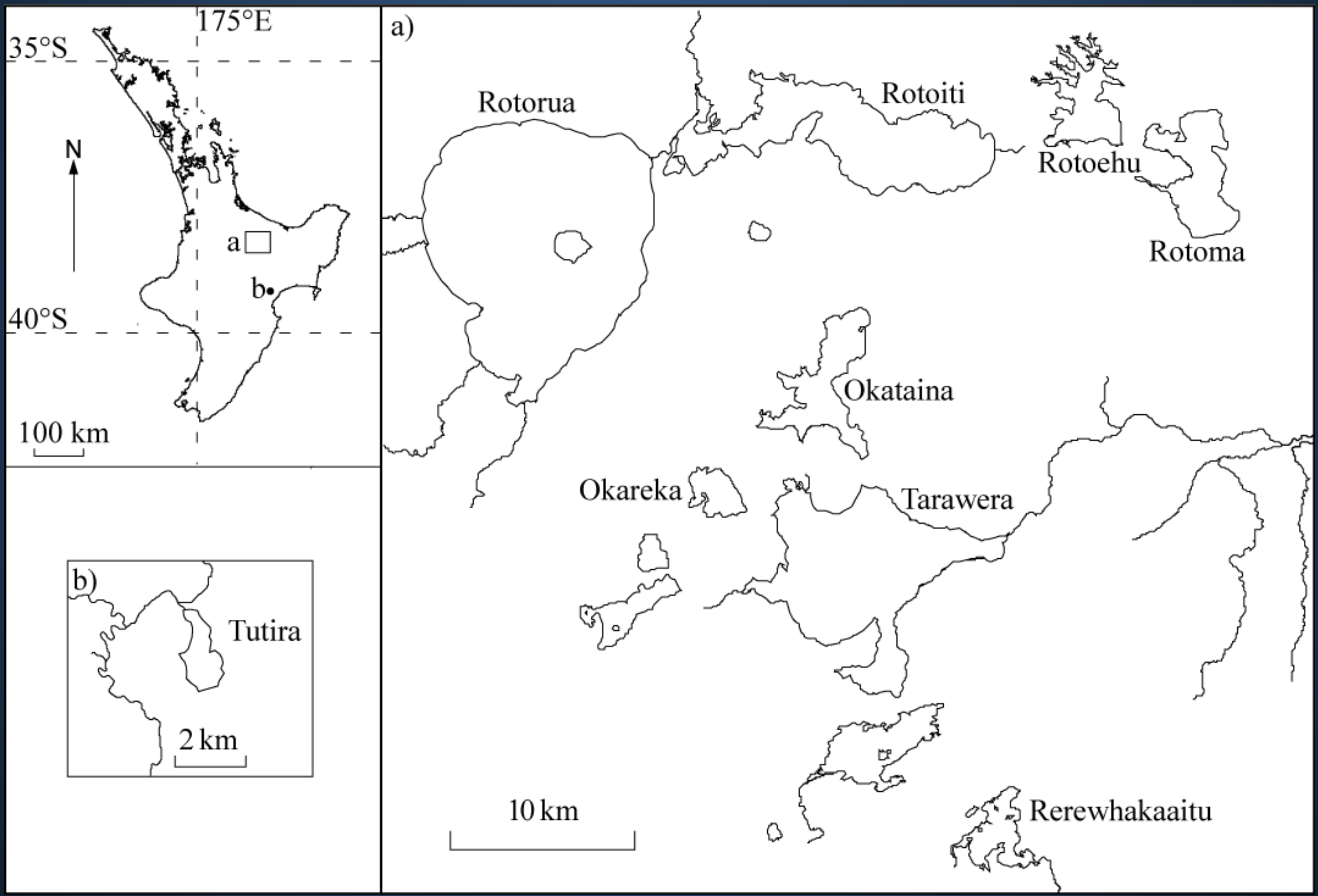
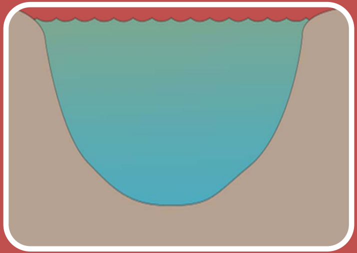
Study lakes


175°E
35°S
N
a
b
40°S
100 km
b)
Tutira
2 km
a)
Rotorua
Rotoiti
Rotoehu
Rotoma
Okataina
Okareka
Tarawera
Rerewhakaaitu
10 km

