# Latitudinal and temporal declines in Great Lakes lake trout energy densities

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# Lake Trout

- Native populations essentially extirpated by the 1960's due to commercial fishing activities and sea lamprey predation. Stocking programs began in 1970's.
- Great Lakes populations (Ex. L. Superior) are principally managed populations, very little or no natural reproduction observed.
- Substantial fluctuations in forage base species composition, quantity and quality have occurred to lake trout primary prey (alewife, smelt, coregonids, sculpins) throughout the Great Lakes since inception of stocking programs.
- Stocked into each Great Lake with other salmonid predators including chinook, coho, and Atlantic salmon in addition to rainbow and brown trout.

# Lake Trout

- Fisheries and Oceans Canada has collected lake trout from four of the Great lakes since 1977 as a sentinel of environmental remediation practices occurring throughout the Great Lakes watershed.

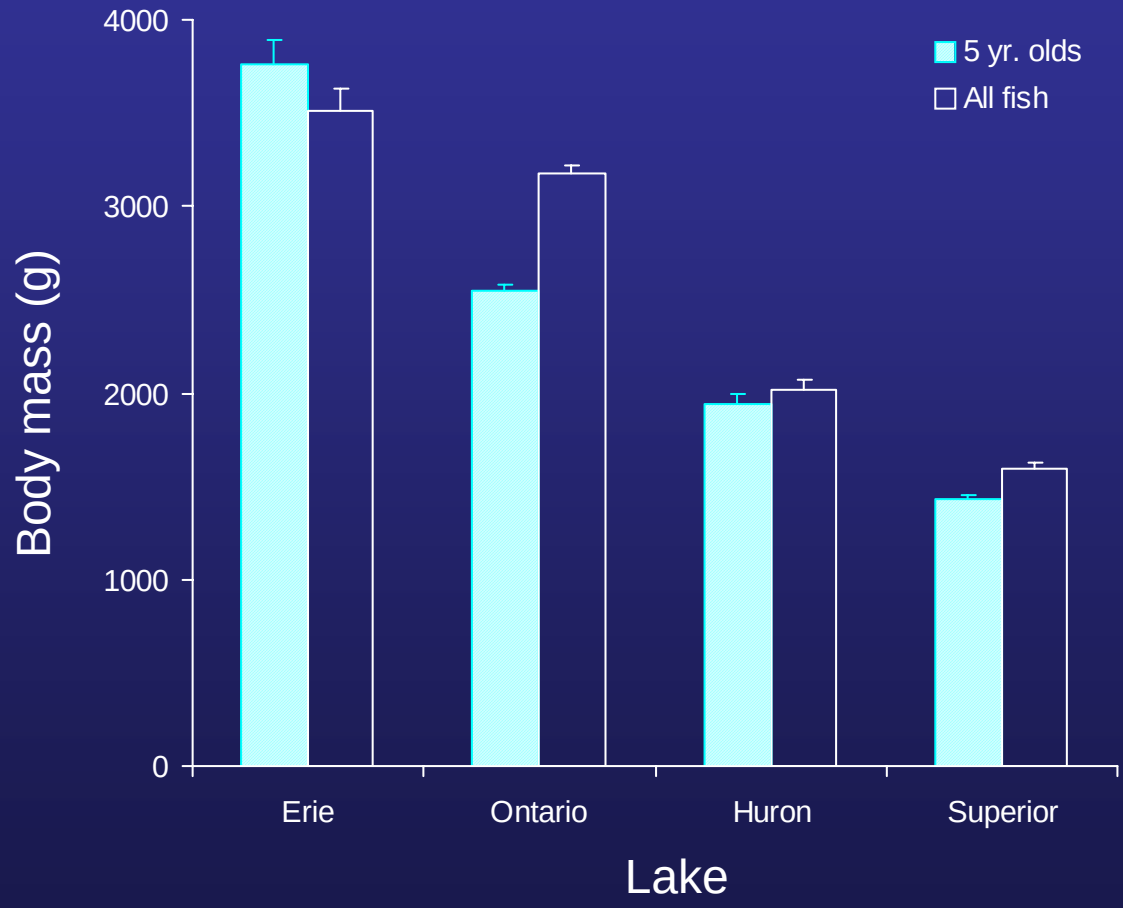
- Contaminants surveillance program database provides not only historical trends on pollutant concentrations measured in lake trout, but also information on the growth and condition of Great lakes populations.

- Importantly, the surveillance program collects data on lake trout whole body lipid content and thus energy density.

