Building a science for landscape fisheries management

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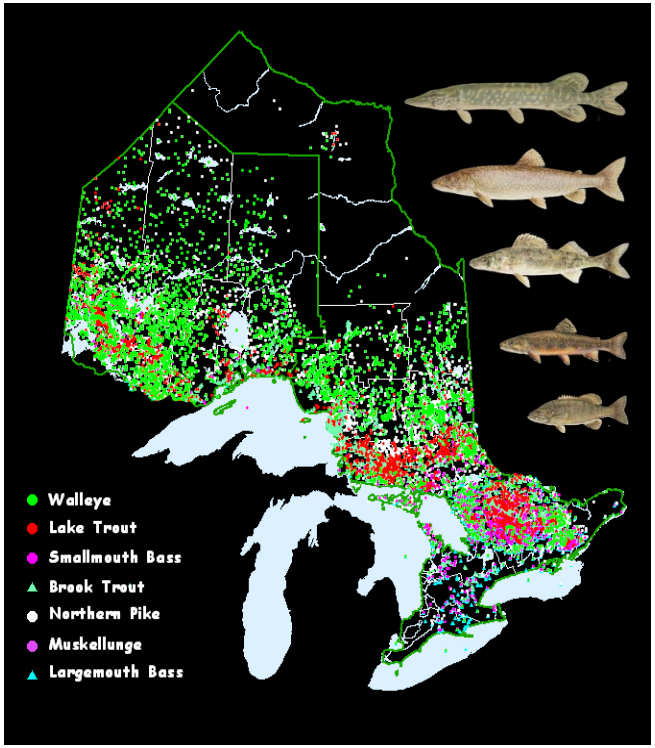
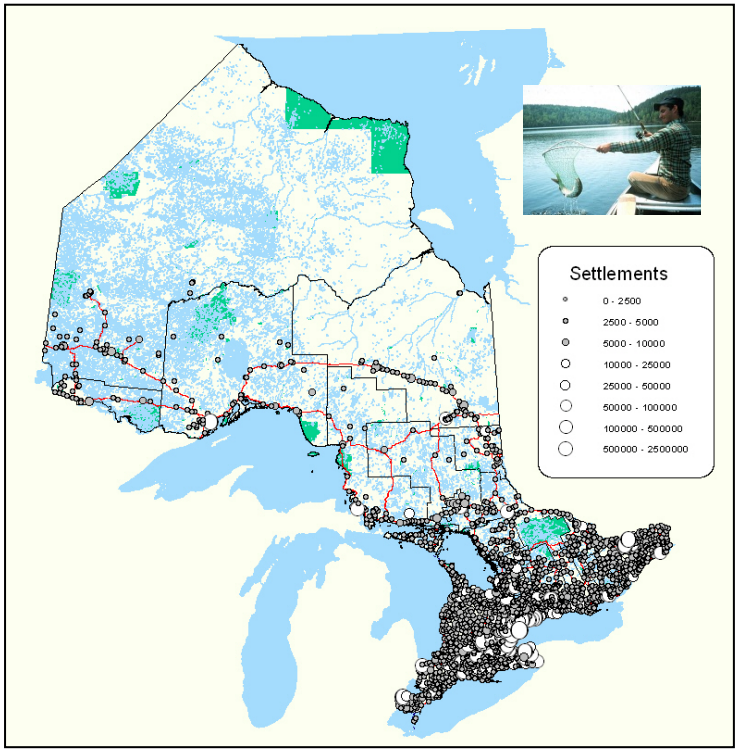
Fish



