Life-history traits for predicting invasiveness in non-native freshwater fishes

Gordon H. Copp, Michael G. Fox & A. Serhan Tarkan

Rationale

- A difficult NNS management task is identification of which species are invasive and which are not

- Predictive invasiveness 'screening' tools range from qualitative to quantitative

- Models based on life-history traits (LHTs) to predict invasiveness are rare

- Which native-range traits can reveal invasiveness?

Outline

- Development of a life-history traits (LTHs) model to predict invasiveness in pumpkinseed (*Lepomis gibbosus*)

- Testing/validation of the LHTs model as a predictor of pumpkinseed invasiveness

- Applications of this model with other species and for future climatic conditions

Background

Pumpkinseed (*Lepomis gibbosus*) is:

• A freshwater sunfish native to eastern North America (Atlantic coast & Mississippi drainage basins)

• Nest-guarder

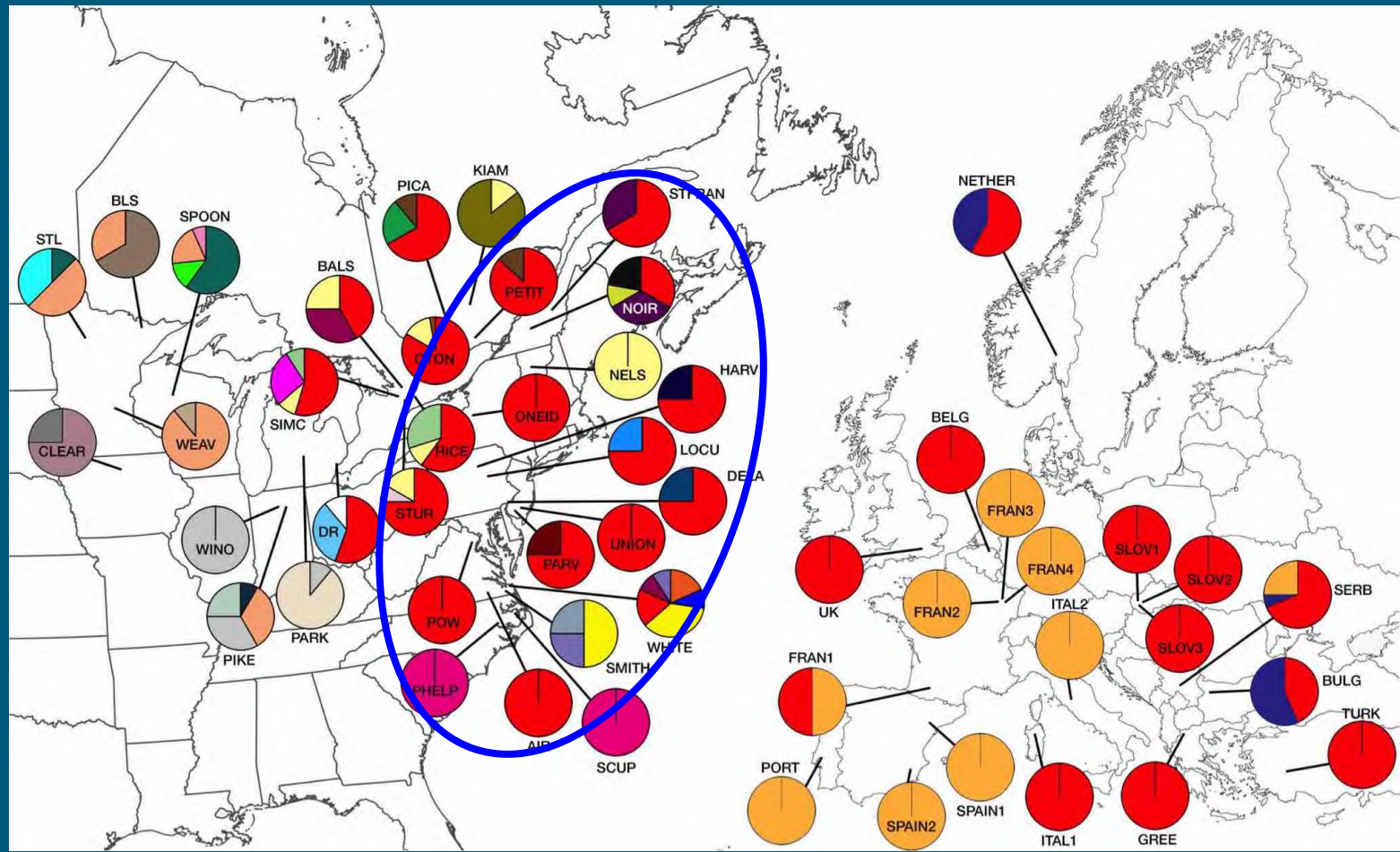• Female & reproduction respond to environmental conditions

Fox (1994) *Ecology*

Background

• Amongst most successful NN fishes in Europe (28+ countries)

