United States
Environmental Protection
Agency

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Summary Report:
Risk Assessment Forum Technical Workshop on Population-level Ecological Risk Assessment


Supplementary Material:
Workshop Presentations

Office of the Science Advisor
Risk Assessment Forum

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Supplementary Material:
Workshop Presentations

Risk Assessment Forum
U.S. Environmental Protection Agency
Washington, DC 20460

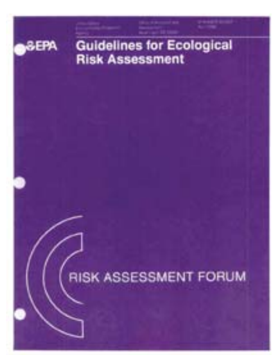
NOTICE

RAF's Activities in Ecological Risk Assessment

June 16, 2008
Elizabeth Lee Hofmann, Ph.D.
Executive Director
Risk Assessment Forum

Long-term RAF Accomplishments

- **1992:** EPA's Risk Assessment Forum developed *"Framework for Ecological Risk Assessment"*
- **1998:** Published the *"Guidelines for Ecological Risk Assessment"*
- **2003:** Produced the *"Generic Ecological Assessment Endpoints (GEAEs) for Ecological Risk Assessment"*
- **2006:** RAF held a Population Ecological Risk Assessment Modeling Training Workshop



Current State of ERAs

- Current practice focuses on organism-level endpoints
  - Practical (uses toxicity testing)
  - Expedient (extrapolate to the population)
- This approach assumes if you protect the individual (organism), you in turn protect the population

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- Shift from organism-level to population-level endpoints
  - Allows direct evaluation of risk to populations
- This shift will require:
  - Improved assessment planning
  - Evaluation of historical precedence
  - Evaluation of practice and use of population assessments

Meeting Goals, Process & Outcomes

- Goals:
  - Solicit your individual opinions
  - Assess current state-of-the-science
  - Discuss population ecology's methods and tools
- Three approaches for conducting assessments
  - Observational, Experimental, and Modeling
- Summary workshop report

- RAF Staff (Seema Schappelle, Colleen Flaherty, Gary Bangs)
- Wayne Munns (ORD) and Jim Chapman (Region 5)
- Todd Bridges (from USACE)
- Richard Sibly (University of Reading)

Risk Assessment Forum

Workshop on
Population-Level Ecological Risk Assessment

Workshop Overview

EPA RAF Workshop on Population-Level Ecological Risk Assessment

Context for Workshop

- Continuing dialog revolving around populations as fundamental ecological units to consider in environmental decisions
- Lack of consensus & guidance about approaches for assessing risk
- Assessments at population level are:
  - becoming more commonplace
  - *ad hoc*
  - often contentious

EPA RAF Workshop on Population-Level Ecological Risk Assessment 2

Why We're Here

- To draw a line in the sand regarding maturity of science and practice
- To inform decisions by U.S. EPA's Risk Assessment Forum regarding development of guidance



Workshop Objectives

1. Identify current approaches, methods & tools
2. Identify strengths, current limitations, tradeoffs & outstanding research needs
3. Identify technical needs with respect to development of guidance & additional steps to facilitate development of guidance

Approach

- Plenary interactions
  - provide background information
  - communicate needs of EPA & others
  - illustrate case studies
  - identify additional issues to be addressed
- Breakout group discussions
  - gather expert opinion re. state of science & practice
  - organized broadly by methodological approach
- Plenary discussions
  - summarize breakout discussions
  - facilitate cross-approach interaction

Breakouts

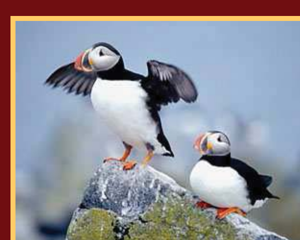
- Observation Approaches
  - monitoring responses of populations to stressors & natural variables in real-world situations
  - sometimes called "ecoepidemiology"
- Experimental Approaches
  - manipulative experiments (e.g., toxicity tests) to evaluate population response
  - performed in laboratory, field or semi-field systems
- Modeling Approaches
  - application of process models to evaluate general & specific population risk problems
  - often based on underlying biological processes

General Considerations

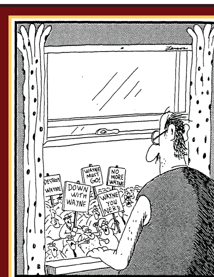
- Helping to define maturity of science & practice, and not recommending specific approaches or developing guidance/best practice descriptions
- Exploring technical issues & considerations, and not policy issues
- Seeking individual input & opinions, and not consensus statements

Expected Products & Uses

- Workshop report
  - summarizing discussions
  - communicating steering committee recommendations
  - input to RAF follow-on activities & potentially to guidance
- Distribution & publication
  - RAF web site
  - peer refereed article(s)?



Key Contacts



The world was going down the tubes. They needed a scapegoat. They found Wayne.

- Seema Schappelle, RAF Liaison
- Jerry Cura, Workshop Facilitator
- Breakout Groups Leads
  - Observational approaches: Glenn Suter, Mary Sorensen
  - Experimental approaches: Tom Forbes, Diane Nacci
  - Modeling approaches: Steve Newbold, Rob Pastorok
- Amy Barnes, Muncie Wright, Joan Gades, logistics & recording
- RAF Working Group & Steering Committee

Risk Assessment Forum

Workshop on
Population-Level Ecological Risk Assessment

Setting the Stage: Relevant Past Activities

Some Precursors

- U.S. EPA Risk Assessment Forum activities
- SETAC Pellston workshop in Denmark
- SETAC LEMTOX workshop in Germany

Initiating RAF Activities

- 1998 *Guidelines for Ecological Risk Assessment*
- RAF Colloquium in 1999
  - to identify nature & scope of follow-on projects
  - focused on assessment endpoints, risk characterization & effects at higher levels of biological organization
  - identified specific activities for population & communities endpoints, including guidelines (model development, selection, use & interpretation)

Current RAF Project

- Working group of EPA staff
- Training in use of models in population-level ecological risk assessment
- This workshop
- Follow-on activities?

SETAC Pellston Workshop

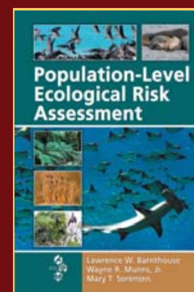
- *Population-Level Ecological Risk Assessment*
- August 2003 in Roskilde, Denmark
- Experts from USA, Europe, Japan & Australia
- Focus on advancing acceptance & practice of population-level ecological risk assessment

Pellston Objectives

- Evaluate policy contexts for assessments
- Explore technical issues & opportunities
- Identify appropriate empirical & modeling methods w/in varying decision contexts
- Develop a framework for conducting population-level assessments to support risk management decisions

Key Pellston Conclusions

- Science sufficiently mature
- Develop program-specific guidance for use of models & data within a tiered assessment format
- Develop training to improve communication with managers & stakeholders
- Define acceptable population risk in different management contexts



SETAC LEMTOX Workshop

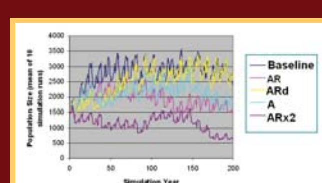
- *Ecological Models in Support of Regulatory Risk Assessments of Pesticides: Developing a Strategy for the Future*
- September 2007 in Leipzig, Germany
- Experts from Europe, USA & Asia
- Primary focus on role of population modeling in risk assessments supporting regulatory submissions in the EU

Specific LEMTOX Questions

- Benefits of population modeling to pesticide registration?
- Obstacles preventing use of population models in pesticide risk assessment?
- How can obstacles be overcome?
- What recommendations will help ensure good population modeling practice in pesticide risk assessment?

Key LEMTOX Conclusions

- Develop guidance on Good Modeling Practice
  - model development & evaluation
  - documentation & communication
  - analysis & interpretation
- Case studies to explore value added by using models



Is There a Potential for Using Population Models in the Aquatic Life Criteria Program?

Charles Delos
Office of Water

June 16, 2008

Aquatic Life Criteria & Standards

- Define biological goals in terms of community, not particular species.
  - Biocriteria: densities of indigenous species
- Claim to protect populations, not individuals.
- Chemical criteria describe level of protection based on toxicity test responses:
  - % of individuals
  - % of species

Program Use of Population Models

- Saltwater dissolved oxygen criterion (2000):
  - Used population model in deriving the time-variability facet of the criterion.

- Future toxicant criteria derivation method:
  - Talked to Science Advisory Board three times (1993-2005) about our proposed approach incorporating population modeling as a critical component.

Case Study:
Time-Variable Exposure Problem

- concentrations vary rapidly in flowing waters -

- To address the question:

  How often can toxicant criteria concentrations be exceeded without impairing aquatic life beneficial uses?
  - Traditionally the program had cited ecological recovery time as a key determinant.
  - Office of Water and Office of R&D favored use of population modeling considerations.

- How does a population respond to exposure to time-variable levels of effect?
  - How quickly does attrition take place when reproduction or early life stage survival is reduced?
  - How long does it take to replace individuals lost to toxicity?

Components of the Case Study Assessment

Consider the Sensitivity of Tested Species

Genus	Chronic EC20 (mg/L)
Ceriodaphnia	16.10
Daphnia	12.30
Ictalurus	8.84
Catostomus	4.79
Micropterus	4.56
Pimephales	3.09
Lepomis	2.85
Muscullium	2.26
Hyalella	1.45

For Each Species, Consider the Effect of a *Long* Series of Daily Exposures, Applying Two Models

- Kinetic toxicity model to translate from lab test exposures to continuously variable concentrations.
- Life-stage structured population model to reflect:
  - Population reduction from effects on survival and reproduction.
  - Rate of recovery after population loss.

Kinetic Toxicity Model

- Structured as a first-order, single-compartment accumulation model:
  - Accumulation-depuration
  - Damage-repair
- Calibrated to acute & chronic effects data.
- May take one of two forms:
  - Stochastic Process Model
  - Deterministic Process Model

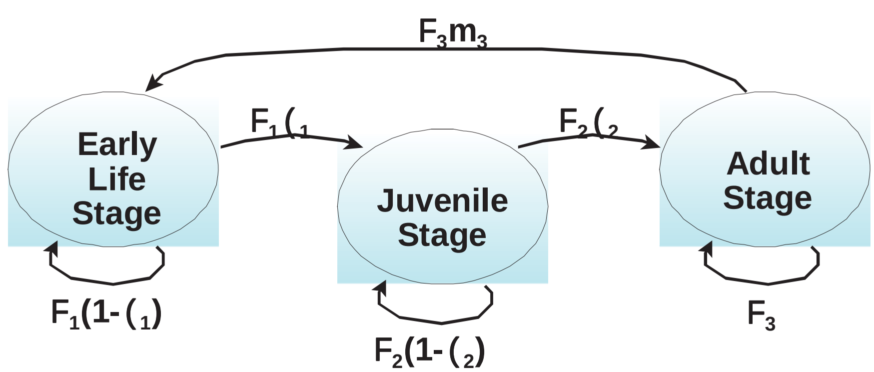
One Form of Toxicity Model

- Stochastic Process Model
  - An organism ***might*** die if stress exceeds a certain threshold.
  - All individuals in a life stage have identical sensitivity.
  - Partial toxic responses are a manifestation of probabilities of effects appearing among the identical individuals.

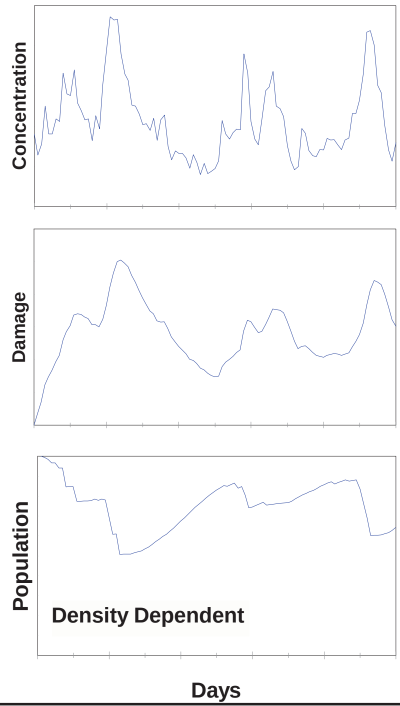
Second Form of Toxicity Model

- Deterministic Process Model
  - An organism ***will*** die if stress exceeds a certain threshold.
  - Different individuals have different sensitivity.
  - Partial responses stem from these differences.
  - Better fits the data. Recognizes “survivor bias”.
  - Requires that population model maintain an accounting of groups having differing sensitivity.

Stage-Structured Population Model



- Toxicant concentration, short example
- Accumulation of stress or damage
- Population response



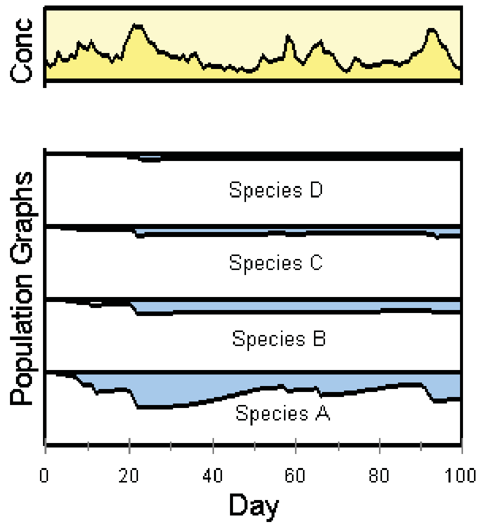
Risk Measure

- Society for Risk Analysis definition of "risk":

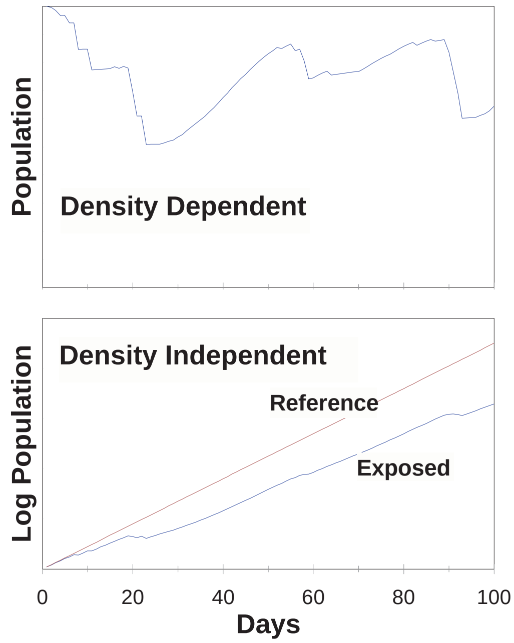
The probability of the event occurring times the consequence of the event if it occurs.

- The expected value of loss: $\Sigma\, p_i\, loss_i$
- Measured in the units of what is lost, in our case, percentage of the population.

Obtaining Criterion that Protects One Assemblage
- Using Density-Dependent Model -



Density-Dependent versus Density-Independent Approaches



- Reduction in population density
- Reduction in population growth rate

How to Make Density and Growth Reduction Mathematically Equivalent

Condition 1
Define Endpoints as Long-Term Fractional Reductions

Density-dependent density reduction	Density-independent growth reduction
$\sum_{t=1}^{T} \frac{N_{Ref} - N_{Exp}}{N_{Ref}}$	$\frac{r_{Ref} - r_{Exp}}{r_{Ref}}$

Condition 2
For the Density Dependent Approach
Use Beverton-Holt Survival Function

Reference daily survival is the joint probability of surviving:

– Ordinary perils. *Density-independent* background survival probability: ***a constant***.

– Crowding. *Density-dependent* survival probability: ***Beverton-Holt function***.

$$\frac{1}{1 + \alpha N}$$

How to Make Density and Growth Reduction Mathematically Equivalent

Condition 3
Set Density-Dependence Parameter, α, to Maintain Density-Independent, Unlimited Growth Age Distribution

- For two life stages, $\alpha_1/\alpha_2 = N_2/N_1$ where N is from unlimited growth model results.
- The DD model ends up with the same degrees of freedom as the DI model.

