Assessing pollution exposure for a long-lived top predator population

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CONTEXT

- The ongoing mass extinction threatens many **long-lived top predators**
- Threats include **multiple stressors**, e.g. trophic downgrading, climate change, habitat alteration, environmental pollution.
- Long-lived species can show **cumulative and delayed responses** due to their ability to store energy reserves, and features such as late sexual maturity.
- **Reptiles** are particularly vulnerable, e.g. territorial, slow metabolism, limited detoxification capabilities.
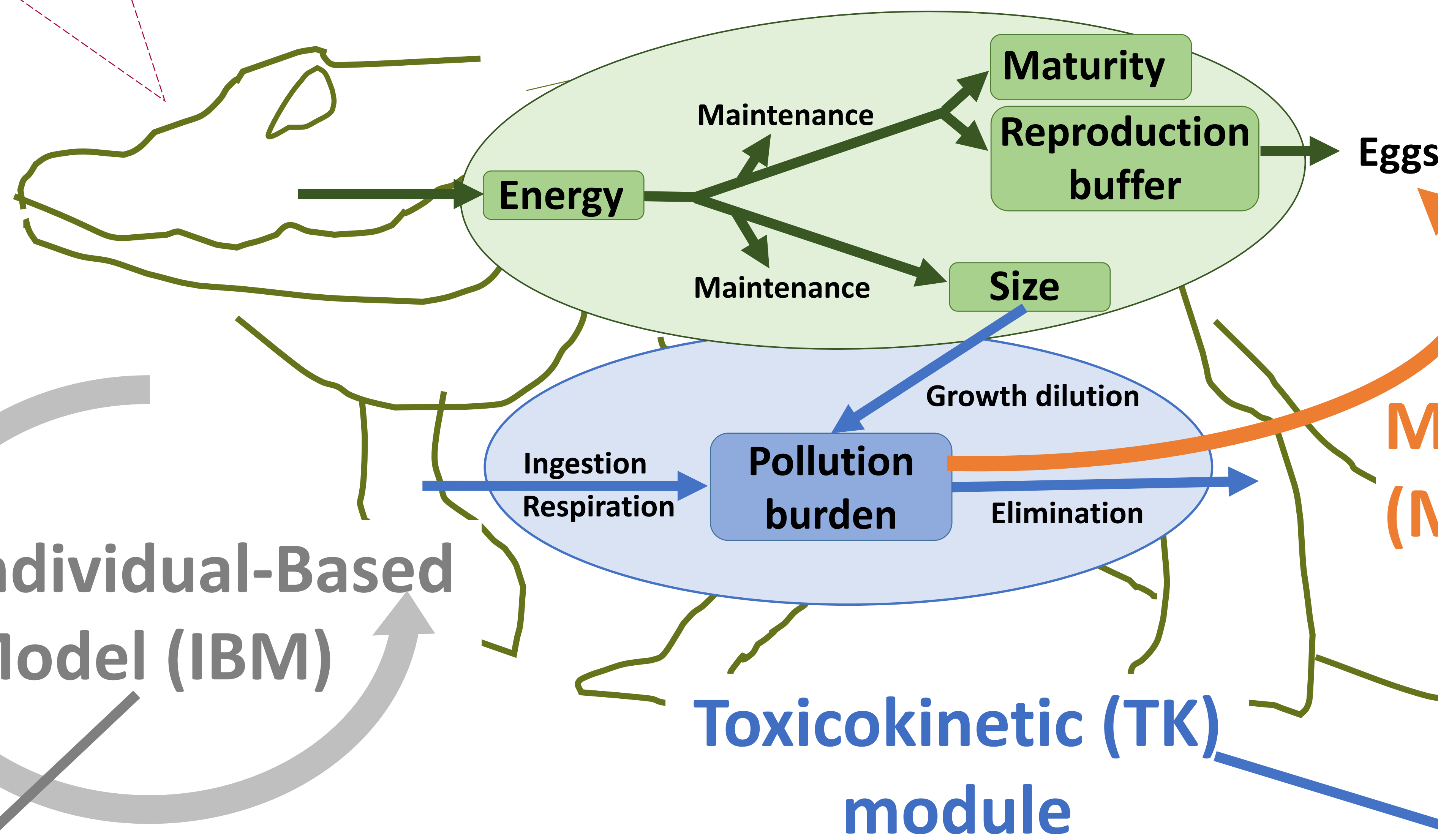
OBJECTIVES

Develop a model to:
- Increase **understanding of mechanisms** leading to lifetime accumulation of *persistent organic pollutants* (*POPs*).
- Assess **risk to populations** from accumulated POPs.
- Evaluate influence of **individual variation** and **multiple stressors**.