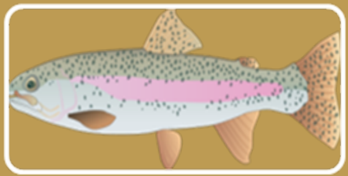
Methods



Environmental variables

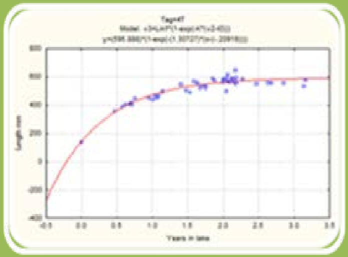
TN, TP, Chl *a*, Secchi depth

DO and temperature at 1-2 m intervals



Condition of hatchery and wild rainbow trout

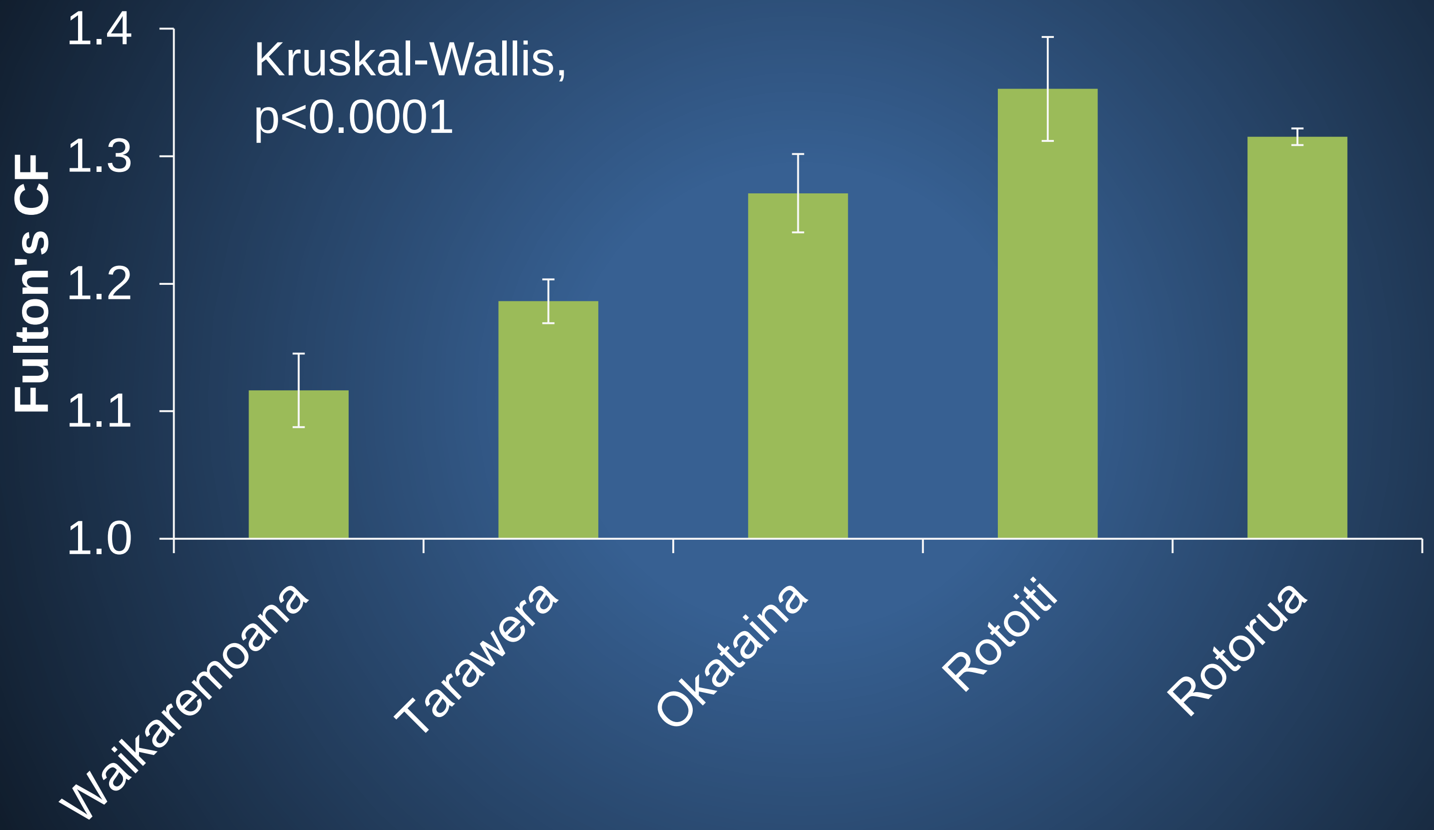