Result of Applying the Previous Three Conditions

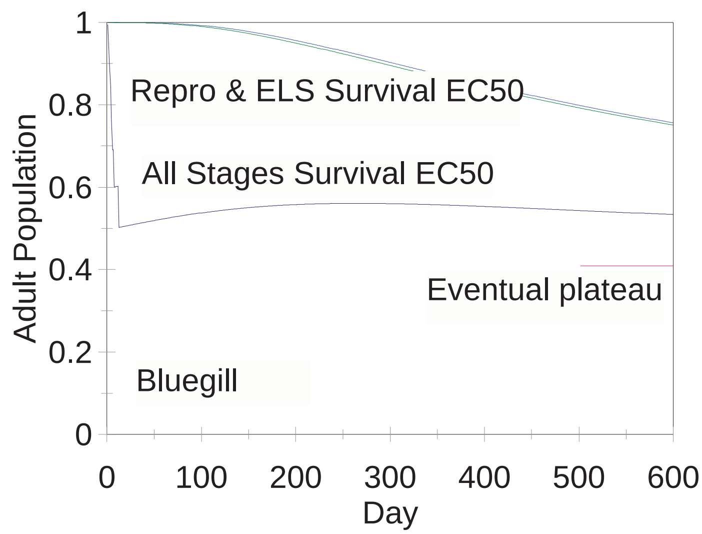
- The combined density-independent and density-dependent assessment can be thought of as:
  - A *population growth assessment,*
  - Made more understandable through a *density translation or interpretation*, given certain assumptions about the density dependence.

Another Question Suited to Application of Population Models

- The WQ Criteria Program routinely says it protects species populations by protecting:
  - Survival of the most sensitive life stage.
  - Reproduction.
- Does reducing reproduction have the same effect as reducing survival?
- Does reducing early life stage survival have the same effect as reducing adult survival?

Rapidity: Mortality v. Repro Effects

Bluegill: maturity time 2 yrs, λ = 1.002 (/day) = 2 (/yr)



What About Time-Varying Background Conditions?

- This assessment
  - Does not address seasonality.
  - Does not address good years versus bad years for the reference population.
- Thus, the reference population growth rate or density is uniform throughout the simulation.
- If the background varied between favorable, midrange, and adverse conditions, how would it affect the results?

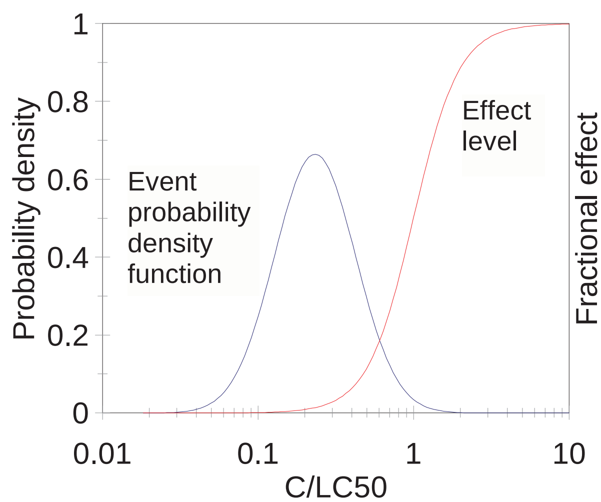
Effect of Time-Variable Background Conditions

- The endpoints used by this assessment are not affected.
- But other possible endpoints, such as used in PVA, would be strongly affected.
- Conclude: what needs to be included in the analysis depends on the question asked.

Can We Effectively Address Time Variable Exposure Without Using Population Modeling?

Combining Probability of a Concentration with the Toxicity-Test Response Curve

Alternative Risk Paradigm

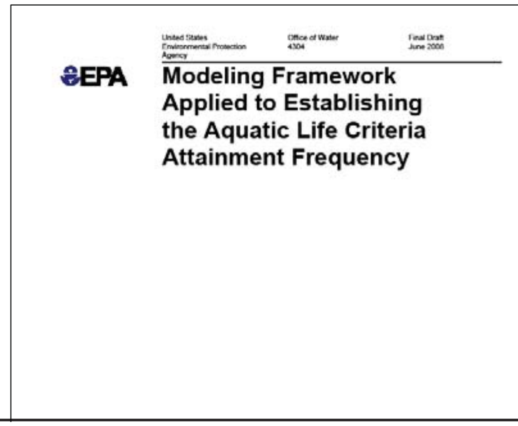


Comparing the Alternative Risk Paradigm with the Coupled Toxicity Model & Population Model

- Alternative risk paradigm:
  - Omits kinetics of toxicity.
  - Omits sequencing of events.
  - Cannot discern life-stage sensitivity differences.
  - Omits persistence of loss (recovery time).
- For same exposure series, fingernail clam:
  - 4.4% reduction, alternative risk paradigm.
  - 6.9% reduction, kinetic & population models.

Future of Population Models in Aquatic Life Criteria?

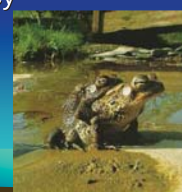
- Additional complexity not especially welcome.
- Mature program: change is problematic.
- But… the program has allowed release of the draft assessment document to the workshop participants.


United States Environmental Protection Agency | Office of Water 4304 | Final Draft June 2006

Modeling Framework Applied to Establishing the Aquatic Life Criteria Attainment Frequency

Population Modeling in Ecological Risk Assessment Regulatory Perspective

Edward Odenkirchen, Ph.D.
Office of Pesticide Programs
United States Environmental Protection Agency
June, 2008



Goals of the presentation

Explain:

- How population modeling fits into the regulatory process
- Benefits of population modeling
- Requirements of models used for regulatory purposes
- Challenges facing use of models in regulation
- Current Efforts in OPP
- Perspective of pesticide regulation

"your mileage may vary"

FIFRA Regulatory Decisions

- The Administrator shall register a pesticide if he determines that “when used in accordance with widespread and commonly recognized practice it will not generally cause unreasonable adverse effects on the environment”

  PL 95396, sec. 3(c)(5)(D)

- “Unreasonable adverse effects on the environment means any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide”

  PL 95396, sec. 2(bb).

Prediction of population effects has been part of Agency concerns for some time

- *“Reputable presumption of risk shall arise if a pesticide’s ingredients, metabolites, or degradation products …can be reasonably anticipated to result in significant local, regional, or national population reductions in nontarget organisms.”*

Federal Register Vol. 40 number 129, July 3, 1975

Prediction of population effects has been part of Agency concerns for some time

- *"Define ecological risk assessment. . . as estimating the likelihood or probability of adverse effects (e.g. mortality to single species of organisms, reduction in populations of non-target organisms due to acute, chronic, a reproductive effects, or disruption in community and ecosystem level functions"*

Urban and Cook, 1986

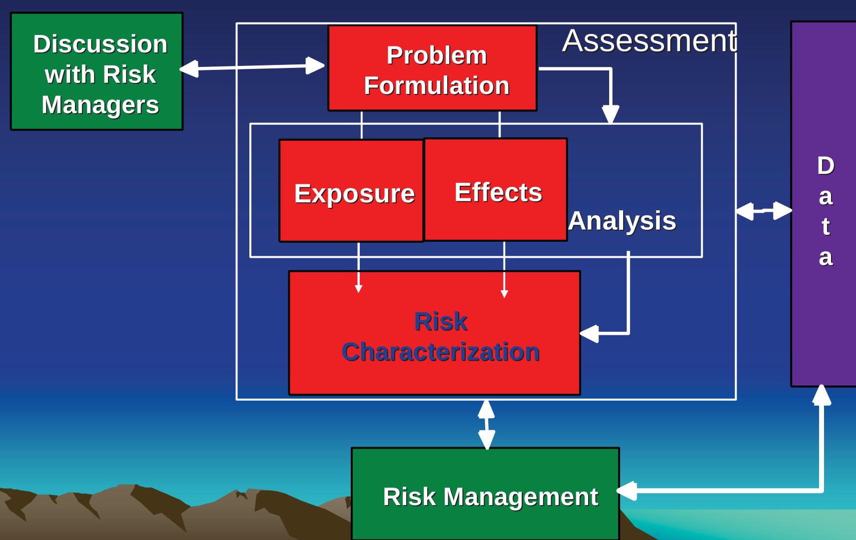
Prediction of population effects has been part of Agency concerns for some time

Risk Manager Questions

- What are the effects of concern?
- What is the magnitude and probability of these effects ?
- Are the effects seen across different species ?
- **Will there be population effects?**
- Will the effects influence the density and diversity of the species?
- How confident are we in our estimates of effects?

(Steve Johnson 1997, currently EPA Administrator)

EPA's Risk Paradigm



Screening-Level Ecological Risk Assessments

- Focus on assessment endpoints related to survival, fecundity, and growth
- *"These assessment endpoints, while measured at the individual level, provide insight about risks at higher levels of biological organization (e.g., populations)."*
  Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency 2004
- For many risk management decisions these assessment endpoints and their inference to population effects are sufficient to inform the management decision

The Regulatory Picture Informs the Rigor/Complexity of the Assessment

- Decision components such as the predicted benefits and the nature of the expected effects may dictate the level of risk assessment complexity.
- Some cases may require only the initial screening efforts
- Others may progress from simple risk quotient approaches to estimation of the probability and magnitude of individual effects and (in the future) on to model predictions of population responses.

Benefits of Population Modeling

- Provide limited interpretations of screening level risk assessment results
  - RQs → magnitude of effects → simple generic population tools
- Refine problem formulation for future risk assessments
  - Explore demographic characteristics
  - Identify types of species of greatest concern
- Provides for common evaluation metric for cross chemical and cross effects prioritizations
  - When are acute or chronic effects more important?
  - Which chemical's suite of risk predictions is of more concern?

Benefits of Population Modeling

- Allow for considerations of temporal and spatial variability in evaluating the consequences of predicted individual effects
  - When or where can populations sustain temporary impacts?
  - Support biologically relevant mitigation options
- Evaluations of effects consequences for species of special concern (e.g., federally listed threatened or endangered species)
  - Assessments under the Endangered Species Act to inform the question of species jeopardy
- Future: support efforts to establish risk and benefit measures in common units

Requirements of models used for regulatory purposes

- Make use of existing effects data sets
  - Minimize reliance on effects endpoints that are outside current testing capability
- Model variables can be readily populated with existing data sources
- Compatibility with existing individual risk prediction tools

Requirements of models used for regulatory purposes

- Adapt/Use existing Models from other programs and scientific literature when practical
- Use of publicly accessible models (avoiding proprietary models if possible)

Requirements of models used for regulatory purposes

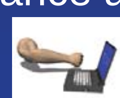
- Explicit about model assumptions, uncertainties, and limitations
  - What simplifying assumptions have been made?
  - How do those assumptions limit the application and interpretation of predictions?
- Explicit about the model predictions
  - Statements of the nature of the predictions being made
  - Output of the model is based on agreed upon needs from risk managers

Requirements of models used for regulatory purposes

Model architecture that allows for advancement of the model in complexity and realism

- Avoiding different tools at different levels of refinement when practical
- Allow for incorporation of additional variables without developing a new tool at each iteration

Requirements of models used for regulatory purposes

- Scientific peer review following Agency approaches (e.g. OPP SAP) 
- Fulfills Agency quality assurance and quality control requirements 
- Validation? 

Challenges facing use of models in regulation

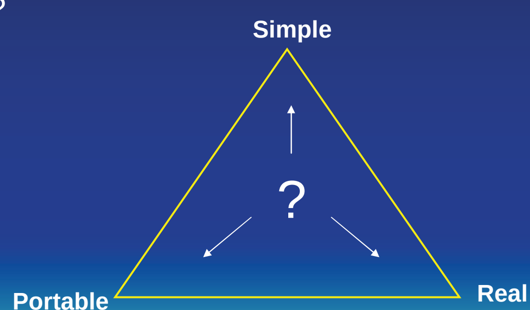
Achieving appropriate balance between three factors:

- Model Simplicity
  - Mathematical/software construct and information requirements
- Model Realism
  - The extent to which the model represents real organisms under real situations
- Model Portability
  - The ability to apply the model across risk assessment scenarios, geographical areas, and organism types

Challenges facing use of models in regulation

Where to position the model?

Is there just one desired position or many depending on situation?



Challenges facing use of models in regulation

- Selecting Informative Outputs
  - Numbers of organisms
  - Age structure changes
  - Trajectories over time
  - Time to some threshold of concern
  - Chance of recovery or extinction
- Outputs as stand alone measure or relative changes to some null/background condition

Challenges facing use of models in regulation

- Dealing with the propagation of uncertainties in individual effects risk predictions
    - Can we avoid zero to infinity uncertainty bounds?
- Overcoming the temptation to account for all possible variables at every level of assessment
- Deciding between generic life histories and actual species

OPP Efforts

- Currently partnering with the Office of Research and Development on several projects
- The goals for these projects
  - Produce tools for near term application
  - Provide a framework for development of more refined population tools
  - Establish a basis for dialogue with risk managers on expected outputs and capabilities of population models

OPP Efforts

ORD Mid-continent Ecology Division

- Methods to extract reproduction endpoints from avian reproduction tests for future population modeling
  - Move from existing hypothesis testing based assessments
  - Incorporate the full extent of measurement endpoints
  - Apply these endpoints to appropriate stages in the avian reproduction cycle
  - Utilize OPP refined risk assessment model outputs

OPP Efforts

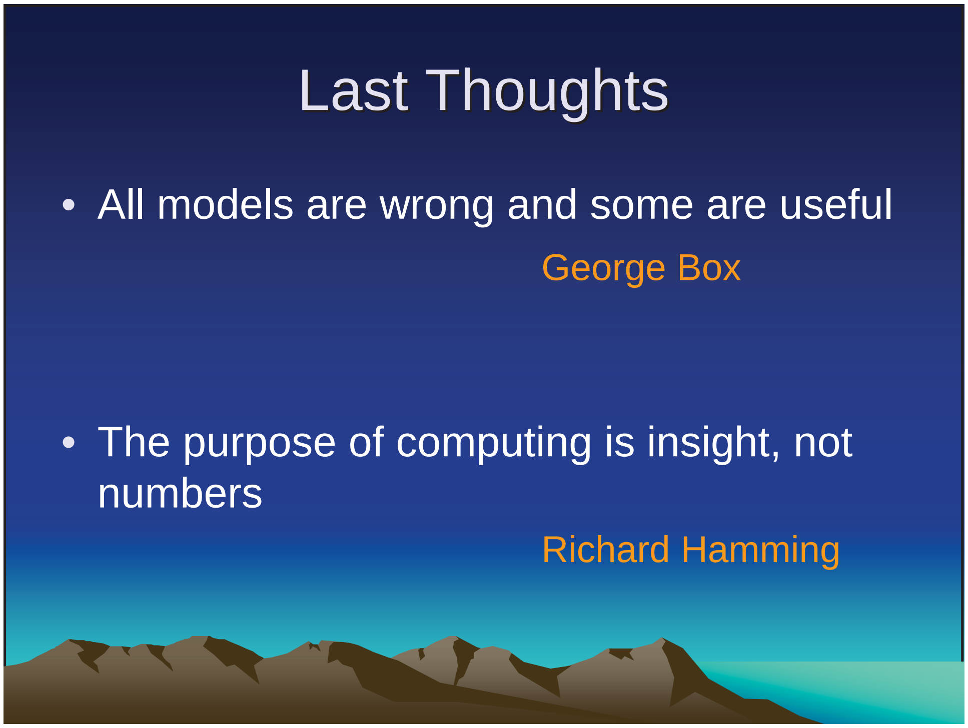
ORD Atlantic Ecology Division

- Proof of concept model for estuarine invertebrates using mysids
- List publicly available aquatic organism population models
  - I.D. models suitable for use in OPP risk assessment
  - I.D. taxa in need of population model development
- Group birds by population demographics/life history for large scale crops
- Matrix population models for life history groups of birds

OPP Efforts

ORD Western Ecology Division

- Developing a spatially explicit meta-population model (PATCH) to predict avian population responses to pesticide use in selected agro-environments
  - Make use of AED matrix models
  - Incorporate OPP refined risk mortality outputs
  - Incorporate MED reproduction impairment output


Last Thoughts
• All models are wrong and some are useful
George Box
• The purpose of computing is insight, not numbers
Richard Hamming

David W. Charters

Environmental Response Team
Office of Remediation and Technology Innovation
Office of Solid Waste and Emergency Response

Risk Assessment Forum
June 16, 2008
Washington D.C.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)

- CERCLA requires EPA to assess risk to Human Health and the Environment at Sites
- Risk is only one of nine criteria for Remedial Decisions

OSWER Directive 9285.7-17

- CERCLA Ecological Risk Assessment Should:
  - 1. Identify and characterize current and potential threats to the environment from a hazardous waste spill
  - 2. Evaluate the ecological impacts of alternative remedial strategies
  - 3. Establish Clean-up levels in the selected remedy that will protect those natural resources.