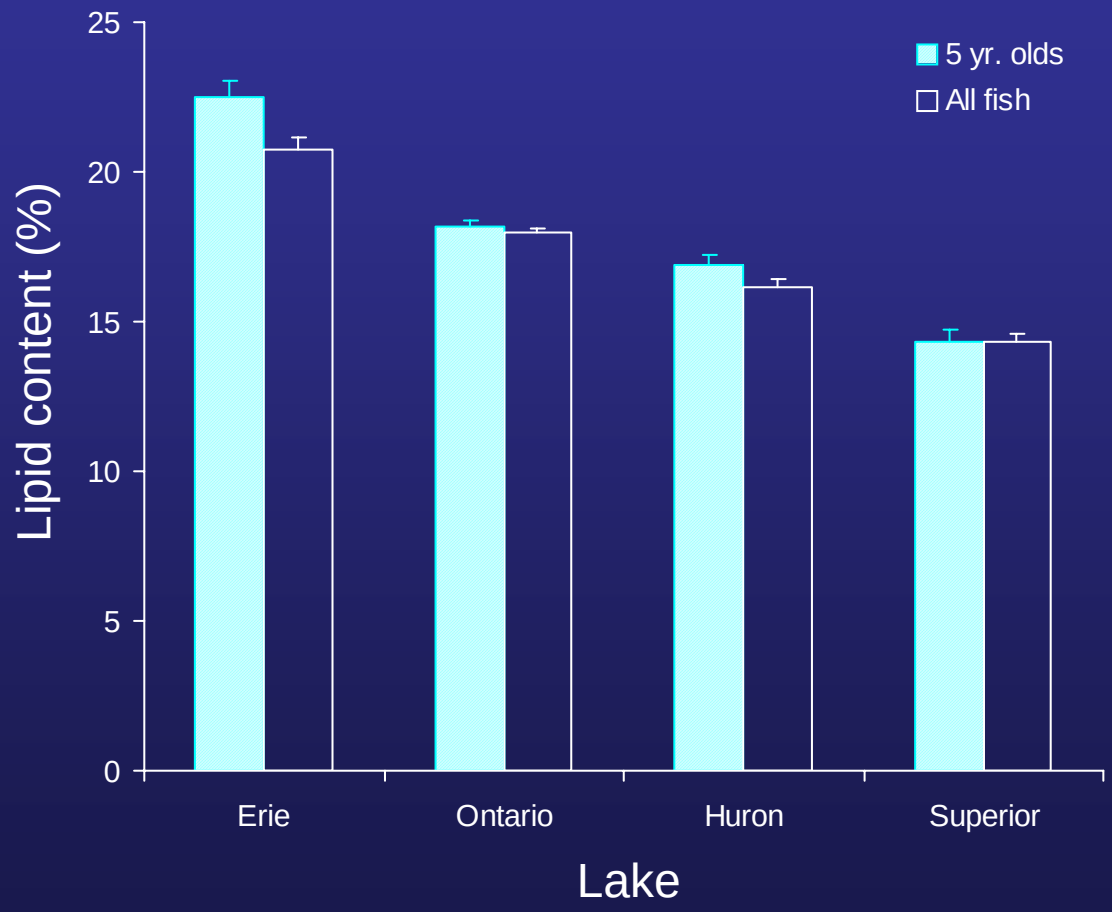
# Materials & Methods

- Lake trout collected from various locations throughout each lake using bottom sets of gill nets. (6.4 – 15.3 cm).
- Biological data collected included total length, weight, age, sex, reproductive status, extent of lamprey scarring.
- Lipid content analysis completed on 5g of whole body homogenate.
- Moisture content estimated from the relationship observed between whole body lipid content and moisture contents for 245 lake trout collected from 21 Canadian lakes (D. Muir, Environment Canada, unpubl. data).
- Energy densities ($kJ \cdot g^{-1}$) estimated for lake trout 2 – 10 years of age using tissue caloric contents of 9.03 and 4.27 $kcal \cdot g^{-1}$ used for lipid and protein, respectively, and a conversion value of 4187 $J \cdot kcal^{-1}$.

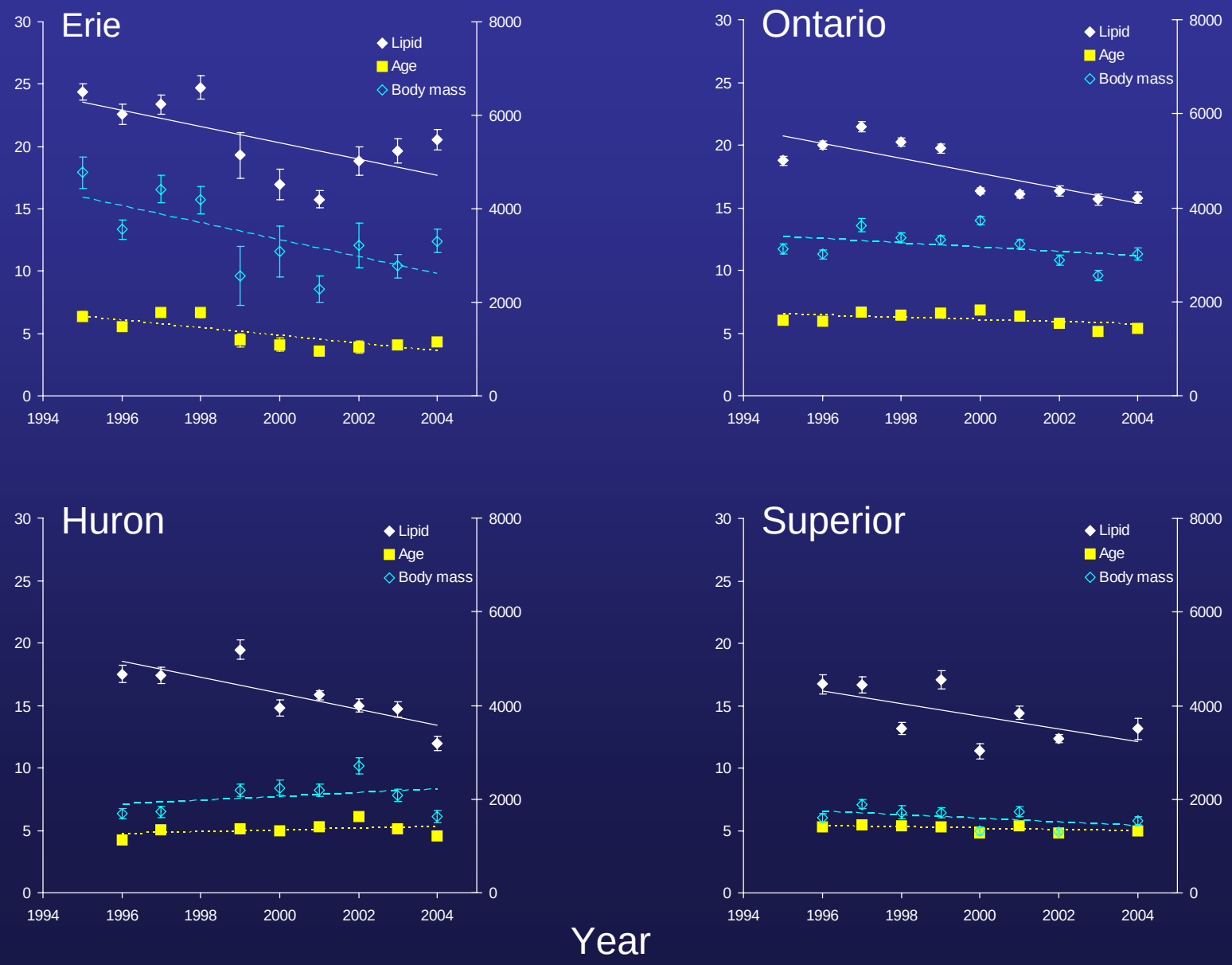
# Latitudinal trends (Body mass)



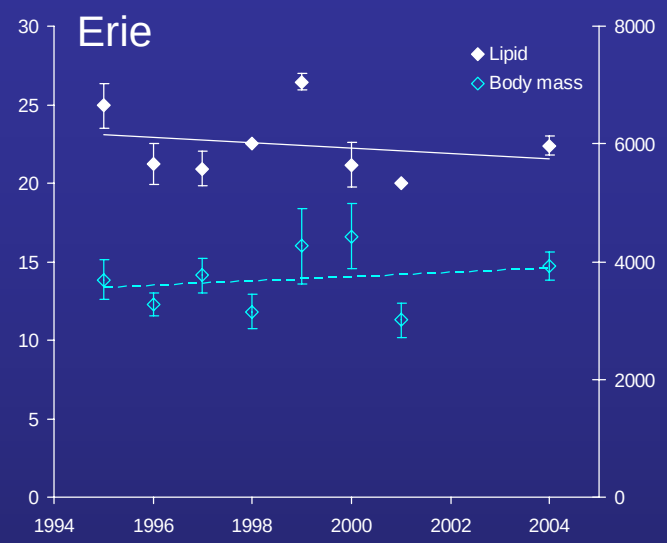
# Latitudinal trends (Lipid content)