Fulton's condition factor over limited length range (450 mm = 2 years old), 5 lakes



Growth rates of hatchery rainbow trout

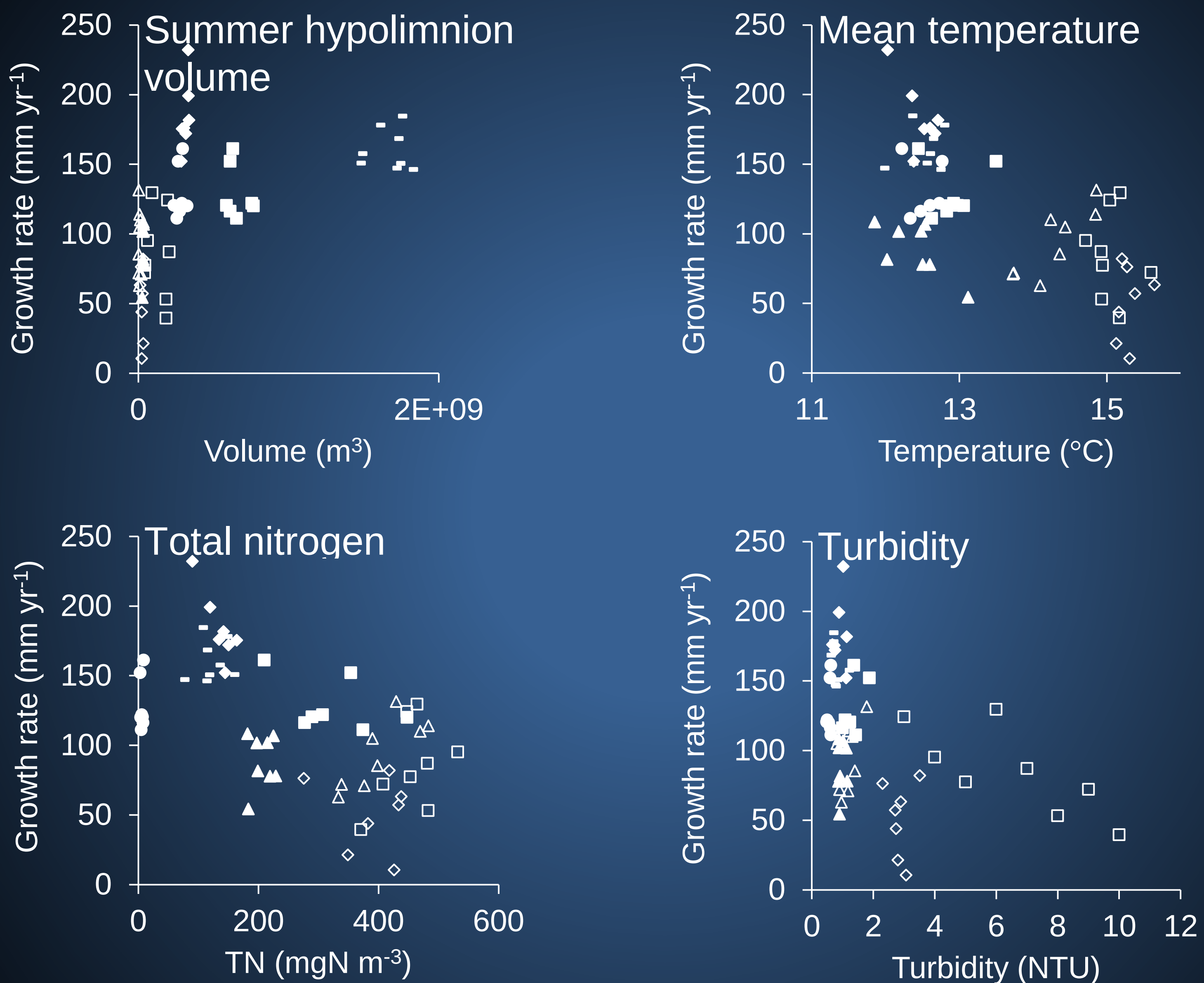
- Tag return data from 9 lakes, 2002-2009
- von Bertalanffy growth equation – growth rate at approx. 2 years old