OSWER Directive 9285.7-28P

- Superfund ERAs gather effects data on individuals in order to predict or postulate potential effects on local wildlife, fish, invertebrates, and plant populations and communities that occur in specific habitats at sites.

EPA as a Natural Resource Trustee

- EPA is not a Natural Resource Trustee
- We do not do damage or restoration, we do risk

Superfund Extrapolates Toxicity Data including Benchmarks to Potential Impacts (risk) to Local Populations

- Superfund based on causal relationships
- Superfund is based on hazardous material spills (“spills” not permitted)
- “Severe” liver damage in a population (laboratory or field collected) is extrapolated to impacts (e.g., increases in mortality, decreases in reproduction).
- Frequently the Cleanup goals are based on No Observed Adverse Effect Levels or Low Observed Adverse Effect Levels or another range of Tox. Benchmarks of which there are many.
- It does not require that impacts are documented on sites, consistent with human health assessments that do not require an epidemiological study showing impacts to take action.

Challenges to Assessing Population Risk at Hazardous Waste Sites

- Size Matters…Small sites restrict data collection...Large sites take time
- Short time frames allotted for a Remedial Investigation/Feasibility Study do not allow for long term studies
- Effects must be linked to hazardous substances releases
- We are probably weakest in the terrestrial and aquatic areas
- Some believe that we can assess risk to individual organisms on a site
- Reference locations
- Unfortunately, a learned aversion to research at sites, there is a great need to unlearn this reaction.

What would be Useful for a Positive Impact of Population Sciences in the Superfund Program?

- Short term studies that could be implemented in two years or less.
- In rare cases that the assessment could take several years, what population metrics could be utilized to develop a numeric cleanup goal.
- Technical projections of individual level effects (e.g., liver toxicity) to population impacts.
- How impacts on relatively small local populations can impact larger populations.
- How very small populations, e.g., threatened or endangered species might be evaluated.

Take Home Message

- We need help in population science
- We are a frustrating bunch many are linear thinkers (like that is a bad thing)
- We generally are engineering based (We are there to fix the problem)
- Many went to school specifically to learn to build walls (and other structures)
- Frontal assaults denigrating our intelligence is met with withholding of funds (Golden Rule)
- We are not quite as slow as people would think
- And talking slower and louder usually does not help

Questions?

Bruce Duncan
U.S. EPA Region 10, Seattle
(WA, OR, ID, AK)

EPA Risk Assessment Forum
Workshop on Population-Level ERA
Crystal City
June 16-18, 2008

**Regional perspective:
Population-level ERA**

EPA REGION 10 DIVE TEAM

Population-level ERA issues

Regional (10) Perspective – with focus on contaminants

•Are there regulatory requirements?
•Management or stakeholder goals to protect populations?
•Are population-level risks involved directly in decisions that are made?
•Where do you think the science is sufficiently developed, and where are advancements needed?
•Are there issues with respect to the state of practice of that science? Application issues? Interpretation issues?
•Do you think some sort of guidance would help to address these?
•Relevant case studies

Population-level ERA issues

Regional (10) Perspective – with focus on contaminants

- Are there regulatory requirements?
- Management or stakeholder goals to protect populations?
- Are population-level risks involved directly in decisions that are made?
- Where do you think the science is sufficiently developed, and where are advancements needed?
- **Are there issues with respect to the state of practice of that science? Application issues? Interpretation issues?**
- **Do you think some sort of guidance would help to address these?**
- Relevant case studies

Population-level ERA issues

Regional (10) Perspective – with focus on contaminants

Shared Goal: To evaluate/predict population-level effects relative to contaminant stress

How might we bring population-level ecological risk assessment into:

- ***CERCLA risk assessments, and***
- ***State water quality standards approval process?***

Why these two uses of *PLERA*?:

•Scale (state v smaller/tiny)
•Purpose (prospective v retrospective)
•Role of trustees (protective v damage assessment)

Looking for:

•How to evaluate & predict at population-level

•How to extrapolate UP from levels below

Keep in mind we do not assess individuals

*Issues related to evaluating population-level effects**

- Definition of population
- Population parameters/measures/etc.
- Interpretation
- Uncertainty Analysis -

these have been well-articulated before

Issues related to evaluating population-level effects

- Definition of population –
relative to the needed decision, (scale, purpose – protect/recover, etc.)

Breeding, migratory, subpopulation, habitat

Issues related to evaluating population-level effects

- *Definition of population*

- Population parameters/measures/etc.*- which are best for:
  - Evaluating contaminants?
  - Existing effects? Potential effects? – *we generally need to predict potential effects and what may happen after an action is taken or even if habitat changes*

density, sex/ratio, age structure, intrinsic rate of growth, …

Issues related to evaluating population-level effects

- *Definition of population*

- *Population parameters/measures/etc.*

- Interpretation
  - what is adverse*?
  - How to make comparisons - with reference conditions/ gradients?

***determining "adverse" is helped by:**
- ***strong relationships (cf vetted paradigms – AWQC; SpS Curves)***
- ***better use of dose/response data***
- ***consider the management decision and the role of protectiveness in balancing uncertainty***

Issues related to evaluating population-level effects

- *Definition of population*
- *Population parameters/measures/etc.*
- *Interpretation*
- Uncertainty Analysis –
  - What happens to the role of the population selected as an indicator/surrogate?
  - Does the assessment become too species-specific?

What I would like to come away with from this Workshop:

1. Ideas on how to mainstream PLERA in regions
   - *Framework,*
   - *Tools,*
   - *Case studies (decisions-protective levels),*
   - *Technical papers*

What I would like to come away with:

2 Useful tips on population measures/parameters *(e.g., analogy to tox testing & tissue residues). How to expand experimental studies*

- *crosswalk measures of exposure & effects for populations*
- *contaminants as a subset of multiple stressors*

Population modeling in economic analysis

Steve Newbold
U.S. EPA National Center for Environmental Economics

EPA Risk Assessment Forum workshop
"Population-level Ecological Risk Assessment"
16 June 2008

The views expressed here are those of the author and do not necessarily represent those of the U.S. EPA. No official Agency endorsement should be inferred.

1

Outline

1. Preliminaries
2. Section 316(b) economic analysis
3. Improved ecological benefits assessments through population modeling

2

Preliminaries

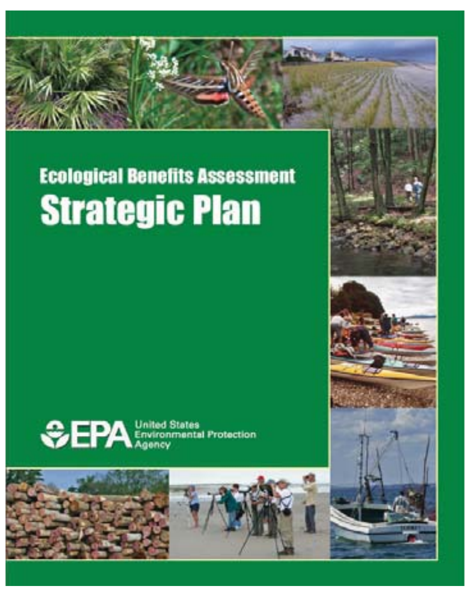
What is the relevance of economic analysis for ecological risk assessment?

1. Many important ecosystem services derive from population-level phenomena. Thus, economic valuation models often will require population-level impacts as inputs.

2. The needs of an economic analysis can help inform the selection of risk assessment endpoints.

3. Improved ERA practices should also help improve economic assessments at the Agency.

3



http://yosemite.epa.gov/ee/epa/eermfile.nsf/vwAN/EE-0485-01.pdf
/$File/EE-0485-01.pdf

4

Section 316(b) of the CWA

"...location, design, construction and capacity of cooling ater intake structures shall reflect the best technology available for minimizing adverse environmental impact" from entrainment and impingement.

In 1994, Riverkeeper sued EPA for failing to implement national standards.

Regulations passed in three phases—new facilities, existing large facilities, existing small facilities.

5

Section 316(b) of the CWA

Benefit-cost analysis:

1. Costs to facilities of installing and maintaining control equipment

2. Benefits of expected increases in commercial and recreational fish harvests from reduced I&E

6

Section 316(b) of the CWA

Final rule:

Of 550 in-scope facilities, 150 to install impingement controls, 200 to install impingement and entrainment controls, 200 required no new controls.

Expected to increase total fishery yield by 65 million lbs / yr.

Total social costs = $390 million / yr
Commercial fishing benefits = $3.5 million / yr
Recreational fishing benefits = $80 million / yr
Total (monetized) net social benefits = -$310 million / yr

7

Section 316(b) of the CWA

Biological model:

$$Y_k = \sum_j \sum_a L_{jk} S_{ja} W_a (F_a / Z_a)(1 - e^{-Z_a}) \quad \text{(Equation 7)}$$

where:

- Y_k = foregone yield (pounds) due to I&E losses in year k
- L_{jk} = losses of individual fish of stage j in the year k
- S_{ja} = cumulative survival fraction from stage j to age a
- W_a = average weight (pounds) of fish at age a
- F_a = instantaneous annual fishing mortality rate for fish of age a
- Z_a = instantaneous annual total mortality rate for fish of age a

(http://www.epa.gov/waterscience/316b/phase2/casestudy/final/cha5.pdf.)

8

Section 316(b) of the CWA

Simplifying assumptions:

"All of the key parameters used in the yield model, F, M, and size-at-age, were assumed to be constant for a given species regardless of changes in I&E rates... EPA recognizes that the assumption that the key parameters are static is an important one that is not met in reality... [but]...the use of more complex fish population models would rely on an even larger set of significant data uncertainties and would require numerous additional and stronger assumptions about the nature of stock dynamics that would be difficult to defend with available data."

9

The only slide with equations

Consider an aggregate biomass, or "scalar," model:

(1) $$\frac{dN}{dt}\frac{1}{NH} = r(1 - N/K) - f - i$$

(2) $$N = K\left[1 - (f + i)/r\right]$$

(3) $$H = fN = fK\left[1 - (f + i)/r\right]$$

(4) $$L = iN = iK\left[1 - (f + i)/r\right] = (K/r)\left[(r - f)i - i^2\right]$$

(5)H $$\Delta H = f\Delta L$$

(6) $$-\frac{\partial H}{\partial L} = -\frac{\partial H/\partial i}{\partial L/\partial i} = \frac{fH}{r - f - 2i}$$

10

Examples

(1) $r = 2, f = 0.5, i = 0.1 \rightarrow \quad -\partial H / \partial L = 0.384$

About 25% lower than prediction from proxy model.

(2) $r = 1.5, f = 0.75, i = 0.2 \rightarrow \quad -\partial H / \partial L = 2.14$

Nearly 200% higher than prediction from proxy model. (Harvest increases by more than the number of fish "saved" per year!)

11

Conclusions

1. Ignoring density-dependence not always "conservative."

2. Improved population modeling and risk assessment practices can improve ecological benefits assessments.

12

The Relevance of Populations to USACE

Todd S. Bridges, Ph.D.

Senior Scientist, Environmental Science

U.S. Army Engineer Research and Development Center

Vicksburg, MS

Ecological Risk

- Ecological Risk Assessment: "…a process…to evaluate the likelihood of adverse ecological effects", USEPA, Fed. Reg. Vol. 61 No. 175 (1996)
  - Ecology: "The scientific study of the interactions that determine the distribution and abundance of organisms." Krebs (1972)
- The two key questions:
  - Where are they?
  - How many are there?

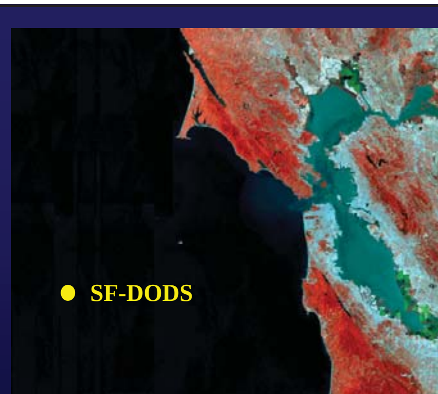
USACE Missions and Problems

- Navigation
  - Dredged material management
- Hydropower and reservoir management
  - Fish passage and "take"
- Ecosystem restoration
  - Sturgeon and Interior Least Tern
  - Contaminant remediation
- Invasive species management

U.S. Navigation Dredging Program

- 400 U.S. Ports
  - Transport for 95% of international trade
- 25,000 miles of navigation channel
- 200 million cubic yards of sediment dredged annually
- $1 billion budget

Marine Protection, Research and Sanctuaries Act of 1972, § 102: "...changes in marine ecosystem diversity, productivity, and stability; and species and community population changes."