CASE STUDY: American alligators exposed to POPs

OUTCOMES

- The research contributes to integrating and synthesising limited data on reptile **ecotoxicology**, **physiology** and **ecology**.
- The model allows *in-silico* **experimentation** to **reduce animal testing** and assess risks for **long-lived species** for which laboratory experiments are often unfeasible.
- Preliminary modelling approach shows growth, reproduction and pollution accumulation can be recreated.
- Preliminary scenarios indicate high initial accumulation due to maternal transfer, and differences between sexes in the adult stage.

INPUTs

- **Food** availability & individual variability
- **Temperature** time series
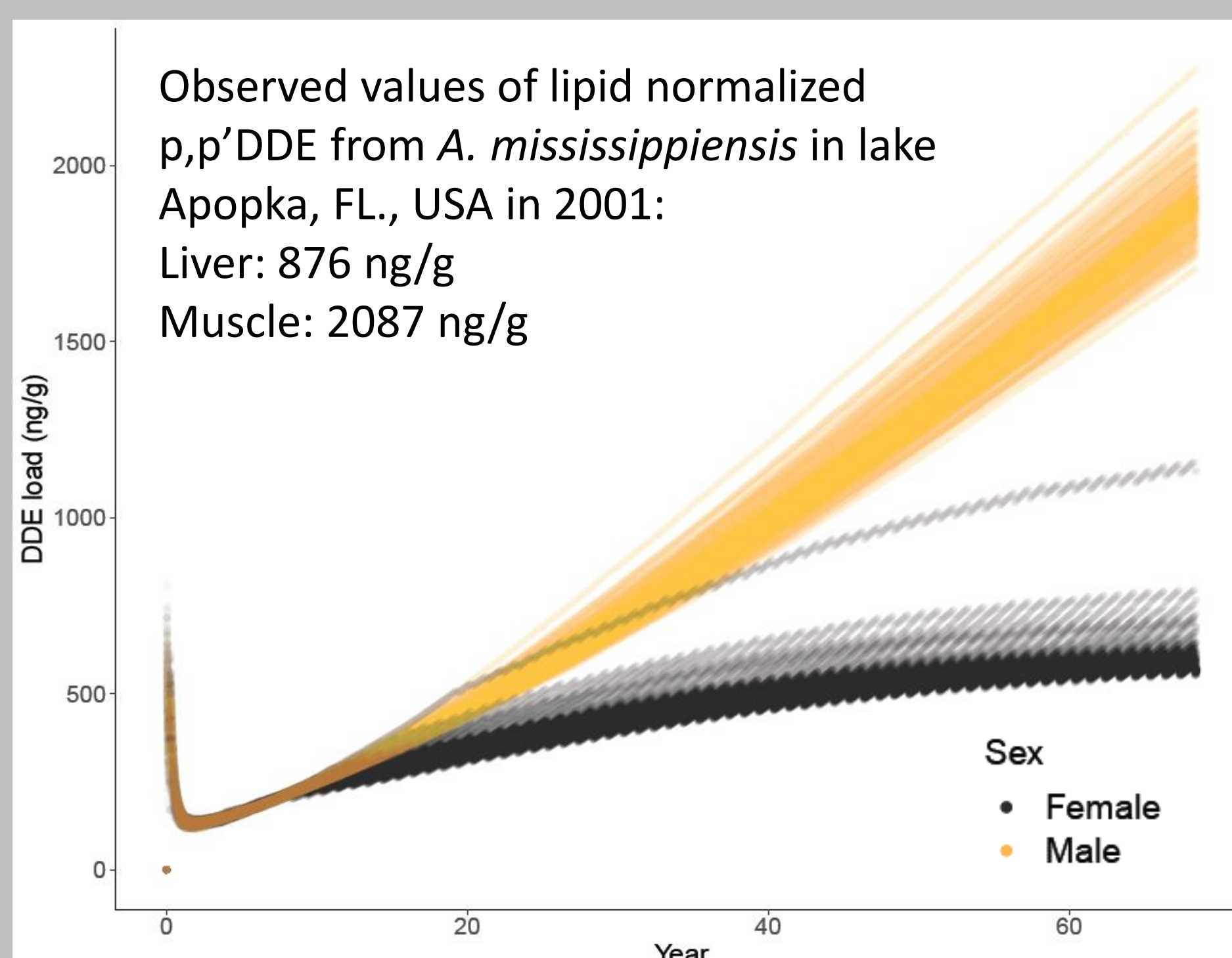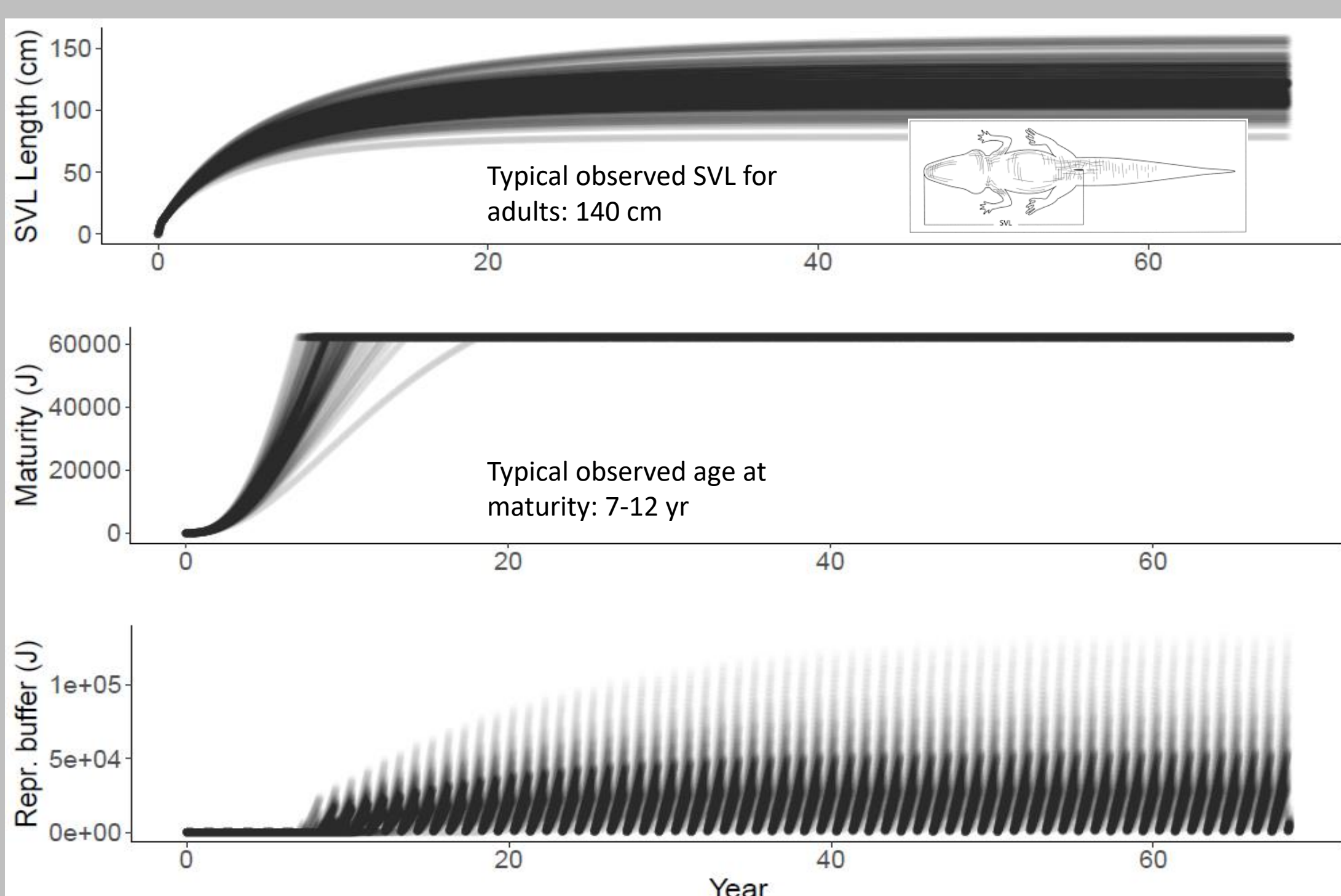- **Pollution** levels in fish