Condition factor



Oligotrophic ⟶ Eutrophic

Error bars = ± standard error.


Summer hypolimnion volume
Growth rate (mm yr-1)
250
200
150
100
50
0
0
2E+09
Volume (m3)
Mean temperature
Growth rate (mm yr-1)
250
200
150
100
50
0
11
13
15
Temperature (°C)
Total nitrogen
Growth rate (mm yr-1)
250
200
150
100
50
0
0
200
400
600
TN (mgN m-3)
Turbidity
Growth rate (mm yr-1)
250
200
150
100
50
0
0
2
4
6
8
10
12
Turbidity (NTU)

Classification and regression tree analysis

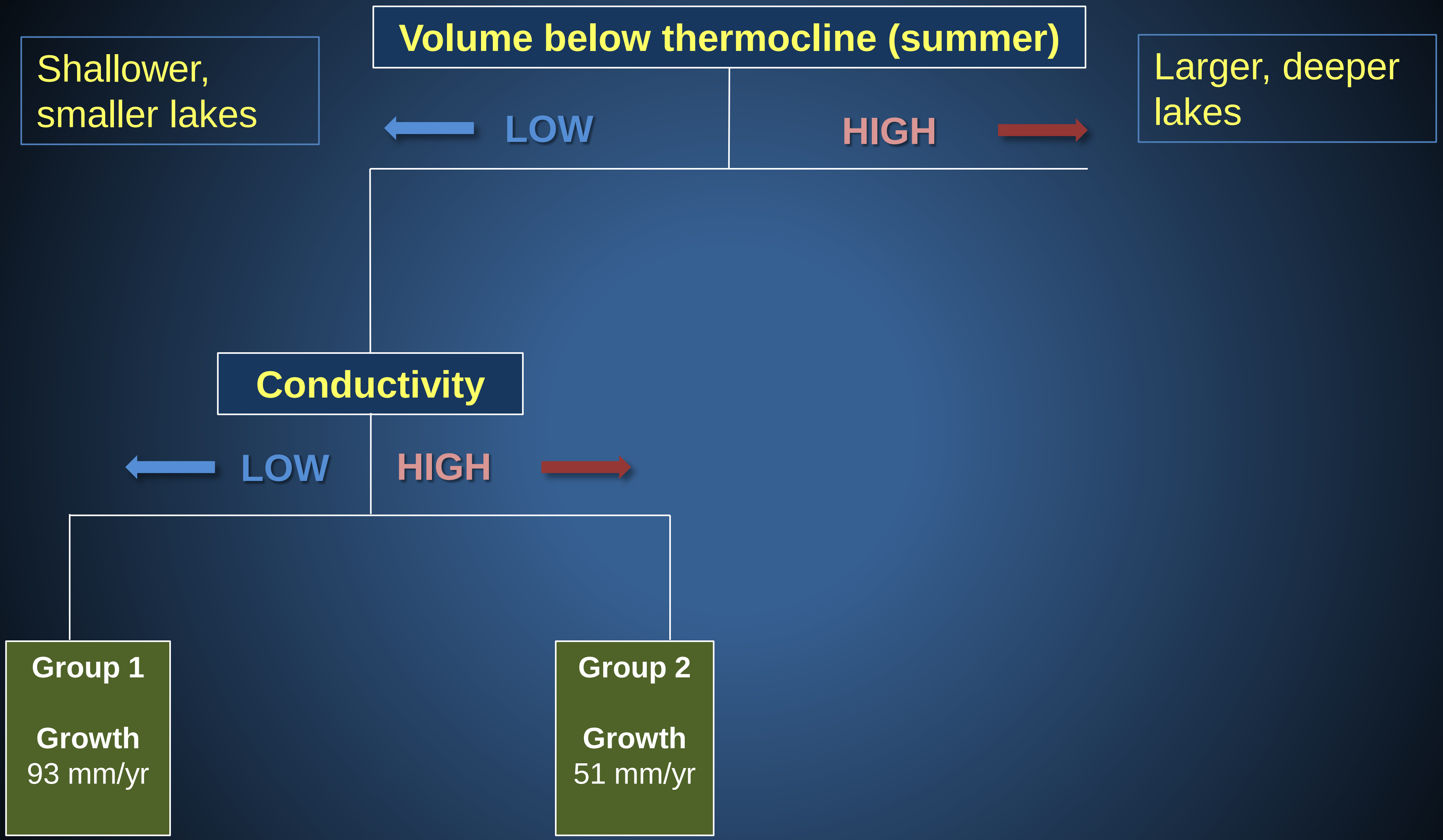
Shallower, smaller lakes = Low trout growth rates