40 CFR § 227.27(b)
"Materials…will not cause unreasonable
acute or chronic toxicity or other sublethal adverse effects…"

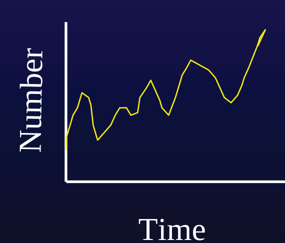
Population Modeling

Individual >>>>>>>>>>>>>>> Population

Survivorship, Growth, Reproduction

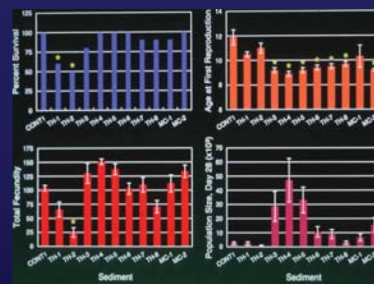
$$\underbrace{\begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \\ \vdots \\ n_s \end{bmatrix}}_{\boldsymbol{n}_{(t+1)}} = \underbrace{\begin{bmatrix} F_1 & F_2 & F_3 & F_4 & \cdots & F_s \\ P_1 & 0 & 0 & 0 & \cdots & 0 \\ 0 & P_2 & 0 & 0 & \cdots & 0 \\ 0 & 0 & P_3 & 0 & \cdots & 0 \\ \vdots & \ddots & \ddots & \ddots & \cdots & \vdots \\ 0 & 0 & 0 & \cdots & P_{s-1} & 0 \end{bmatrix}}_{\boldsymbol{A}} \underbrace{\begin{bmatrix} n_1 \\ n_2 \\ n_3 \\ n_4 \\ \vdots \\ n_s \end{bmatrix}}_{\boldsymbol{n}_{(t)}}$$

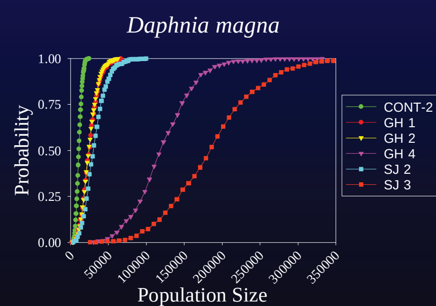
$$\boldsymbol{n}_{(t+1)} = \boldsymbol{A}\boldsymbol{n}_{(t)}$$



Daphnia magna

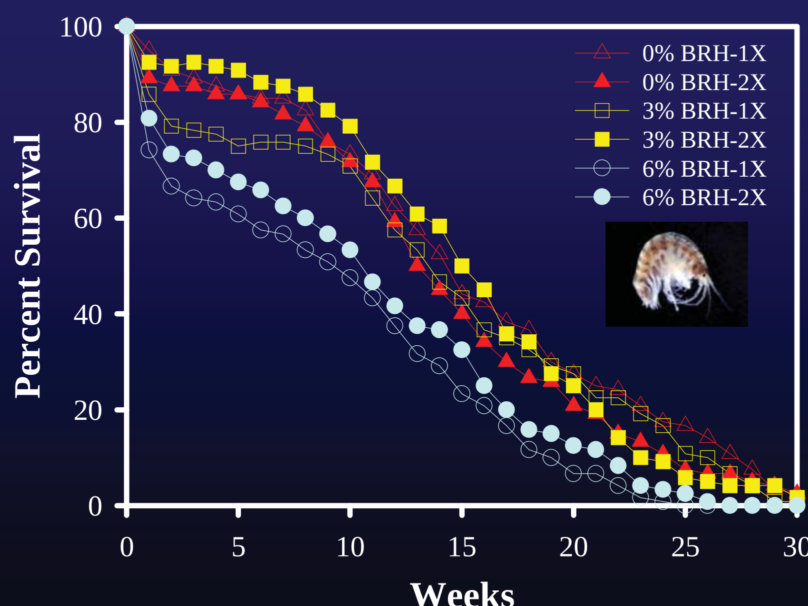
- Evaluated chronic toxicity of 17 Great Lakes sediments over 21-d exposure
- Measured effects on survival, development rates, reproductive rates
- Summarized effects using an age-classified population model

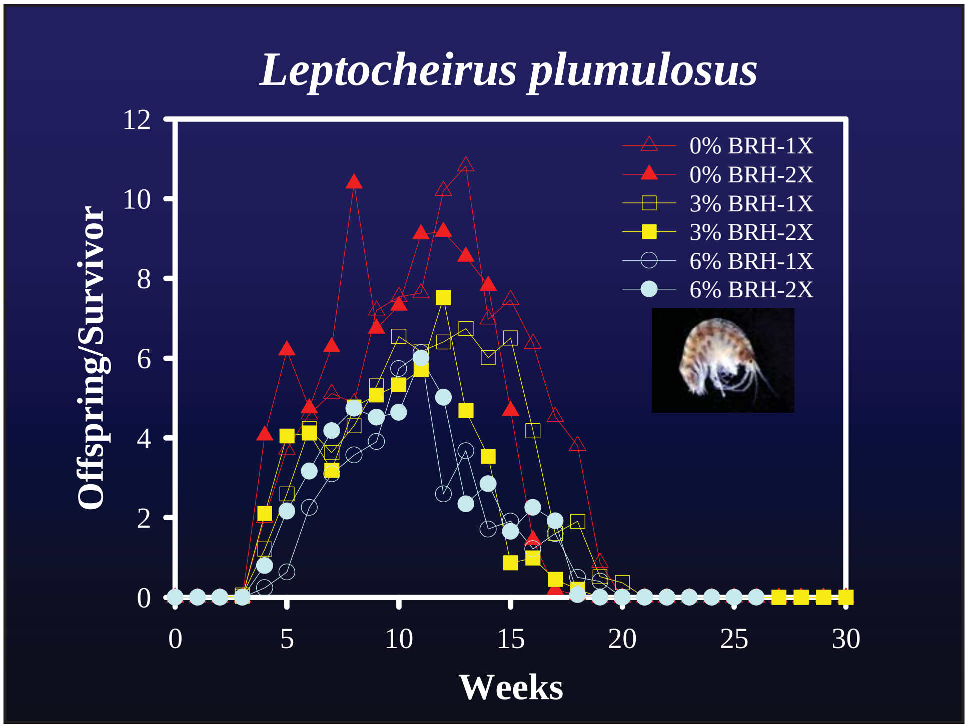


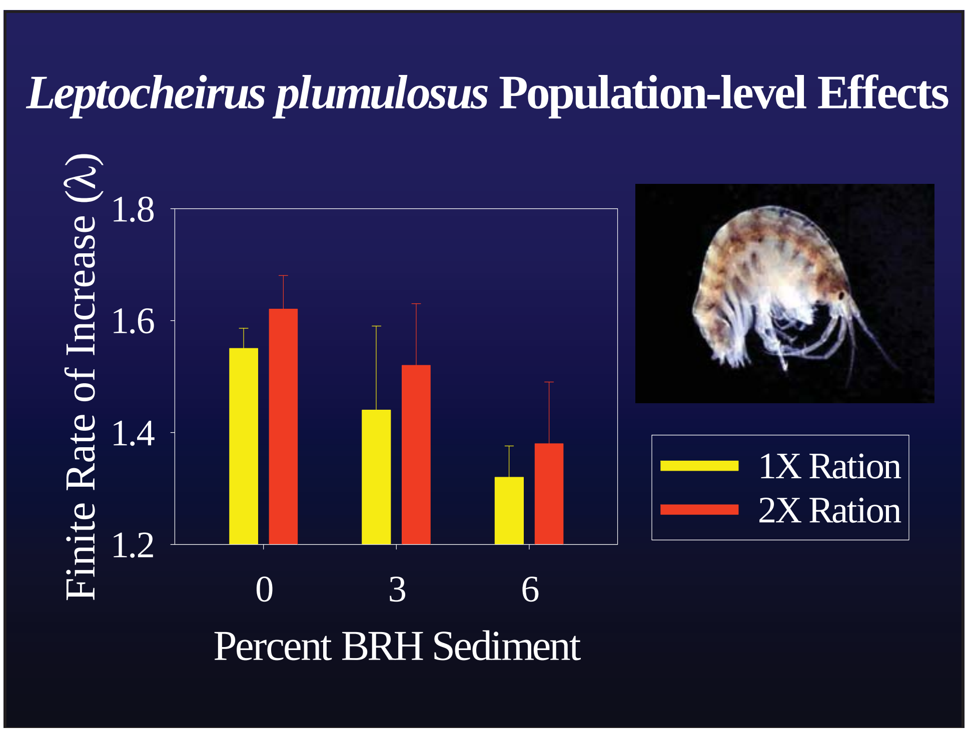


Bridges, T.S., R.B. Wright, B.R. Gray, A.B. Gibson, and T.M. Dillon. 1996. Chronic toxicity of Great Lakes sediments to *Daphnia magna*: elutriate effects on survival, reproduction, and population growth. *Ecotoxicology* 5: 83-102.

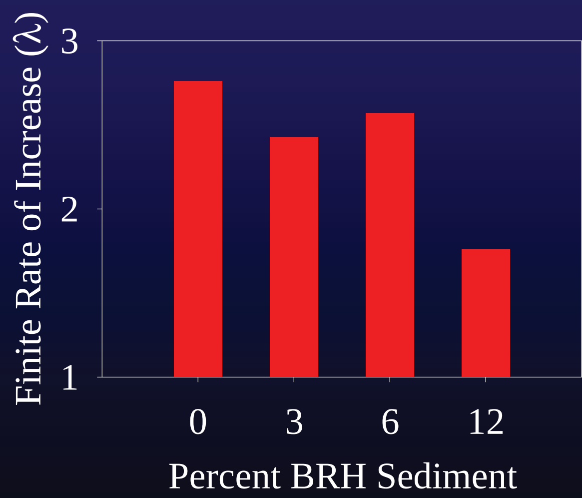
Leptocheirus plumulosus




Leptocheirus plumulosus
Offspring/Survivor
Weeks
0% BRH-1X
0% BRH-2X
3% BRH-1X
3% BRH-2X
6% BRH-1X
6% BRH-2X
0
2
4
6
8
10
12
0
5
10
15
20
25
30

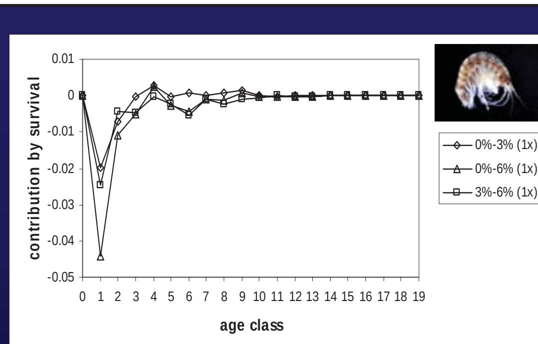

Leptocheirus plumulosus Population-level Effects
Finite Rate of Increase (λ)
1.8
1.6
1.4
1.2
0
3
6
Percent BRH Sediment
1X Ration
2X Ration

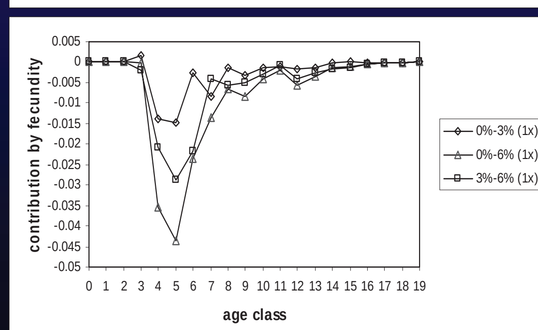
Neanthes arenaceodentata Population-Level Effects



Contributions

- Effect of BRH on lambda due to reduced survival in 0-3 wk olds and reduced fecundity during weeks 4-8
- Magnitude of the contributions from survival and fecundity are similar





Historic Area Remediation Site

- NY Mud Dump Site closed in 1997
- Revising approach for evaluating whether material suitable for use as remediation material
- Using spatially explicit exposure modeling of fish

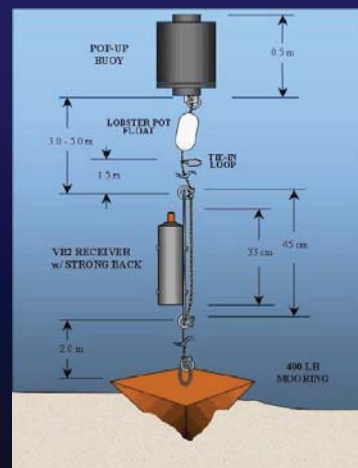
Linkov, I., D. Burmistrov, J. Cura, T.S. Bridges. 2002. Risk based management of contaminated sediments: consideration of spatial and temporal patterns in exposure modeling. *Environmental Science and Technology* 36:238-246.

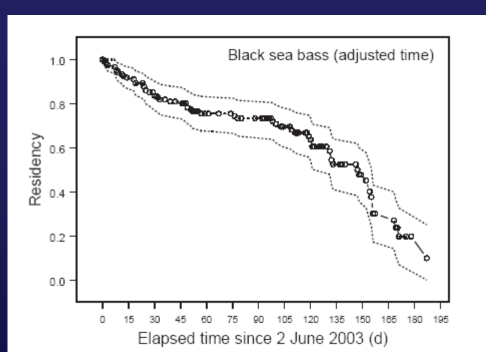
Fish Tagging Study

- Project team from NMFS, Sandy Hook, NJ
  - Fabrizio, Pessutti, Manderson, Drohan, Phelan
- Black Sea Bass and Summer Flounder identified as study species
  - Site use and relevance to humans health

Fish Tagging Study

- 72 moored acoustic receivers placed at HARS in April 2003
  - 800 m apart
- 129 BSB and 24 SF tagged and released in May-Jun 2003
- Completed array retrieval in Sept 2004
  - 1,625,315 detections

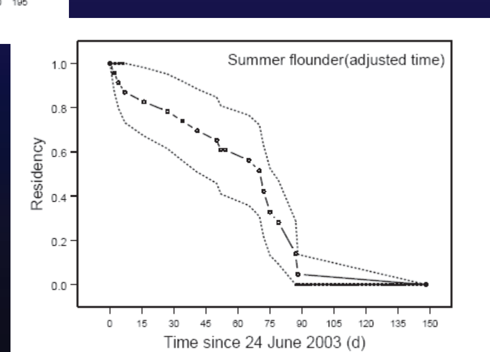




The two key questions:

1. Where are they?
2. How many are there?

•75% of BSB dispersed from HARS by Nov 2003
•75% of SF dispersed from HARS by Sept 2003
•1 SF, 2(?) BSB returned in 2004

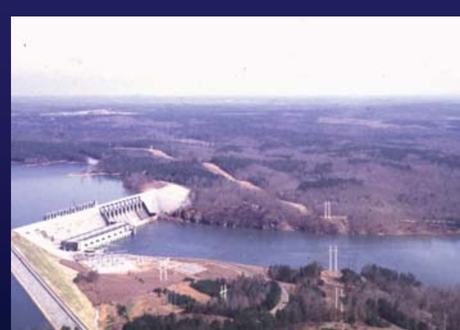


USACE Owns and Operates

- 260 navigation locks
- 600 reservoirs
- 75 hydroelectric facilities
  - Generating 25% of the country's hydropower

Richard B. Russell Dam

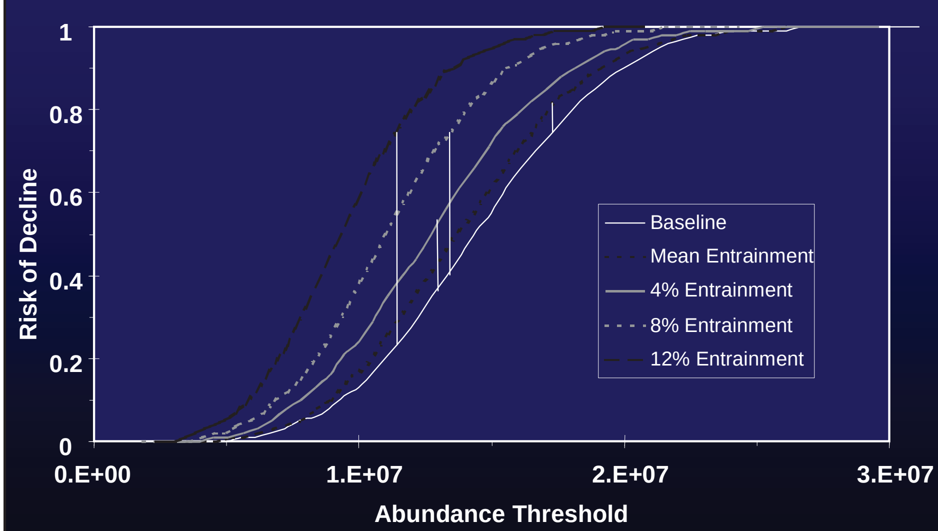
- Pumped storage operations entrain fish from J. Strom Thurmond Reservoir
- Study purpose: evaluate long-term population-level impact of mortality from entrainment
  - threadfin shad, blueback herring, striped bass, hybrid bass, black crappie