Fishers



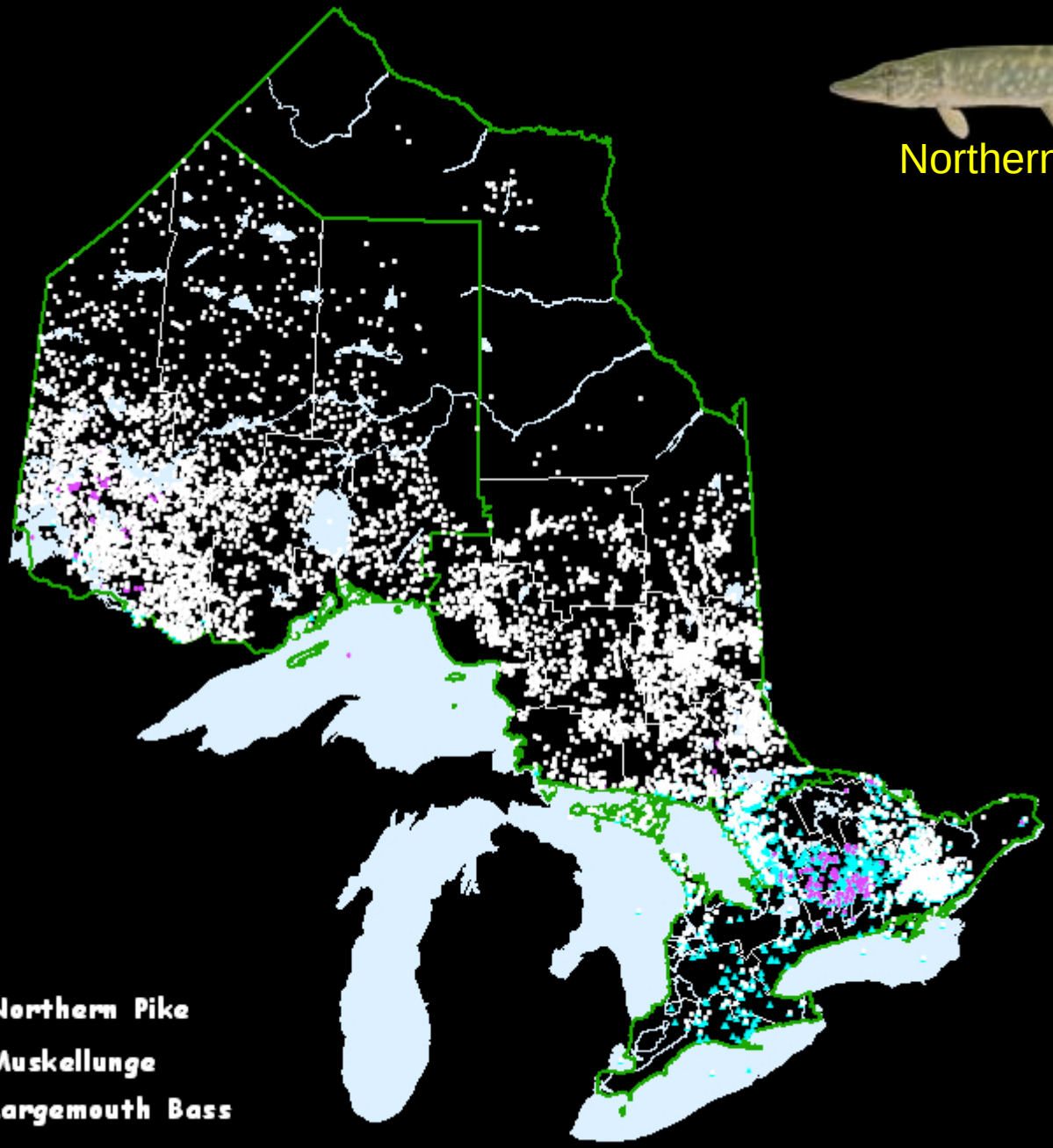
Largemouth Bass

▲ Largemouth Bass

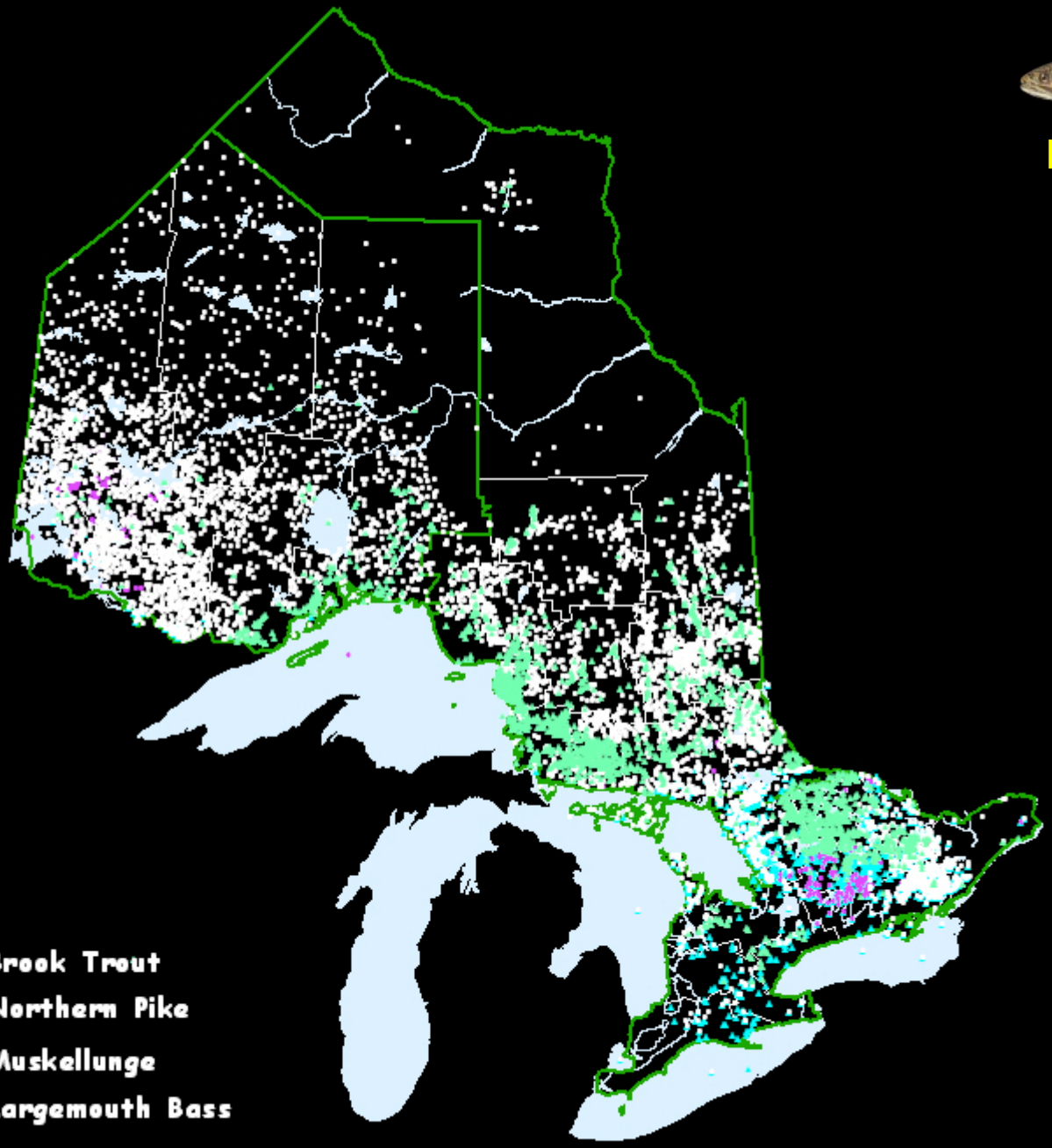
Muskellunge

Muskellunge

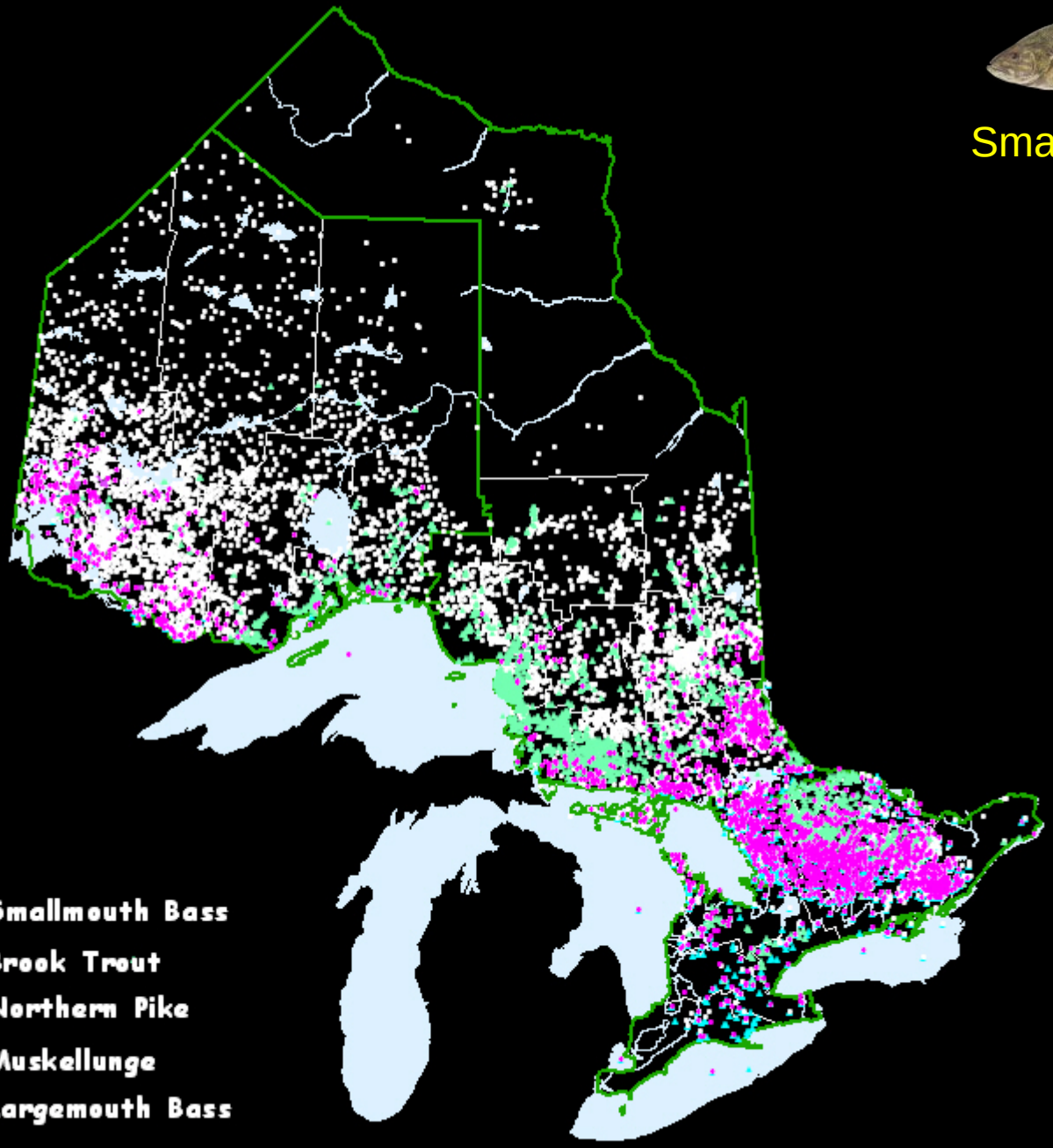
Largemouth Bass


Northern Pike
Northern Pike
Muskellunge
Largemouth Bass

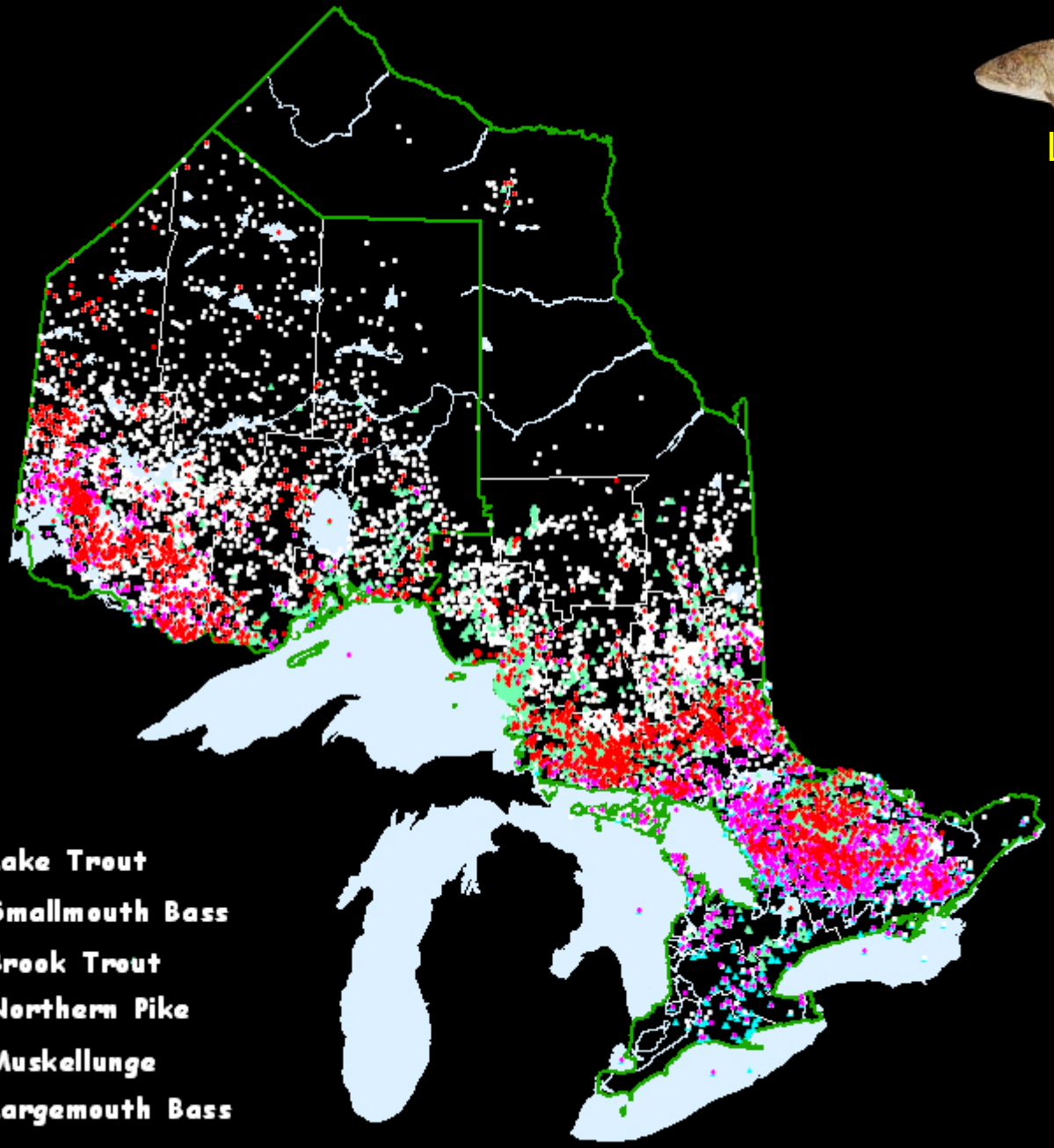
Brook Trout



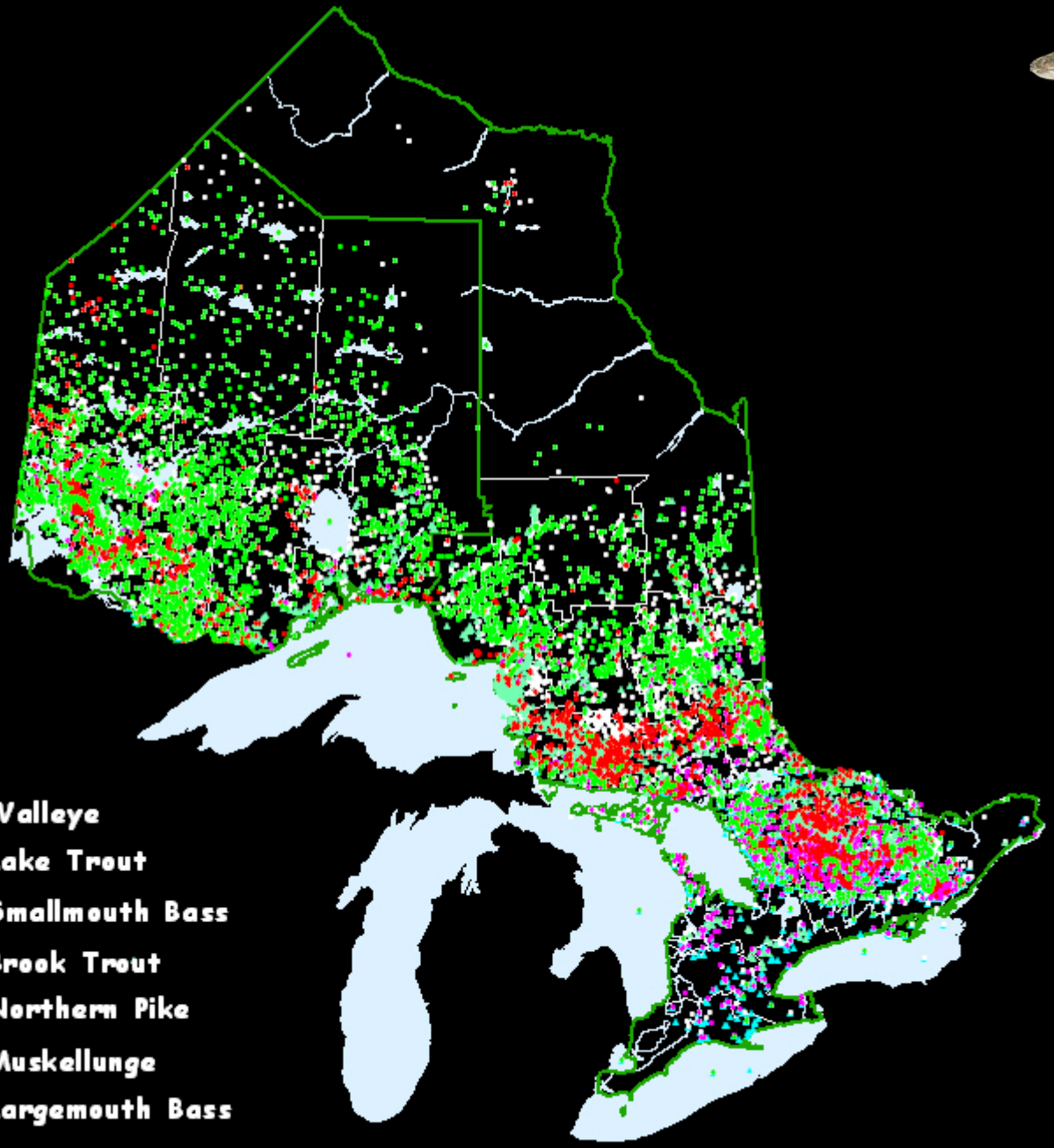
Smallmouth Bass



Lake Trout


Lake Trout
Smallmouth Bass
Brook Trout
Northern Pike
Muskellunge
Largemouth Bass

Walleye


Walleye
Lake Trout
Smallmouth Bass
Brook Trout
Northern Pike
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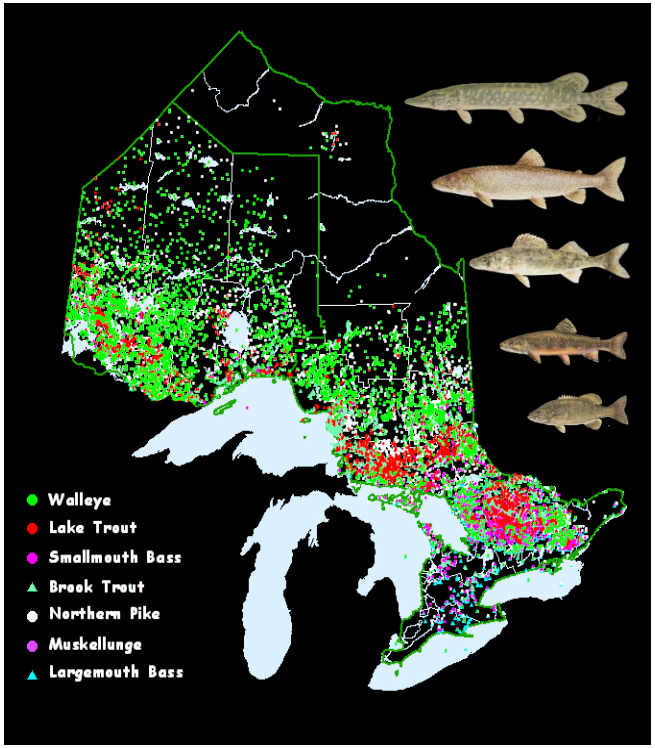
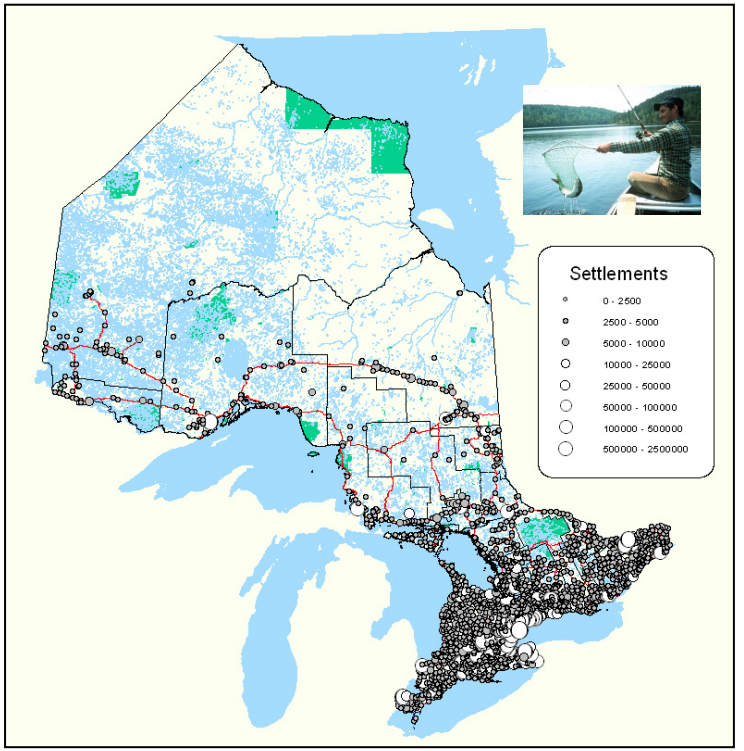
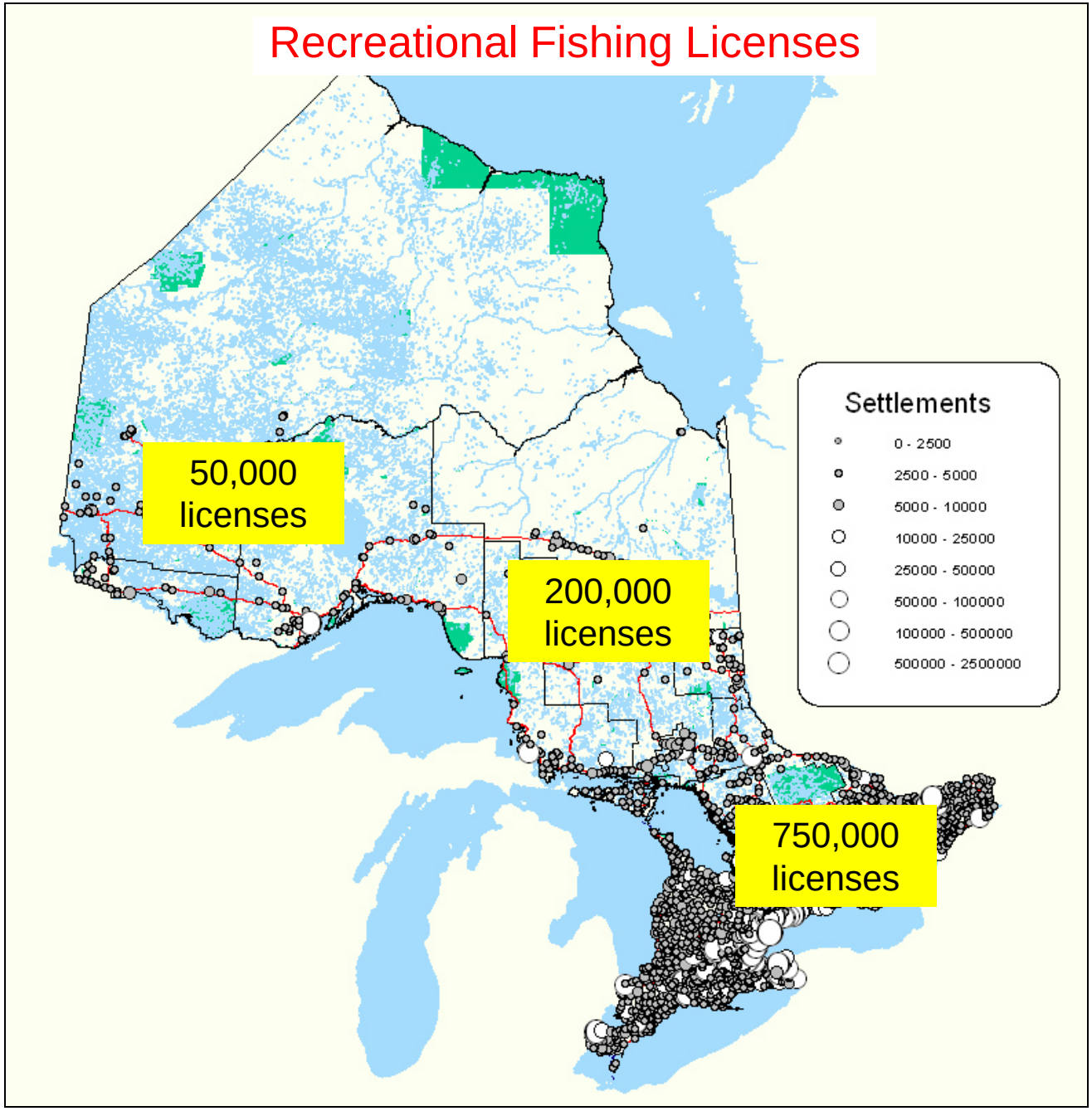
Fish



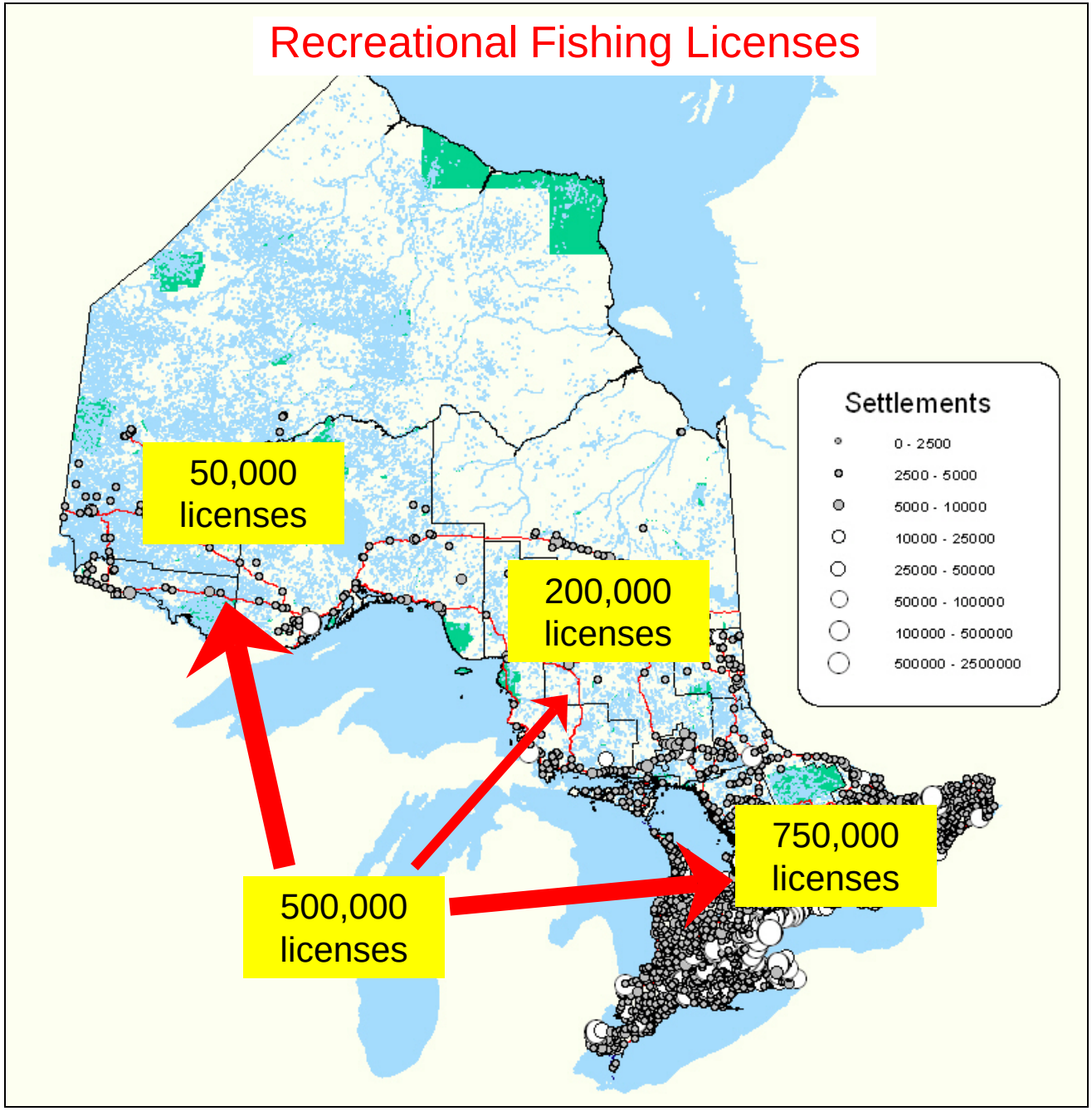
Fishers



Recreational Fishing Licenses



Recreational Fishing Licenses

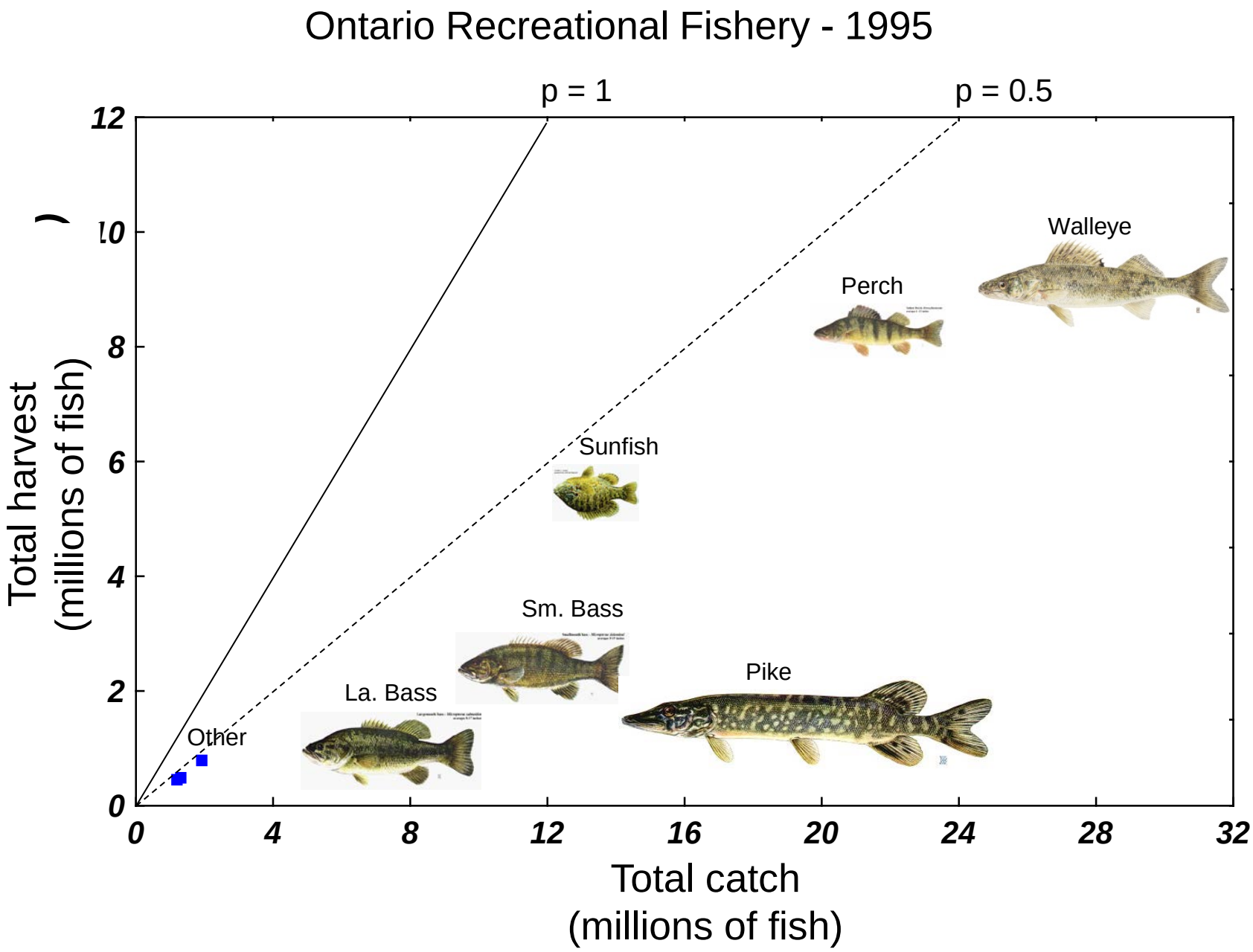


Types of anglers

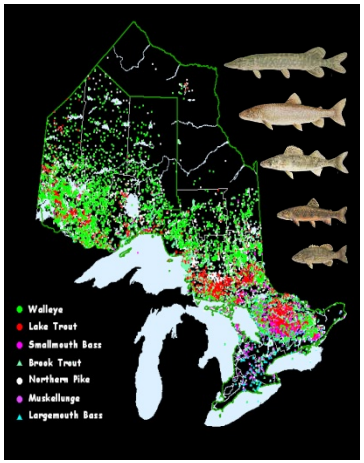
Credit: W. Dunlop

Credit: W. Dunlop

Credit: S. Lawrence

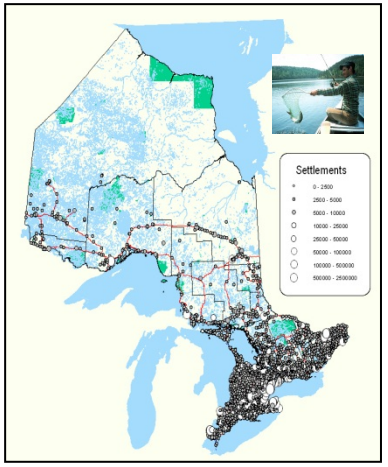

Ontario Recreational Fishery - 1995
p = 1
p = 0.5
Total harvest
(millions of fish)
Total catch
(millions of fish)
0
2
4
6
8
10
12
0
4
8
12
16
20
24
28
32
Walleye
Perch
Sunfish
Sm. Bass
Pike
La. Bass
Other

Fish



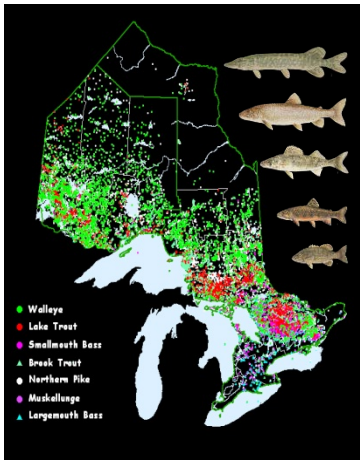
- Live in lakes and rivers
  - Everywhere
- Species abundance varies
  - Temperature
  - Nutrients
- “Isolated” stocks

Fishers



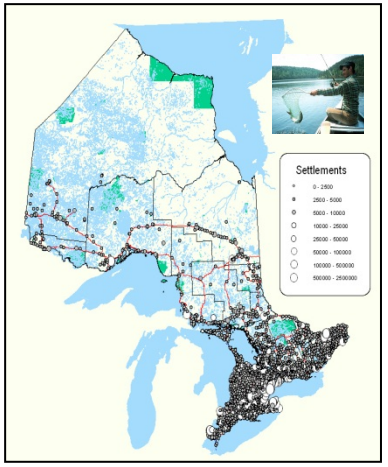
- Live in settlements
  - Clustered
  - More in south
- Species preferences
  - Edibility
  - Fightability
  - Abundance
- “Mobile” fishers

Fish



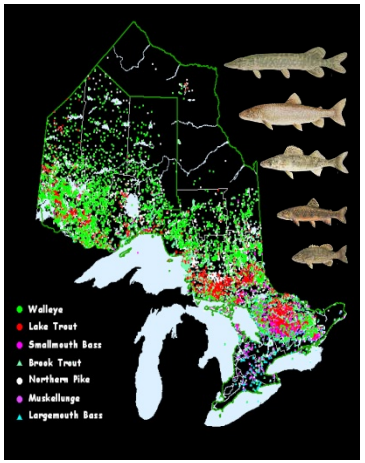
- What types?
- Spatial distribution
  - How many fish?
  - Where?
- Response to changes in:
  - Fishing
  - Habitat
  - Community

Fishers



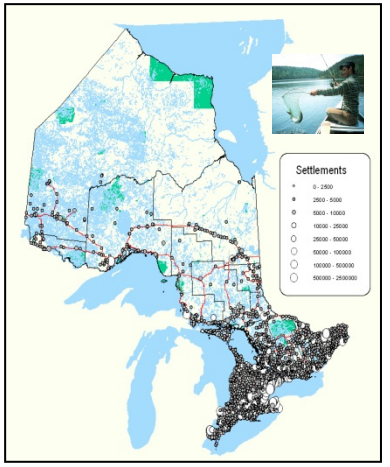
- What types?
- Spatial distribution
  - How much fishing?
  - Where?
- Response to changes in:
  - Fish abundance
  - Regulations

Fish



Landscape Fisheries Management

Fishers



- Divide the landscape
  - Fisheries Management Zones
- Set goals for Zones (not lakes)
  - Involve fishers (and non-fishers)
  - FMZ Advisory Councils
- Evidence-based decision-making
  - 5-year management cycle
  - Monitoring
  - Science Development