Volume below thermocline (summer)

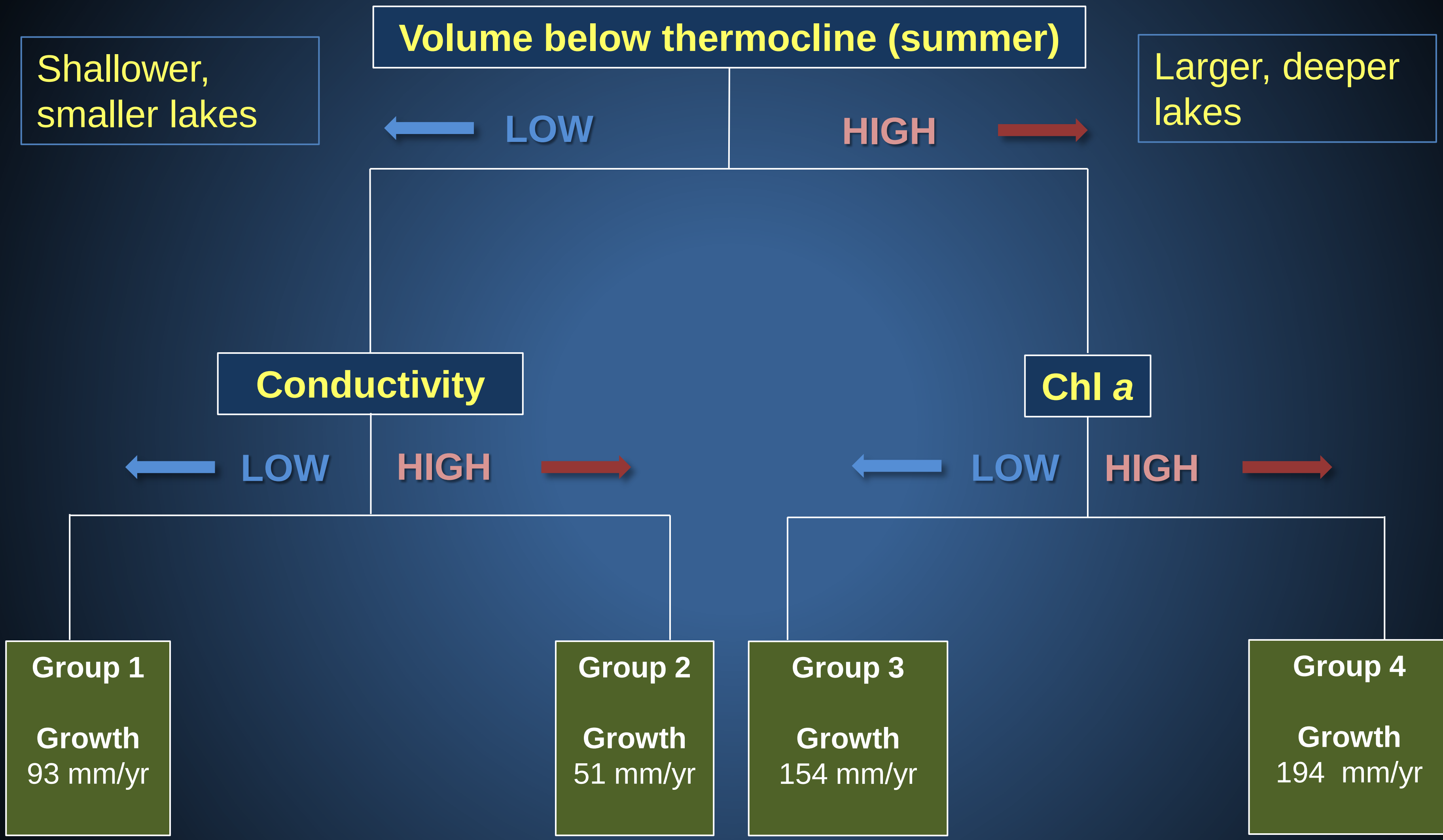
LOW | **HIGH**

Larger, deeper lakes = high trout growth rates

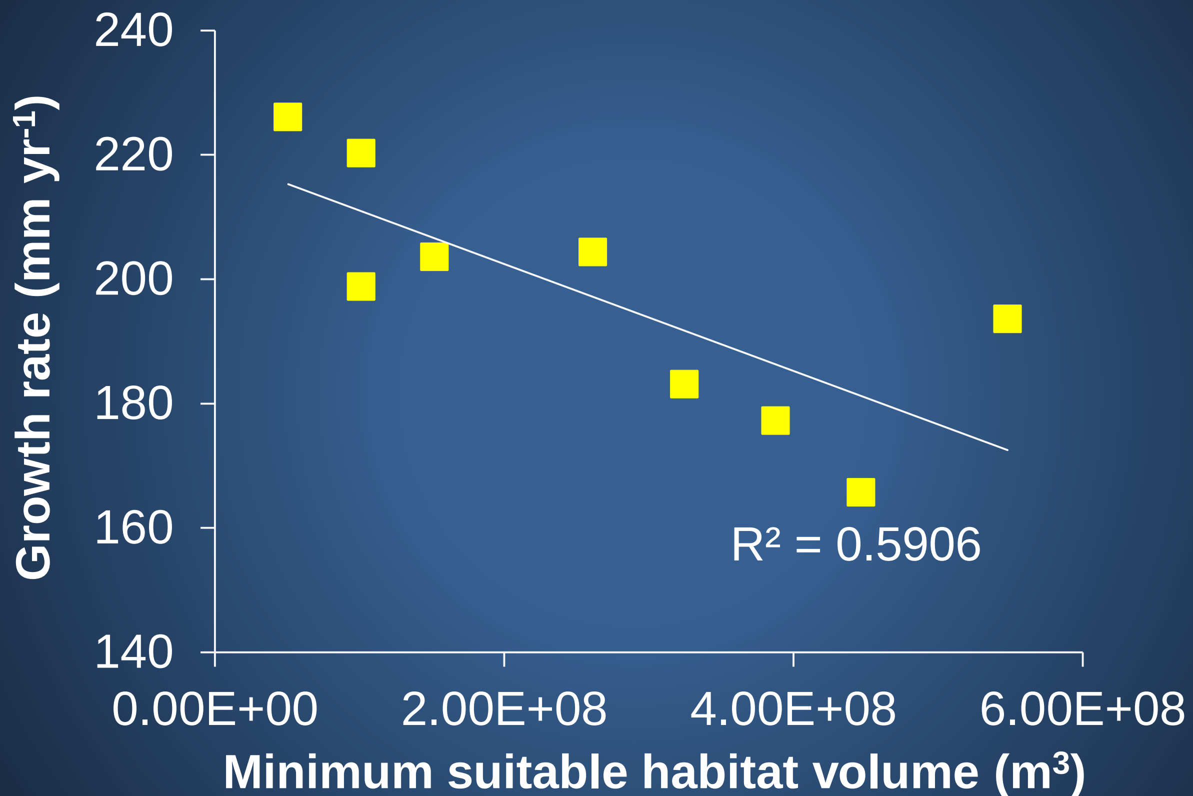
Classification and regression tree analysis



Classification and regression tree analysis



Growth rate changes with habitat volume- Lake Rotoiti



(DO > 6 mg L^{-1} and temperature < 21°C)

Summary: Which ambient conditions cause higher growth in some lakes?

SHALLOWER, WARMER LAKES:

- High nutrient supply leads to high algal growth and loss of oxygen
- Wind-driven mixing leads to sediment in water
- Temperature extremes
- Low smelt production; more bullies and koura eaten

DEEPER, COOLER LAKES:

- Large amount of suitable habitat
- Clear water
- Higher smelt production, more smelt eaten

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Bioenergetics model

Consumption (model output)=

Respiration, Active metabolism, Specific dynamic action (estimated)