Copp & Fox (2007) *Springer*

Background

Historical records & phylogeny indicates Atlantic coast origin of PS in Europe

Yavno *et al.* (2019) *Hydrobiologia*

Background

Also genetic data support long-held belief that NN fish in Iberia arrived from France
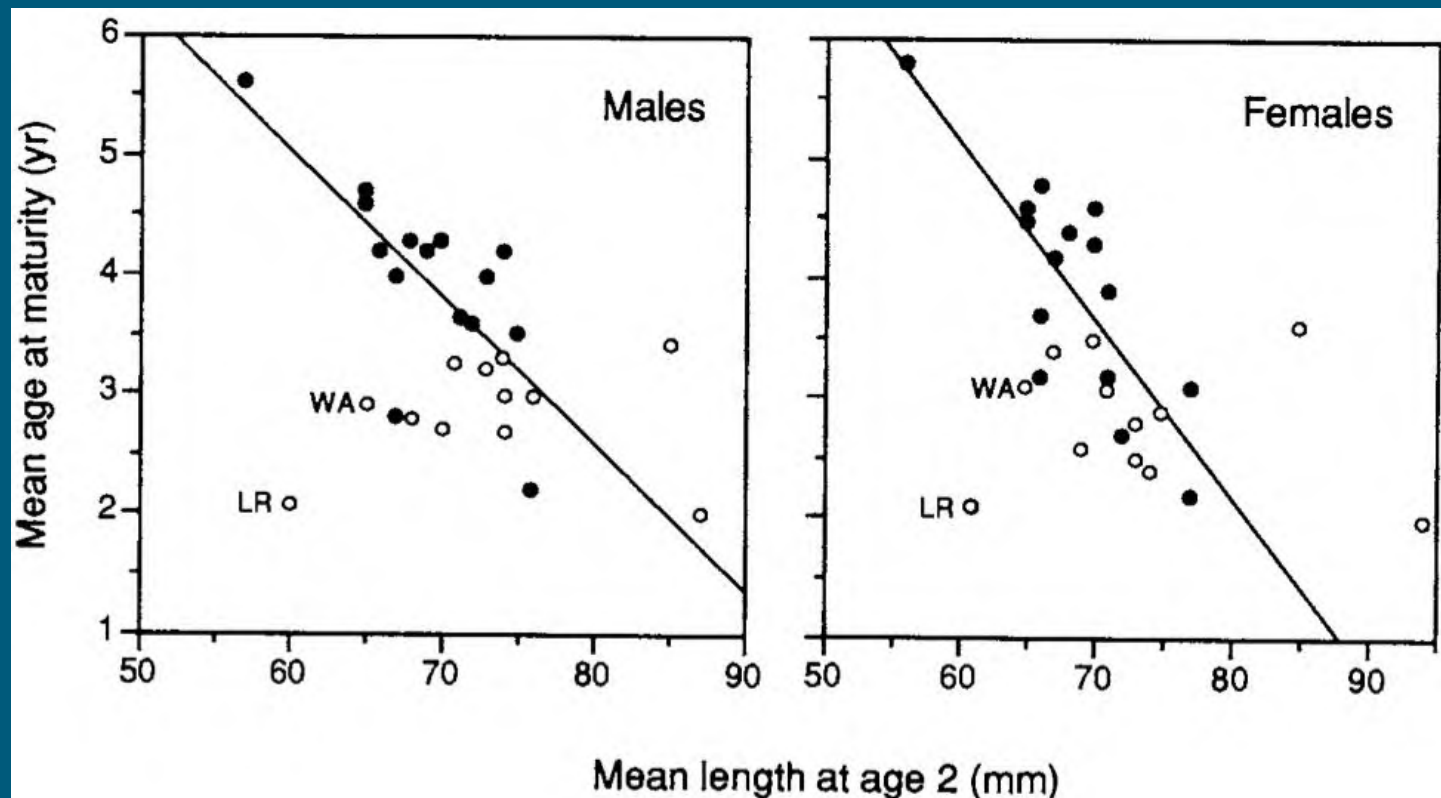
Development of a life-history traits model

• Patterns in native range traits reveal decrease in age at maturity with increasing juvenile growth

(a phenotypic LHT response to favourable conditions: in fishes (and probably most ectotherms)

Fox (1994) *Ecology*

Development of a life-history traits model

In Europe, same relation-ship seemed valid (initial Results 'O')

(data in 1990s)

Copp *et al.* (2002) *Archiv für Hydrobiologia*
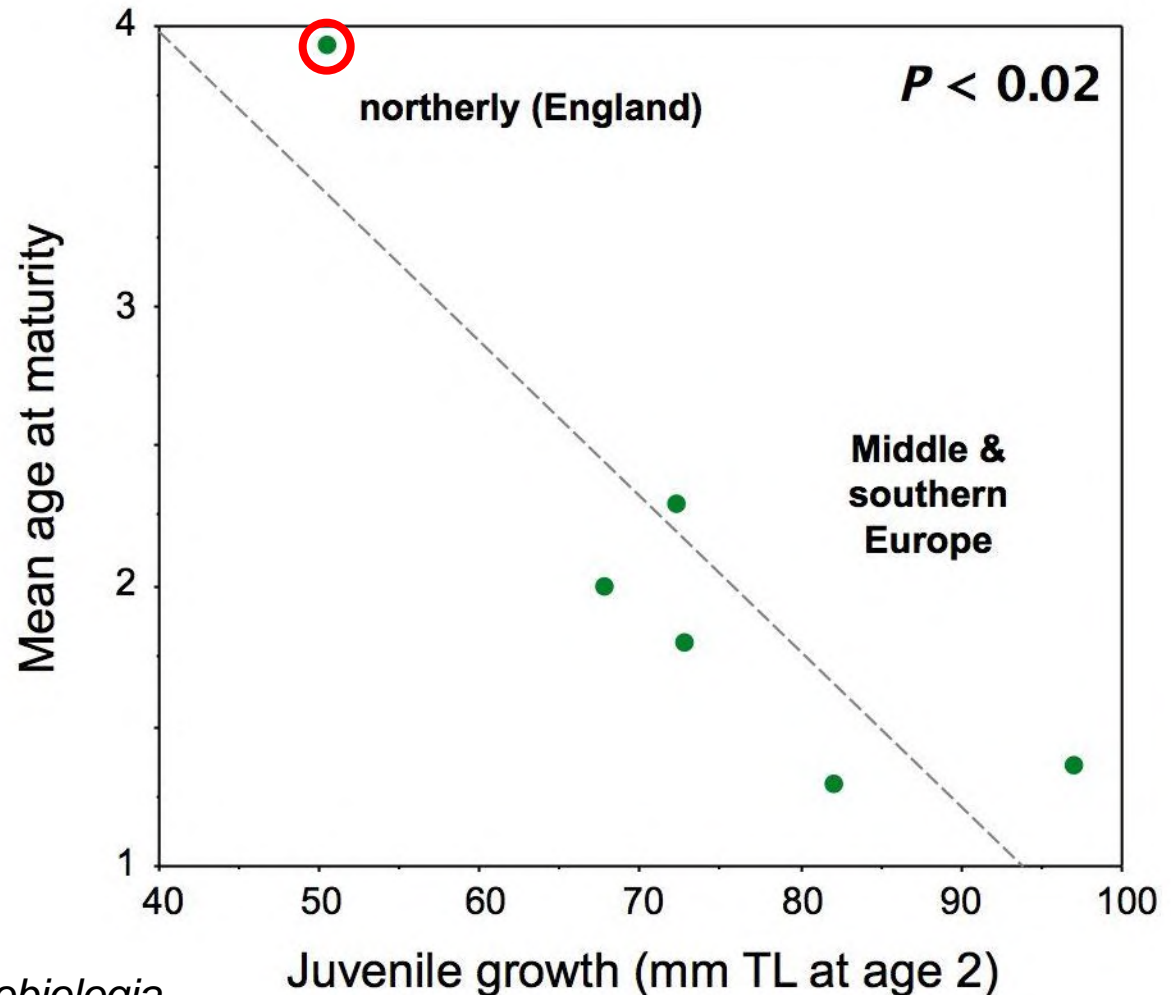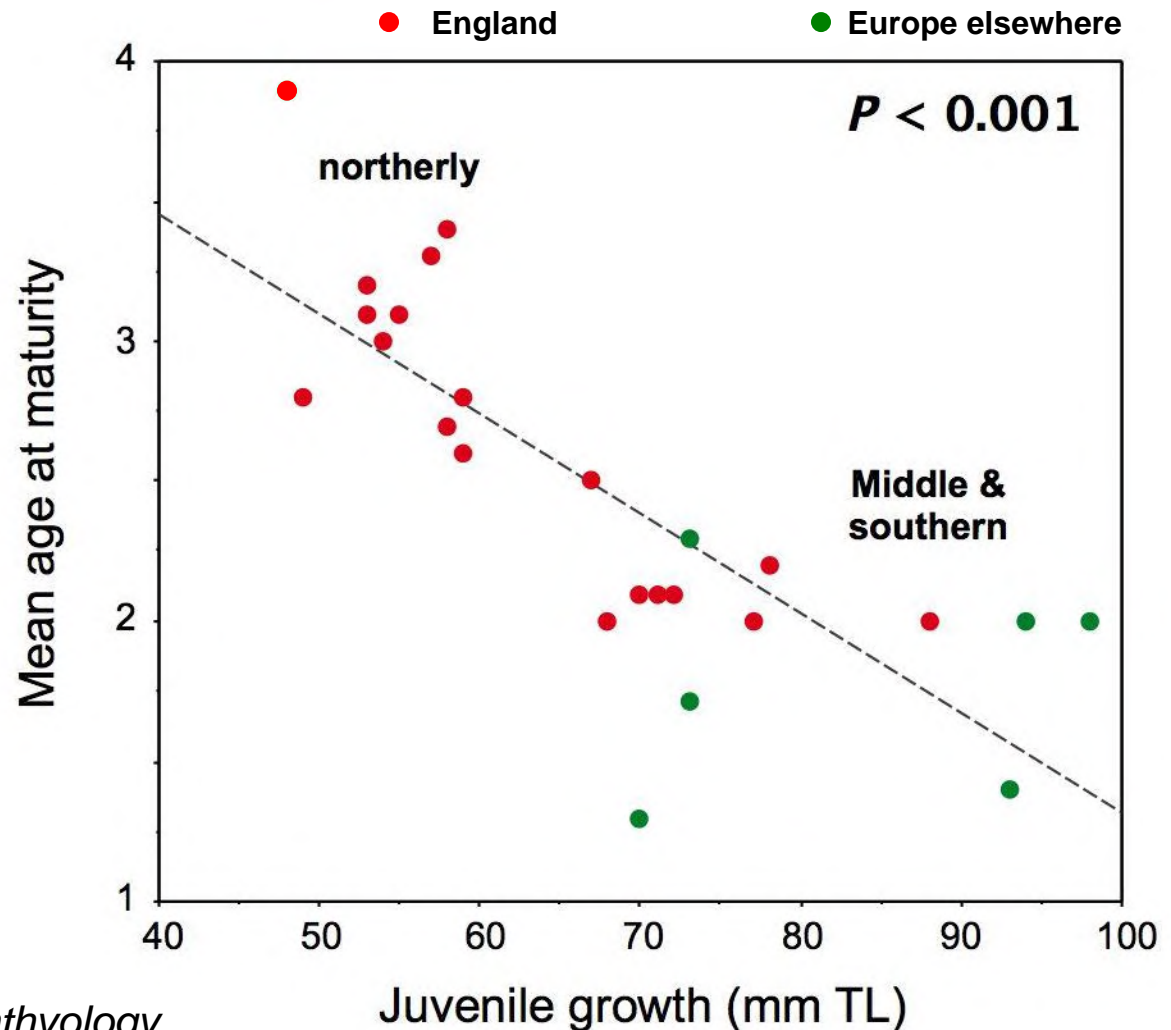
Development of a life-history traits model