Fish

Landscape Fisheries Management

Monitoring Programs

Fishers

Fish

Landscape Fisheries Management

Fishers

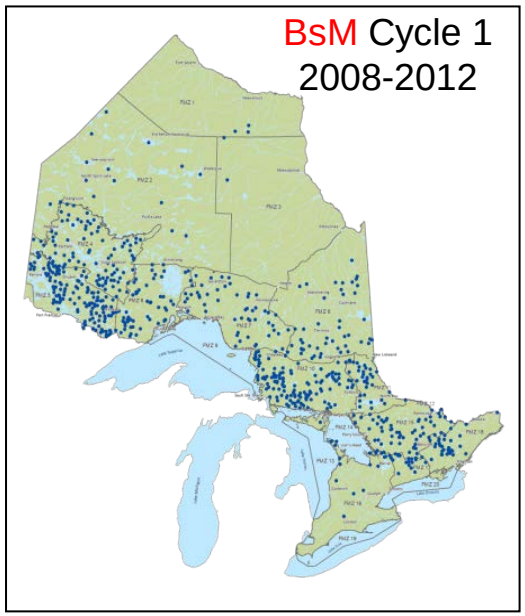
Monitoring Programs

Inland Lakes
Broad-scale Monitoring

- Lake surveys conducted by OMNR
- Data from lakes:
  - Fish abundance and life history
  - Contaminants
  - Aquatic habitat
  - Aquatic community
  - Fishing activity

Fish Landscape Fisheries Management Fishers

Monitoring Programs

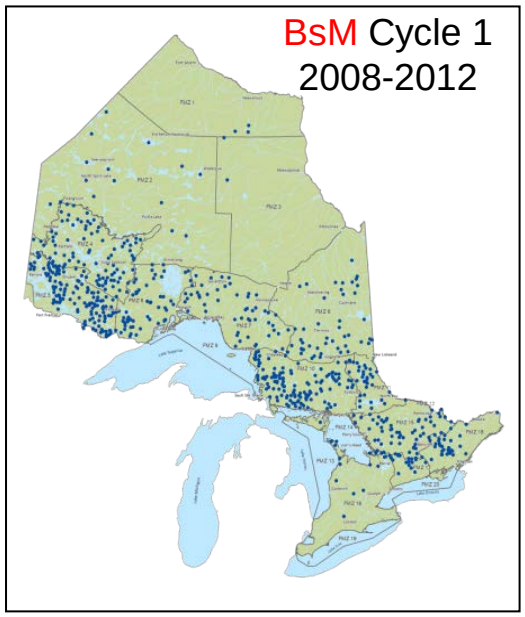


- 5-year cycle (since 2008)
- Stratified random sample of lakes
- Cycle 1 surveyed 700 lakes
  - 8 % of lakes > 50 ha
- Cycle 2 (2013-2017)
  - Re-survey most lakes
  - Survey additional random sample

Fish

Landscape Fisheries Management Monitoring Programs

Fishers



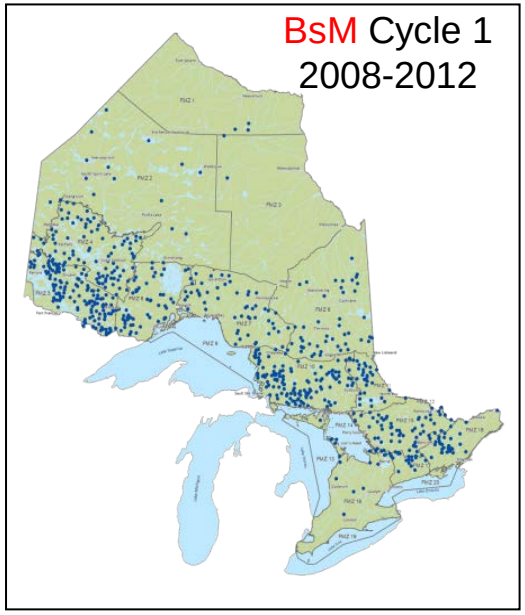
CANADA POSTES
POST CANADA

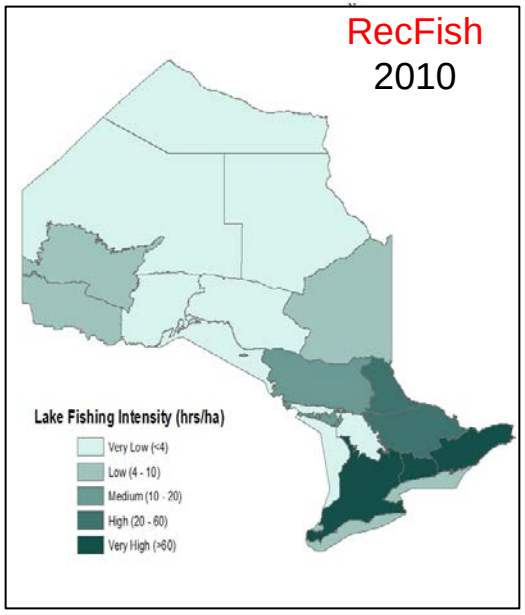
Survey of
Recreational Fishing

- Federal-provincial mail survey
- Data from licensed anglers:
  - Expenditures
  - Opinions
  - Fishing effort, catch and harvest

Fish Landscape Fisheries Management Fishers

Monitoring Programs





- 5-year cycle (since 1975)
- Stratified random sample of anglers
- Survey ~30,000 anglers
  - ~2% of licensed anglers
- Since 2005
  - Georeference the data
  - Get estimates for each Zone

Building a science for
Landscape Fisheries Management

- What's the question?
- An empirical answer
- 'Made in Ontario' Theory
- Apply the theory

Building a science for
Landscape Fisheries Management

- How much fishing effort is sustainable?
- An empirical answer
- ‘Made in Ontario’ Theory
- Apply the theory

Building a science for
Landscape Fisheries Management

- How much fishing effort is sustainable?
- An empirical answer
- ‘Made in Ontario’ theory
- Apply the theory

Building a science for
Landscape Fisheries Management

Acknowledgements

- Ontario MNR
  - Fisheries Assessment Units
  - Districts and Regions
  - Policy and Research
  - BsM Science team
- Other government agencies
  - Quebec
  - Other provinces
  - US states
- Academic partners
  - University of Toronto
  - University of Guelph
  - NSERC

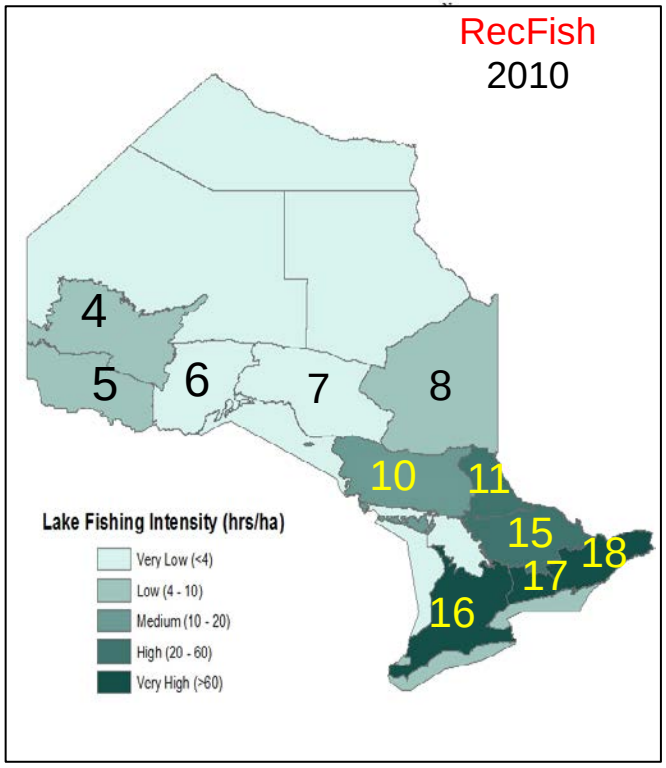
Brian Shuter Peter Abrams

How much fishing effort is sustainable?

Calculating fishing effort on lakes in each zone

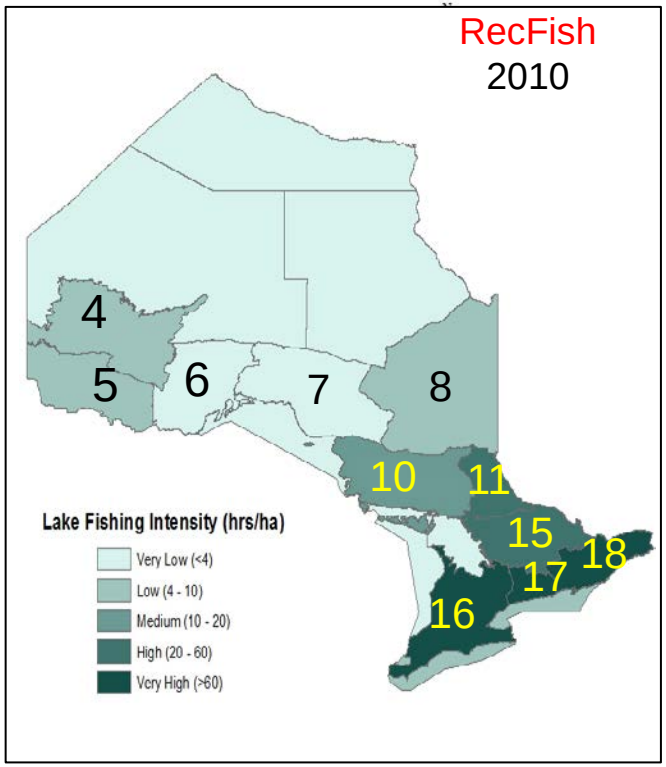
- Total hours of angling in one year
- Total lake area (hectare)

Effort = angler-hours / ha in one year

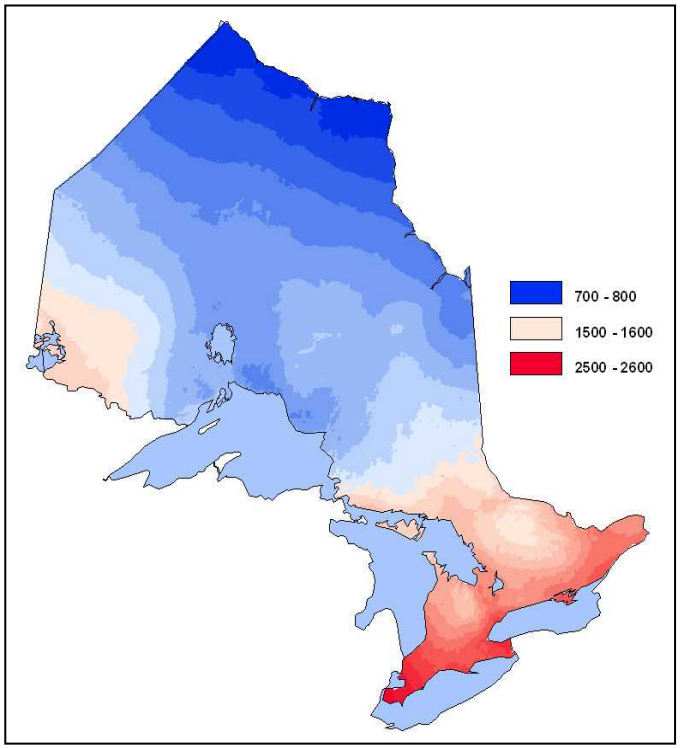


How much fishing effort is sustainable?

Fishing effort
angler-hours / (ha.year)



Growing Degree Days > 5 ^{o}C



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Fishing effort
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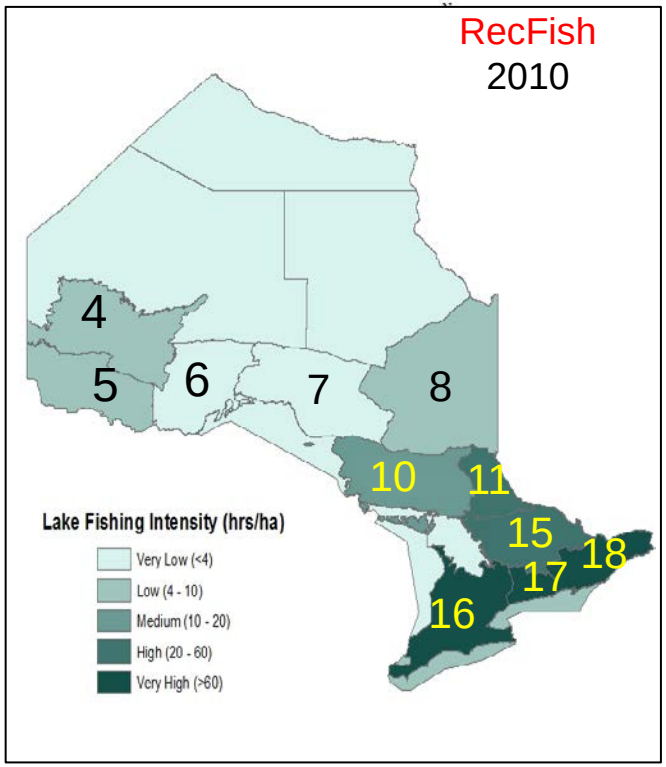
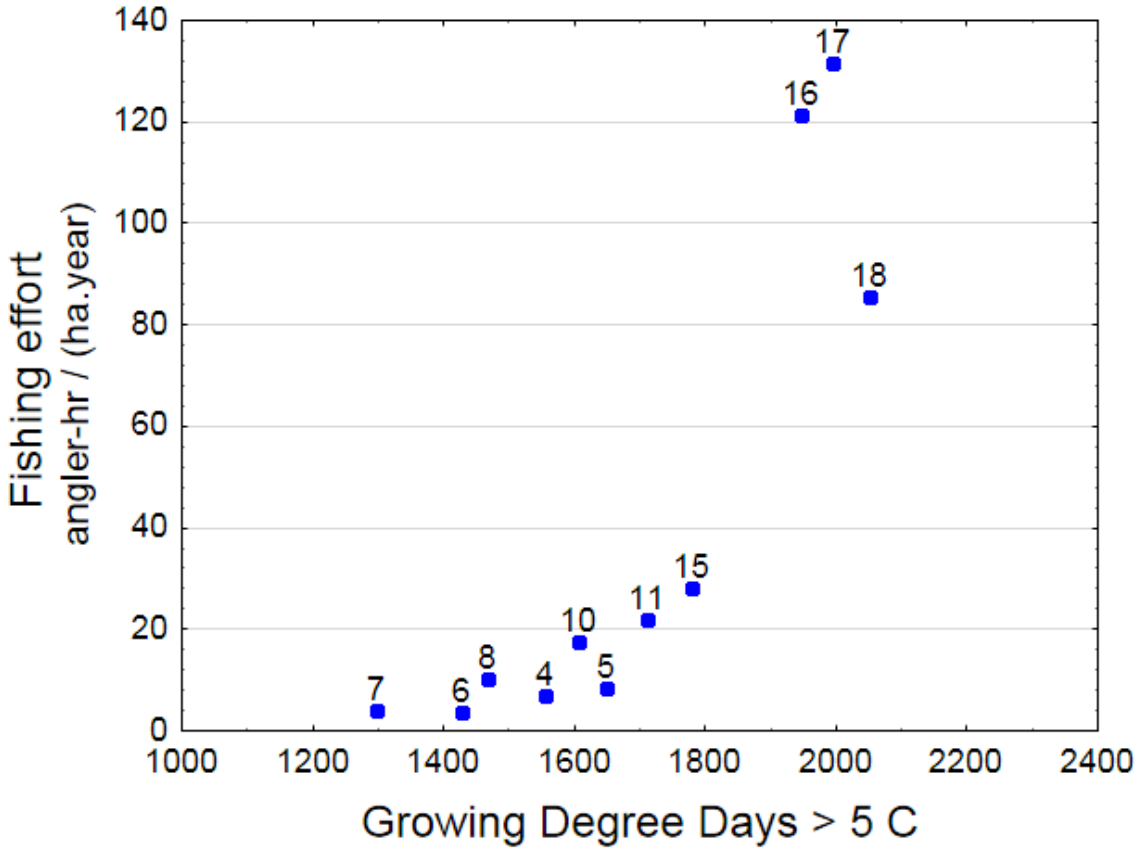




Mail survey estimates

- Probably overestimate effort (Hogg et al. 2010)
- BsM data will be used to assess bias
- Values are used here to demonstrate approach

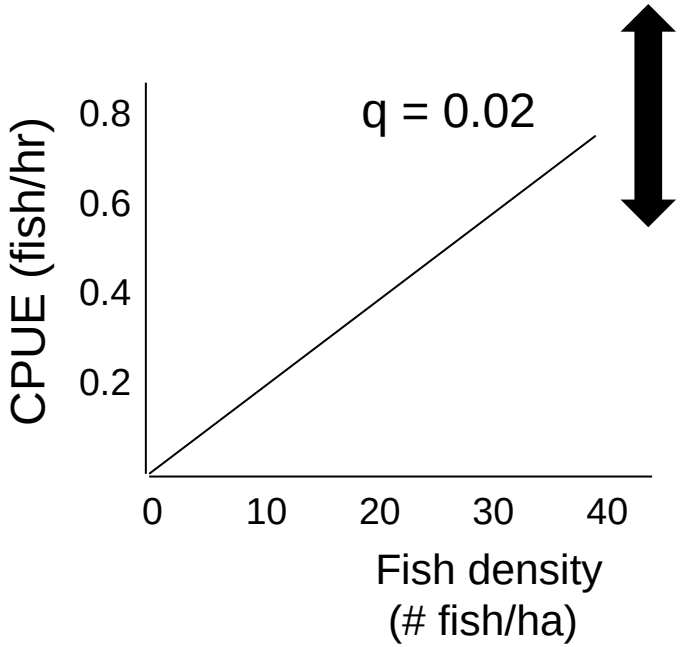
Impact of fishing effort depends on angling skill and regulations

catchability (angling skill)

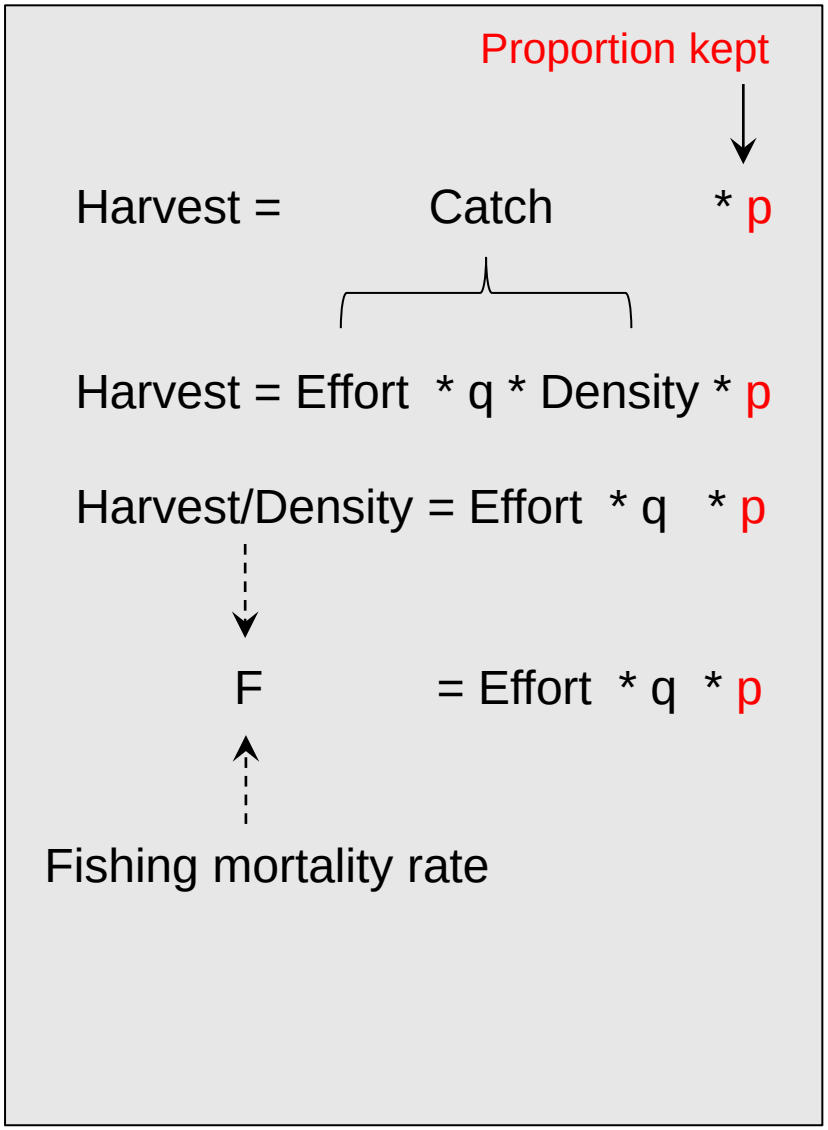
↓

Catch = Effort * q * Density
(# fish/ha) (# fish/ha)