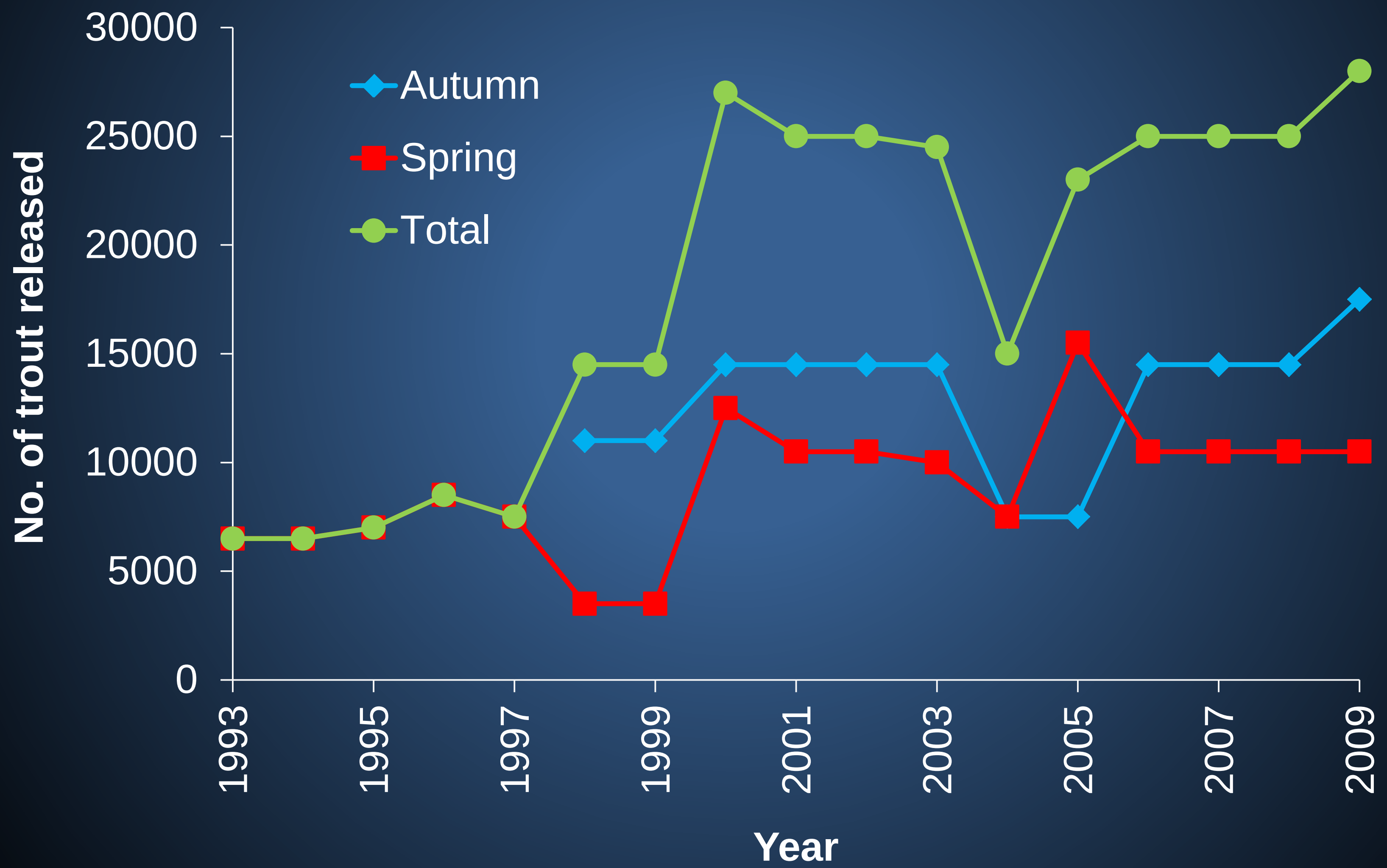
+

Egestion, Excretion (estimated)

+

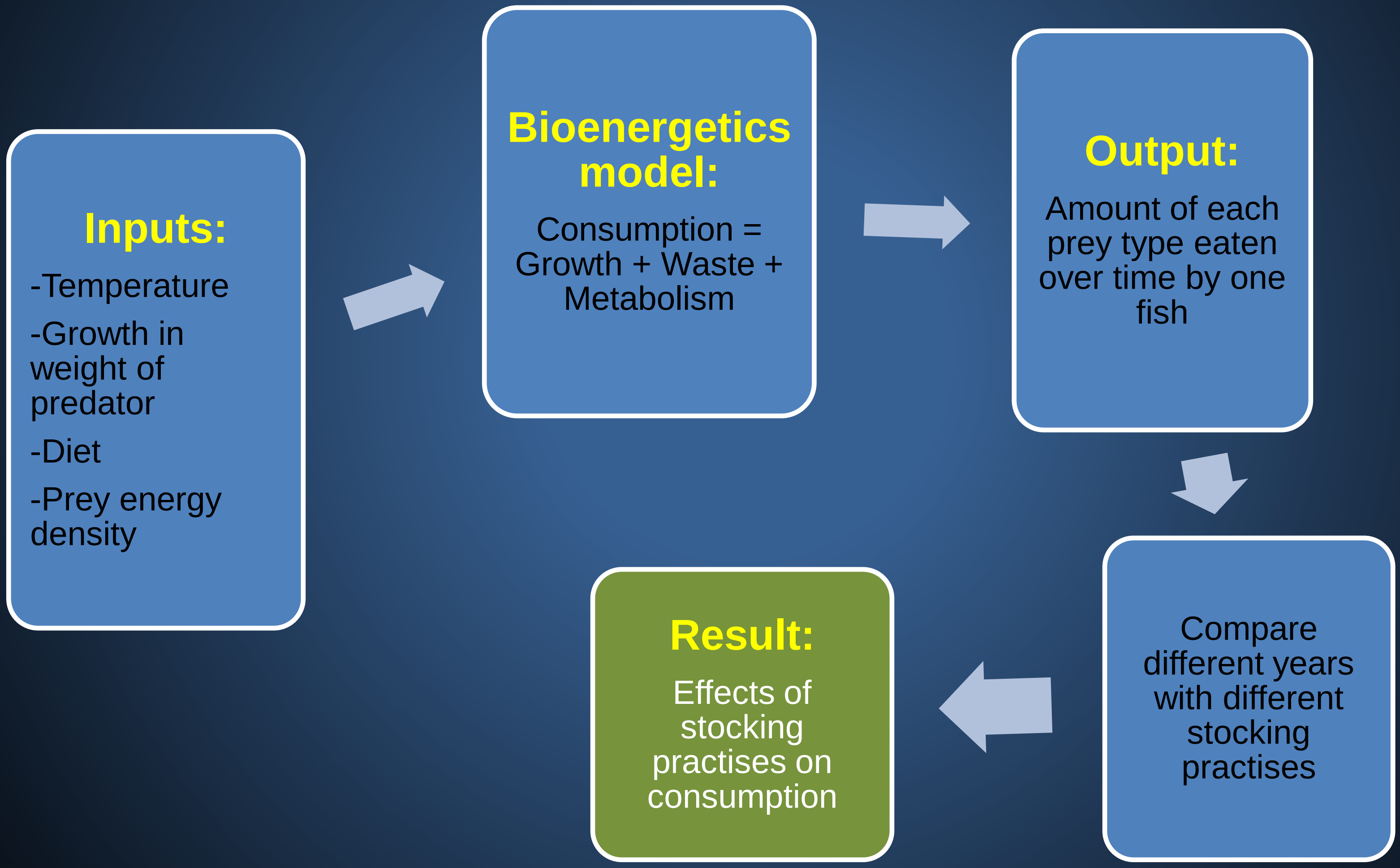
Somatic growth, Gonad production (measured)