In Europe, new data (2003) validated relationship

PS in warmer locations predicted to grow faster & mature earlier

- England
- Europe elsewhere

$P < 0.001$

northerly

Middle & southern

Mean age at maturity

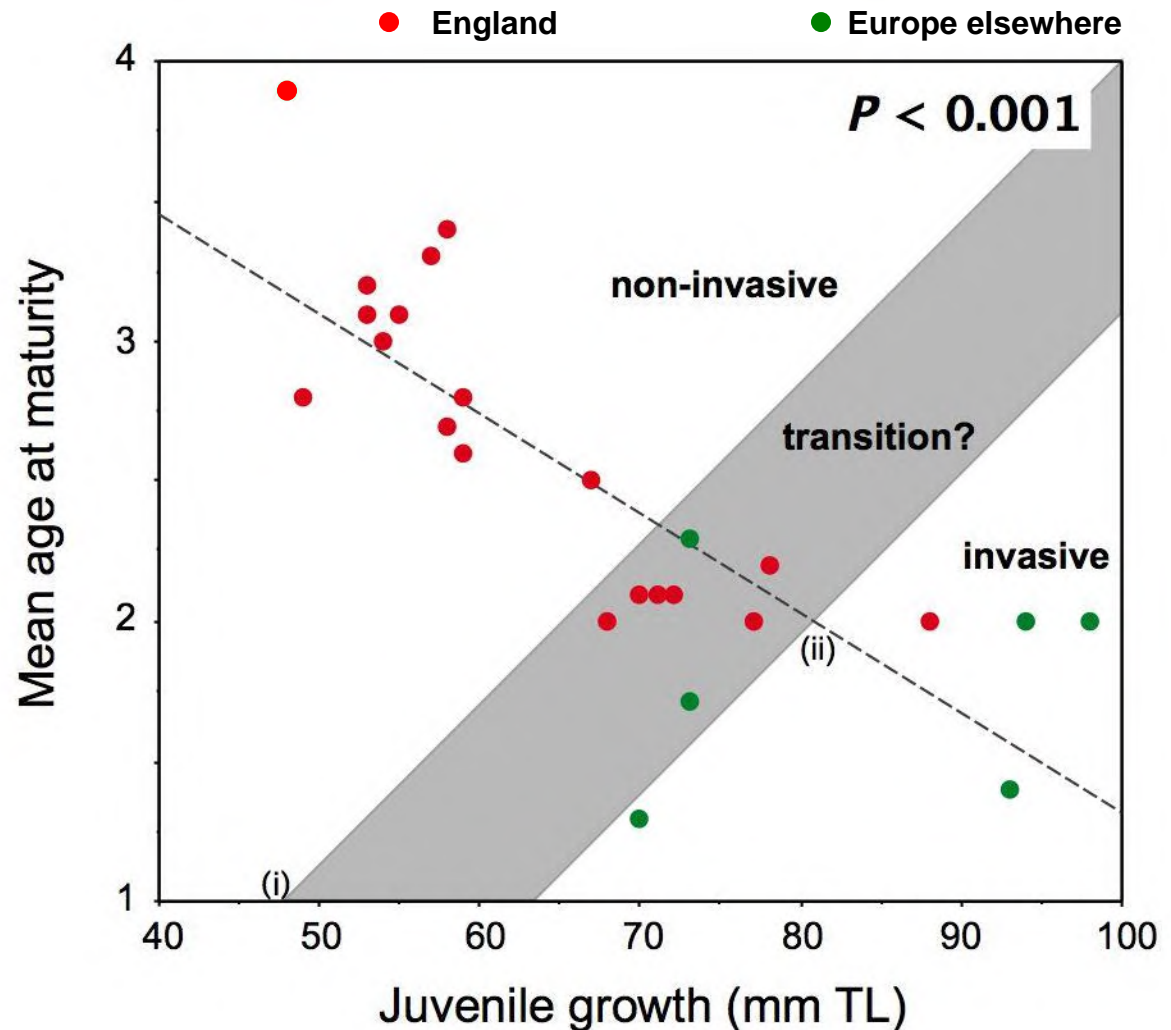Juvenile growth (mm TL)