Catch/Effort = q * Density



Impact of fishing effort depends on angling skill and regulations



Impact of fishing effort depends on angling skill and regulations

Proportion kept

Harvest = Catch * p

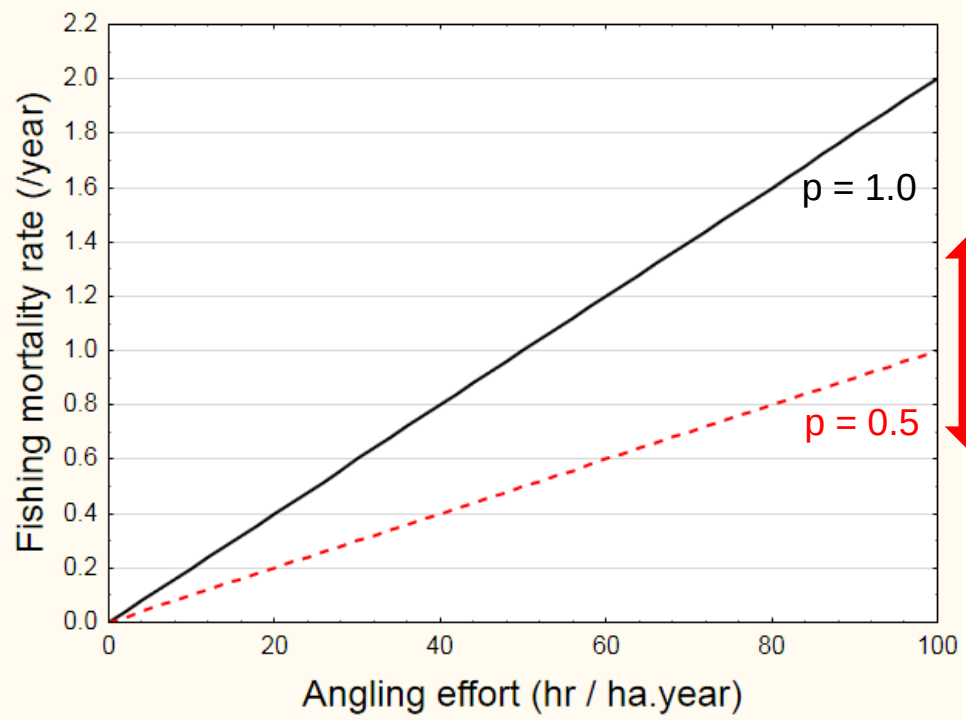
Harvest = Effort * q * Density * p

Harvest/Density = Effort * q * p

F = Effort * q * p

Fishing mortality rate

q = 0.02



Impact of fishing effort depends on angling skill and regulations

Proportion kept

Harvest = Catch * p

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Harvest/Density = Effort * q * p

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Fishing mortality rate

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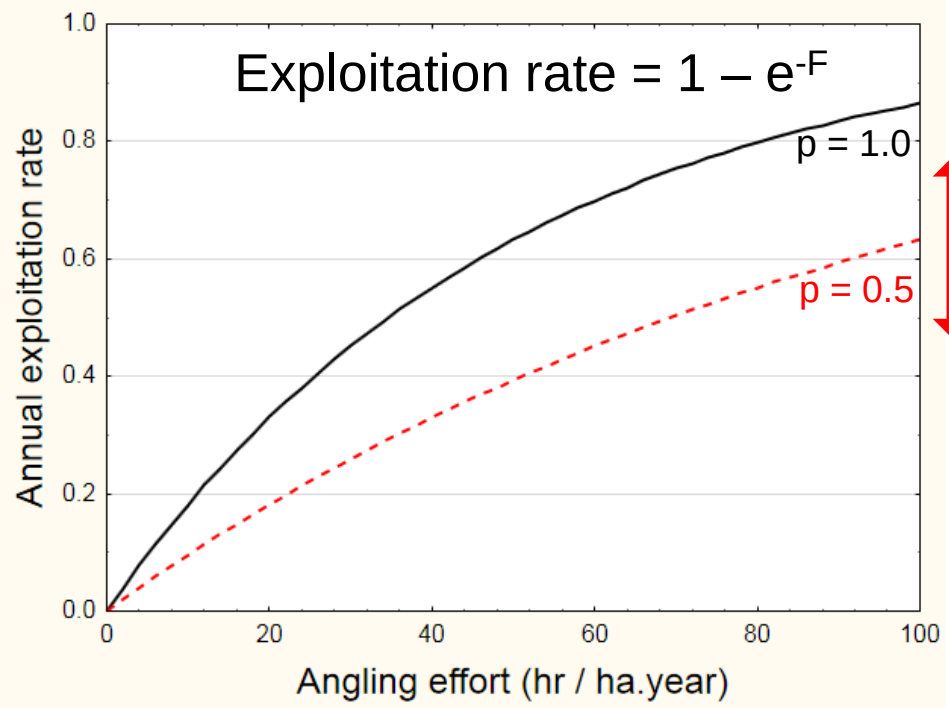
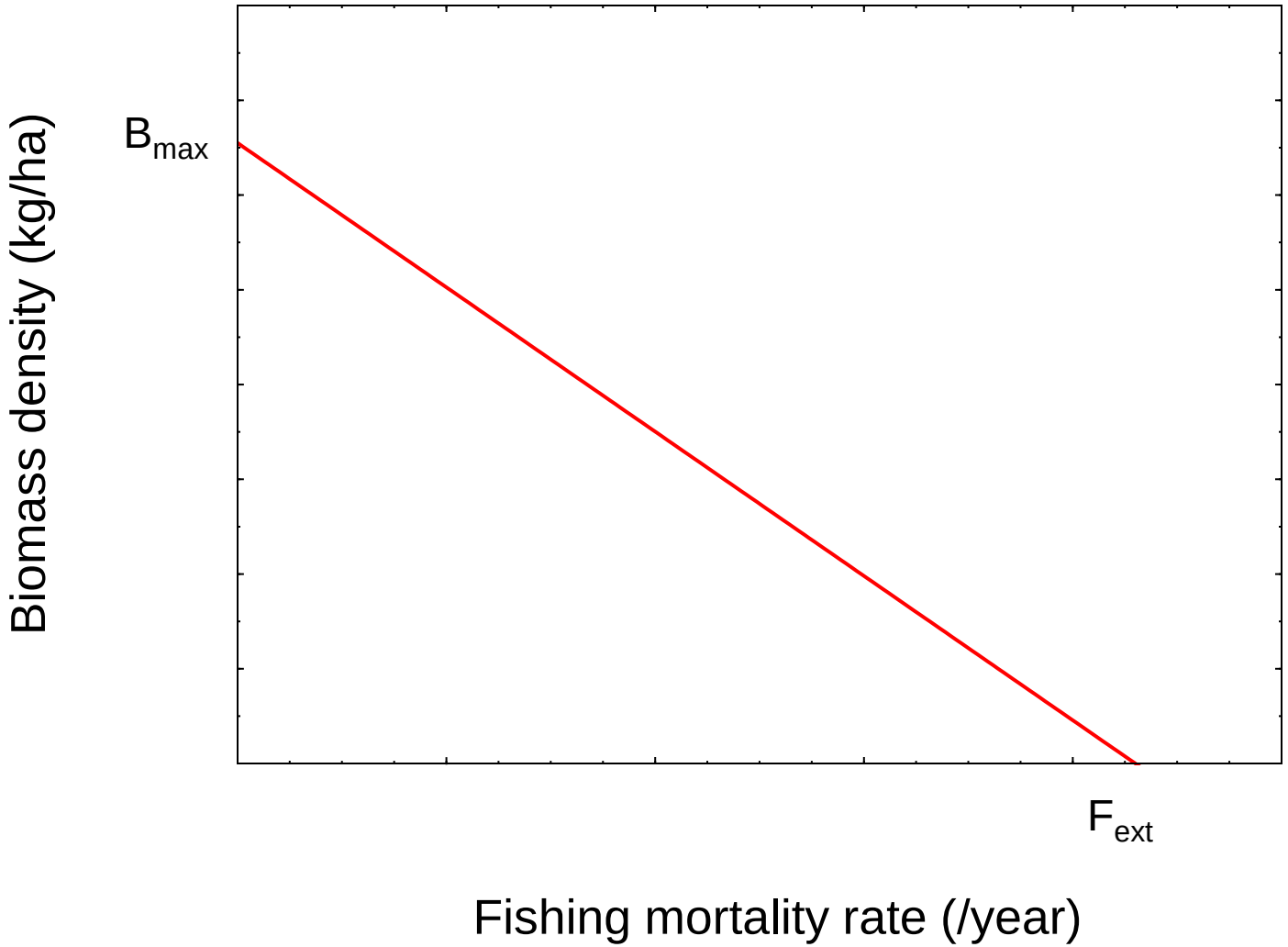


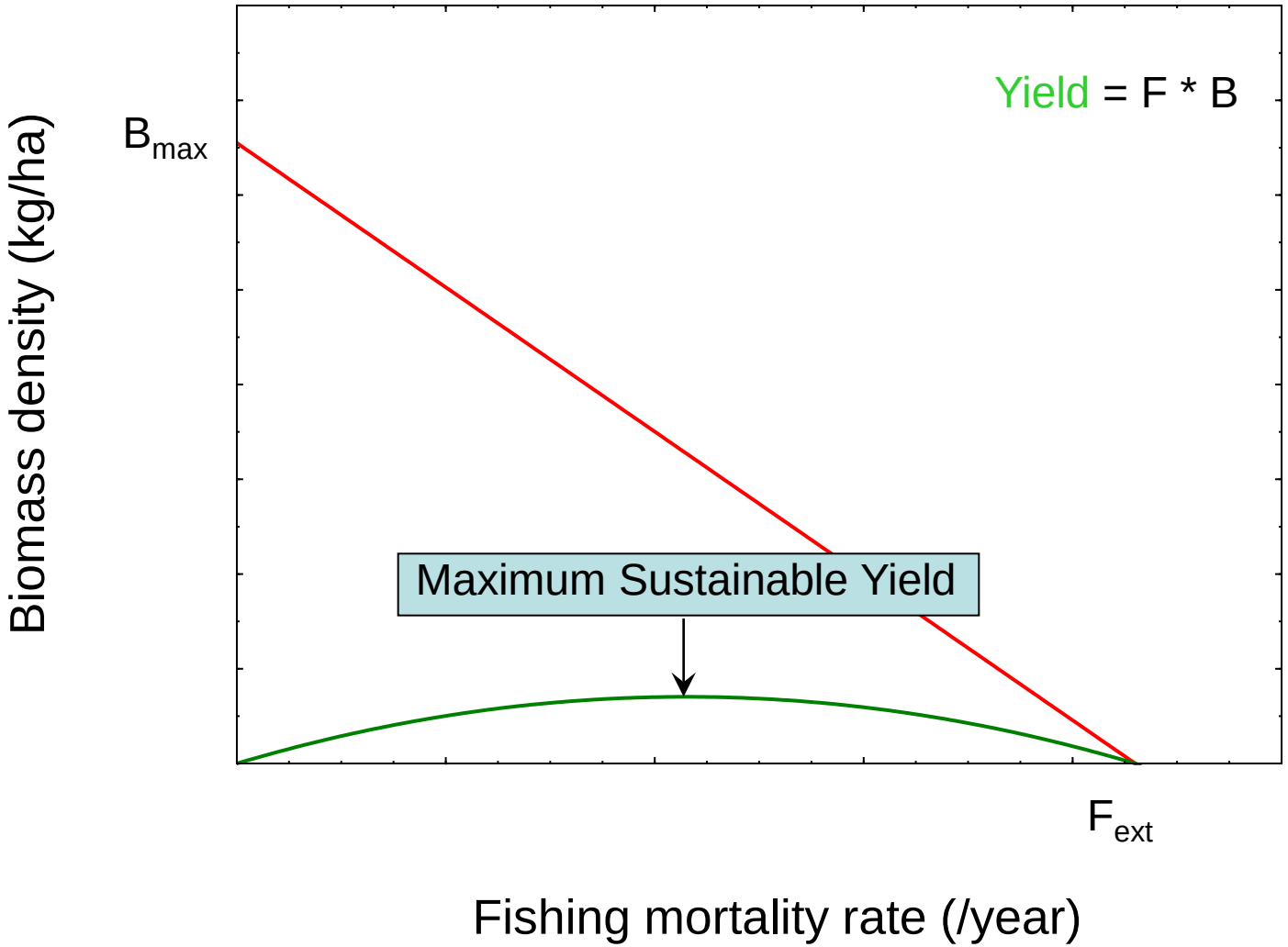
Building a science for landscape fisheries management

- Sustainable effort depends on:
  - Impact on Fishing mortality rate (F)
  - Modified by angling catchability (q) and regulations (p)
- How much F is sustainable?
  - An empirical answer
  - Desirable F < Natural mortality rate (M)

How much F is sustainable?



How much F is sustainable?



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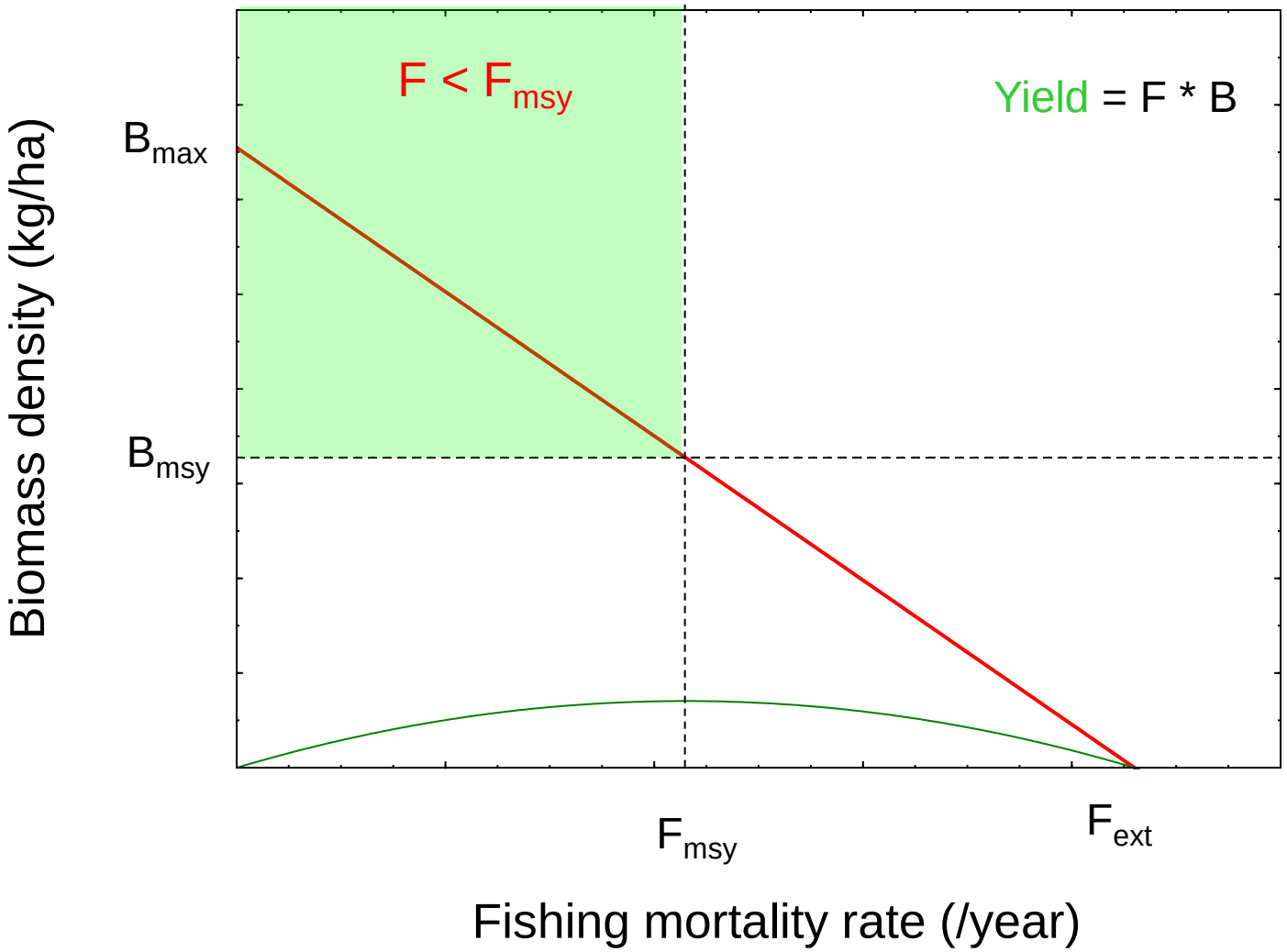


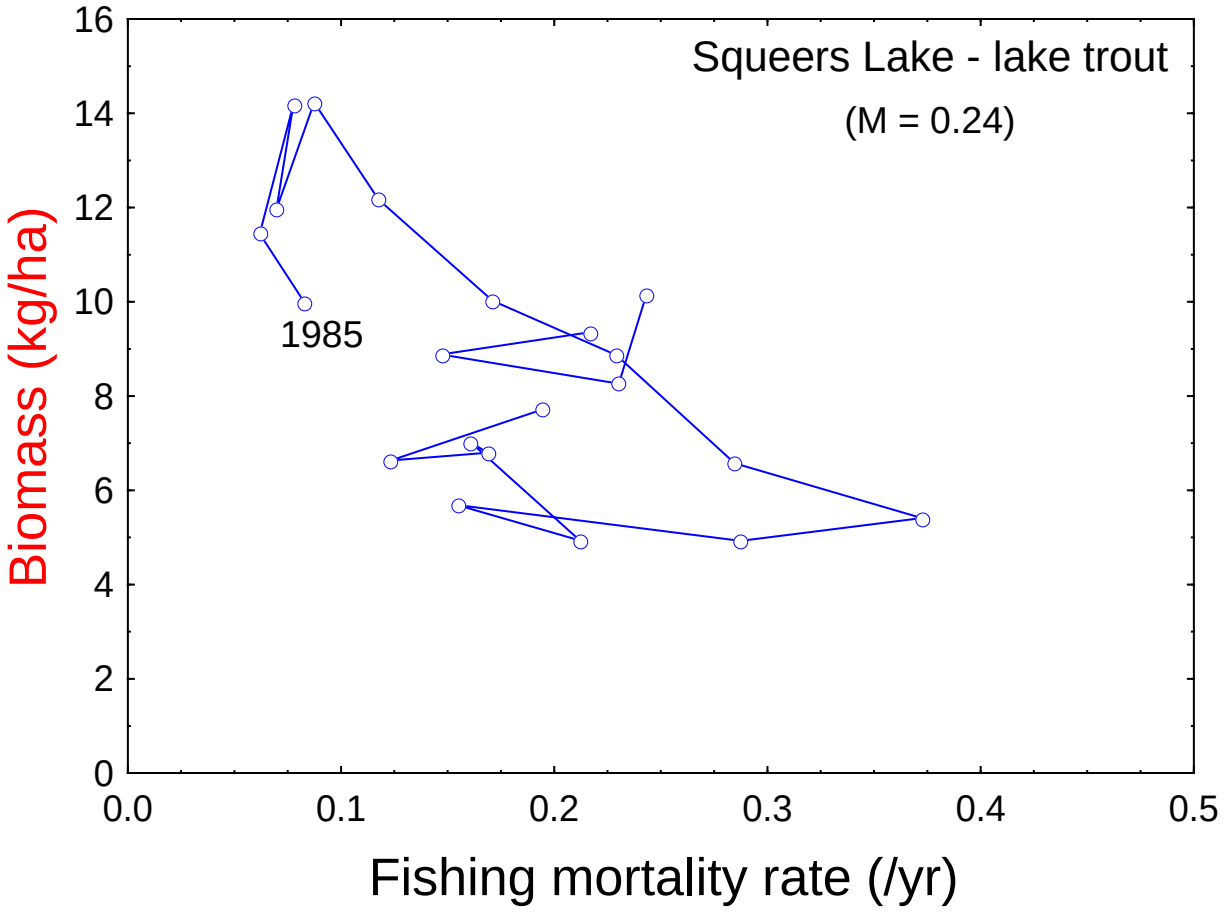
Squeers Lake
Experimental Lake Trout Fishery
Quetico Mille Lacs FAU

- Squeers Lake (384 ha)
  - near Thunder Bay
  - Lake Trout fishery
  - heavy winter fishing
  - closed to fishing in 1979
  - Estimated natural mortality
  - M = 0.24 (Ball 1988)