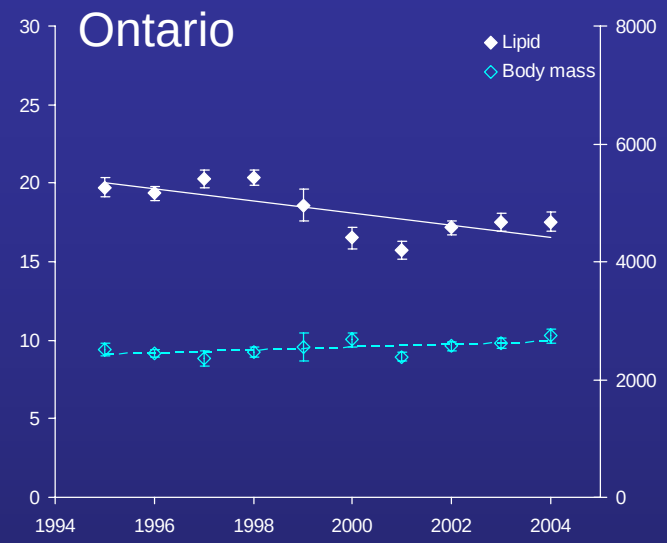


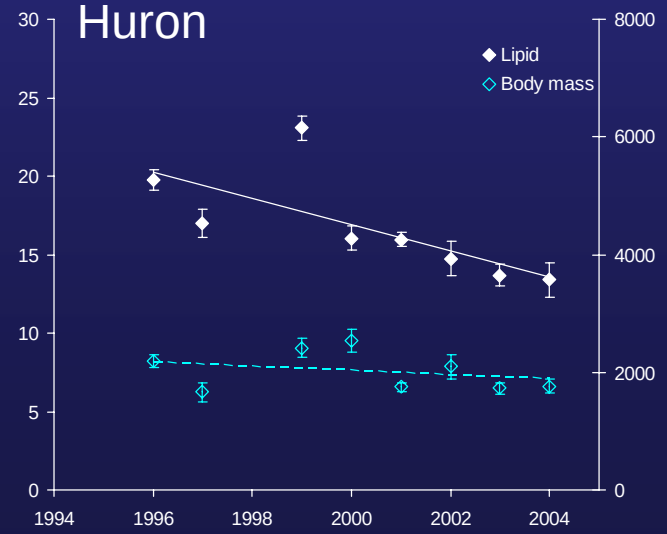
# Temporal trends (Annual collections)