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Testing potential as a predictor of invasiveness
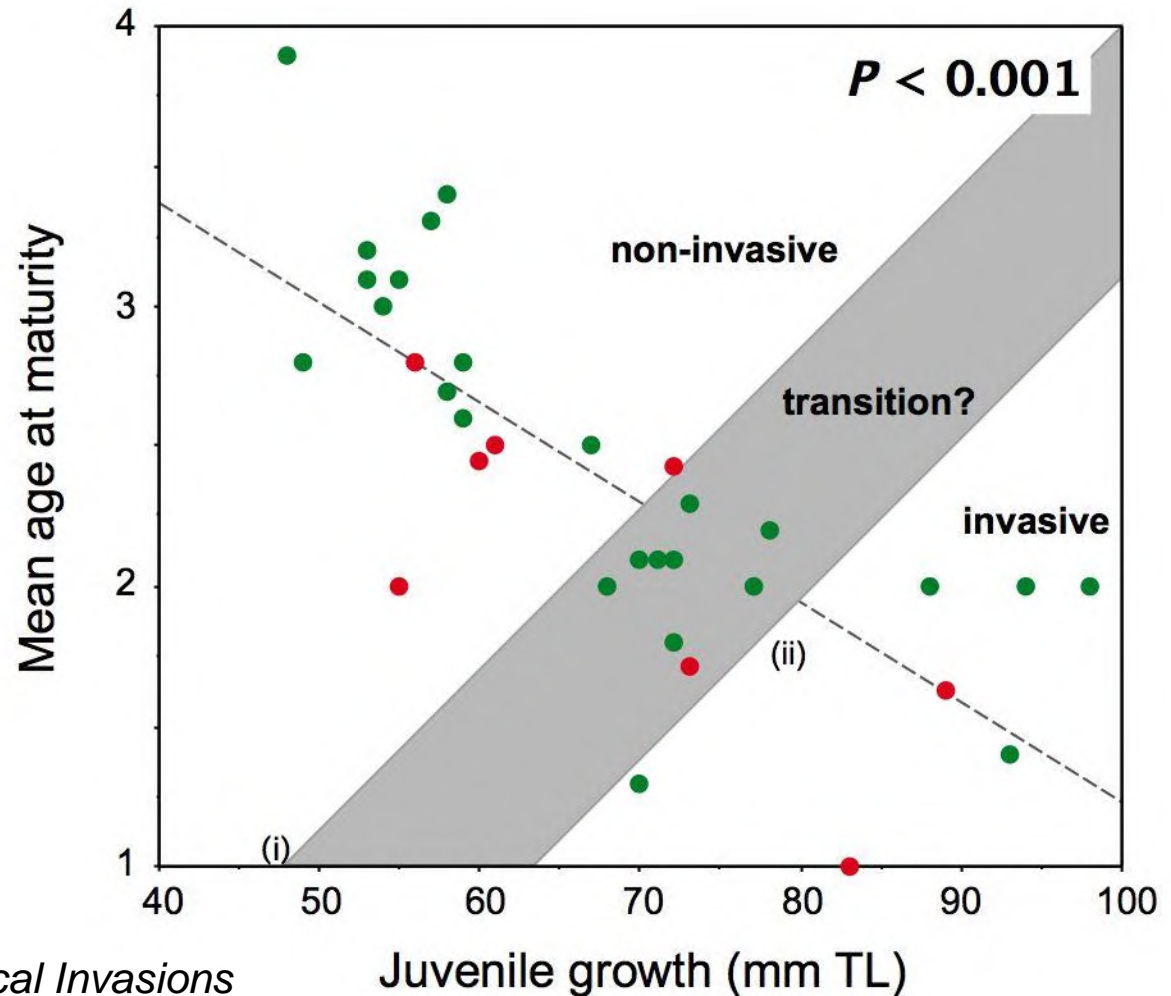
Non-invasives:
slow juv growth
& late maturity

Invasives:
fast juv growth
& early maturity

Copp & Fox (2007) *Springer*

Testing potential as a predictor of invasiveness

Further data from European populations, including northerly pops, support model

Cucherousset *et al.* (2009) *Biological Invasions*

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UK climate-change context

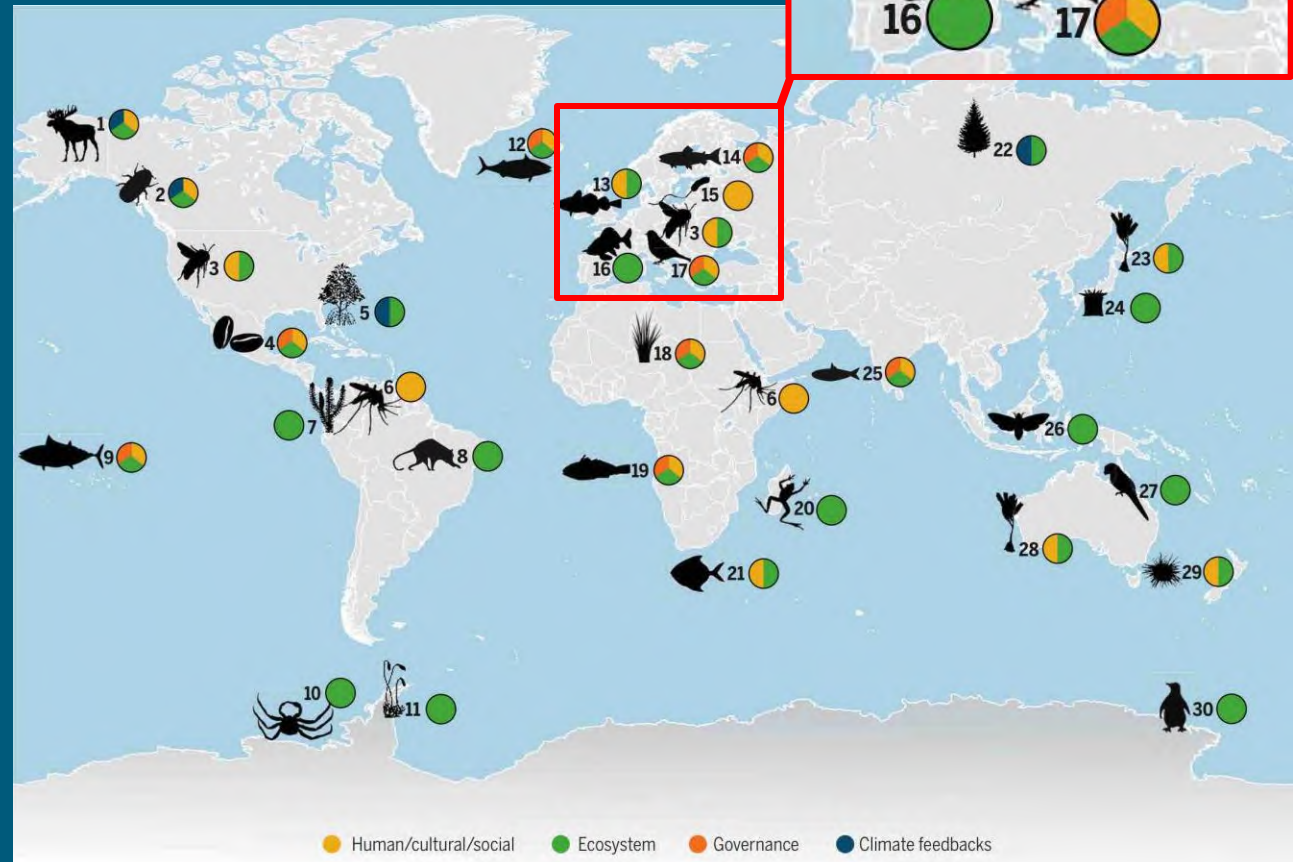In south, increase in water temps. (1.5 – 4.0° C)