Rotoiti trout stocking rates

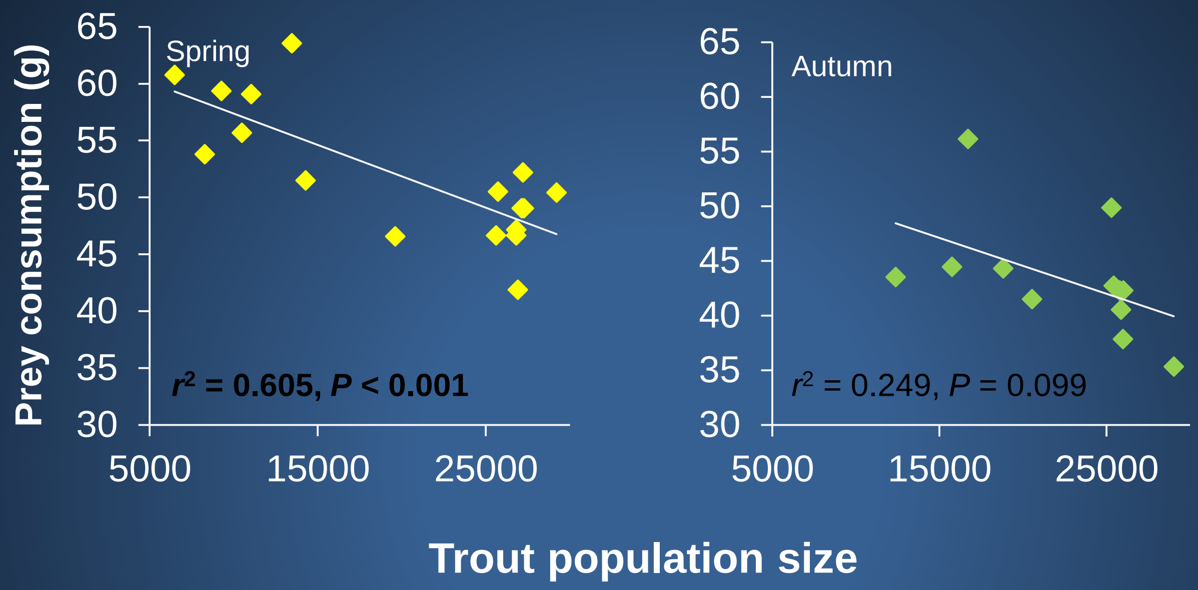


Fish & Game, unpub.

Bioenergetics modelling approach



Model outputs1: Density dependence
Comparing consumption to trout population size



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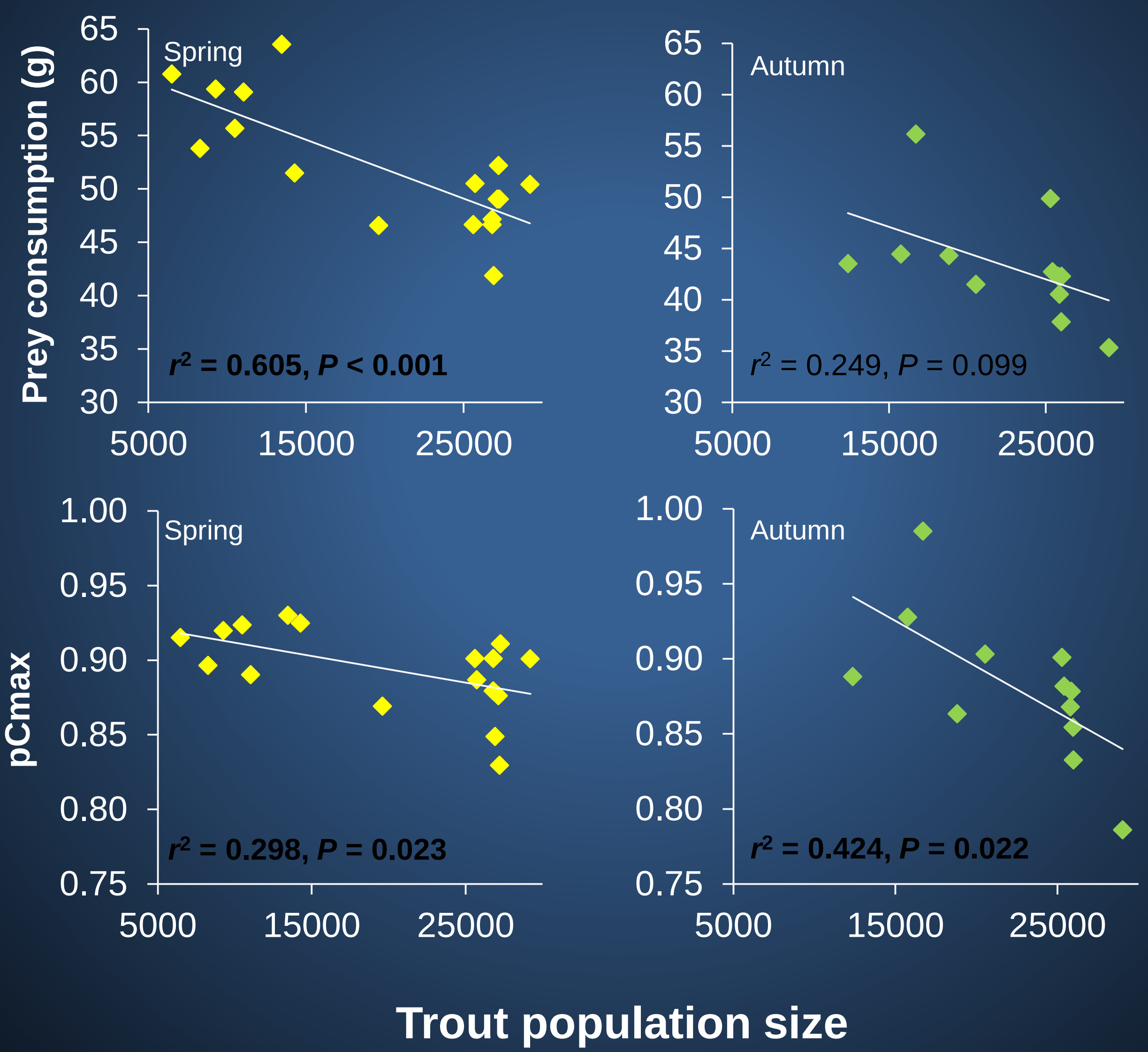
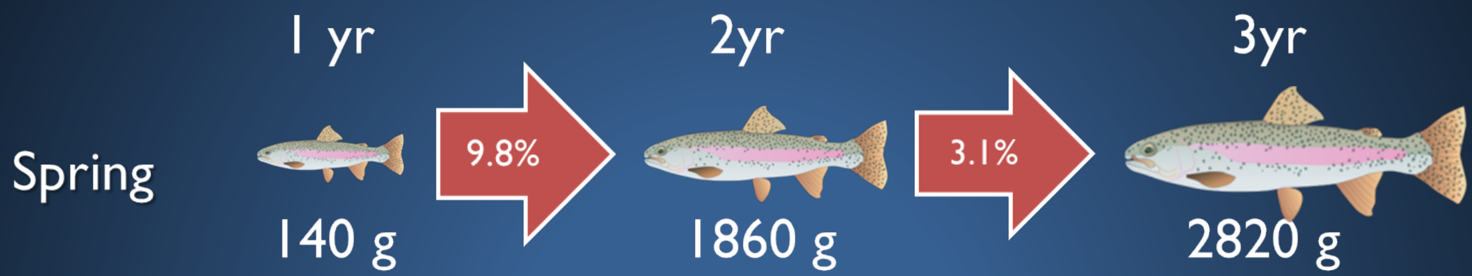