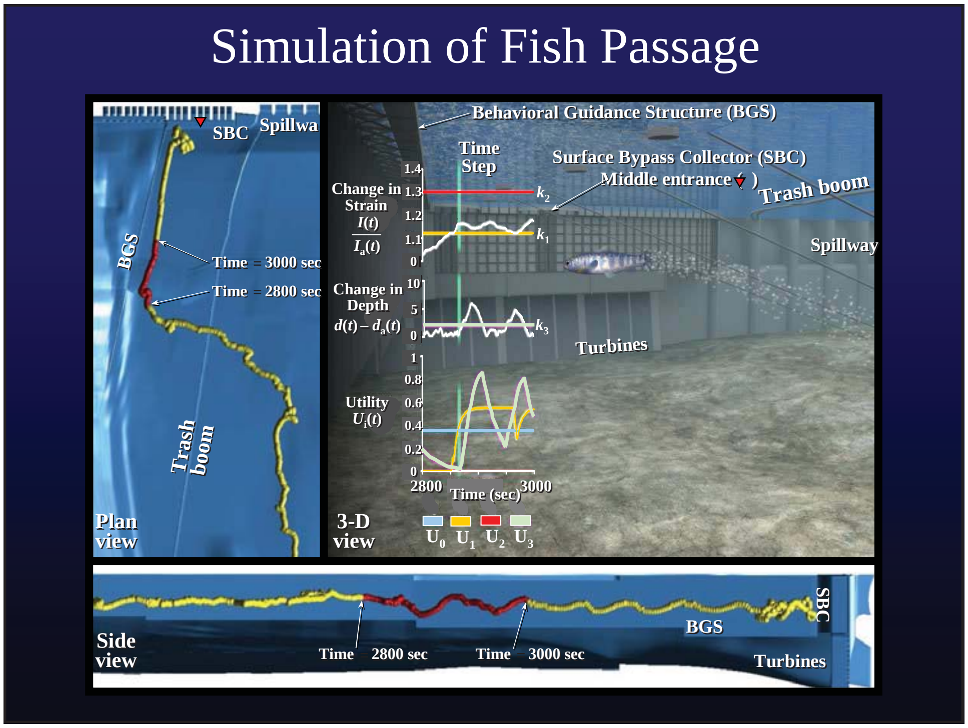


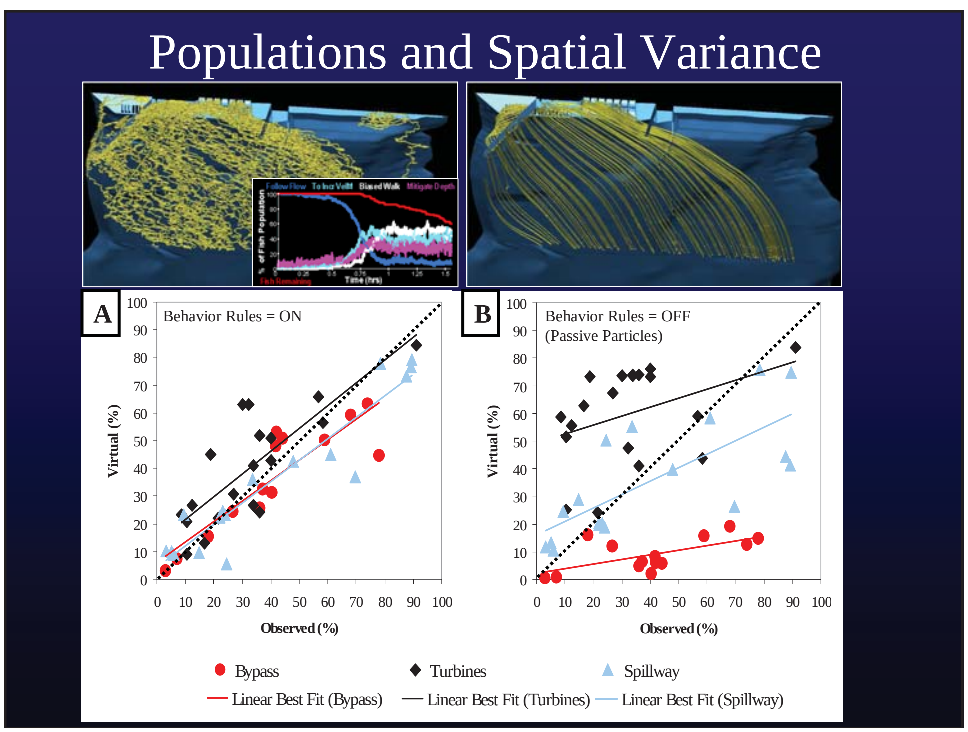
Blueback Herring

- Stochastic matrix population model with 4 age classes built using monthly gillnet data, hydroacoustic surveys, and fecundity estimates using Boltin (1995)
- Density dependence modeled using Beverton-Holt and site data
- Scenarios evaluated included estimates of total entrainment mortality using:
  – Measured estimates of 1.3% (Scenario A) and 0.56% (Scenario B)
  – Hypothetical estimates of 4%, 8%, 12%

Blueback Herring Risk of Decline




Simulation of Fish Passage
SBC
Spillwa
BGS
Time = 3000 sec
Time = 2800 sec
Trash boom
Plan view
Behavioral Guidance Structure (BGS)
Time Step
Surface Bypass Collector (SBC)
Middle entrance
Trash boom
Spillway
Change in Strain
I(t) / I_a(t)
Change in Depth
d(t) – d_a(t)
Turbines
Utility
U_i(t)
2800
Time (sec)
3000
3-D view
U0 U1 U2 U3
Side view
Time 2800 sec
Time 3000 sec
BGS
SBC
Turbines

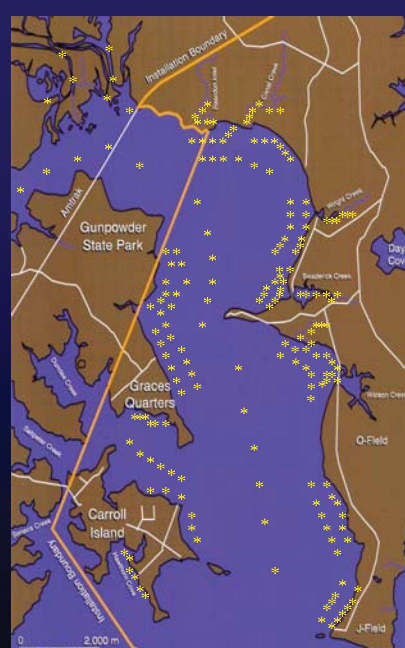

Populations and Spatial Variance
A
Behavior Rules = ON
B
Behavior Rules = OFF
(Passive Particles)
Virtual (%)
Observed (%)
Bypass
Turbines
Spillway
Linear Best Fit (Bypass)
Linear Best Fit (Turbines)
Linear Best Fit (Spillway)

Ecosystem Restoration

- Projects range from small to very large
- Budget justifications closely scrutinized by OMB
- Need to strongly establish quantitative, scientific basis for environmental benefits
  - E.g., more of species x

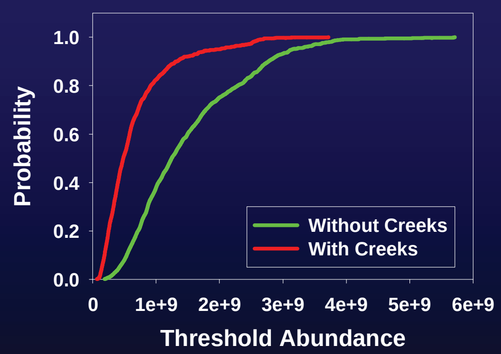
Gunpowder River Sediment Assessment

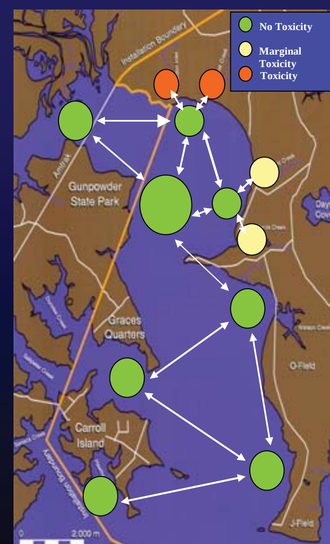
- 100 km^2, 186 sediment samples
- Chronic toxicity
  - *Leptocheirus plumulosus*
    - survival, growth, reproduction



Leptocheirus plumulosus Metapopulation Model For Gunpowder River, Aberdeen Proving Ground, MD

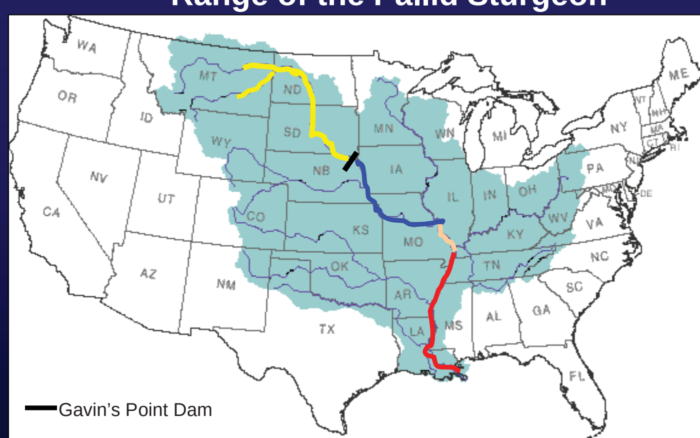
Extinction Risk





T.S. Bridges, H.R. Akcakaya, B. Bunch. 2008. *Leptocheirus plumulosus* in the upper Chesapeake Bay: sediment toxicity effects at the metapopulation level. In, *Demographic Toxicity: Methods in Ecological Risk Assessment* H.R. Akcakaya, J.D. Stark, T.S. Bridges, eds. Oxford University Press, pp. 242-254.

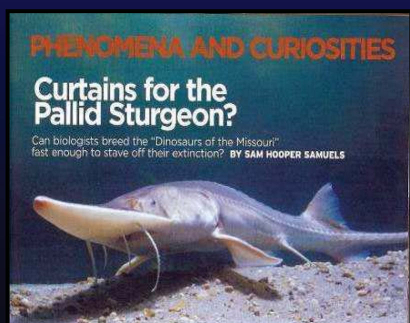
Range of the Pallid Sturgeon



	River Miles
Upper Missouri River – Impounded	960
Lower Missouri River – Free-flowing	811
Middle Mississippi River	200
Lower Mississippi River	985

Issues

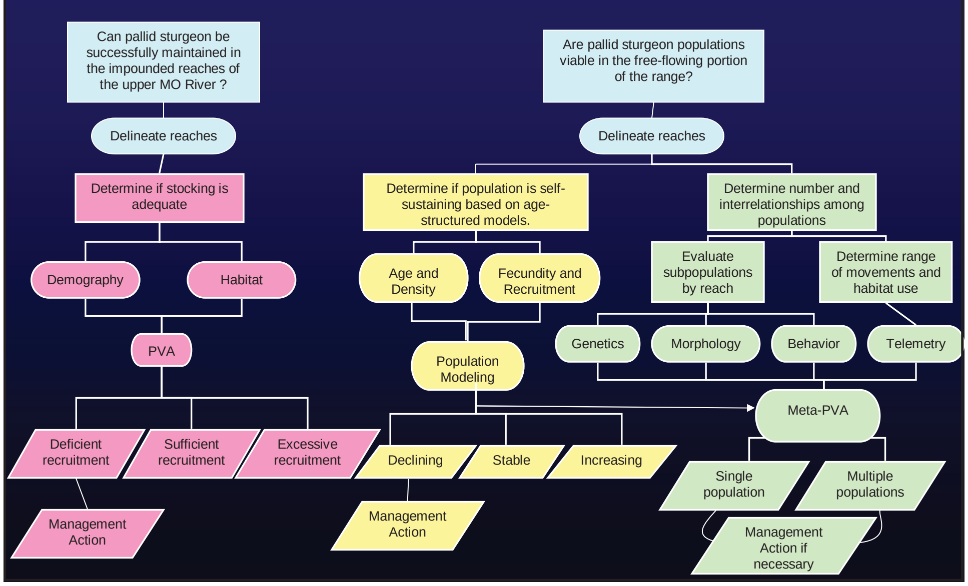
- Latitudinal trends in abundance and size over a 3,000 river mile range
- Population status and threats vary geographically
  - Lower MS River   stable populations; entrainment from water diversions is a threat
  - Middle MS River – harvesting impacts
  - Lower Missouri River – uncertain status; habitat restoration and stocking ongoing
  - Upper Missouri River   no recruitment; stocking necessary to maintain populations
- Movement between rivers has been documented   single or multiple populations?
- Genetic uncertainties undermining progress in recovery



Research results in better understanding

Pallid sturgeon will not go extinct, but is threatened in parts of its range.

Solution – Range-wide Population Viability Analysis (PVA)

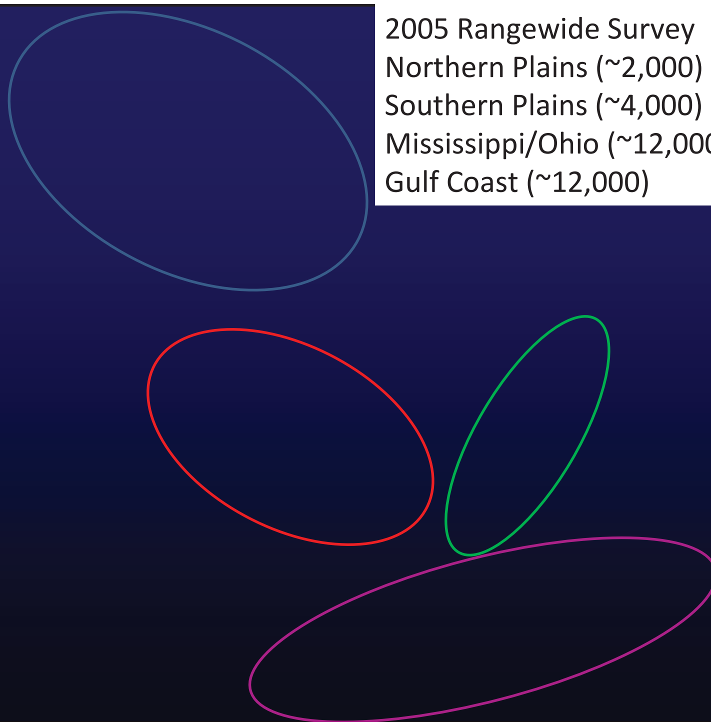


Interior Least Tern

Background:
- Listed in 1985
- Recovery goals set at 7,000 birds
- 2005, ABC and ERDC conducted the first range-wide survey and detected >17,000 individuals.

Problem:
- Recent flooding created habitat
- Habitat is now declining (vegetation encroachment, erosion, lack of flood flows to create new or sustain existing sandbars)
- Long-term sustainability?

2005 Rangewide Survey
Northern Plains (~2,000)
Southern Plains (~4,000)
Mississippi/Ohio (~12,000)
Gulf Coast (~12,000)

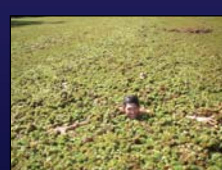


Interior Least Tern

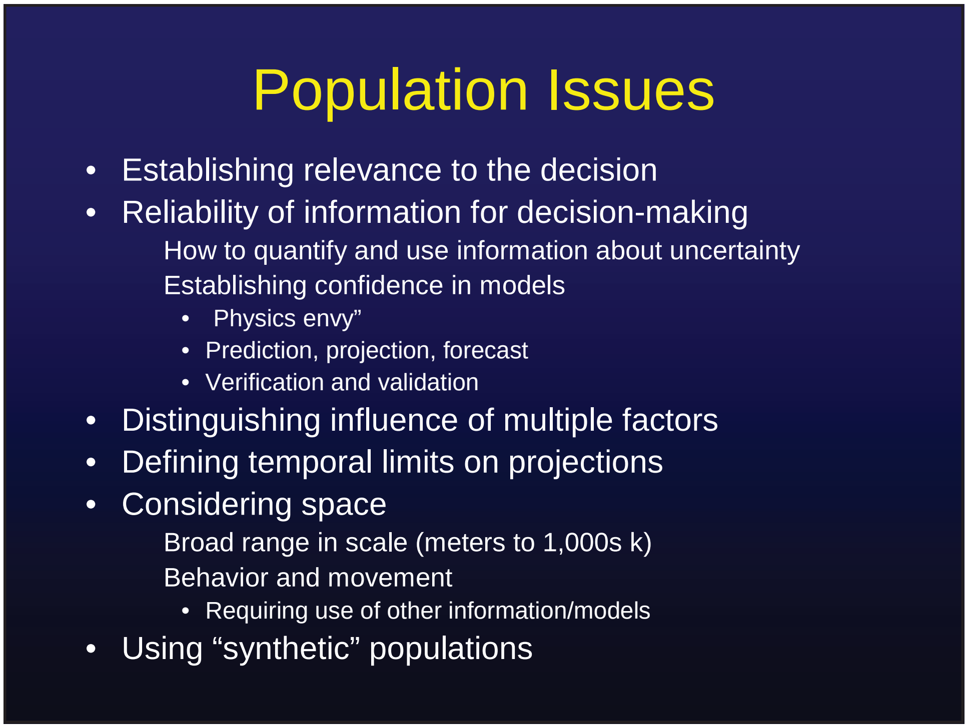
Approach: Develop a habitat-based population model with three primary objectives/capabilities:

1) Evaluate range-wide Interior Least Tern population status
2) Evaluate sandbar habitat conditions for all riverine reaches with >50 ILT
3) Evaluate the effects of different management actions (including no action) on 1) tern populations; and 2) tern habitat.