Increased variability in river discharge regimes

Jenkins *et al.* (2009) Report
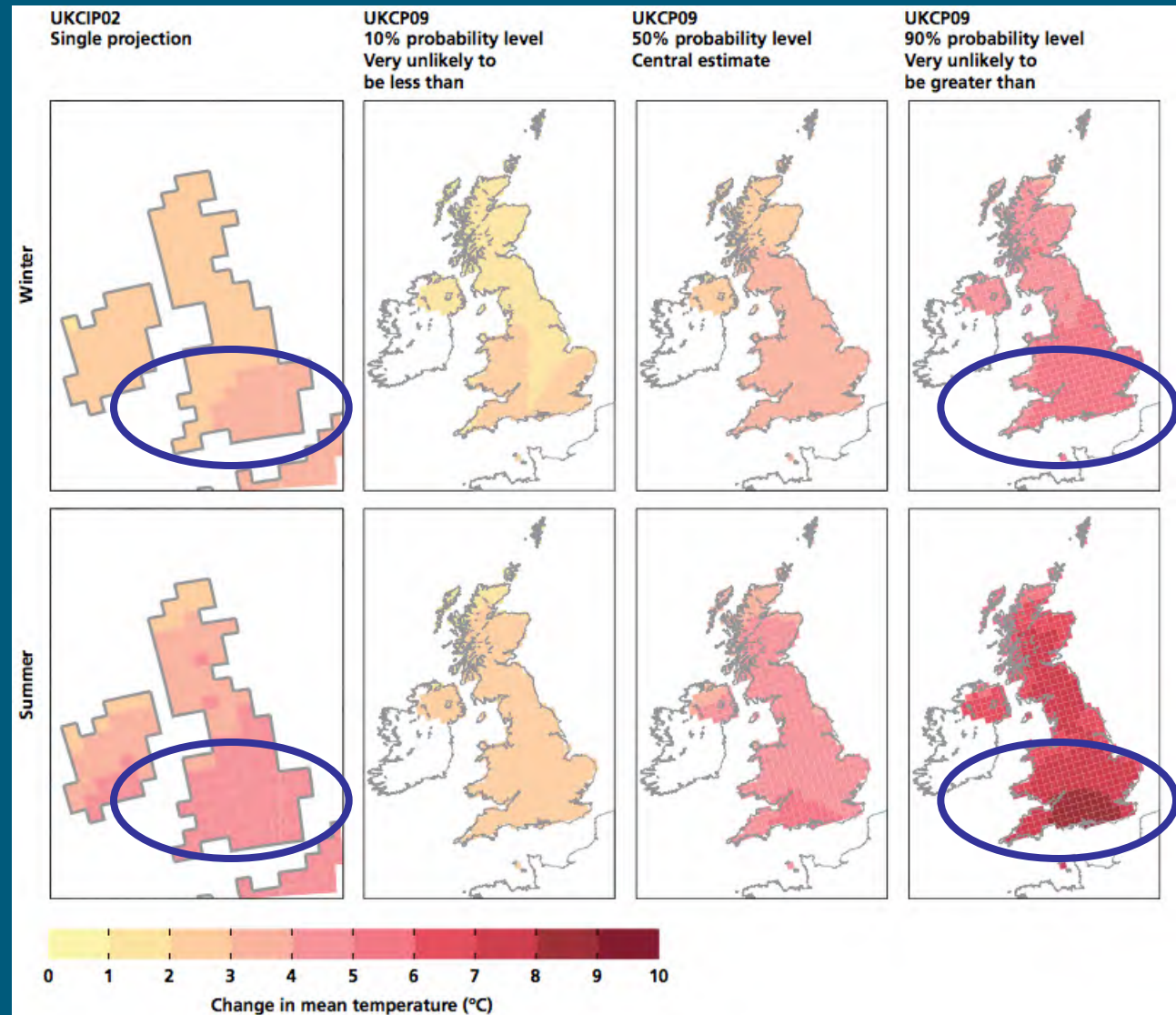
European climate-change context