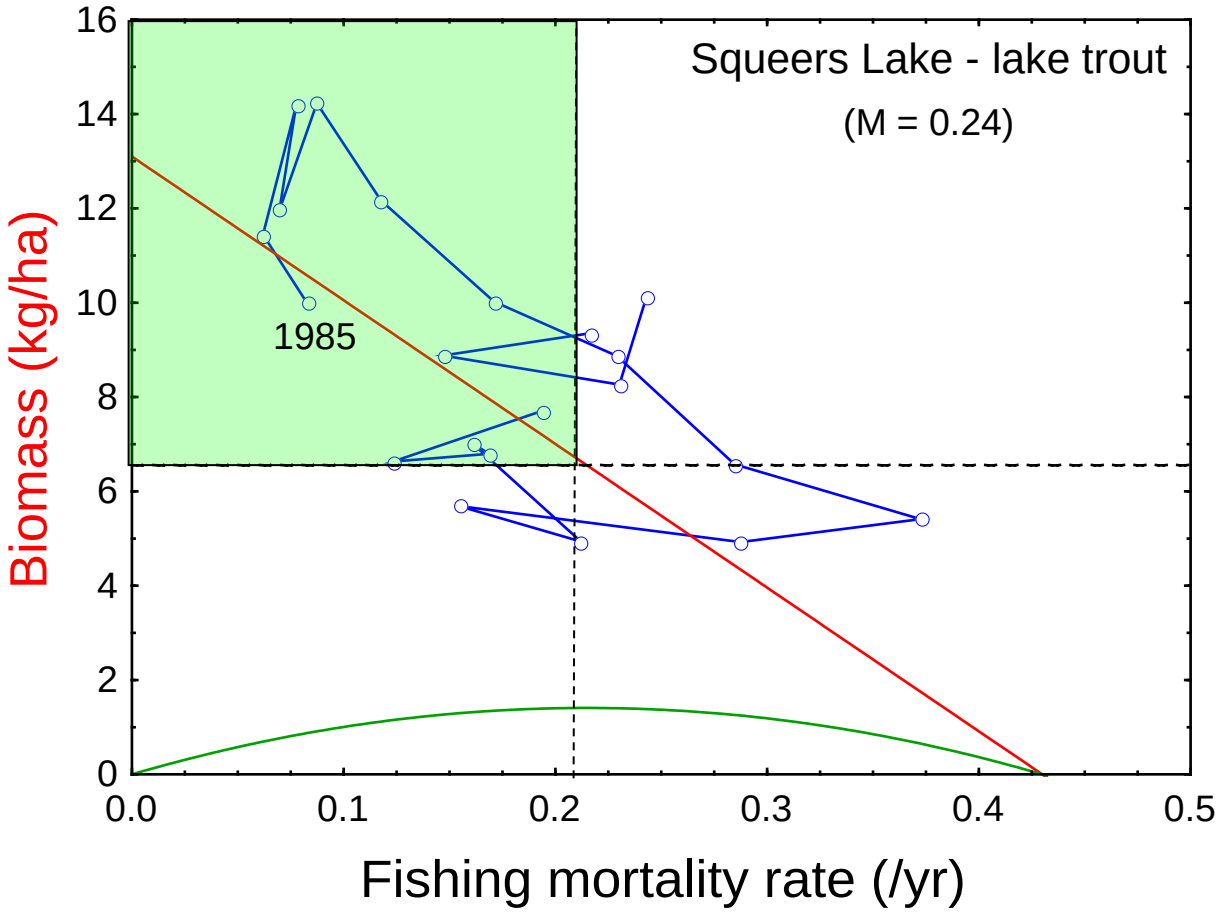
- Experimental fishery
  - opened in 1985
  - 9 days per year (winter)
  - controlled # of anglers
  - target = 2 kg/ha

- Monitoring
  - Creel census to monitor harvest
  - Mark-recapture to monitor abundance
  - Calculated Fishing mortality rate

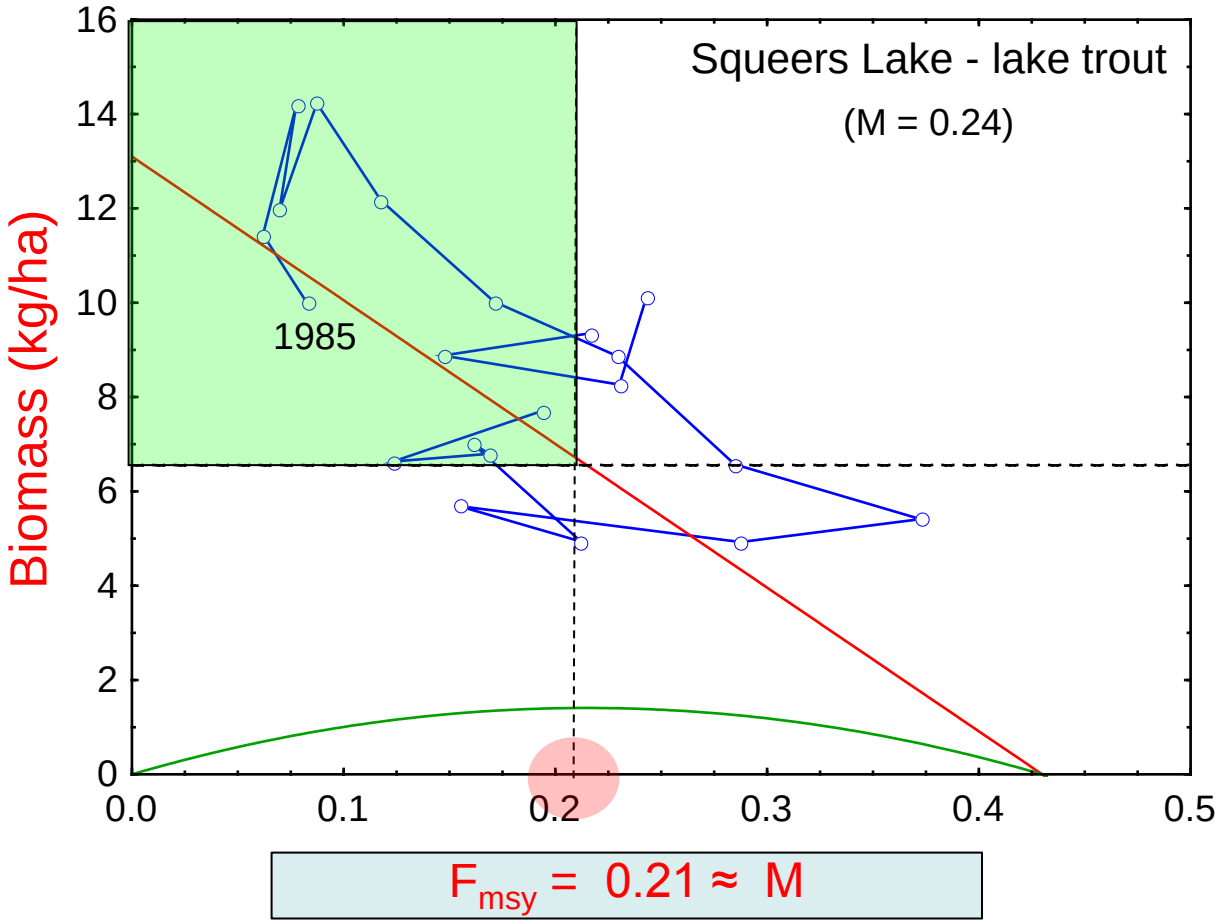
How much F is sustainable?



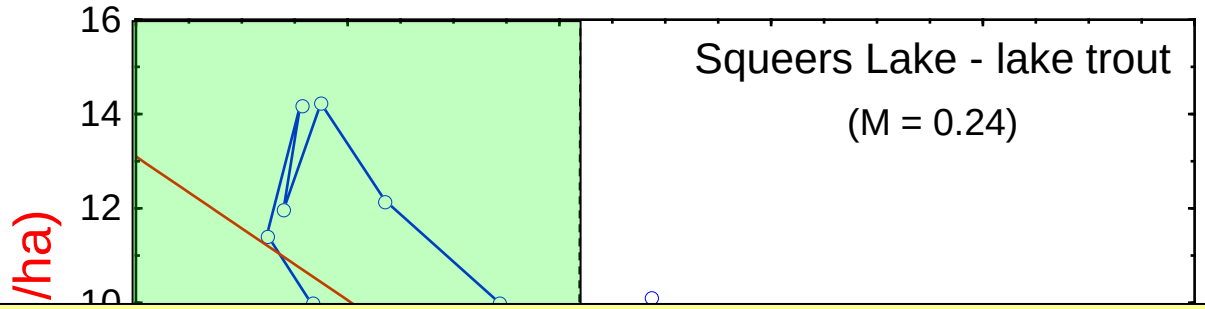
How much F is sustainable?



How much F is sustainable?



How much F is sustainable?



$F_{msy} \approx M$ Suggested rule of thumb (Gulland 1970)

$F_{msy} = 0.9 * M$ Meta-analysis of marine stocks (Zhou et al. 2012)

- 0.9 is mean for 179 Teleost species

$F_{msy} = 0.9 * M$ Predicted for walleye (Lester et al. 2014)

- Assumes harvest mature fish only

$F_{msy} = 0.21 \approx M$

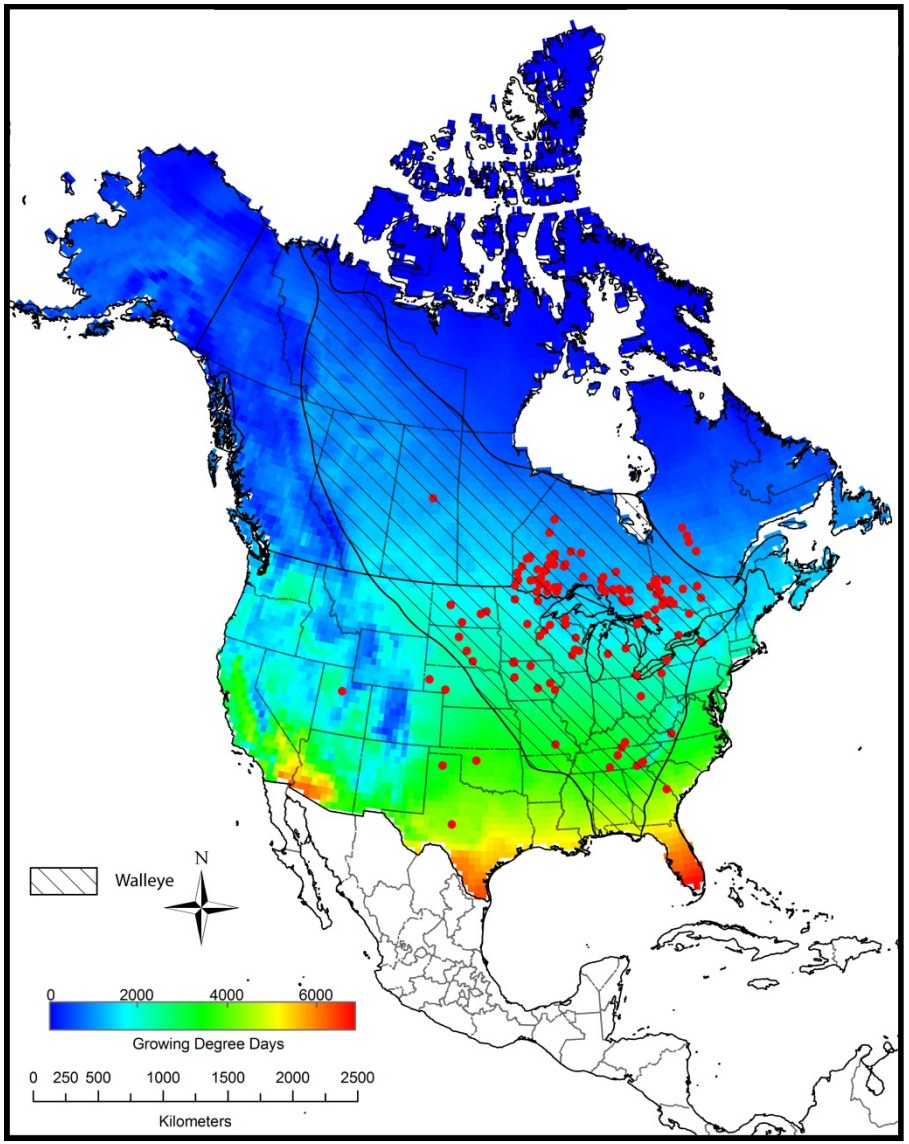
Building a science for landscape fisheries management

- Sustainable effort depends on:
  - Impact on Fishing mortality rate (F)
  - Modified by angling catchability (q) and regulations (p)

- How much F is sustainable?
  - $F_{msy} \approx$ M (natural mortality rate)

- How does one predict M?
  - 'Made in Ontario' theory
    - Biphasic growth model
    - Thermal age
  - M = f(Climate, Body size)

Walleye growth and mortality



Walleye

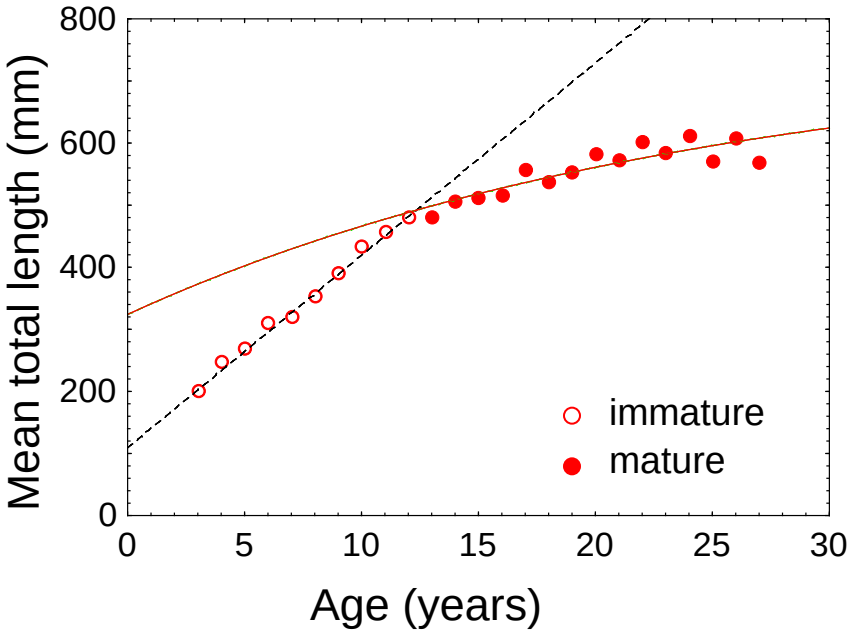
- tastes great, #1 in Ontario
- coolwater species
- broad geographical range
- Growing Degree Days > 5 ^{o}C
  - North: 800 ^{o}C
  - South: 5000 ^{o}C

Lifetime growth pattern

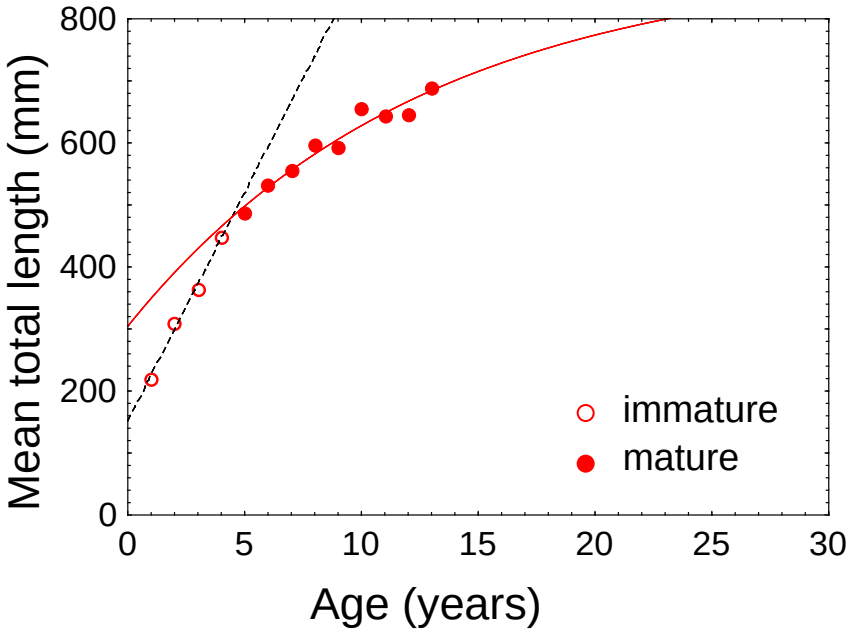
- Effect of reproduction
- Effect of climate

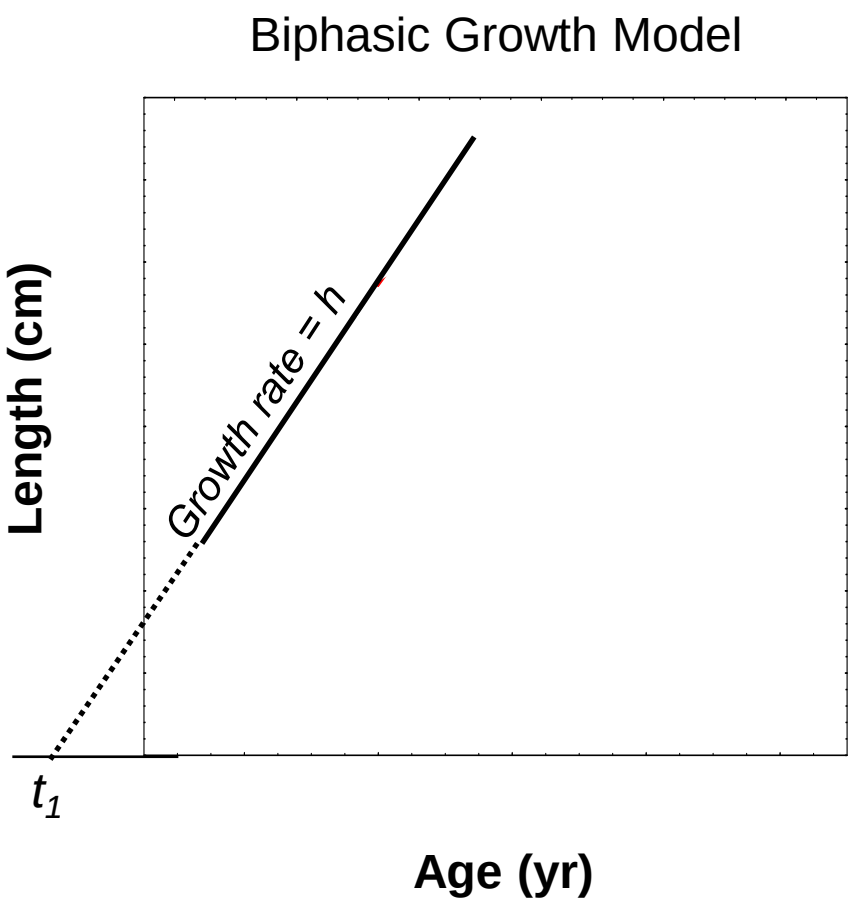
Examples of walleye growth (female)

Lac Regnault
GDD = 1077



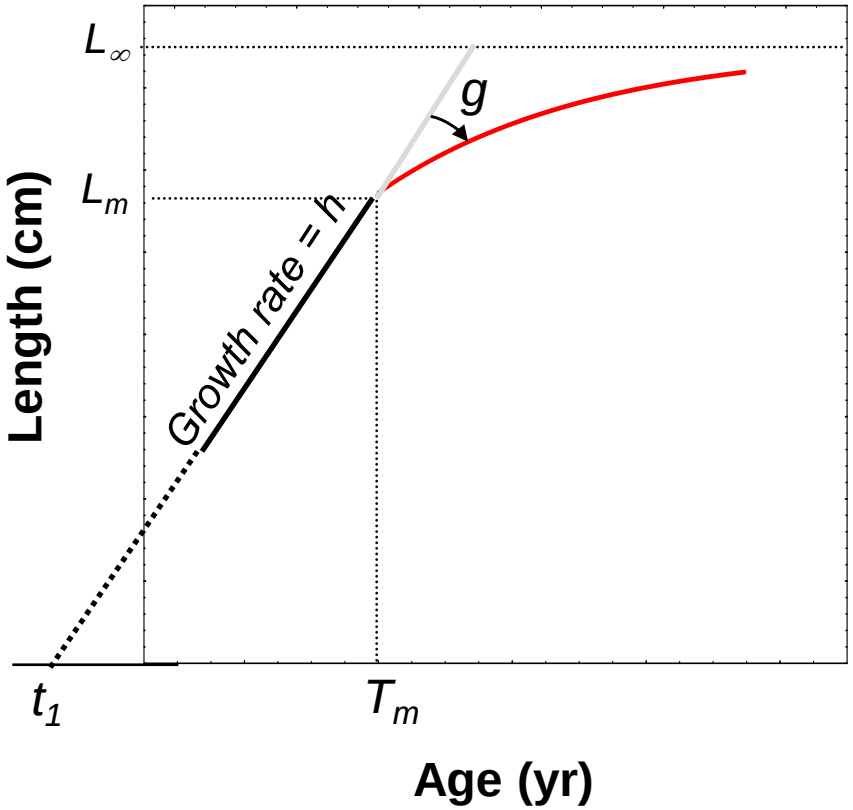
Rice Lake
GDD = 2036





Lester, Shuter and Abrams (2004)