Invasive Species


- Impacts
  - Navigation
  - Flood control
  - Hydropower
  - Recreation
  - Environment
- Population-relevant questions
  - Quantifying "invasiveness"
  - Predicting spread
  - Developing effective control strategies
    - Mechanical
    - Chemical
    - Biological


Population Issues
• Establishing relevance to the decision
• Reliability of information for decision-making
How to quantify and use information about uncertainty
Establishing confidence in models
• Physics envy"
• Prediction, projection, forecast
• Verification and validation
• Distinguishing influence of multiple factors
• Defining temporal limits on projections
• Considering space
Broad range in scale (meters to 1,000s k)
Behavior and movement
• Requiring use of other information/models
• Using "synthetic" populations

Risks of Fishery Mortality to a Seabird Population and Conservation Implications

Jill Awkerman

US EPA, Gulf Ecology Division

Plight of the Albatross – Longline bycatch


Albatross bycatch in artesanal fisheries
Photo: ProDelphinus
Photo: ProDelphinus


Breeding schedule of Waved Albatrosses
May - June
July
August - January
Galapagos
Ecuador
Peru
Galapagos
Ecuador
Peru

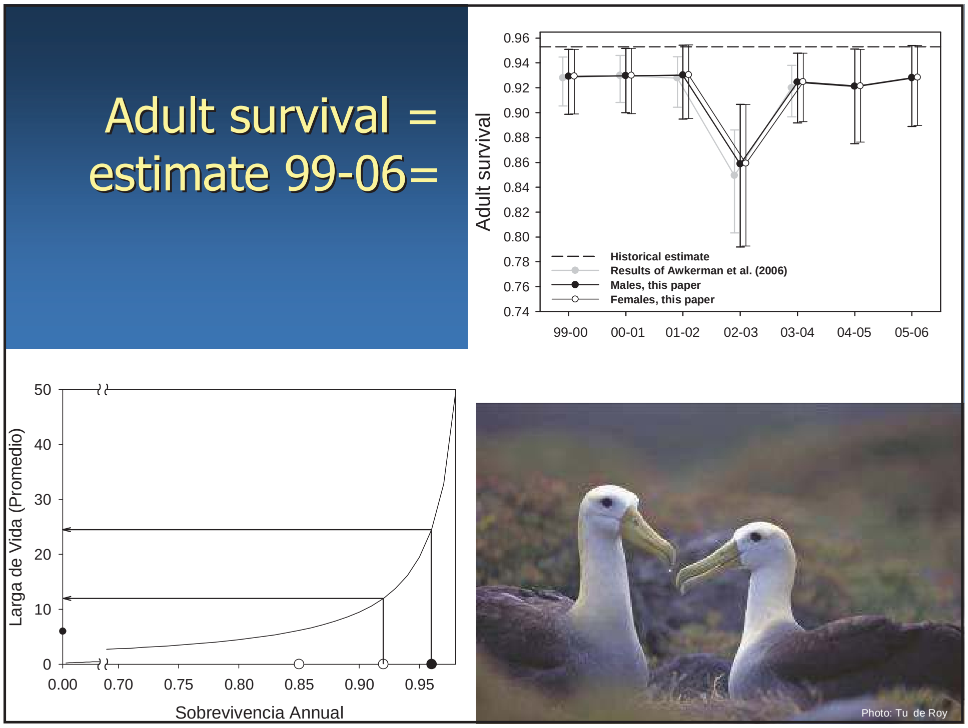
Band recoveries

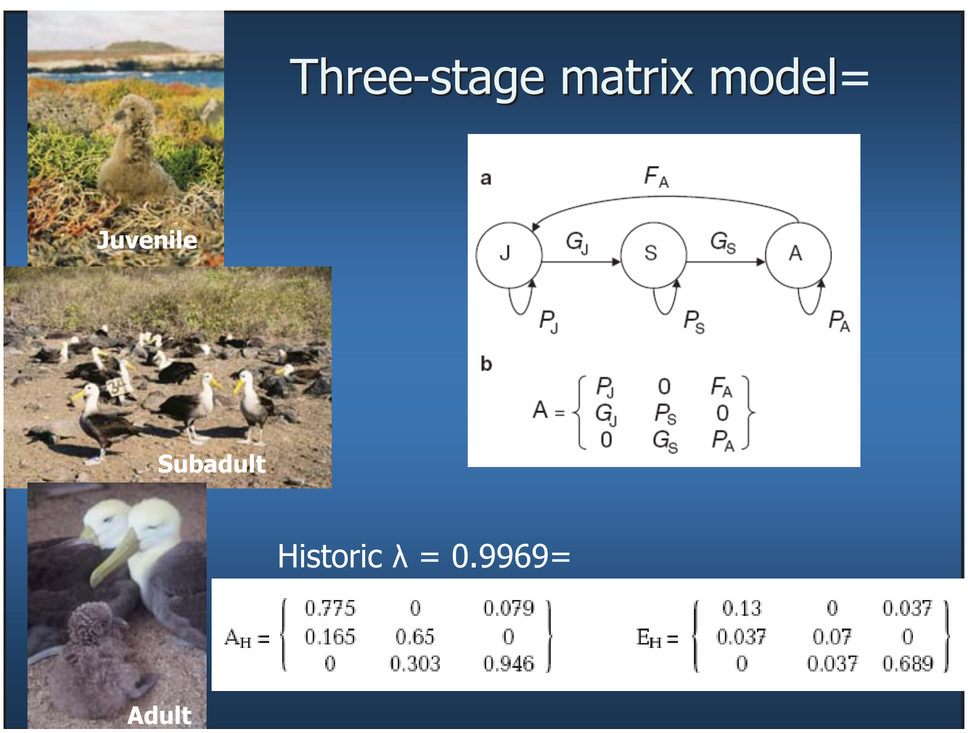
- > 2500 adult albatrosses banded in 2004
- Recovered ~1% bands in 1st year (81.8% males)
- Observers present on 30 trips from Salaverry and Callao

Mark-resight analysis

Model	$QAIC_C$	$\Delta QAIC_C$	$QAIC_C$ Weights	Model likelihood	Number of parameters
Φ (E) p(t)	1823.74	0	0.41	1	10
Φ (E) p(g+t)	1825.14	1.4	0.2	0.5	11
Φ (g+E) p(t)	1825.76	2.02	0.15	0.36	11
Φ (g+E) p(g+t)	1827.15	3.41	0.07	0.18	12
Φ (t) p(t)	1827.3	3.56	0.07	0.17	15
Φ (t) p(g+t)	1828.45	4.71	0.04	0.1	16
Φ (g+t) p(t)	1829.28	5.53	0.03	0.06	16
Φ (g+t) p(g+t)	1830.41	6.67	0.01	0.04	17
Φ (g) p(t)	1830.57	6.83	0.01	0.03	10
Φ (g) p(g+t)	1831.92	8.18	0.01	0.02	11

Φ survival, p = recapture probability
(.) = constant, (t) = year, (E) = El Niño, (g) = sex

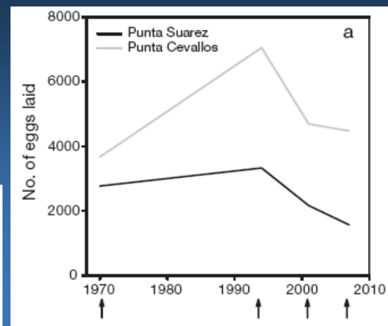

Adult survival =
estimate 99-06=
Adult survival
0.96
0.94
0.92
0.90
0.88
0.86
0.84
0.82
0.80
0.78
0.76
0.74
Historical estimate
Results of Awkerman et al. (2006)
Males, this paper
Females, this paper
99-00
00-01
01-02
02-03
03-04
04-05
05-06
Larga de Vida (Promedio)
50
40
30
20
10
0
0.00
0.70
0.75
0.80
0.85
0.90
0.95
Sobrevivencia Annual
Photo: Tu de Roy


Juvenile
Subadult
Adult
Three-stage matrix model=
a
FA
J
GJ
S
GS
A
PJ
PS
PA
b
A = PJ 0 FA
GJ PS 0
0 GS PA
Historic λ = 0.9969=
AH = 0.775 0 0.079
0.165 0.65 0
0 0.303 0.946
EH = 0.13 0 0.037
0.037 0.07 0
0 0.037 0.689

Stochastic = population growth=

Year	Adult survival probability	Productivity
1960s	0.953	0.254
1999 to 2000	0.929	0.230
2000 to 2001	0.930	0.304
2001 to 2002	0.930	0.369
2002 to 2003	0.859	0.114
2003 to 2004	0.925	0.079
2004 to 2005	0.921	0.278
2005 to 2006	0.928	0.230

Current λ = 0.9615=



Additional Mortality	Years to Extinction
0	212
50	88
100	72
200	56
300	47

Action Plan for Waved Albatross
Phoebastria irrorata

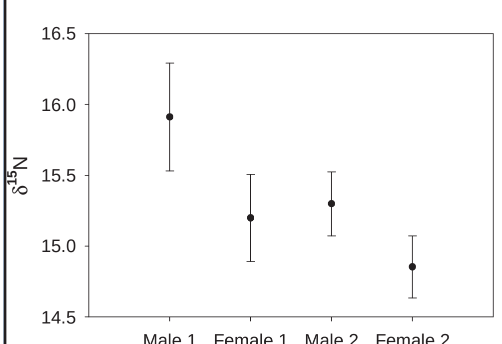
Agreement on the Conservation of Albatrosses and Petrels

ACAP= Action plan

Sex-specific differences

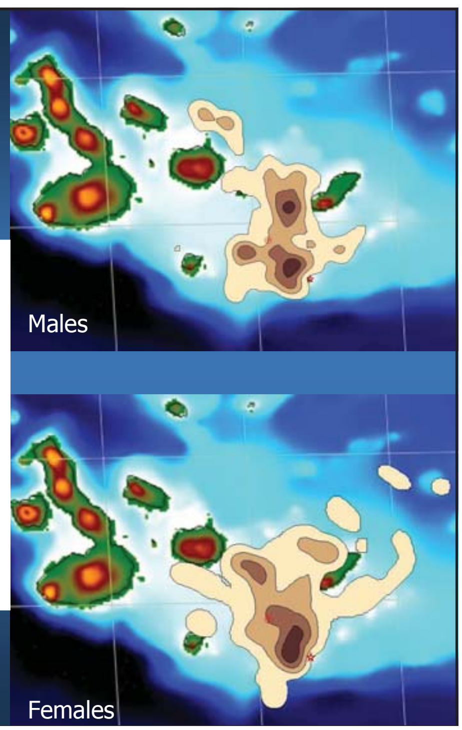
- Higher male band recovery rate (82%)
- Suggestion of differential mortality in mark-resight models
- More female adults
- Differences in foraging behavior

Differences in foraging behavior

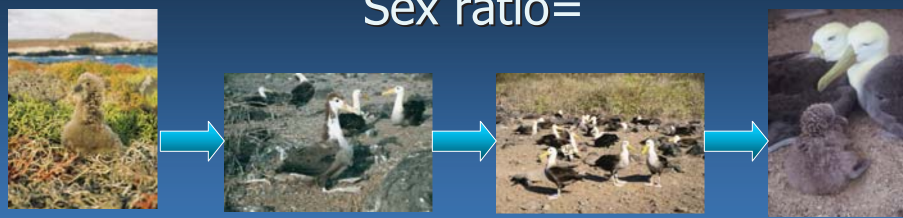


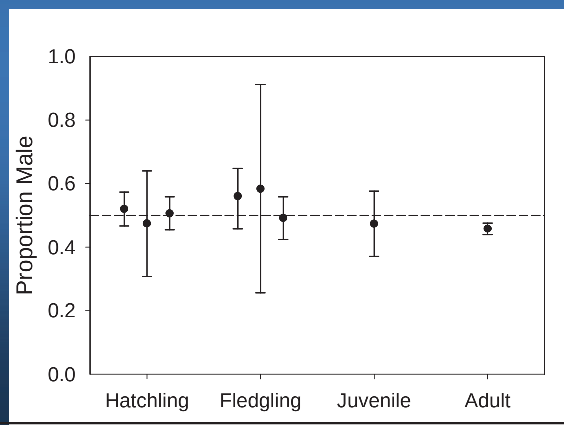
Incubation
Perú

Brooding
Galápagos



Sex ratio



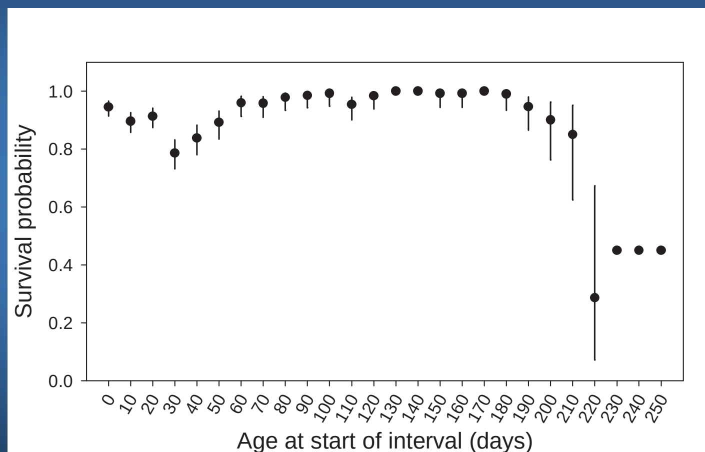


Known fates analysis of chick survival

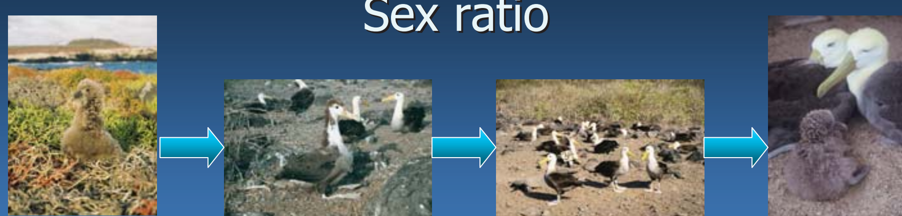
Model	AIC_C	ΔAIC_C	AIC_C weight	Model likelihood	Number of parameters
S(a)	**1452.3**	**0.0**	**0.99995**	**1.0**	**26**
S(g*a)	1472.3	20.0	0.00005	0.0	52
S(g*e)	1515.0	62.7	0.0	0.0	8
S(e)	1516.5	64.2	0.0	0.0	4
S(.)	1636.4	184.1	0.0	0.0	1
S(g)	1637.5	185.2	0.0	0.0	2

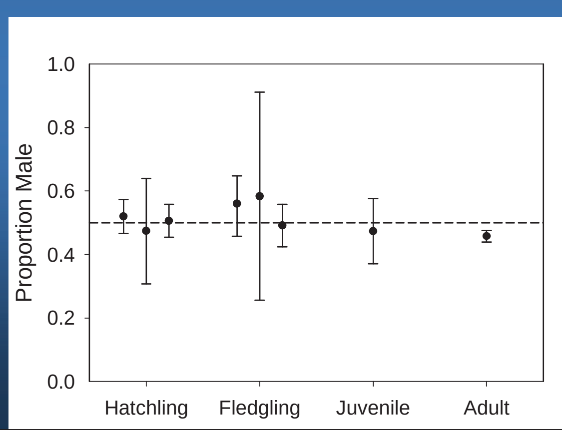
S = survival
(.) = constant, (g) = sex, (a) = age, (e) = effort