Model outputs 2: Seasonal effects
Comparing growth between release seasons



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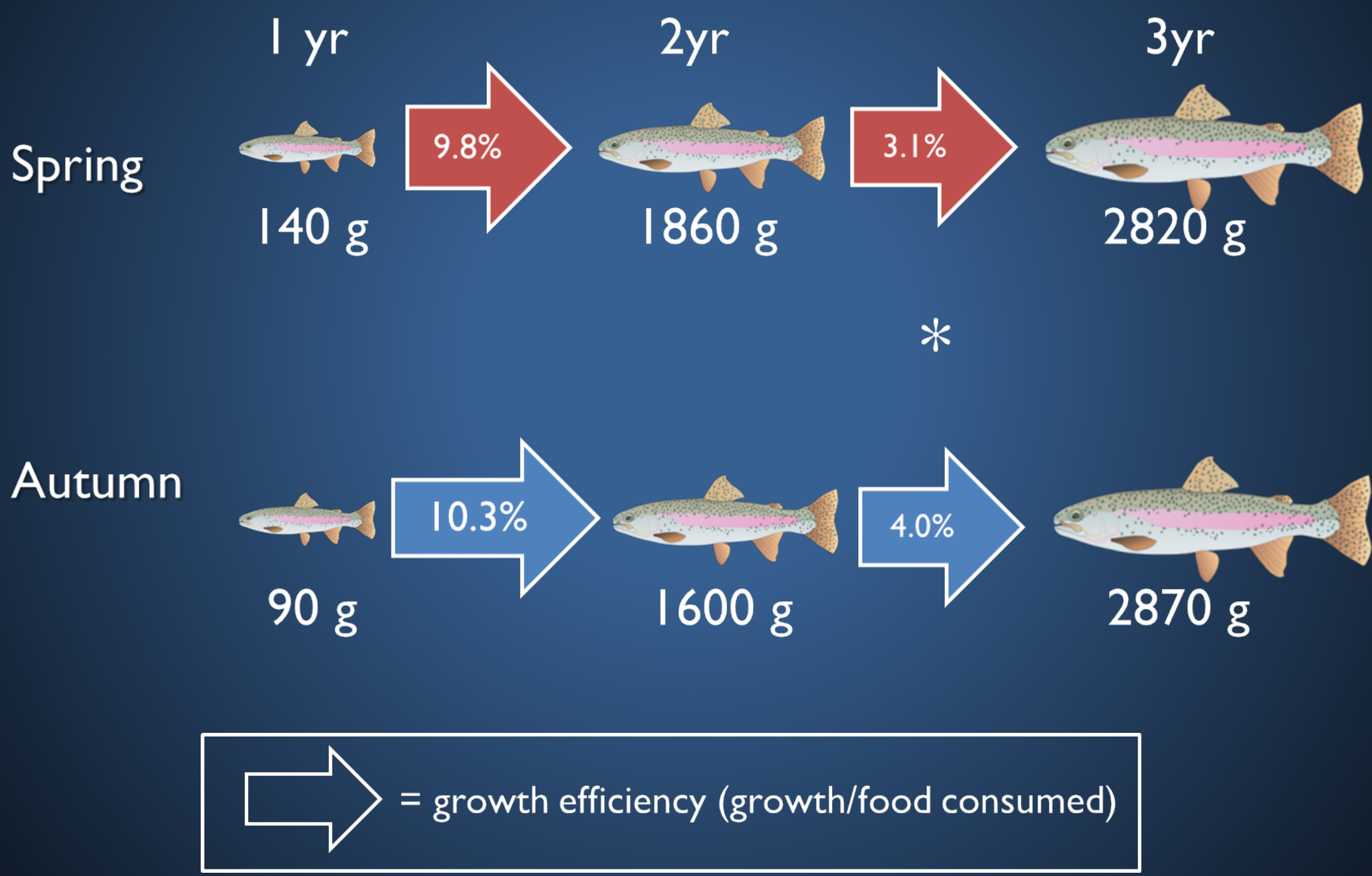

Conclusions

- Ambient conditions and stocking practises both important drivers of trout growth

- Ambient conditions:
  - Effects of eutrophication on trout most severe in shallow lakes
  - High water temperatures in summer detrimental:
    - Stratification, algal blooms and hypolimnetic deoxygenation
  - Habitat availability key factor determining growth.

- Stocking timing and prey availability:
  - Releasing trout in autumn advantageous, because
    - (1) temperature is more suitable for growth
    - (2) prey is abundant.

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Lake Ecosystem Restoration NZ

Thanks!