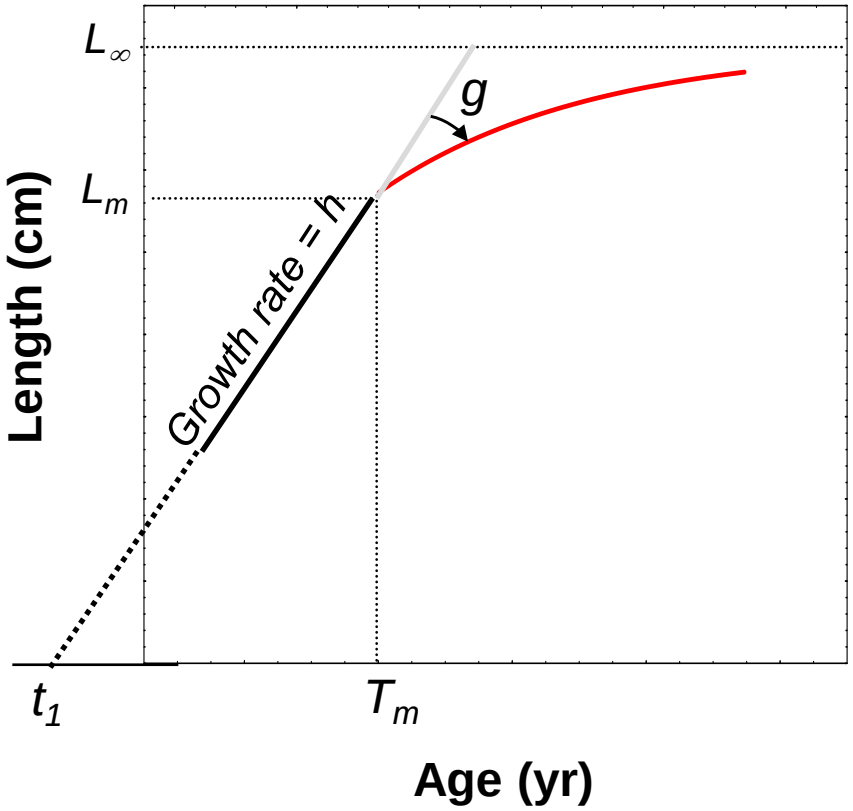
Biphasic Growth Model



$L_\infty = 3\,h\,/\,g$

Lester, Shuter and Abrams (2004)

Biphasic Growth Model



$L_\infty = 3\,h\,/\,g$

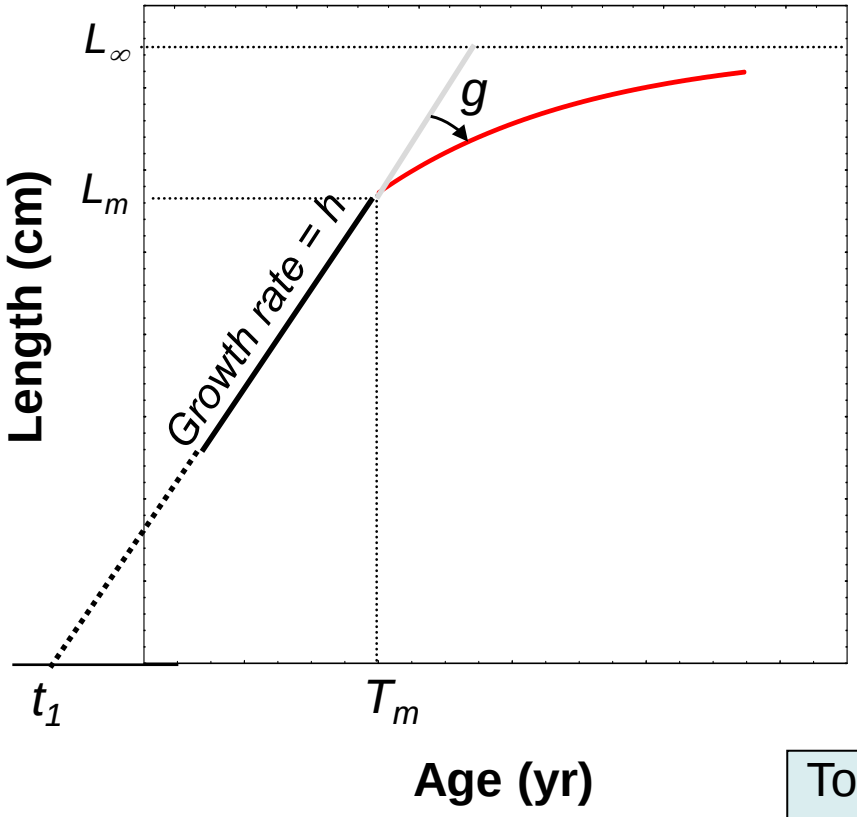
Optimum length at maturity

$L_m = h\,(2/M - 1)$

$$M = \frac{2\,h}{h + L_m}$$

Lester, Shuter, Venturelli and Nadeau (2014)

Biphasic Growth Model



$L_\infty = 3\,h\,/\,g$

Optimum length at maturity

$L_m = h\,(2/M - 1)$

$$M = \frac{2\,h}{h + L_m}$$

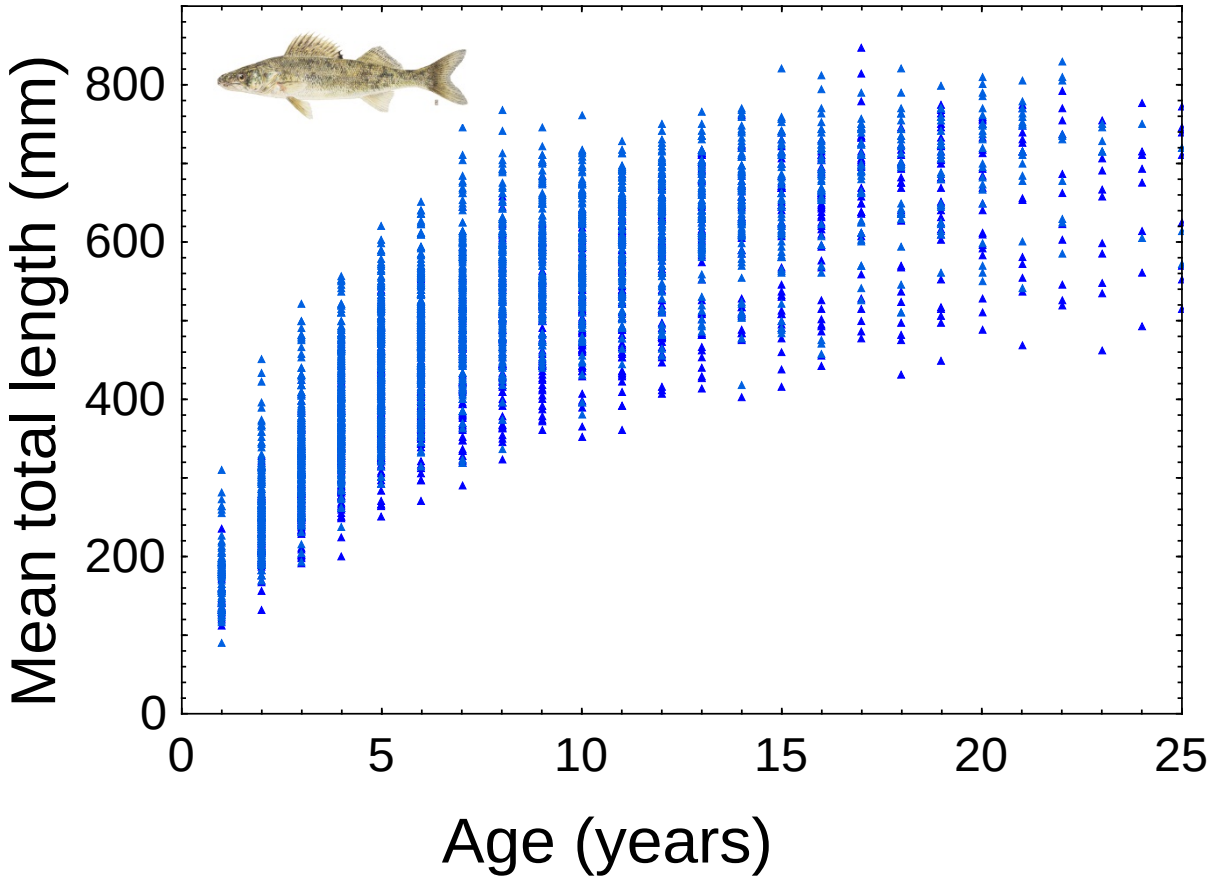
To estimate M need:

- Growth rate (*h*) when unexploited
- Length of maturity (L_m) when unexploited

Lester, Shuter, Venturelli and Nadeau (2014)

Mean length at age (130 populations)

Females



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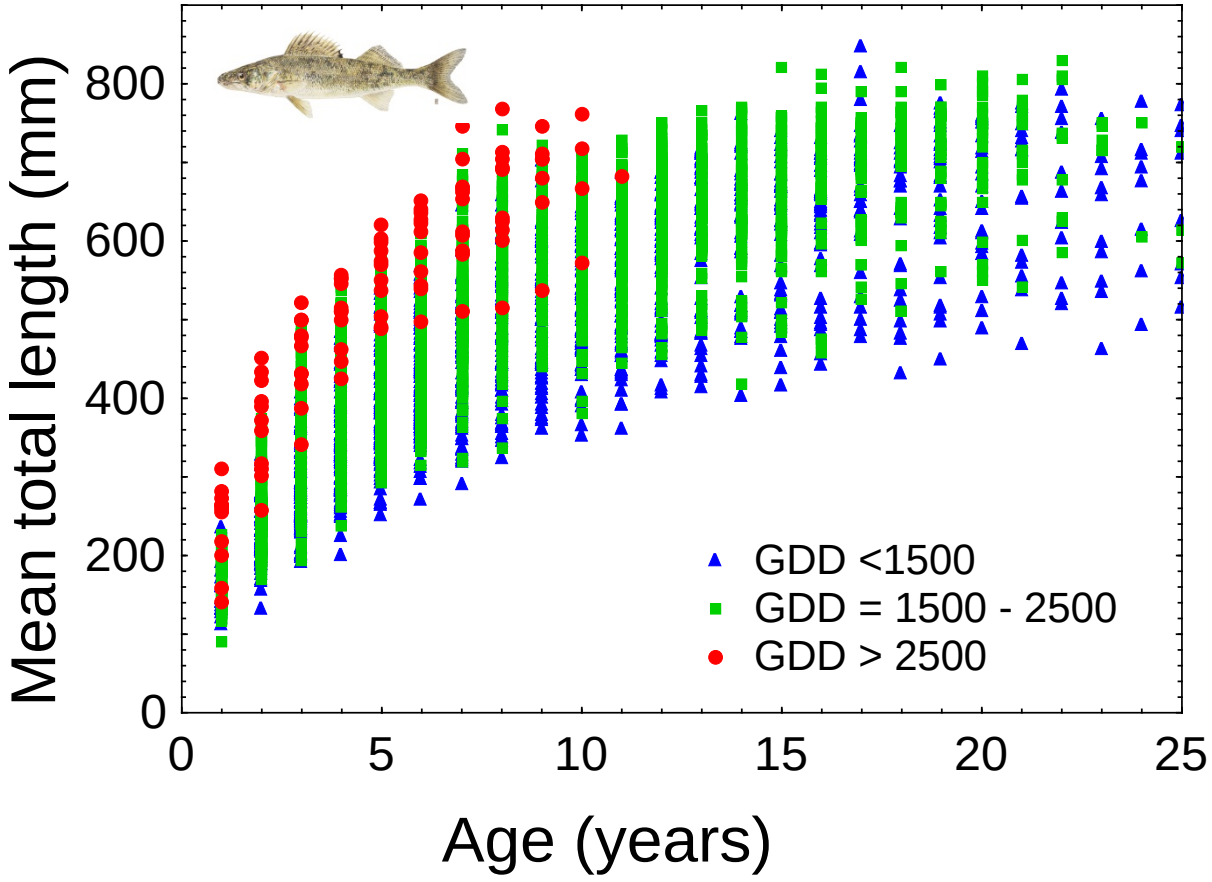
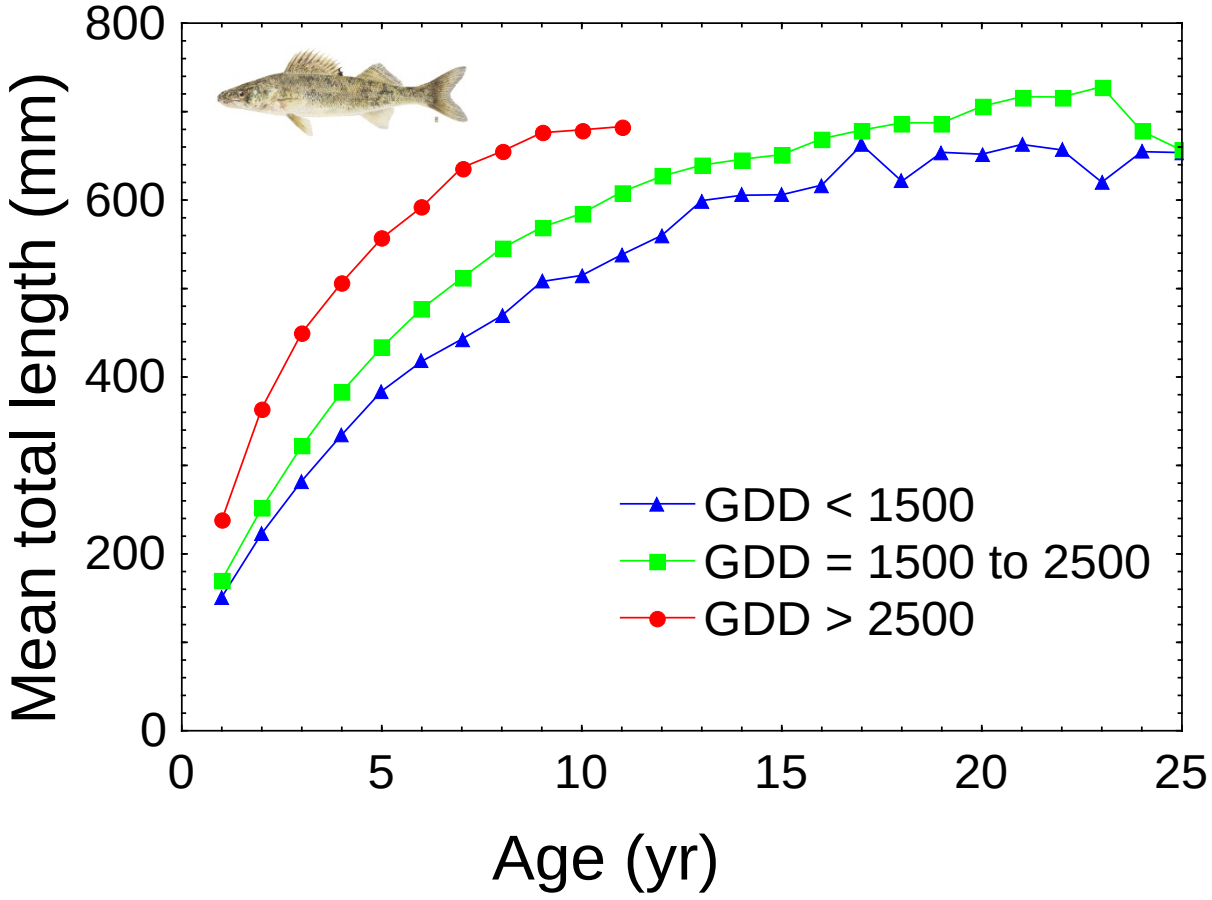


Mean length at age (by GDD zone)

Female



Mean length at age (by GDD zone)

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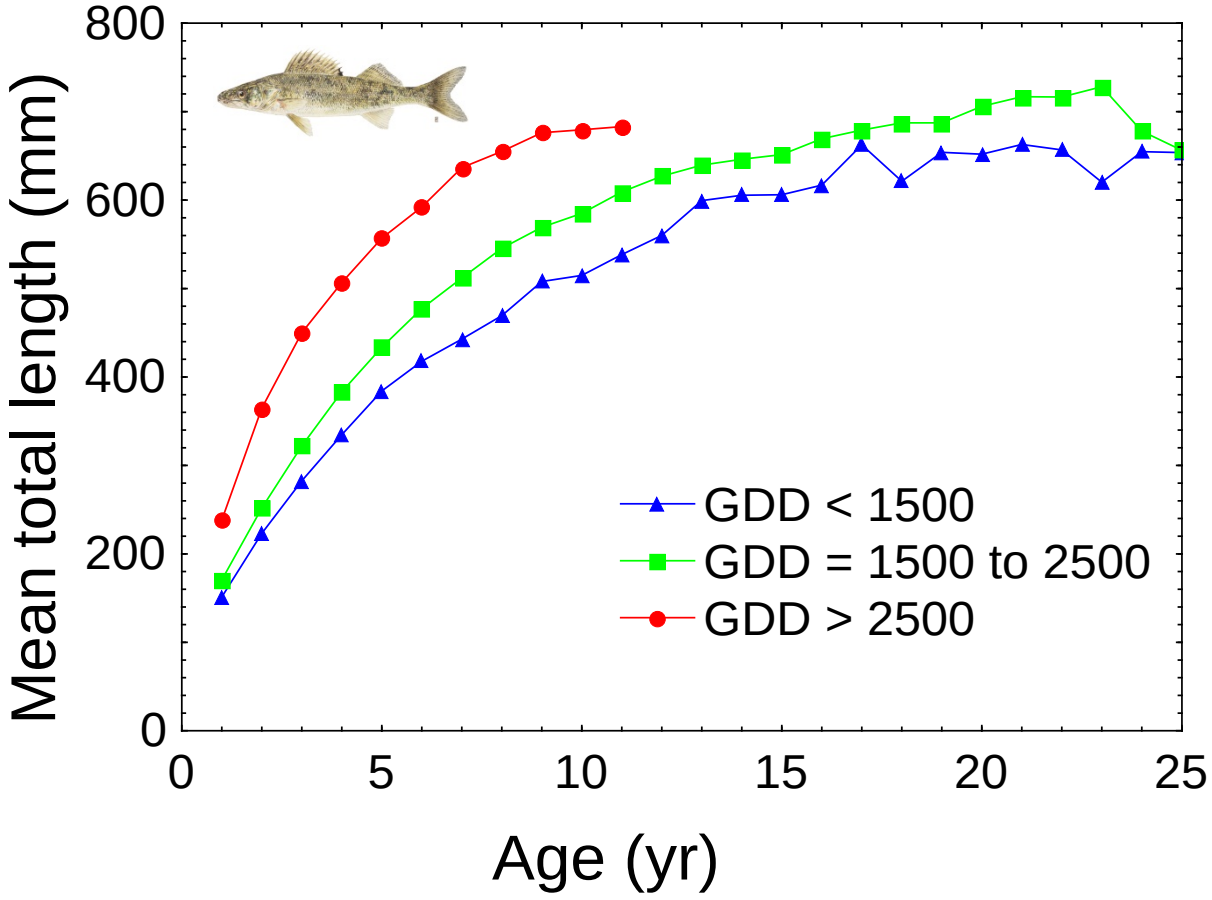
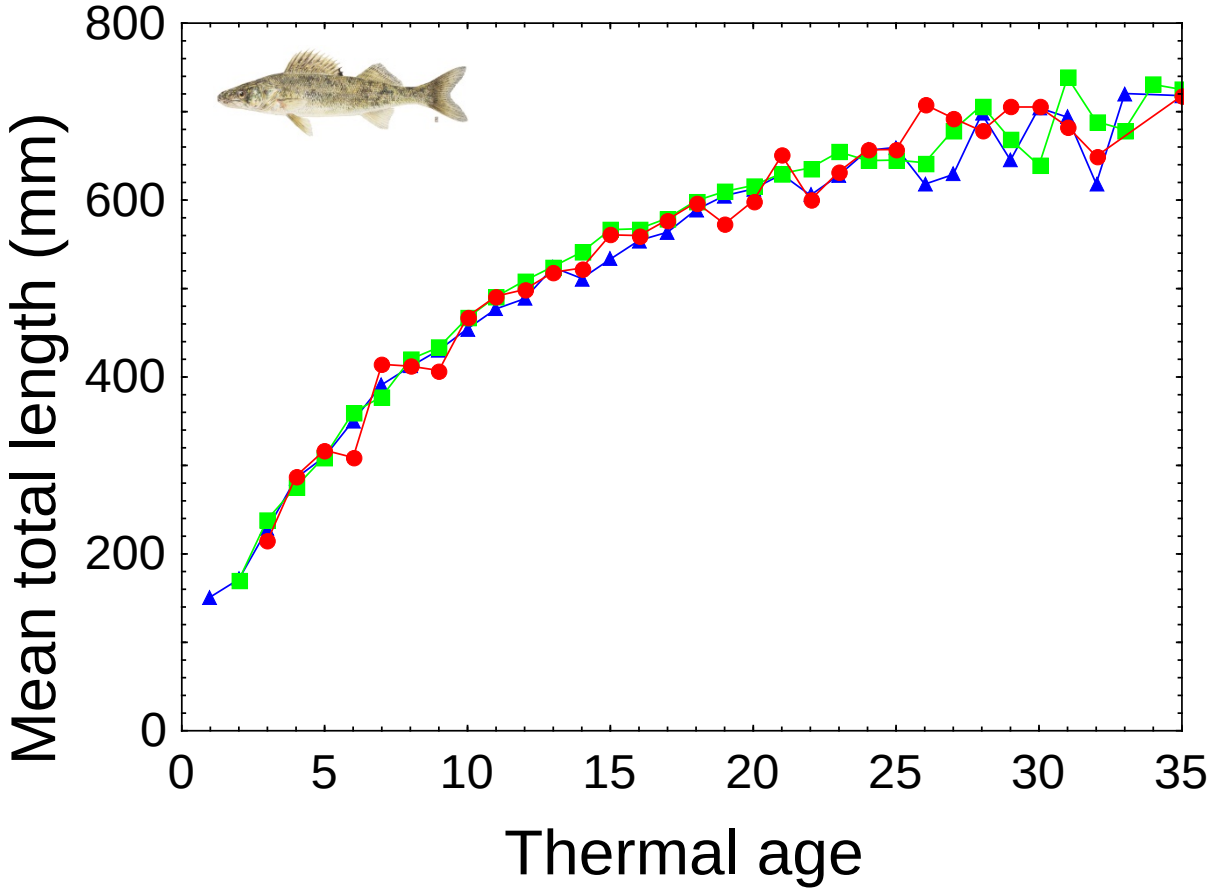