Chick survival throughout rearing



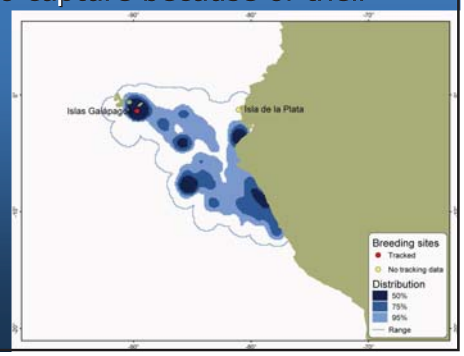
Sex ratio





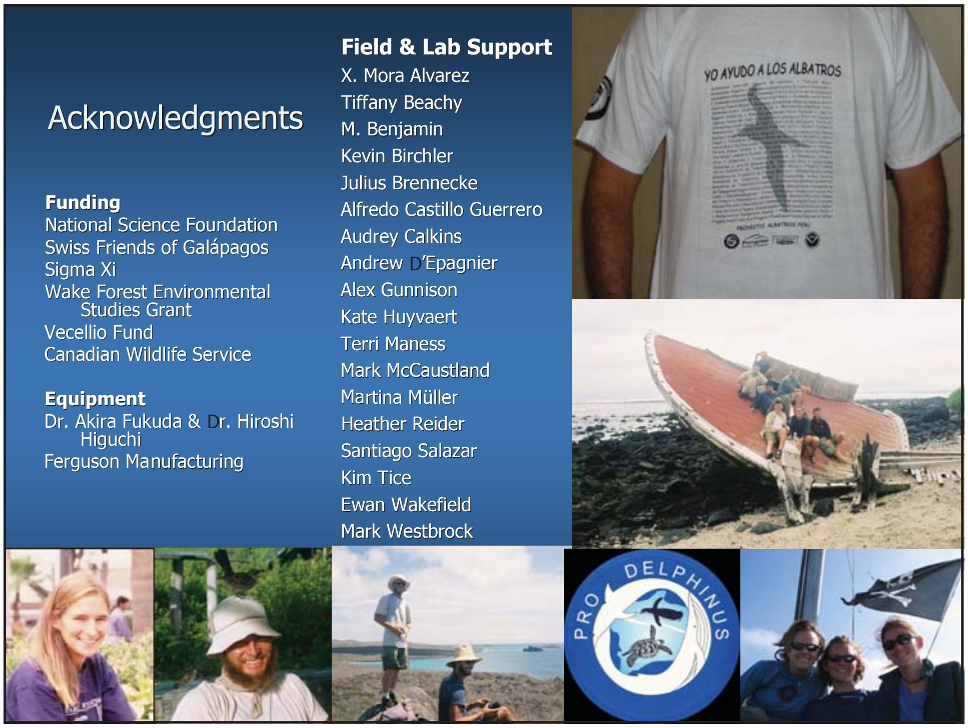
Summary

- Incidental catch and intentional harvest contribute to increased mortality in waved albatrosses
- ENSO events further impact a reduced population growth rate
- Fishery capture possibly contributing to differential mortality
- Males are more susceptible to capture because of their foraging behavior



Benefits of working with albatrosses

- Large
- Long-lived
- Single egg clutch
- Nearly endemic
- Colonial breeders
- Open ground nests
- Approachable
- Low natal dispersal
- Highly philopatric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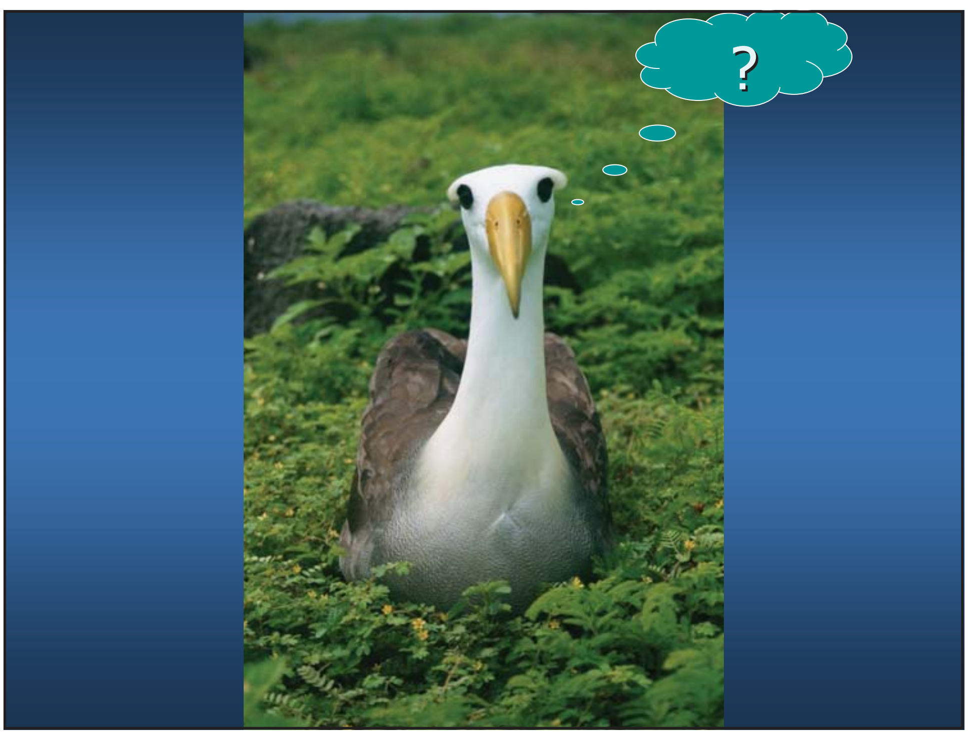
YO AYUDO A LOS ALBATROS
PRO DELPHINUS


?

Population ecology

Richard Sibly

University of Reading, UK

Barnthouse *et al* 2008 Population-level ecological risk assessment

A firm scientific foundation is in place …[but need to include]

- compensatory processes within populations
- heterogeneous environments

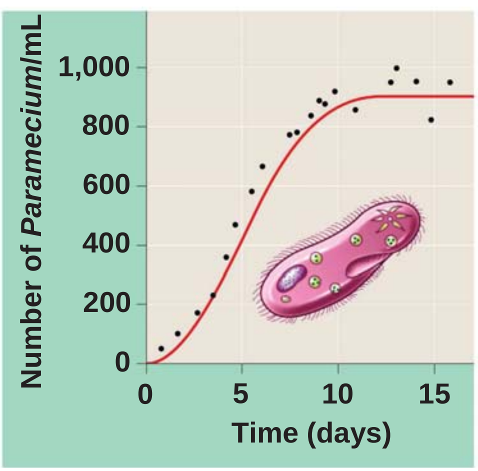
Talk structure

- What are the population endpoints
- Stress and density can be measured in small animals
- Relating lab and field
- Microarrays will one day predict growth reproduction and survival
- York workshop 2004

the scientific foundation …

- abundance
- population growth rate

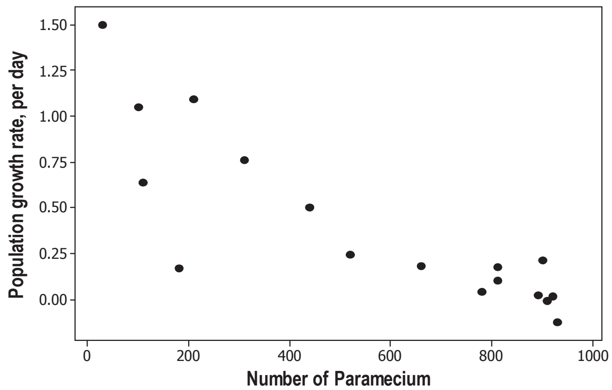
Paramecium in the lab



population growth rate

$= (N_{t+1} - N_t) / N_t$

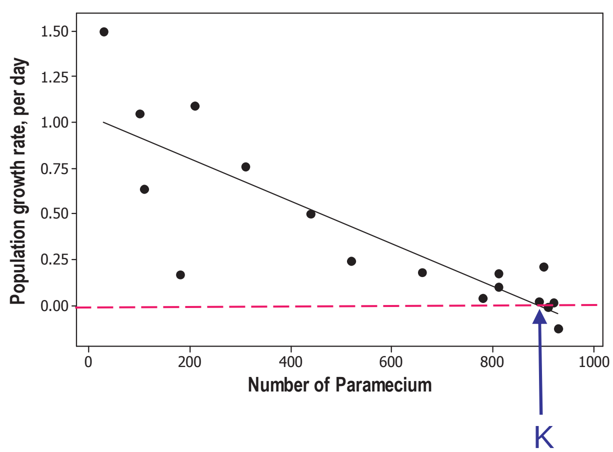
Paramecium in the lab



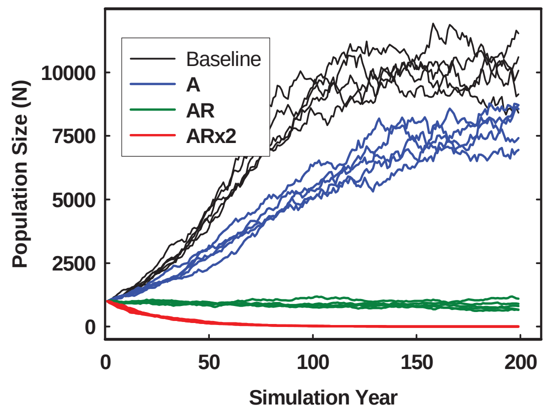
population growth rate

$= (N_{t+1} - N_t) / N_t$

Paramecium in the lab



How stress affects population growth

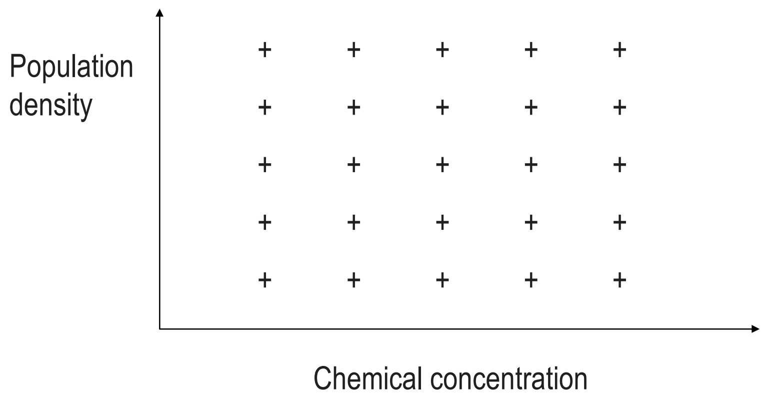


How is pgr affected by stress and density

Springtails *Folsomia candida*

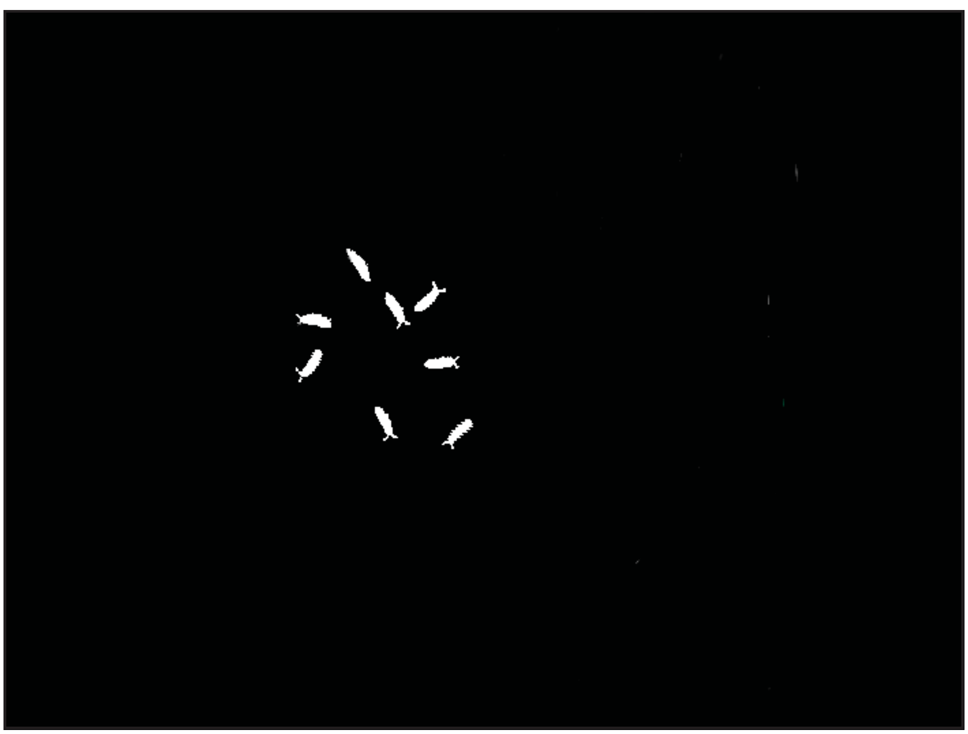
How design experiments?