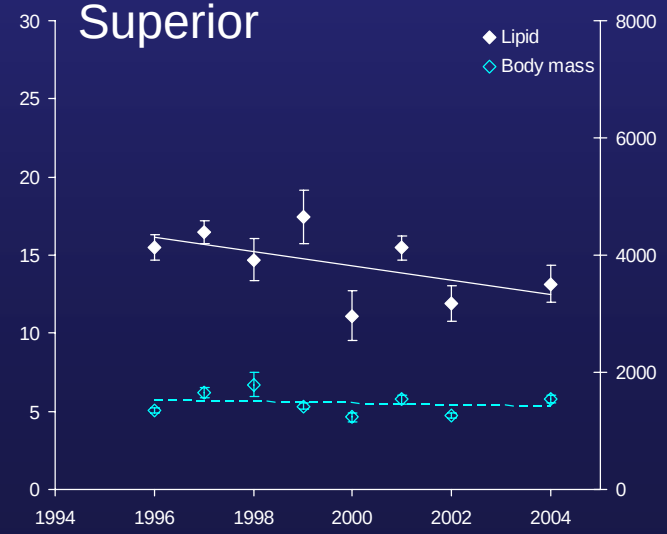


# Trends (5 yr. olds)



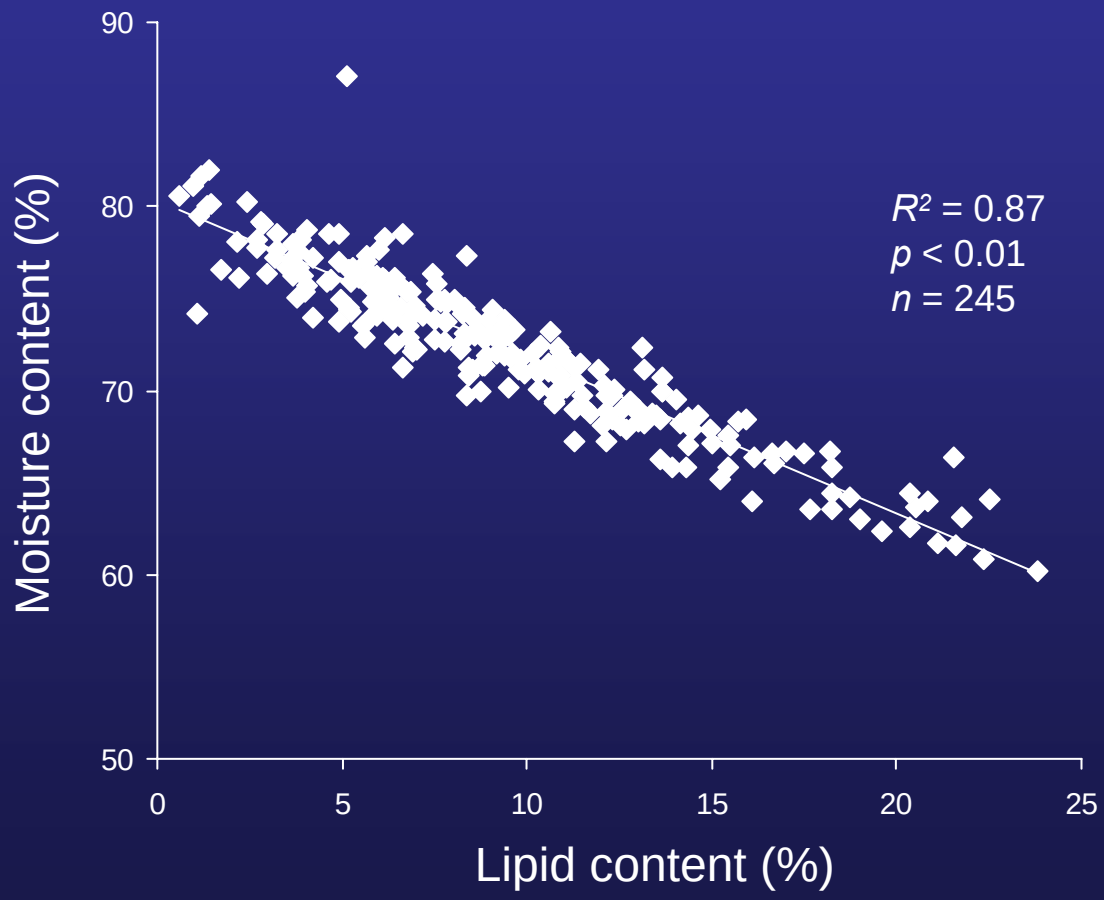




Lipid content (%)

Body mass (g)