Thermal age = age x GDD x 10^{-3}

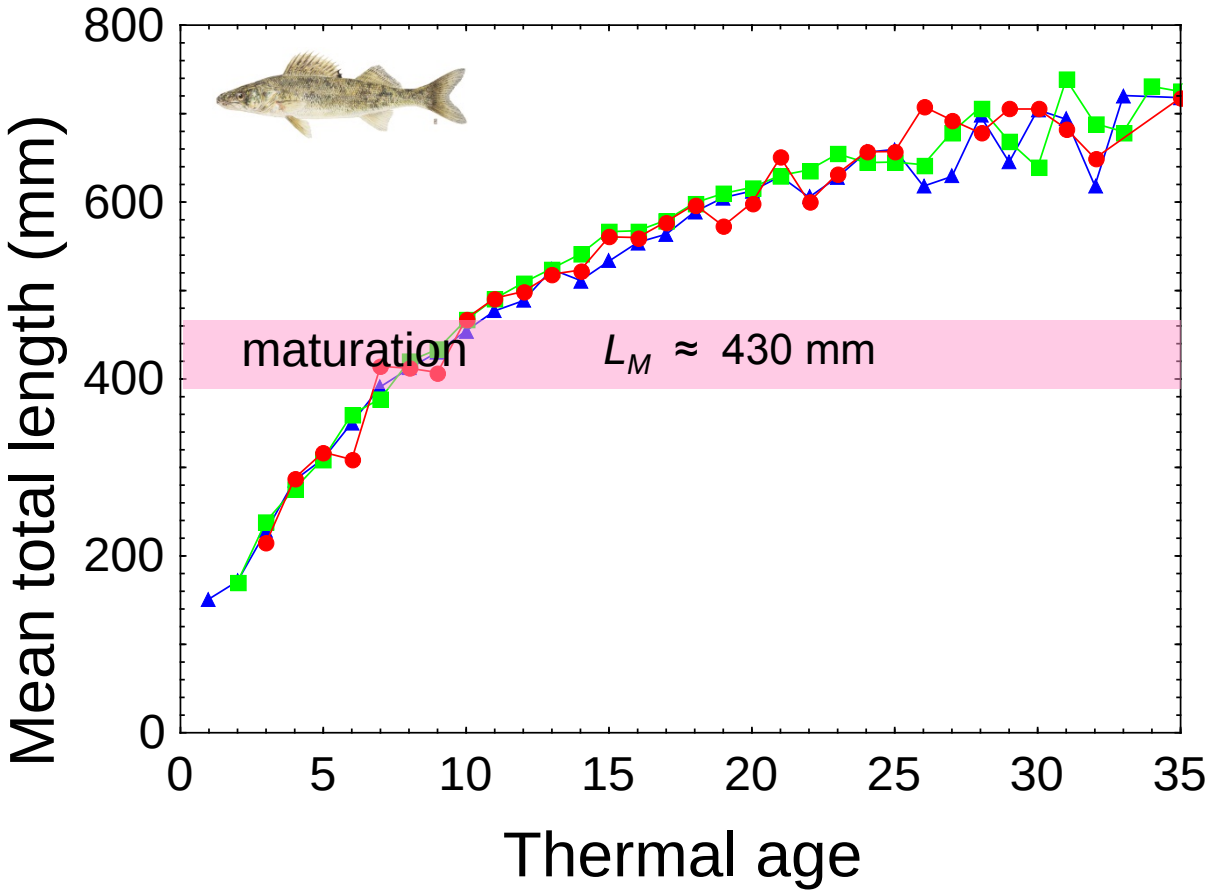
Mean length at **thermal** age

Female



Thermal age = age x GDD x 10^{-3}

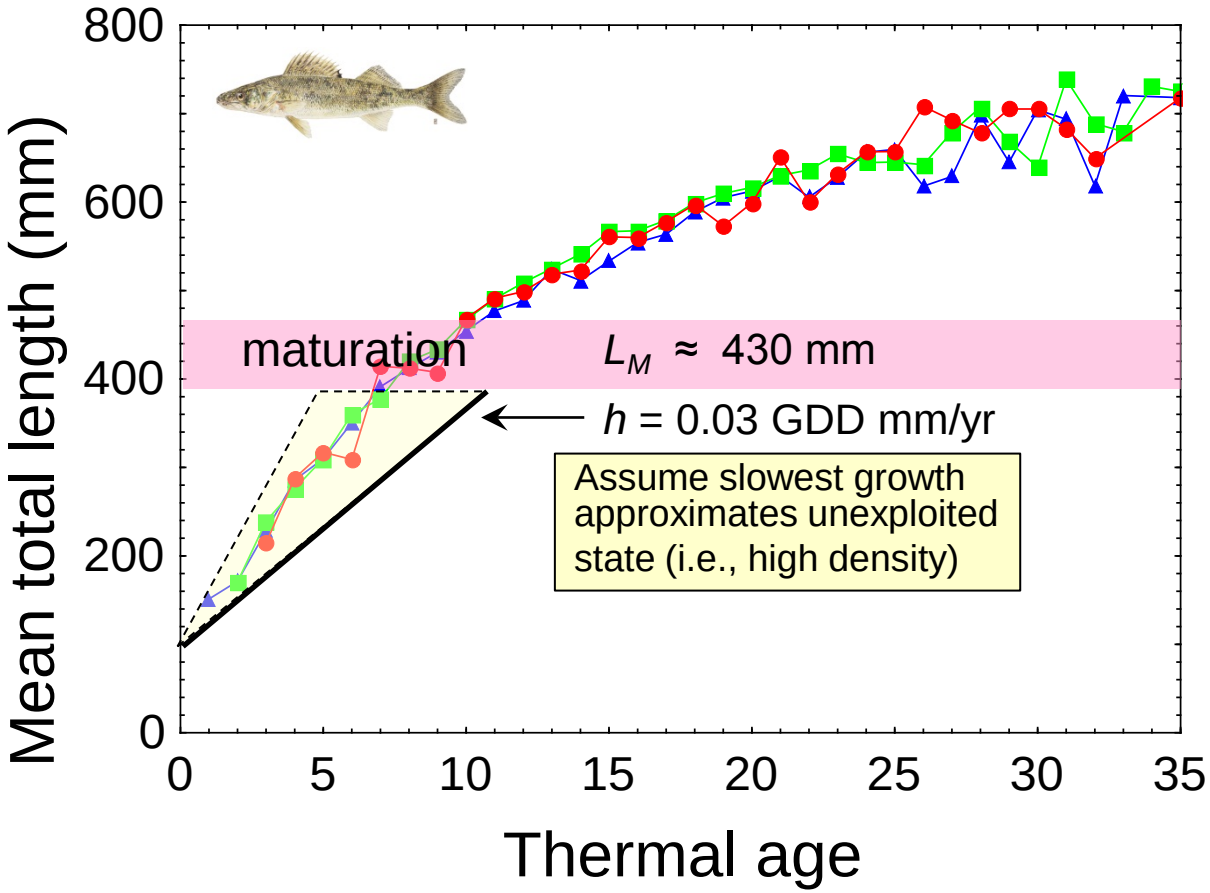
Predicting M for walleye



$$M = \frac{2\,h}{h + L_m}$$

Venturelli, Lester and Shuter (2010)
Lester, Shuter, Venturelli and Nadeau (2014)

Predicting M for walleye



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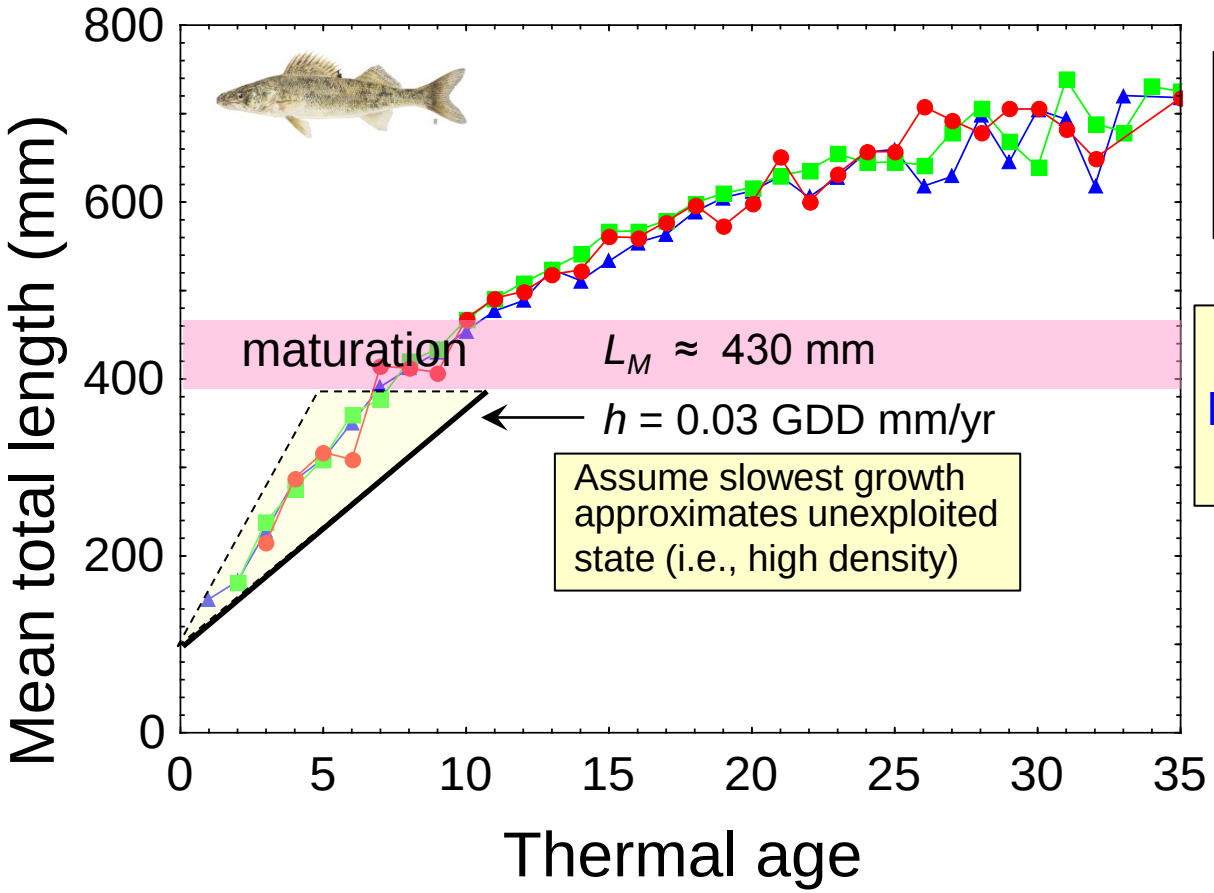


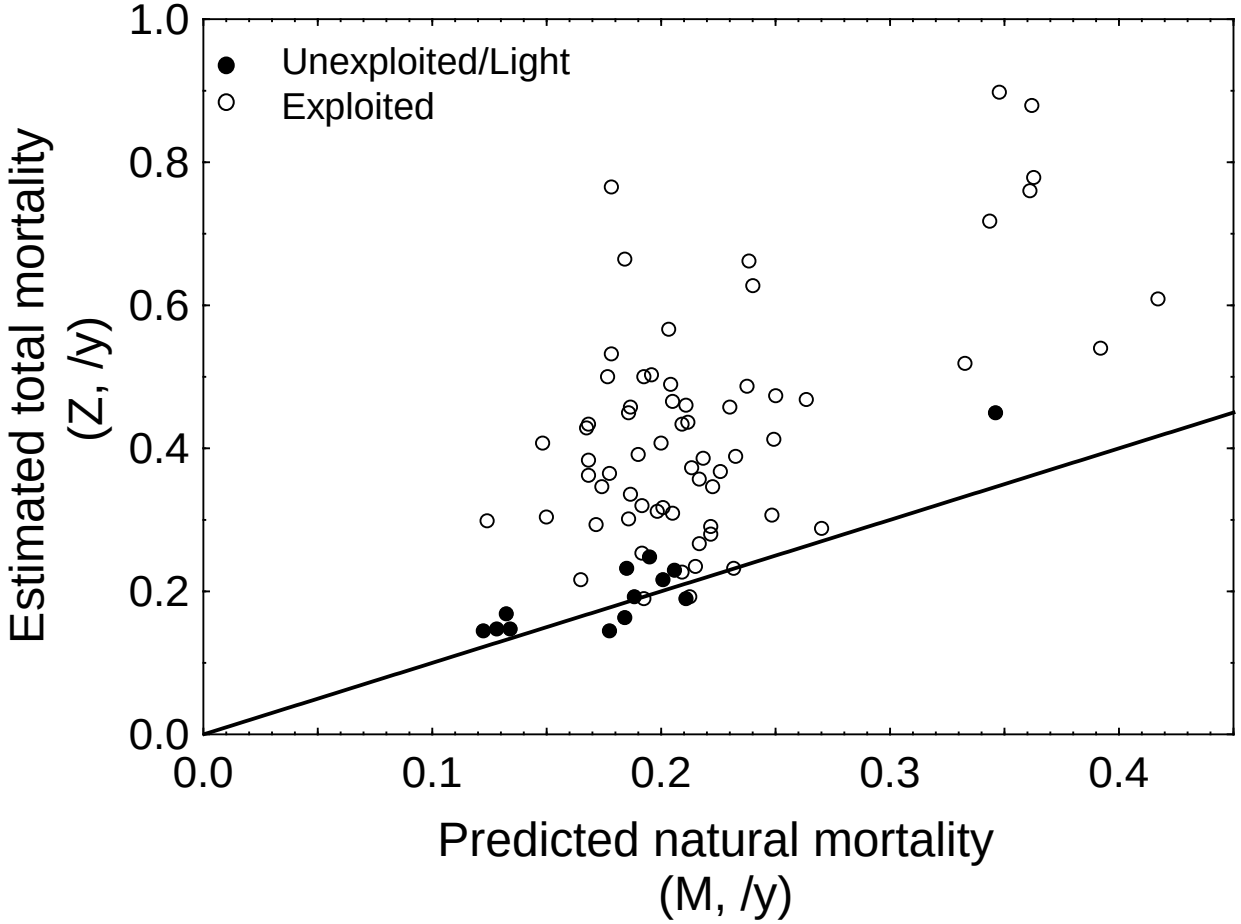
$$M = \frac{2\,h}{h + L_m}$$

$$M = \frac{0.06\ \text{GDD}}{0.03\ \text{GDD} + 430}$$

Venturelli, Lester and Shuter (2010)
Lester, Shuter, Venturelli and Nadeau (2014)

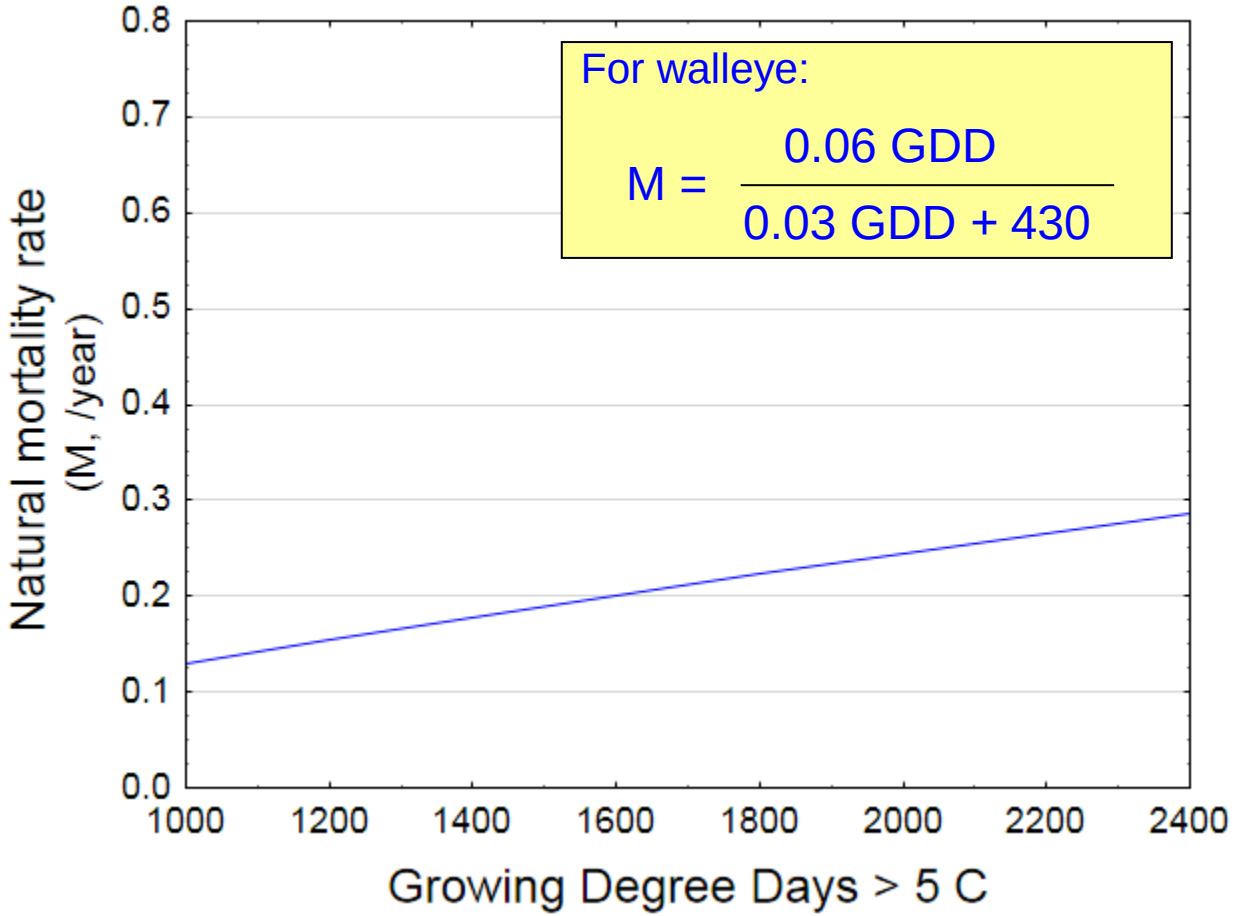
Total mortality versus predicted natural mortality

(FWIN surveys – Ontario and Quebec lakes)



Lester et al. 2014

Predicted M for walleye
(L_{mature} = 430 mm)



Building a science for landscape fisheries management

- Sustainable effort depends on:
  - Impact on Fishing mortality rate (F)
  - Modified by angling catchability (q) and regulations (p)
- How much F is sustainable?
  - $F_{msy} \approx$ M (natural mortality rate)
- How does one predict M?
  - M = f(Climate, Body size)
- Estimate Effort at MSY