Predicted ecosystem changes and impacts on fauna, including fishes
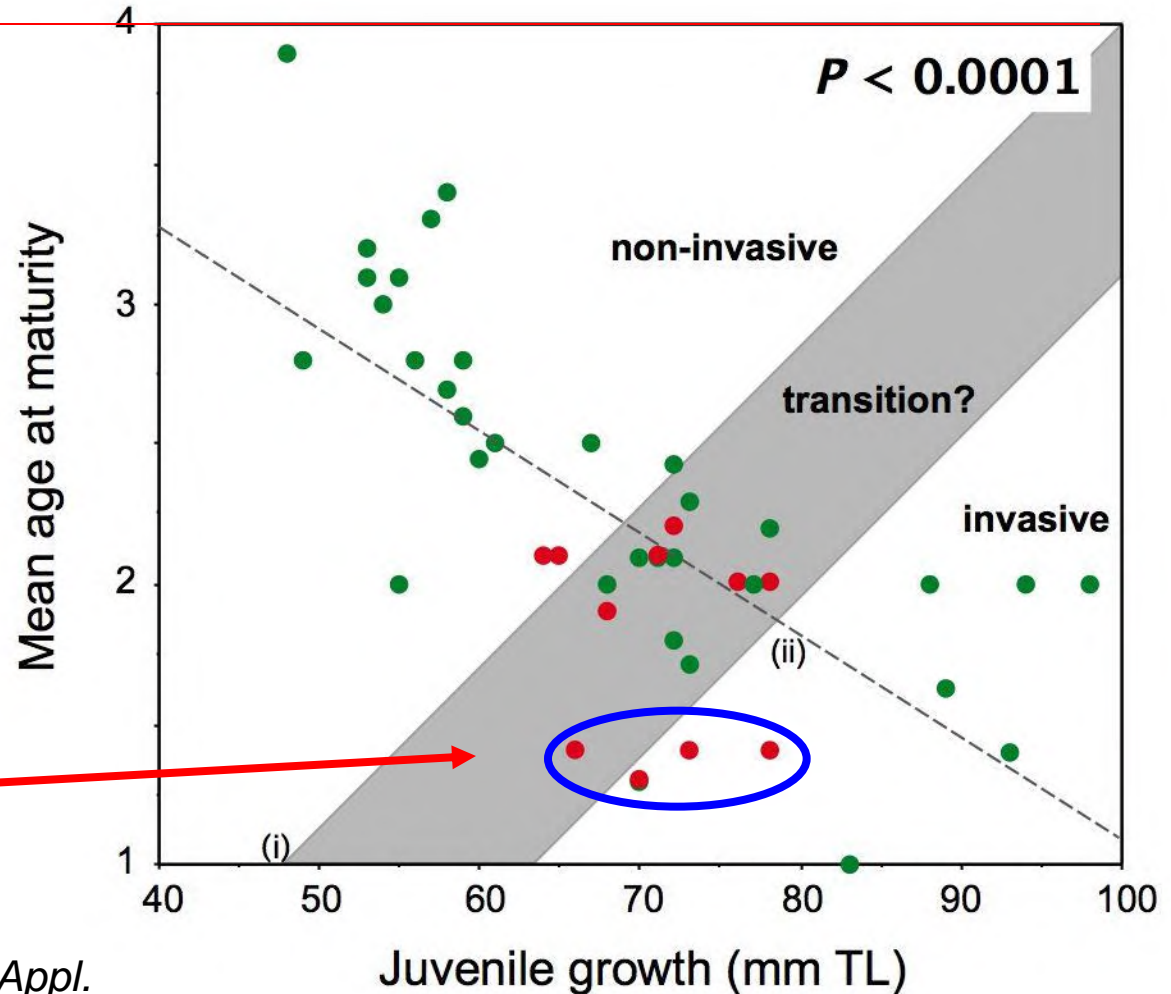

Pecl *et al.* (2017) *Science*

Predicting life-history changes under climate warming (A)

PS in water bodies of River Moselle (France) across a range of temp. regimes fit model
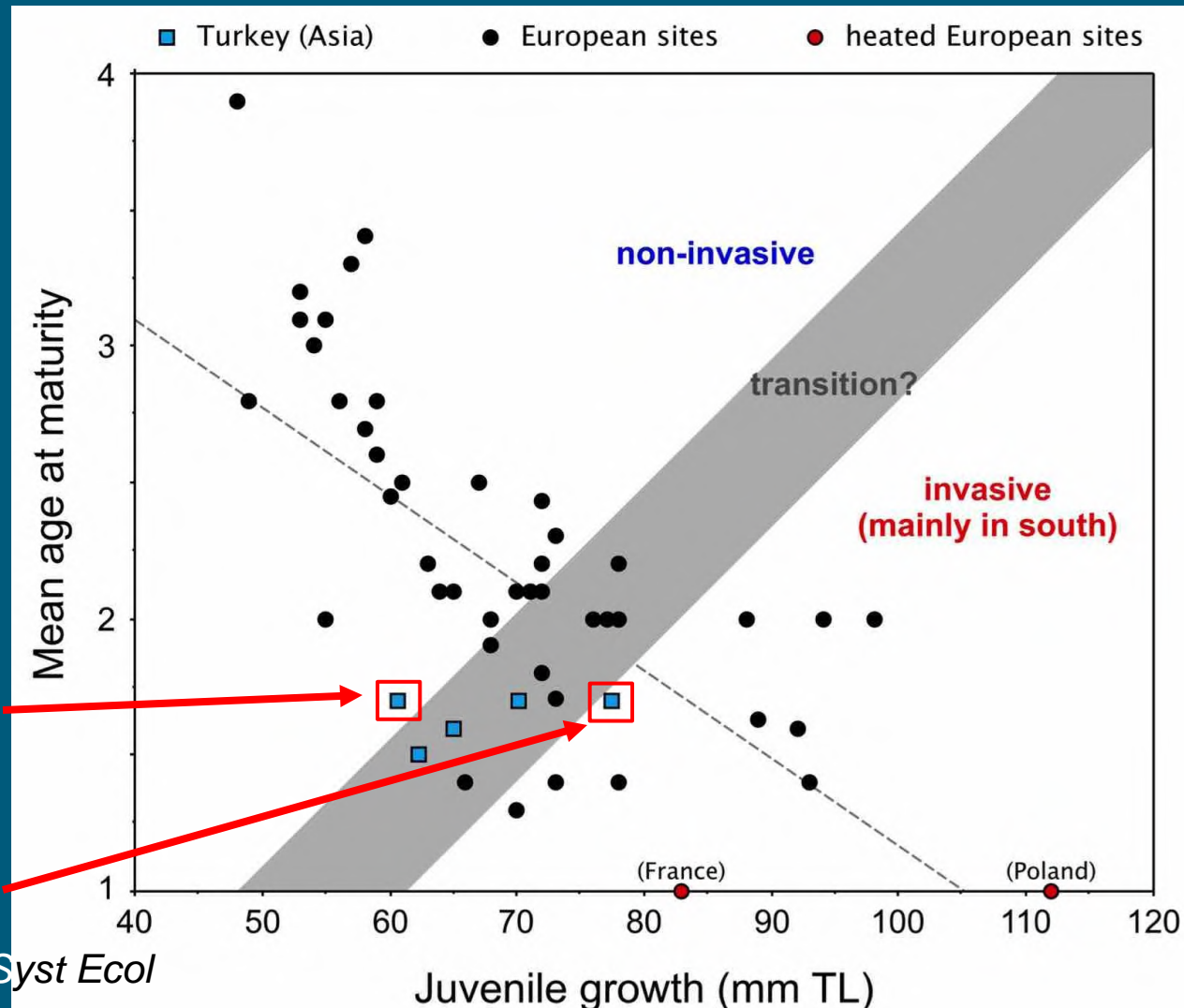
Pops with greatest age 1 growth

Predicting life-history changes under climate warming (B)

Phenomenon also observed in Europe vs. Asia (Turkey)

Turkish populations:
• most temperate climate (just inside Europe)

• most Mediterranean & southerly climate (Asia)

Ağdamar *et al.* (2016) *Biochem Syst Ecol*

Predicting life-history changes under climate warming (greater dispersal due to floods/spates)