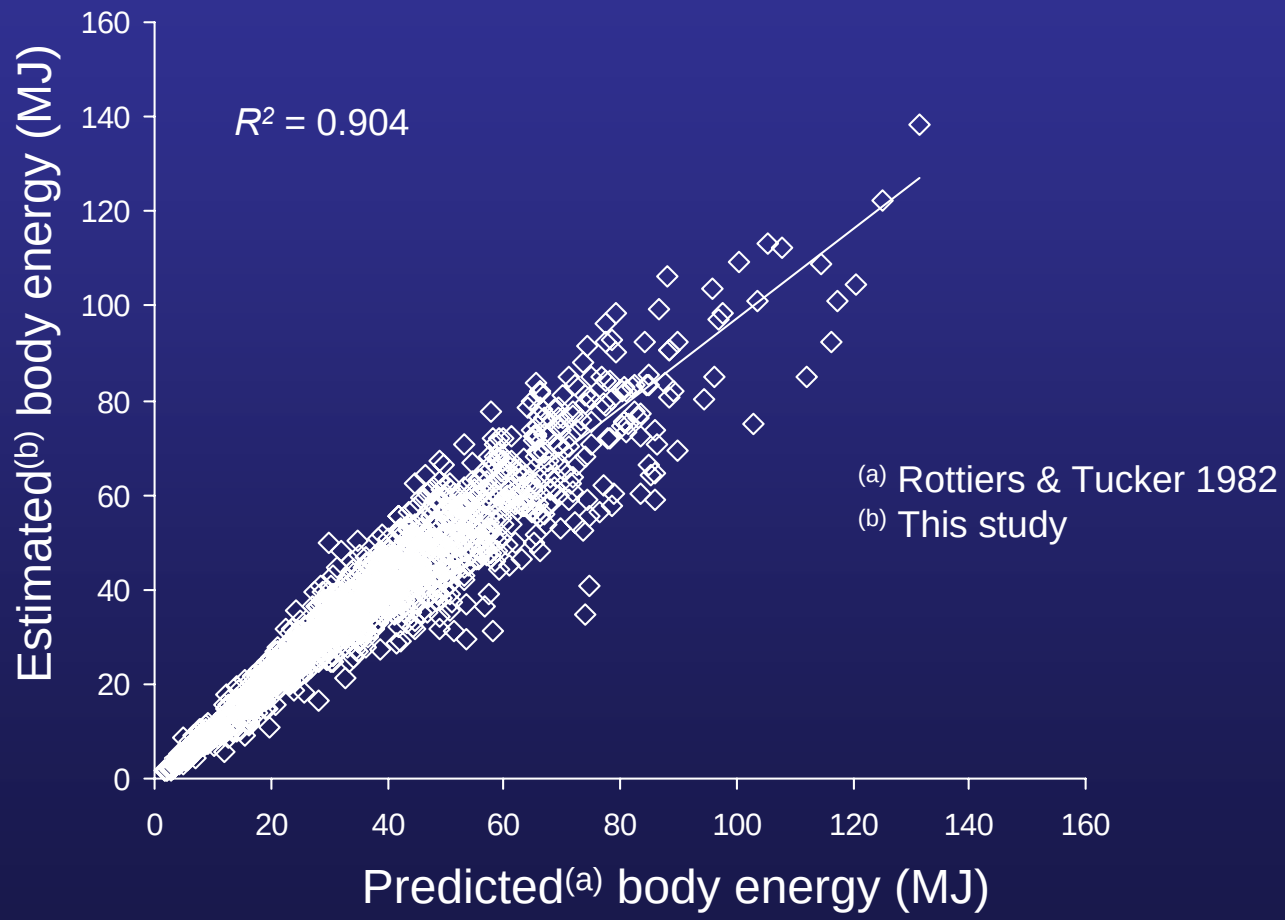
Year

# Moisture vs lipid content

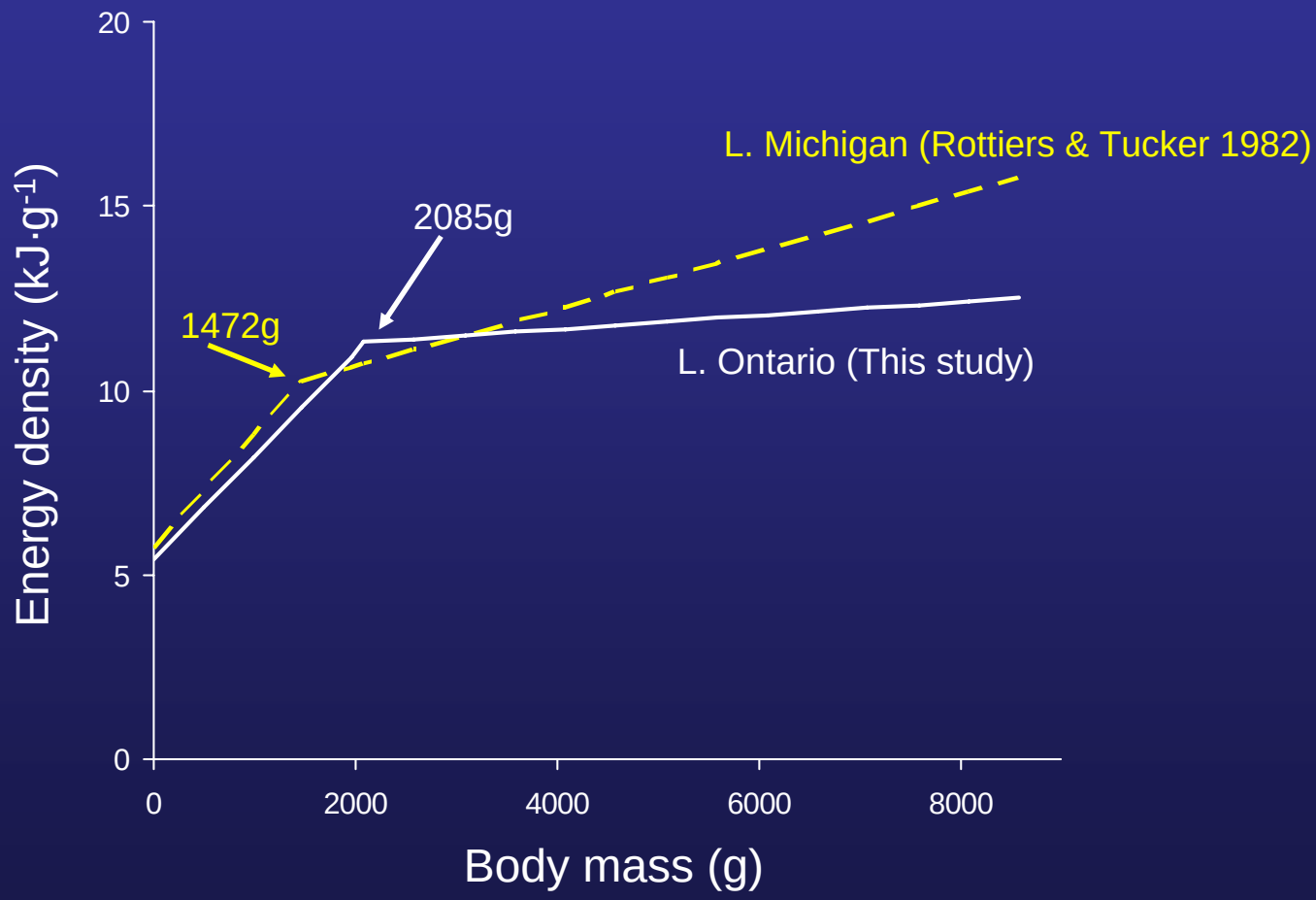



(D. Muir, Environment Canada, unpubl. data)