Dynamic Energy Budget (DEB) module

- **Calibration data** compiled from the literature:
  (1) Embryo and juvenile growth
  (2) Reproductive output of adults
- **Prior information** from the Add-my-Pet database
- **Bayesian inference** to obtain parameter estimates, incl. uncertainty estimates and correlations

Maternal Transfer (MT) QSAR

- Our results in sea turtles demonstrate **compound-specific maternal transfer** rates, related to selective uptake and mobilization of POPs during vitellogenesis. (*Muñoz and Vermeiren 2020 ET&C 39:9-29*)
- The research is being **expanded to other reptile species,** incl. developing a maternal transfer database and a **specific model of selective maternal transfer from a QSAR approach**

Individual-Based Model (IBM)

Toxicokinetic (TK) module

- The **DEB + TK + MT QSAR** modules were combined into an **IBM** (daily timestep, ran for 70 yr.)
- Simulations (with preliminary parameter estimates): 100 females & 100 males with **variable food** availability & **constant pollution exposure** (based on fish levels 2004-08) and **temperature** (33 deg. C)

Typical observed SVL for adults: 140 cm

Typical observed age at maturity: 7-12 yr

Observed values of lipid normalized p,p'DDE from *A. mississippiensis* in lake Apopka, FL., USA in 2001:
Liver: 876 ng/g
Muscle: 2087 ng/g

- A first implementation includes **diet uptake**, **growth dilution** and **maternal offloading**
- Further development incl. **respiration** and **distribution** to key tissue groups + toxic effects