Watersmeet (garden) pond – adjacent to small stream immediately below small in-line reservoir (trout fishery)

- No pumpkinseed in pond found prior to flood in 2007
- Established population found in 2010

source reservoir

Batts Stream

flooded pond at Watersmeet House

Fobert *et al.* (2013) *Ecol. Freshwat. Fish*

Cefas

Predicting L-H changes under climate warming

Relative to source population, PS increased juvenile growth & reduced age at maturity

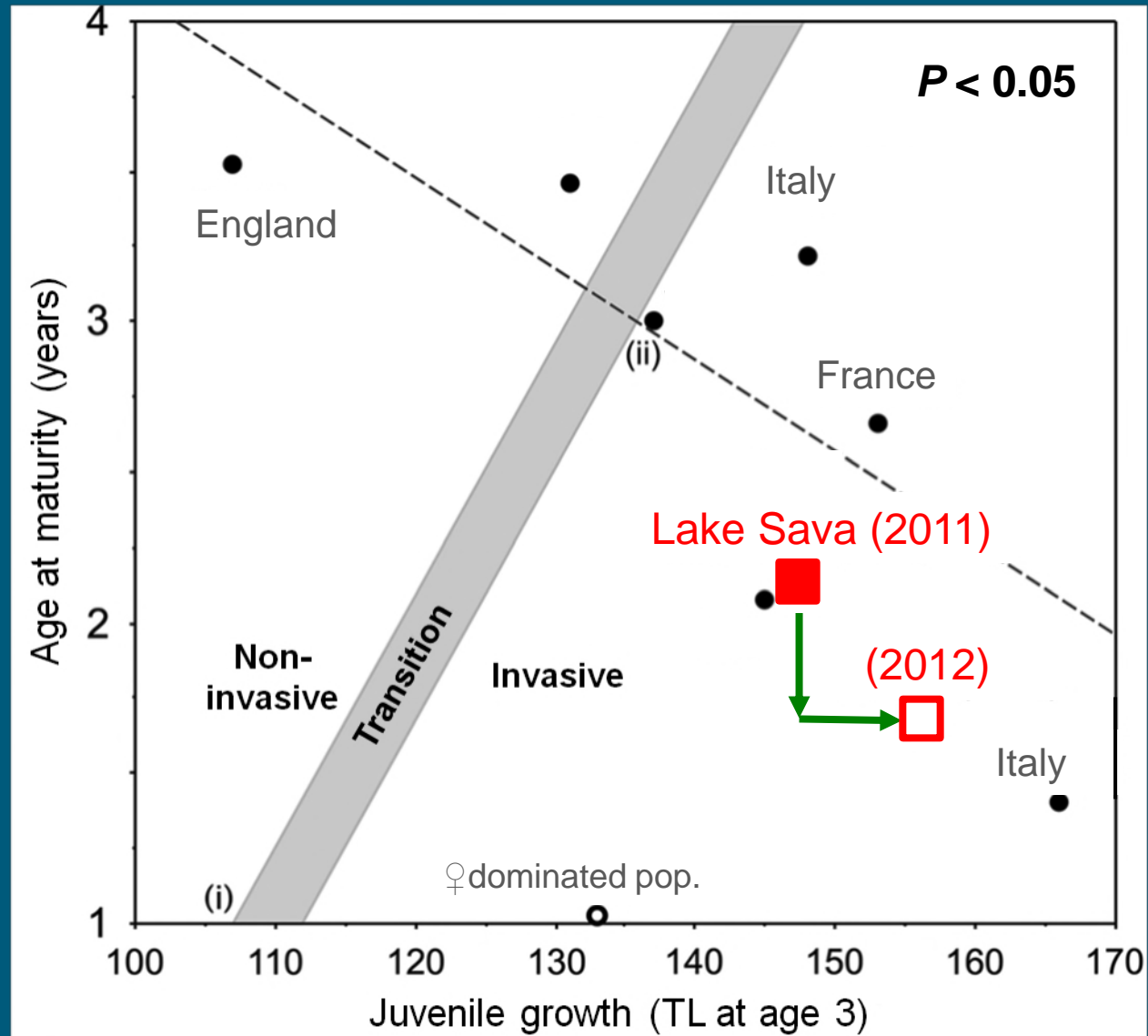Fobert *et al.* (2013) *Ecol. Freshwater Fish*
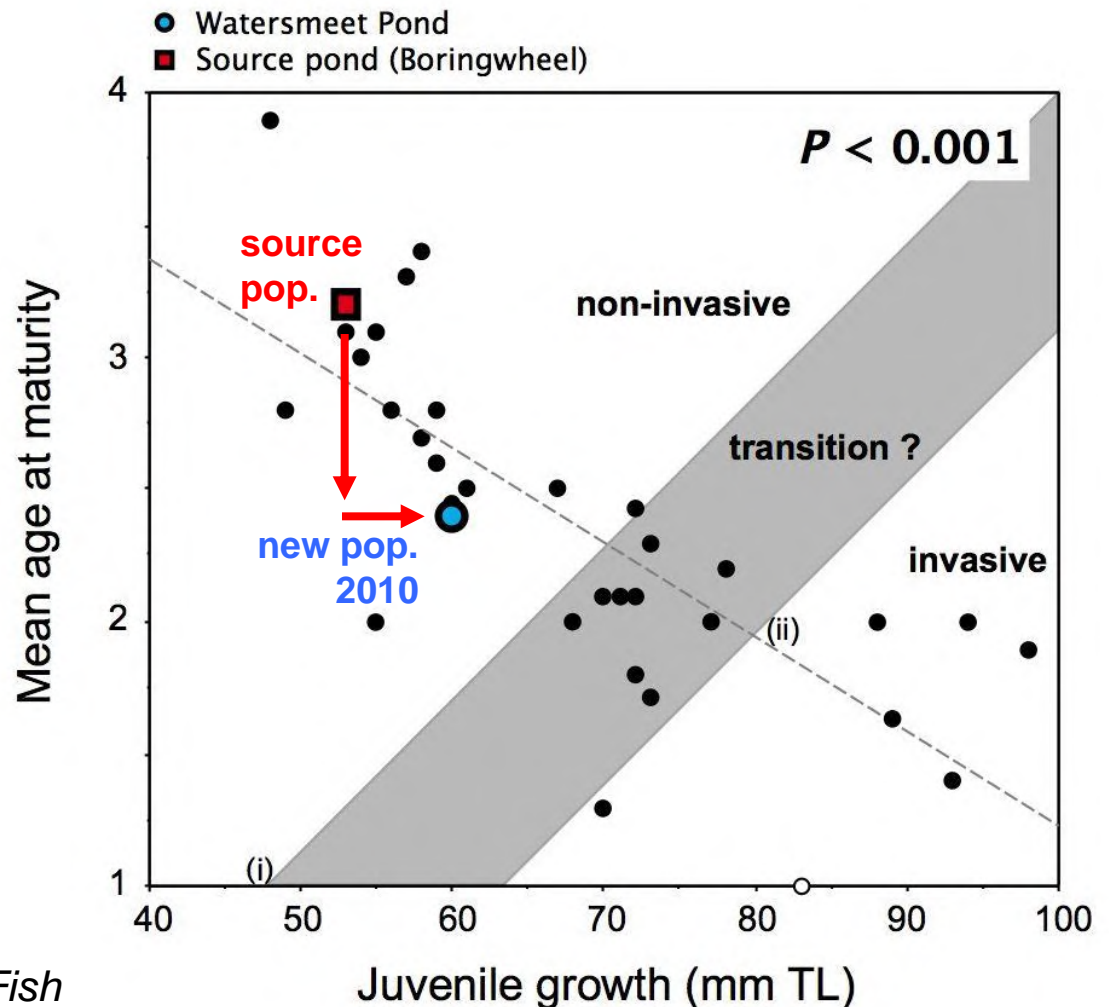
Applying this L-H model to other fish species