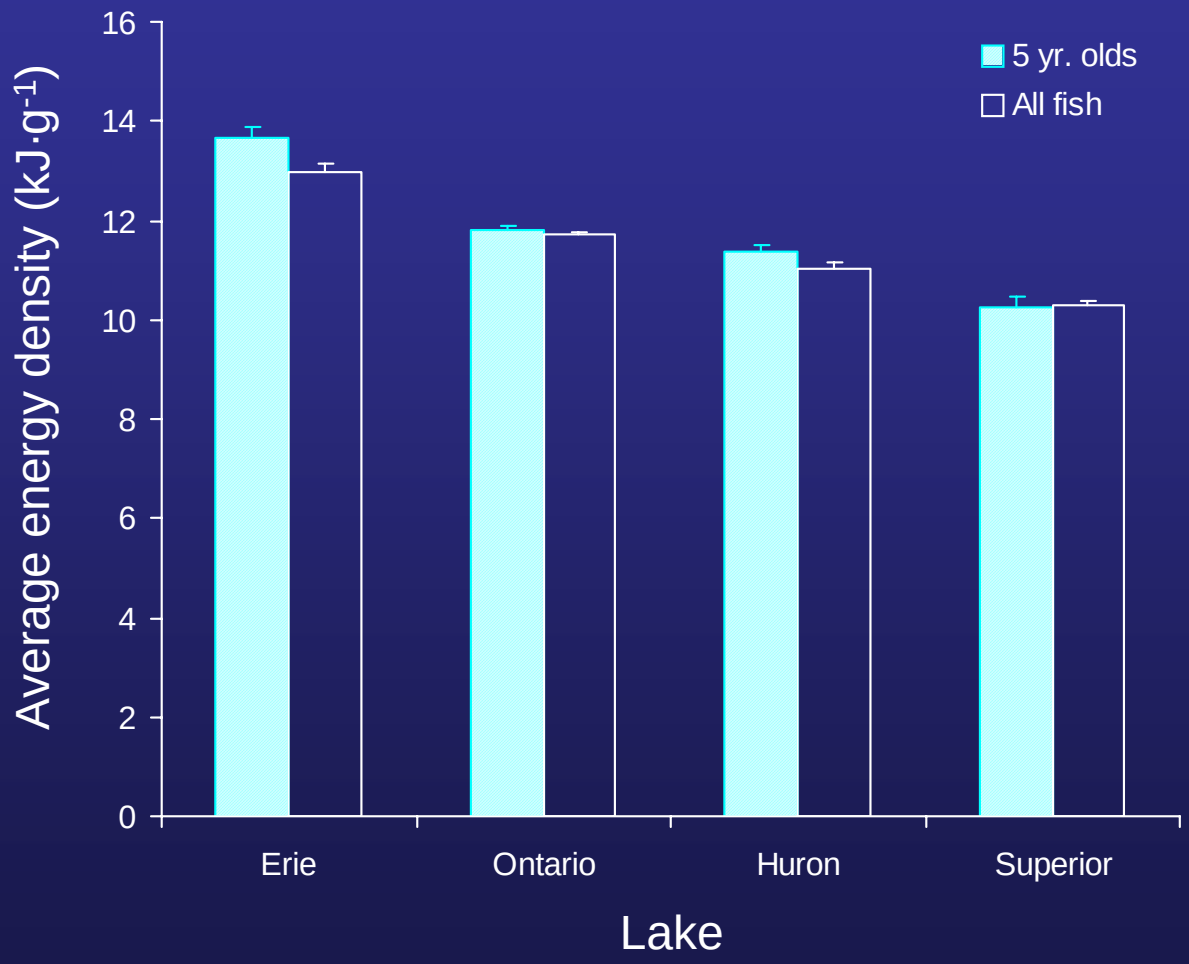
# Energy density comparison



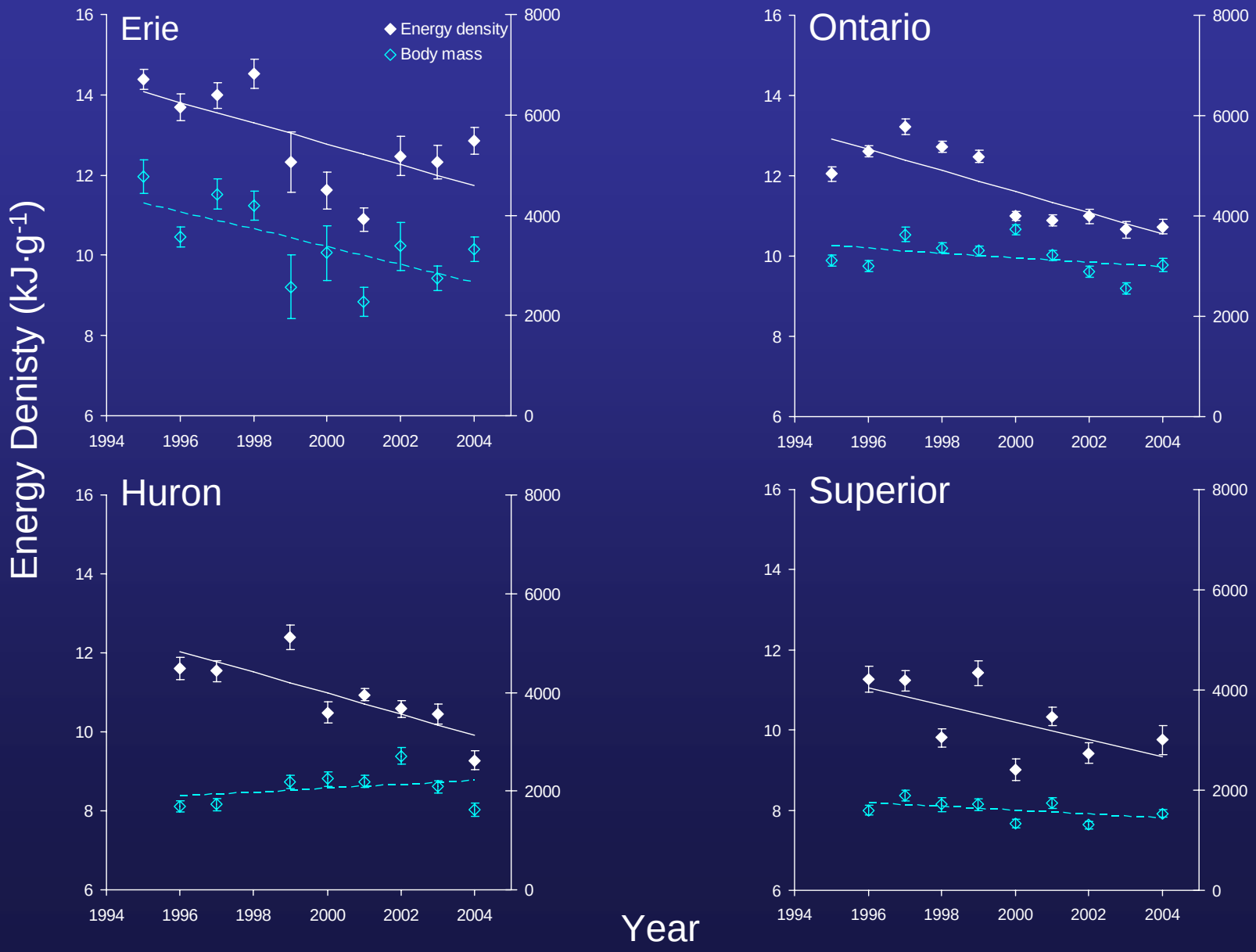
# Ontogenetic relationship



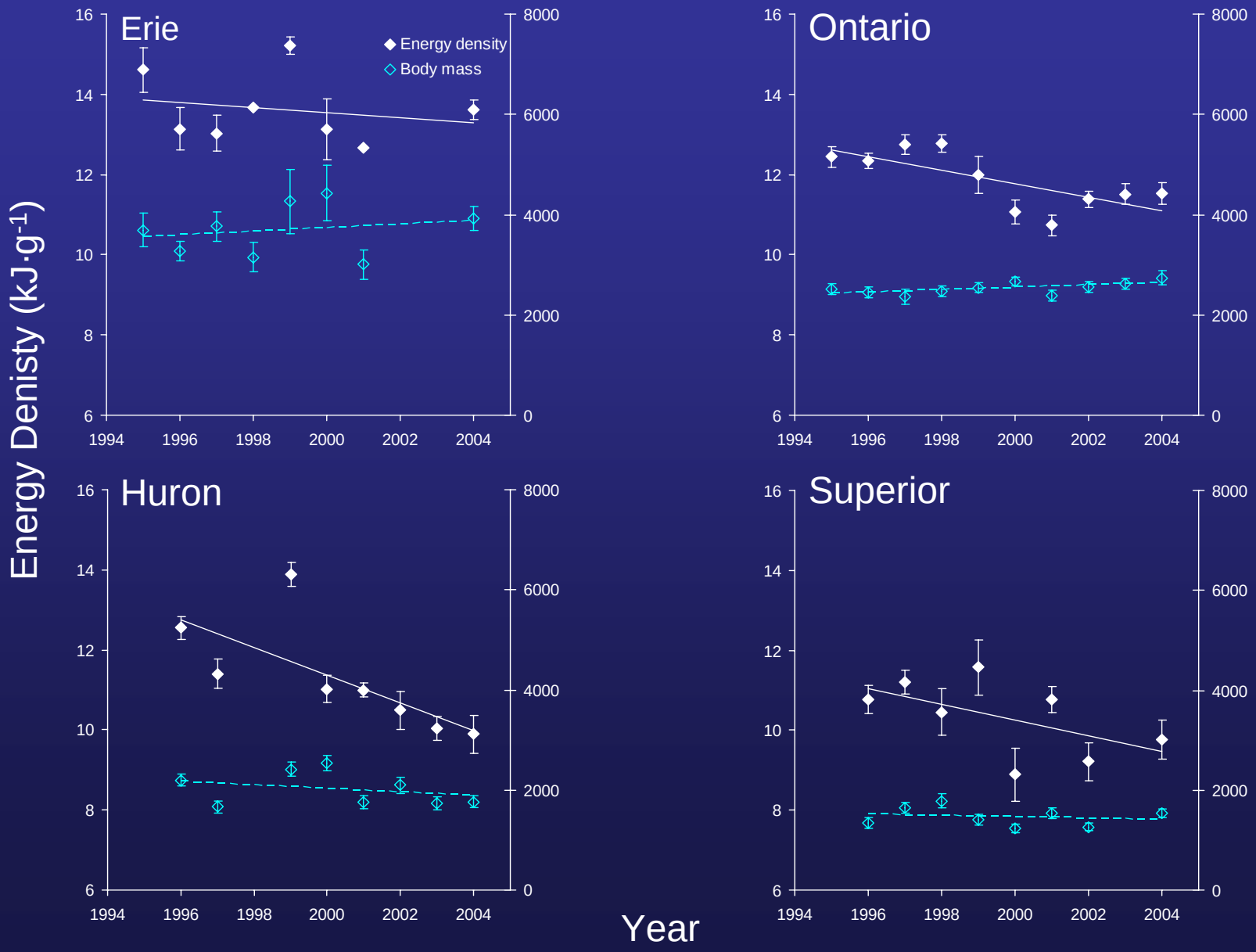
# Latitudinal trends (Energy density)