Effort at MSY

$$Effort_{msy} = \frac{F_{msy}}{q * p}$$

q: Angling skill

p: Proportion kept

Effort at MSY

For walleye:

$$M = \frac{0.06\ GDD}{0.03\ GDD + 430}$$

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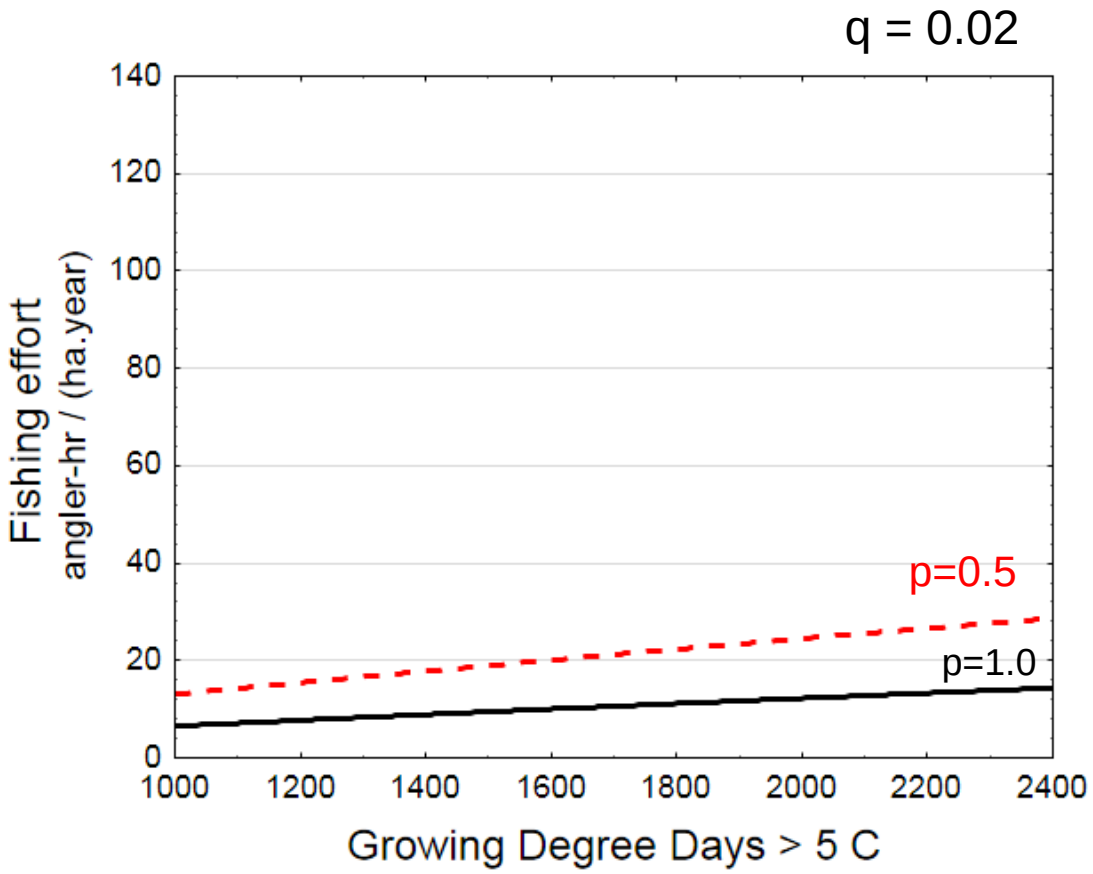
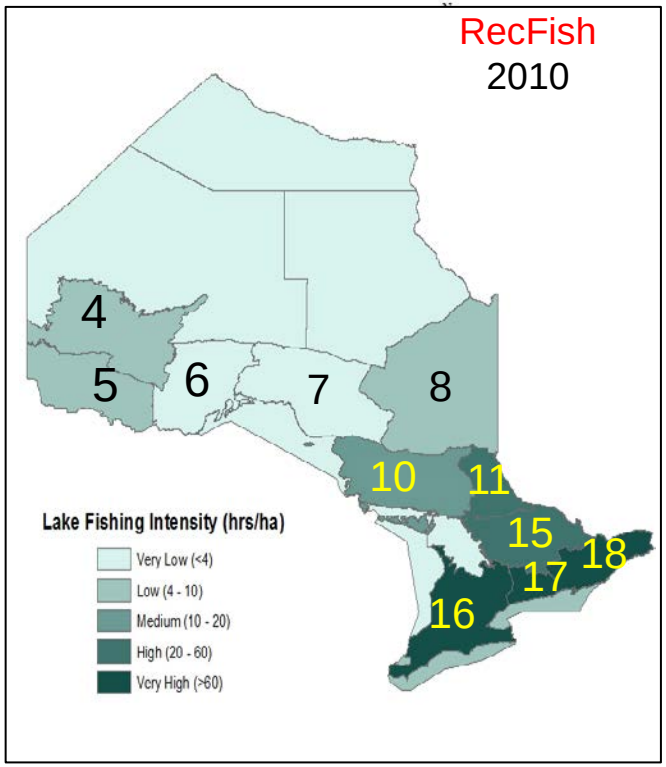
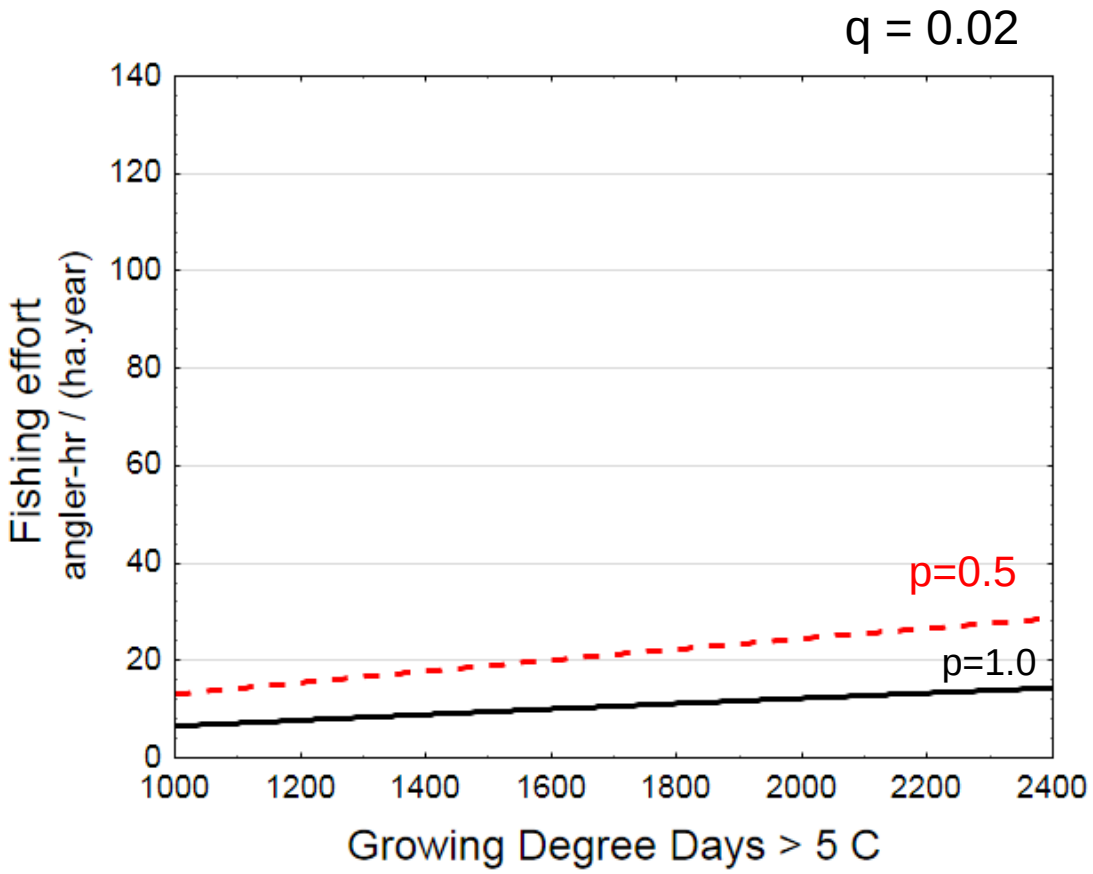


Effort at MSY

Fishing effort
angler-hours / (ha.year)





Effort at MSY

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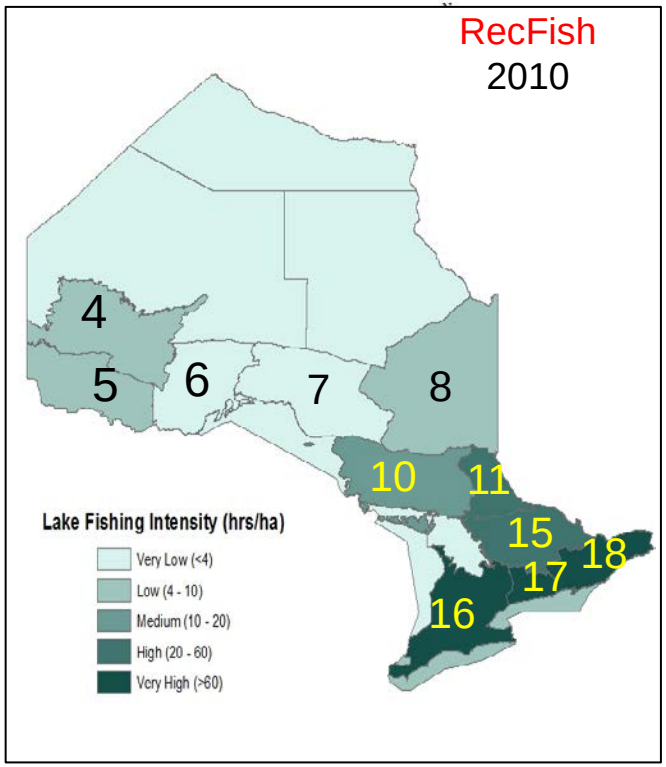
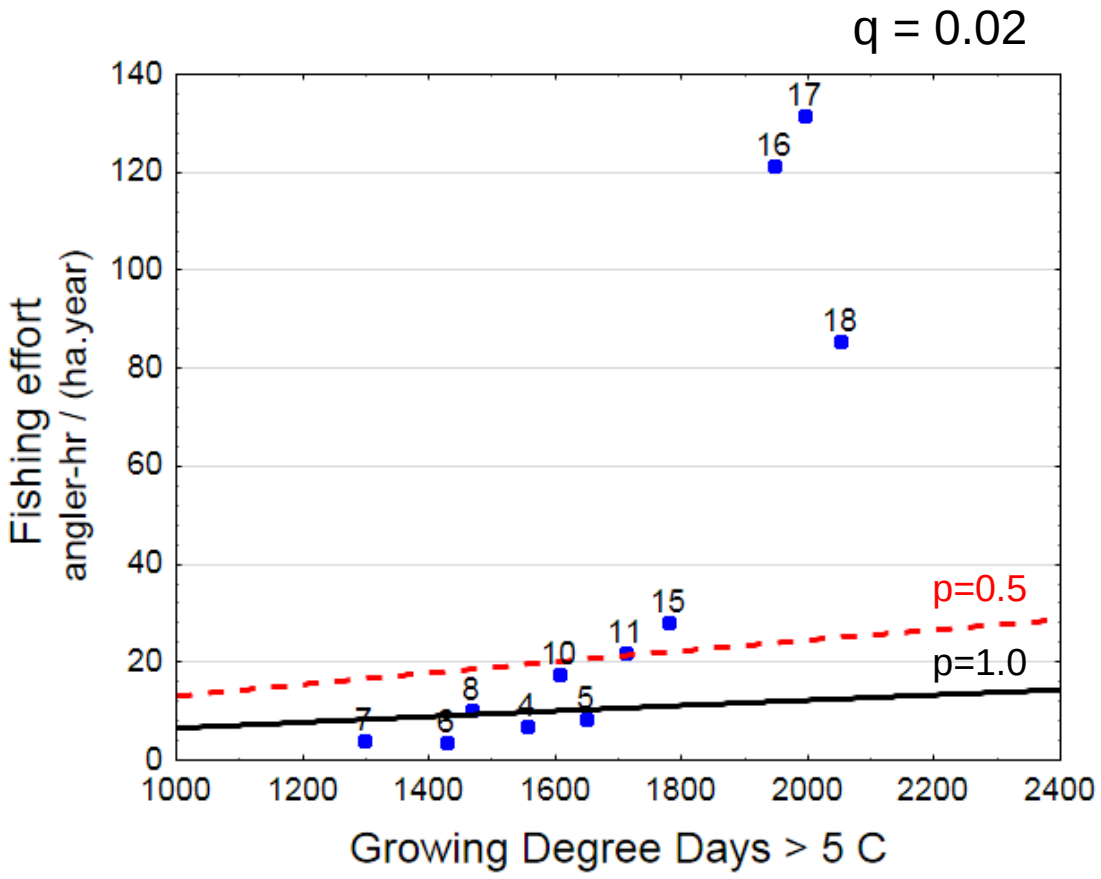
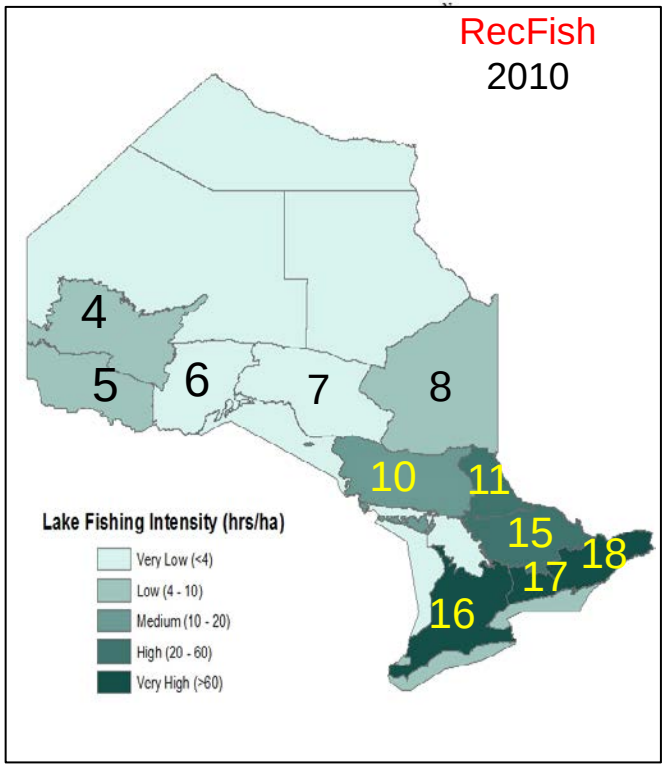


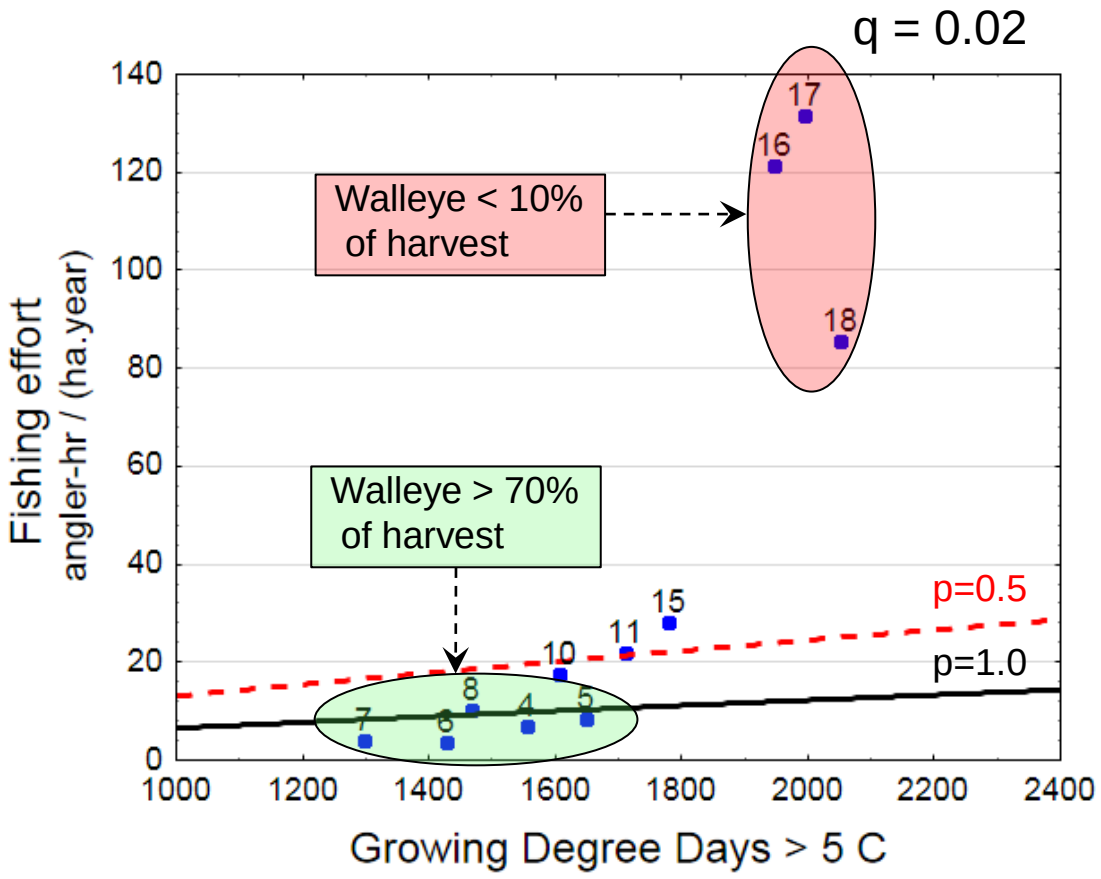


Mail survey estimates
- Probably overestimate effort (Hogg et al. 2010)
- BsM data will be used to assess bias
- Values are used here to demonstrate approach

Effort at MSY

Fishing effort
angler-hours / (ha.year)





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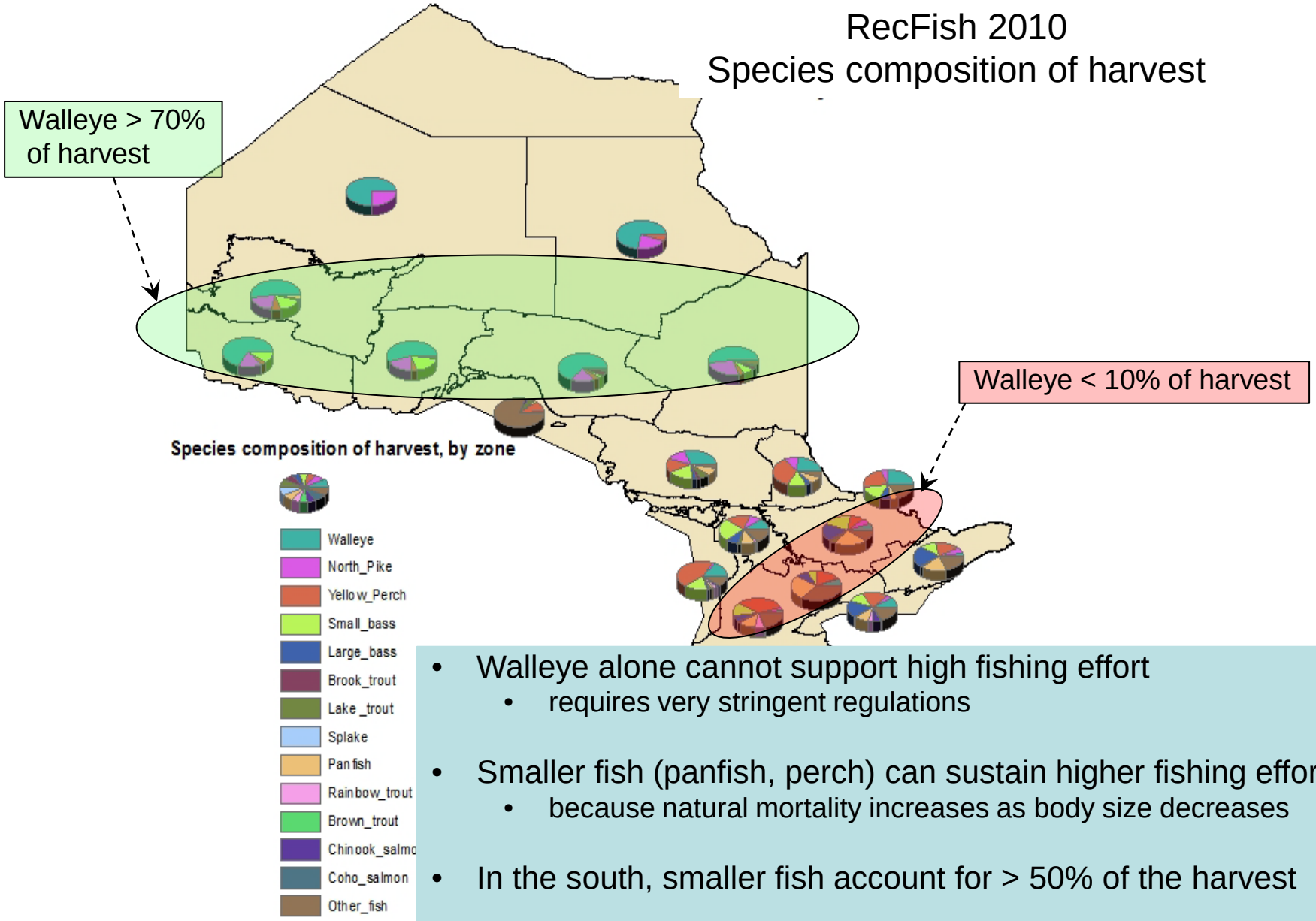
RecFish 2010
Species composition of harvest



- Walleye alone cannot support high fishing effort
  - requires very stringent regulations
- Smaller fish (panfish, perch) can sustain higher fishing effort
  - because natural mortality increases as body size decreases
- In the south, smaller fish account for > 50% of the harvest

Building a science for landscape fisheries management

- How much fishing effort is sustainable?
- Addressing other questions as well:
  - How much harvesting is sustainable (kg of fish)?
  - How is the ‘community size spectrum’ affected by:
    - Environmental factors
    - Fishing

Building a science for landscape fisheries management

- How much fishing effort is sustainable?
- How much harvesting is sustainable (kg of fish)?
- How is the 'community size spectrum' affected by:
  - Environmental factors
  - Fishing

Major symposium planned for AFS 2014

Building a science for landscape fisheries management

- Landscape Fisheries Management
  - new scale of thinking
  - no textbooks, we have to discover the science
  - adaptive management process

- Success requires
  - commitment to monitoring
  - sharing of data
  - public involvement

AMERICAN FISHERIES SOCIETY
ONTARIO CHAPTER

Ontario

THE END