Black bullhead (*Ameiurus melas*)

– After population crash of in Serbian river: increased juvenile growth & earlier maturation

Copp *et al.* (2016) *Rev Fish Biol & Fisheries*

Jaćimović et al. (2019) *Fish Mgmt Ecol*

P < 0.05

England

Italy

France

Lake Sava (2011)

(2012)

Italy

Non-invasive

Transition

Invasive

♀dominated pop.

(i)

(ii)

Age at maturity (years)

Juvenile growth (TL at age 3)

Applying this L-H model to other fish species

Crucian carp (*Carassius carassius*) – cyprinid native to continental Europe introduced to UK (recent genetics study revealed likely intro to UK ≈700 years ago)

Tarkan *et al.* (2016) *Aquat. Conserv.*
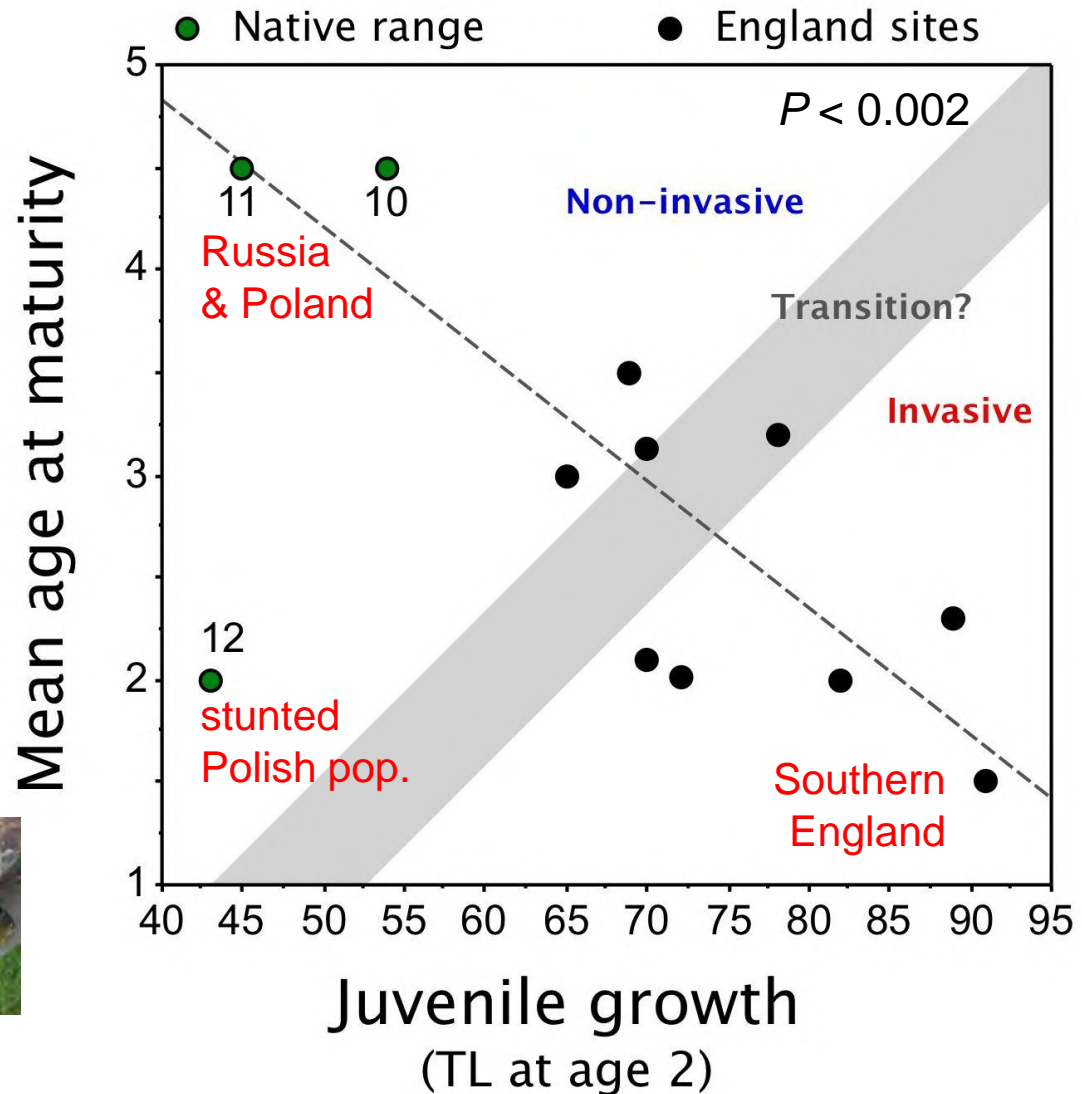
Conclusions & caveats (A)

• Juv. growth *vs*. age at maturity relationship offers potential biological means of predicting invasiveness in pumpkinseed

• This model can also be used to predict likely life-history response of pumpkinseed to higher temperatures and new invasions

• This relationship appears to be valid for other medium-to-long lived (warm-water) fishes, regardless of taxonomic Family

Conclusions & caveats (B)

• Cool-water species may not show increased growth rates in warmer waters. The growth-maturity relationship may still hold, but it may not be a linear function of water temperature

• Early maturity usually assoc. with ⇑ repro. allocation/ effort (i.e. more progeny). This can ⇑ pop. densities & dispersal, but only if more progeny mature & breed

• Biotic or abiotic factors may prevent this, so this general growth-maturity model is only a rough predictor of "invasiveness"

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Cefas

Questions ?

PRIMARY RESEARCH PAPER

New and Old World phylogeography of pumpkinseed *Lepomis gibbosus* (Linnaeus, 1758): the North American origin of introduced populations in Europe

Stan Yavno · Jenilee Gobin · Chris C. Wilson · Anna Vila-Gispert · Gordon H. Copp · Michael G. Fox

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