# Temporal trends (Annual collections)



# Temporal trends (5 yr. olds)



# Von Bertalanffy Calculations

- Used the Von Bertalanffy growth model to estimate lake trout energy density growth rates.

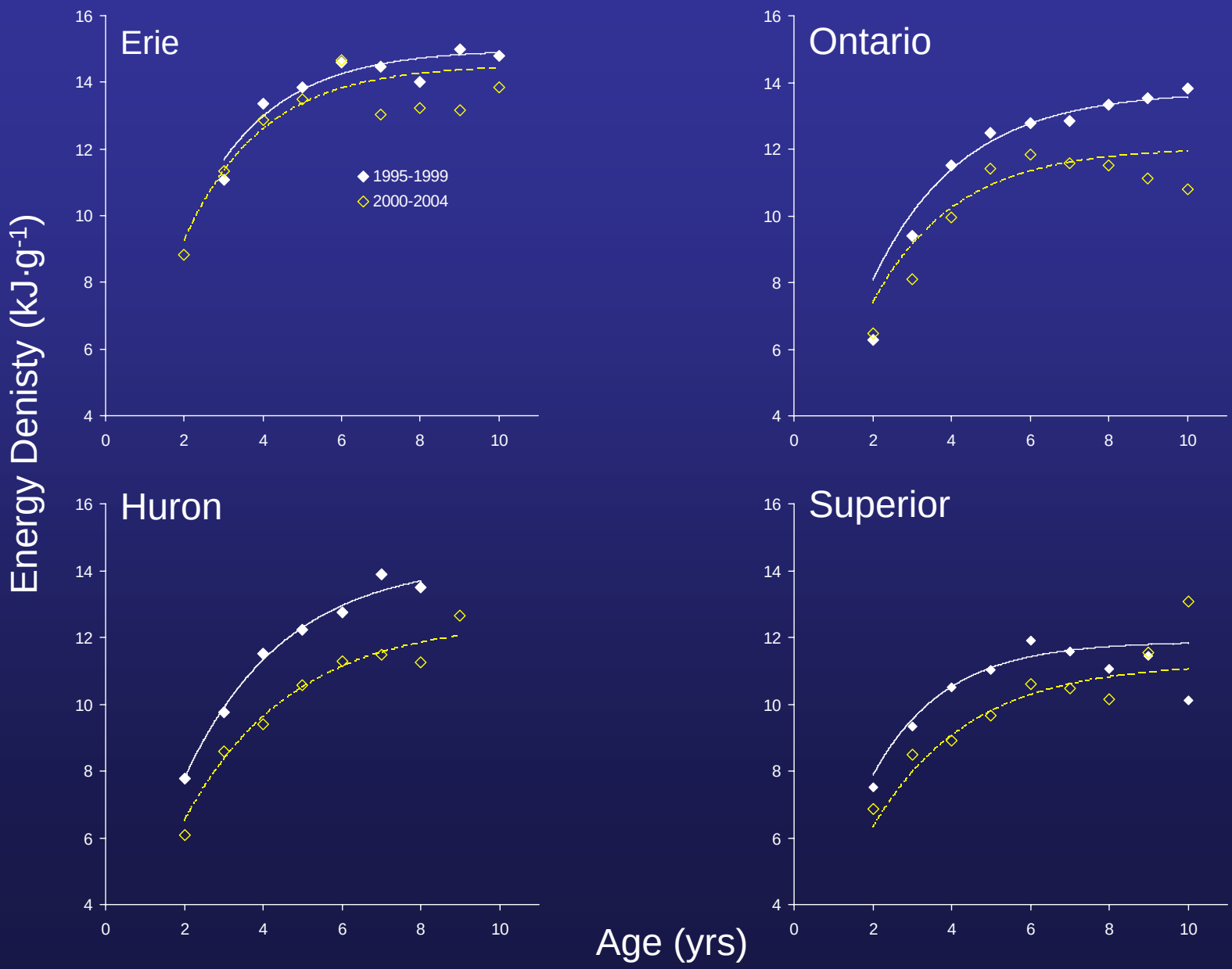
$$Q_t = Q_\infty \cdot (1 - e^{-k(t-t_0)})$$

- Where:
  - $Q_t$ = Energy density at time $t$
  - $Q_\infty$ = Asymptotic energy density
  - $k$ = Von Bertalanffy growth coefficient

And:

- $t_{½}$ = Half life ($\ln[2]/k$)
- $t_{0.90}$ = Predicted time to 90% of asymptotic value ($Q_\infty$) ($\ln[10]/k$)

# Von Bertalanffy Curves



# Von Bertalanffy Calculations

| | $Q_\infty$ (kJ·g$^{-1}$) | $k$ (year$^{-1}$) | $t_{½}$ (years) | $t_{0.90}$ (years) |
|---|---|---|---|---|
| | 1995 - 1999 | | | |
| Erie | 15.0 | 0.502 | 1.4 | 4.6 |
| Ontario | 13.7 | 0.441 | 1.5 | 5.2 |
| Huron | 14.3 | 0.392 | 1.6 | 5.9 |
| Superior | 11.9 | 0.543 | 1.3 | 4.2 |
| | 2000 – 2004 | | | |
| Erie | 14.5 | 0.506 | 1.4 | 4.6 |
| Ontario | 12.0 | 0.474 | 1.4 | 4.9 |
| Huron | 12.5 | 0.367 | 1.7 | 6.3 |
| Superior | 11.2 | 0.412 | 1.6 | 5.6 |

# Salmonid Stocking*

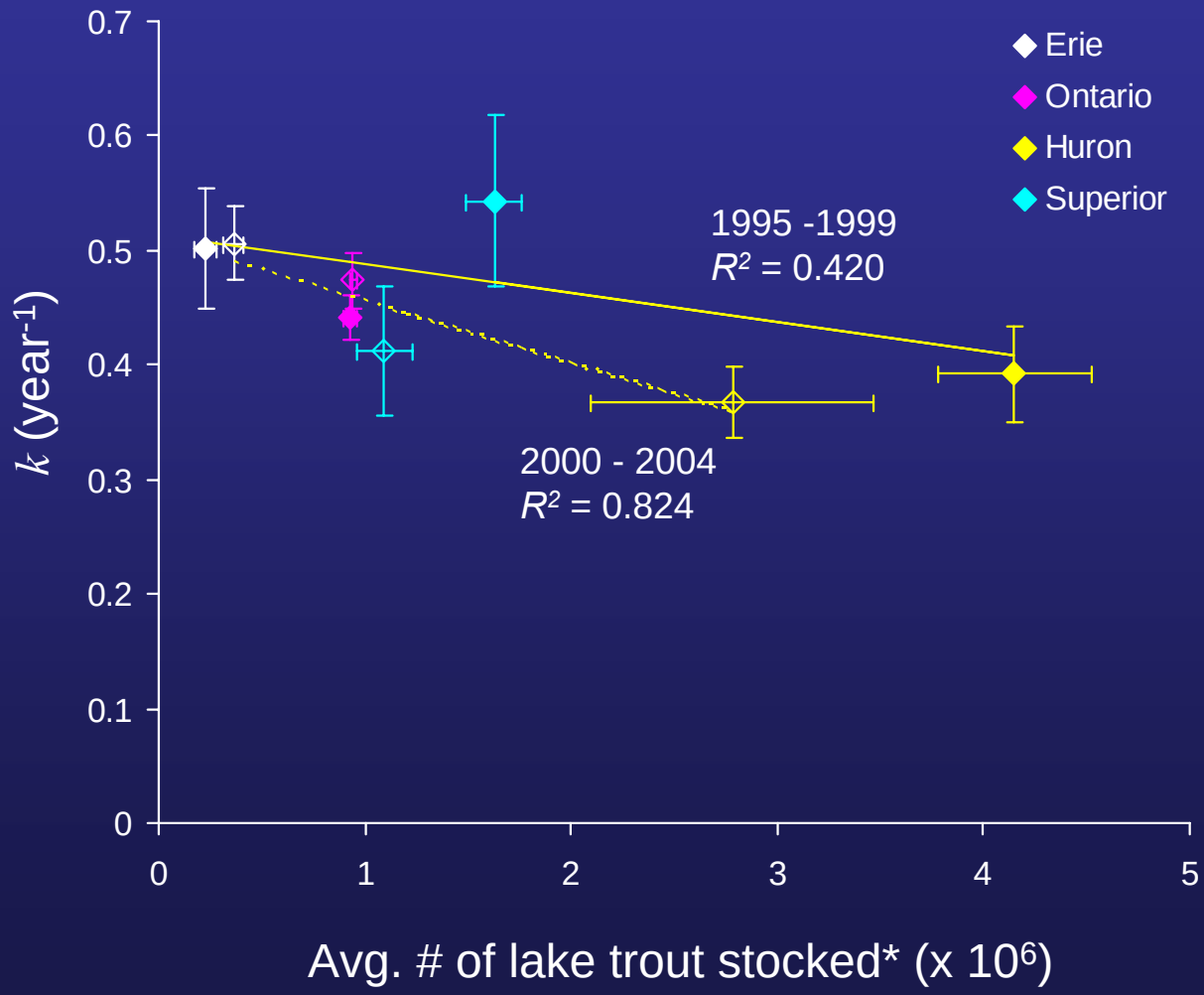
*(http://www.glfc.org/fishstocking/)

| Year | Erie | | Ontario | | Huron | | Superior | |
|---|---|---|---|---|---|---|---|---|
| | Total salmonids[a] | NN:LT[b] | Total salmonids | NN:LT | Total salmonids | NN:LT | Total salmonids | NN:LT |
| 1995 | 5.3 | 20.7 | 4.4 | 3.3 | 10.2 | 15.8 | 4.4 | 1.1 |
| 1996 | 3.9 | 45.6 | 4.4 | 4.2 | 10.7 | 10.9 | 3.9 | 1.5 |
| 1997 | 4.9 | 10.7 | 5.8 | 5.0 | 10.1 | 9.3 | 3.2 | 1.3 |
| 1998 | 2.5 | 12.2 | 5.2 | 5.0 | 11.2 | 5.9 | 3.2 | 0.9 |
| 1999 | 2.5 | 11.5 | 4.7 | 4.1 | 9.1 | 7.3 | 3.4 | 1.5 |
| 2000 | 2.6 | 5.5 | 5.5 | 4.6 | 9.3 | 4.6 | 3.8 | 1.8 |
| 2001 | 2.2 | 5.8 | 5.2 | 4.5 | 8.5 | 5.2 | 3.1 | 4.5 |
| 2002 | 2.2 | 3.2 | 5.6 | 4.9 | 8.0 | 3.3 | 3.1 | 1.9 |
| 2003 | 2.2 | 5.2 | 5.1 | 4.6 | 4.9 | 5.8 | 3.0 | 1.7 |
| 2004 | 1.8 | 7.2 | 5.3 | 4.7 | 4.6 | 3.4 | 3.9 | 1.8 |
| Avg. | 3.0 | 12.7 | 5.1 | 4.5 | 8.7 | 7.2 | 3.5 | 1.8 |
| n | 30.1 | | 51.1 | | 86.6 | | 35.0 | |

[a] Millions of individuals (Chinook & coho salmon, rainbow, brown & lake trout)

[b] NN:LT (non-native:lake trout)

# Von Bertalanffy & Stocking




(* Stocking information from Great Lakes Fisheries Commission (www.glfc.org/fishstocking/))

# Conclusions

- Lipid content and thus energy density has declined continually for nearly all age classes of lake trout in Lakes Erie, Ontario, Huron, and Superior from 1995 - 2004.

- Von Bertalanffy growth calculations indicate that lake trout are currently spending the same amount of time foraging as they did historically only to reach a lower asymptotic energy density.

- Each Great Lake is a unique and dynamic system, but lake trout energy densities are declining similarly.

- Declines in lake trout energy density potentially due to stressors including:
  - Declining quality of prey?
  - Declining quantity of prey?
  - Competition between stocked species for forage base?
  - Establishments of non-indigenous species?
  - Combination of these arguments?

# Acknowledgements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