Obvious way is

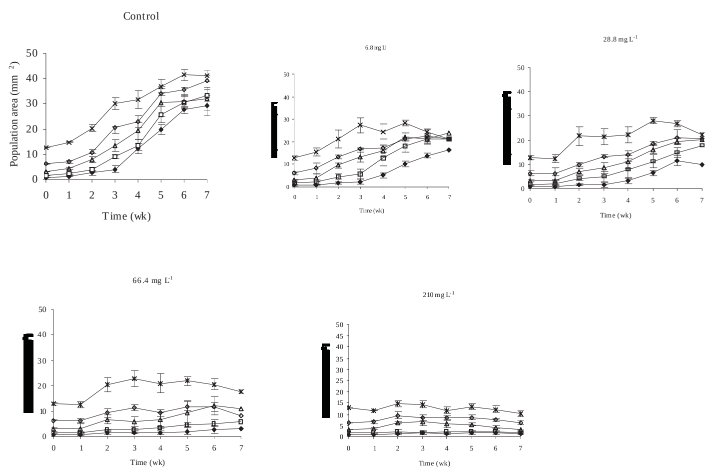


4 replicates

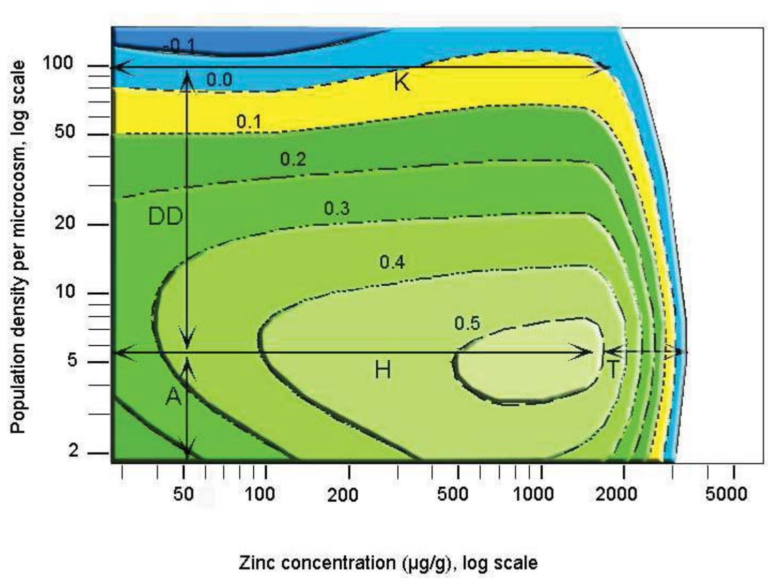
5 densities x 5 zinc concentrations



Varying stress level and density



Contour Plot of pgr

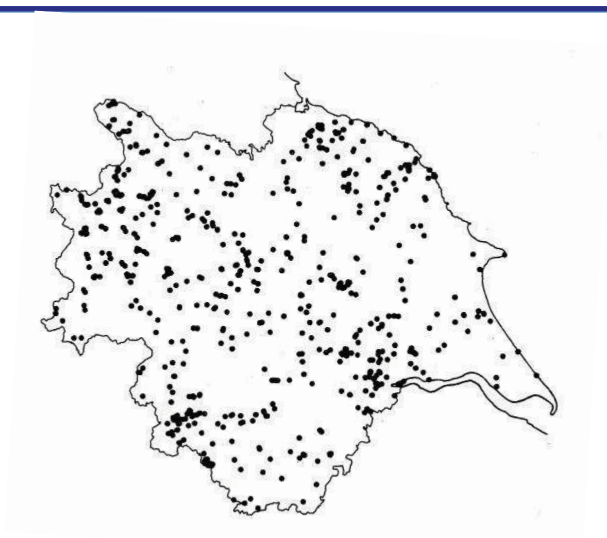


Noel et al 2006

Relating lab and field

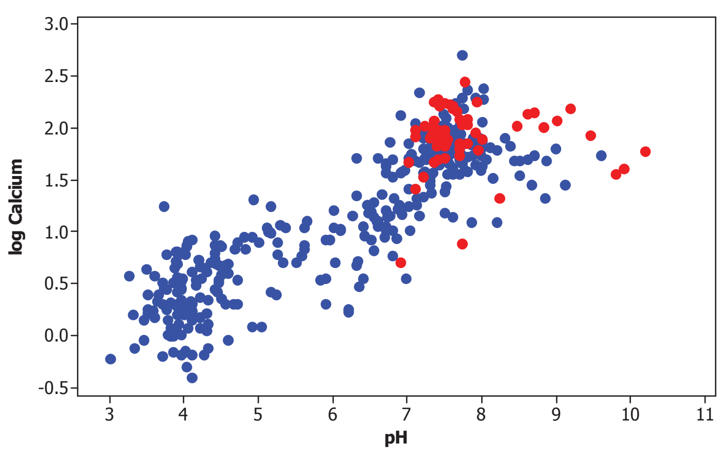
Daphnia magna

Ponds sampled for *Daphnia magna* in Yorkshire by G Fryer



Ponds containing *Daphnia magna*

Occurrence of *Daphnia magna* in relation to pH and Calcium



Experiment to measure pgr at selected positions

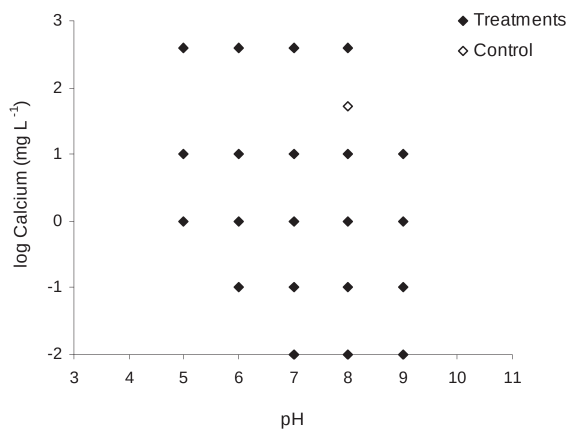


Image analysis

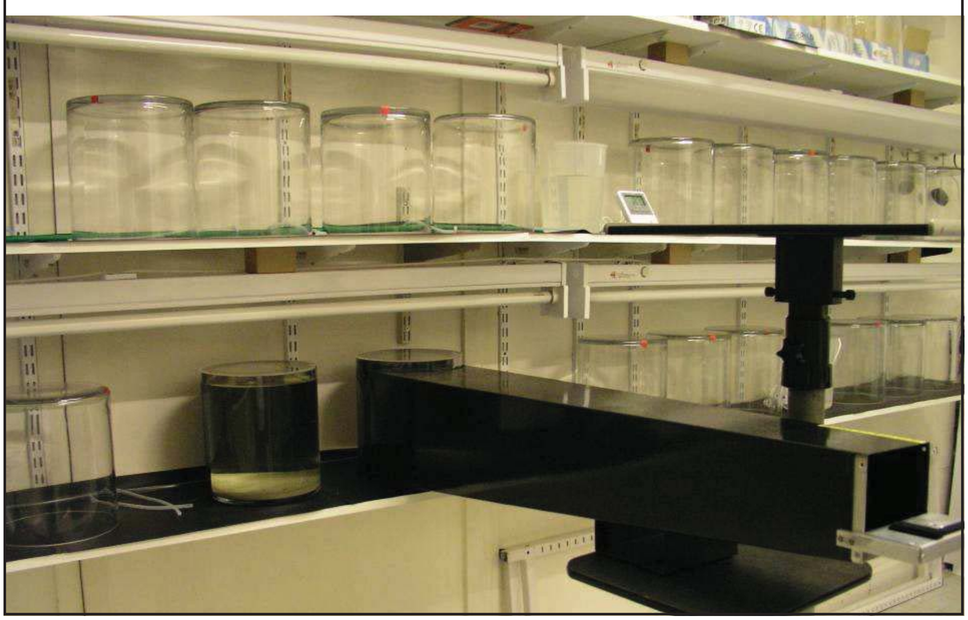
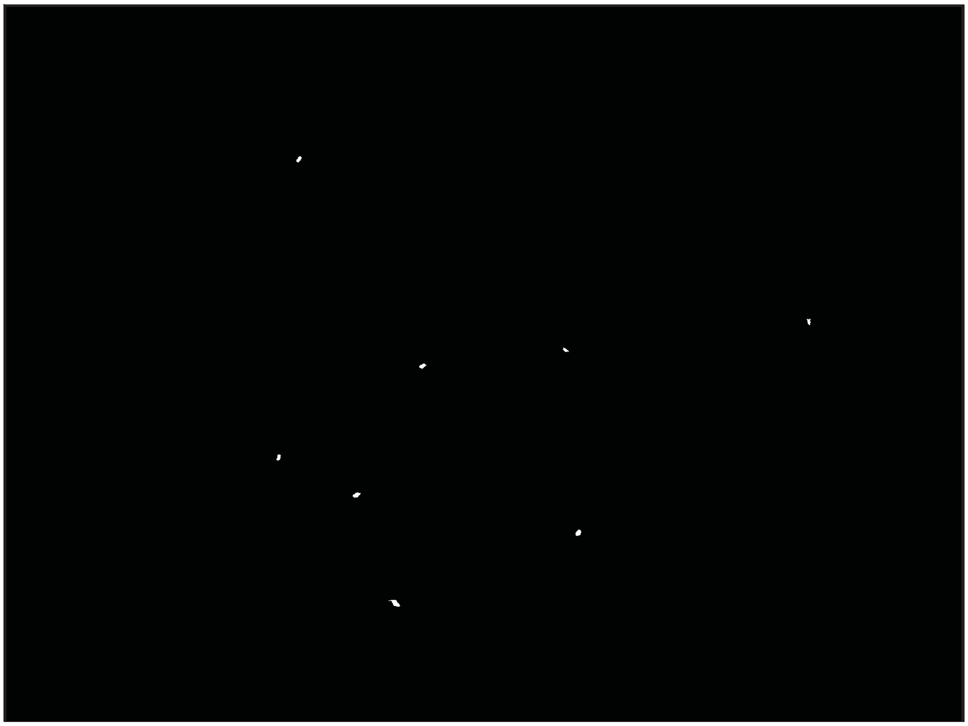



Image
Graphic
Enhance
Morphology
Transform
Segment
Binary
Measure
Evaluate
Data
DensImage - 1 (1600*1200) Colour 0.5 x

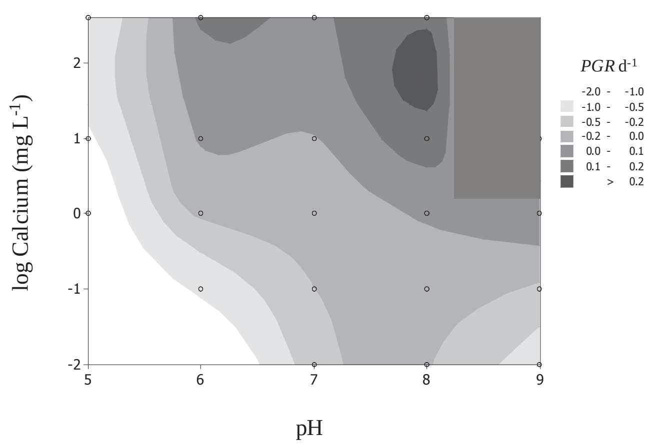


pgr = 1/*t* $\log_{e=} S_t / S_{0=}$

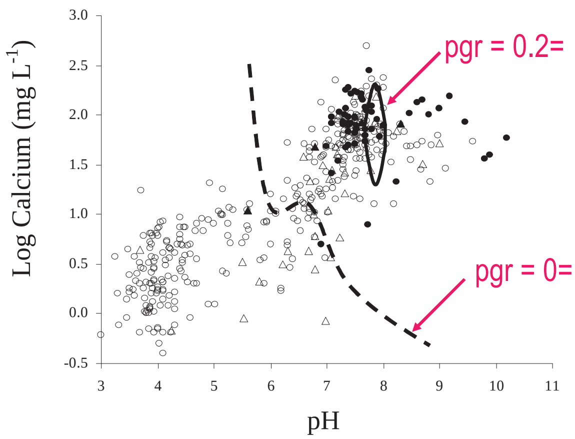
S_t = population surface area at time t=

Hooper et al 2006=

Laboratory niche of *Daphnia magna*=



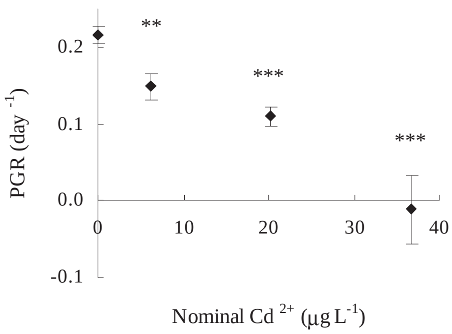
Ecological niche of *Daphnia magna*



How genes control growth, reproduction and survival=

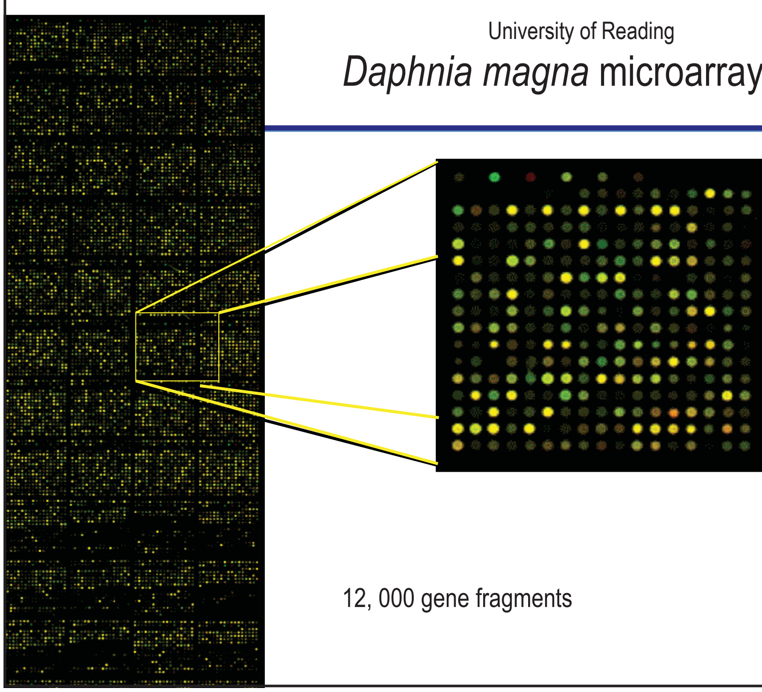
Daphnia magna

Pgr declines as Cadmium concentration increases



University of Reading

Daphnia magna microarray



12, 000 gene fragments

Changes in *D. magna* gene expression

Functional category	Upregulation	Downregulation
1. METABOLISM		
1.1 Carbohydrate and fat metabolism (A)		
Glycolysis/Gluconeogenesis	Glycogen synthase	
	Glucose-6-phosphatase	
Cellulase activity	Endoglucanase 2	
Lipid Metabolism		GM2 ganglioside activator p
1.2 Energy metabolism (B)		
Coenzymes	NADH dehydrogenase subunit 3	NADH dehydrogenase subun
	ATP synthase a chain	
Electron transport	Cytochrome c oxidase subunit 1	Cytochrome b
Citric acid cycle		Succinate dehydrogenase
1.3 Amino acid and polypeptide metabolism (C)		
Oxidative deamination		Glutamate dehydrogenase
Peptidases	Carboxypeptidase A1	
	Trypsin	Trypsin
	Chymotrypsin B2	
Metalloendopeptidase		Astacin (zinc metalloproteas
2.TRANSCRIPTION AND TRANSLATION (D)		
RNA		16S ib l RNA

Where we want to go with microarrays

Identify genes/pathways involved in control of

- Reproduction
- Survival
- Growth

York workshop 2004

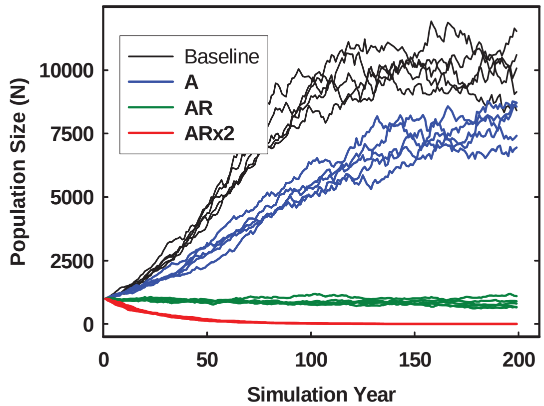
Population risk assessment of birds and mammals in the UK

Andy Hart and Mark Klook

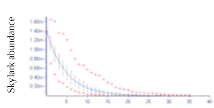
The York approach: five steps to population risk assessment

- toxicity endpoints in the lab
- extrapolate between species
- assess exposure in the field
- extrapolate from lab to field
- evaluate effects on populations of woodmice and skylarks

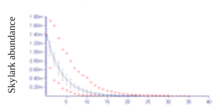
How stress affects population growth



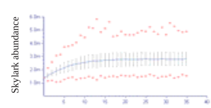
Winter Wheat
No Insecticide



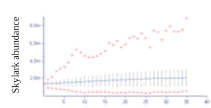
Winter Wheat
With Insecticide



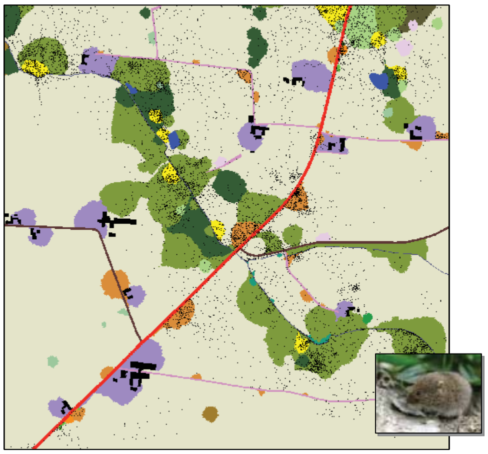
Broad Habitats
No Insecticide



Broad Habitats
With Insecticide

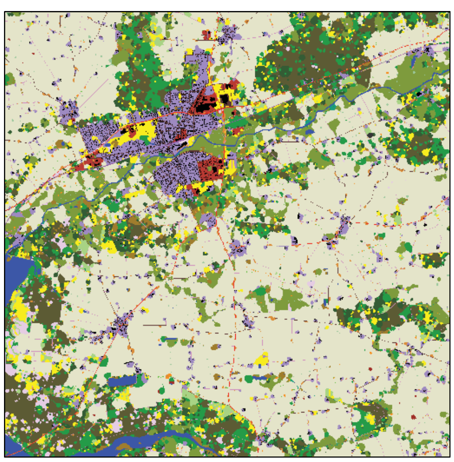


Agent-based model (ABM)



Spatially explicit model of animal behaviour of the vole

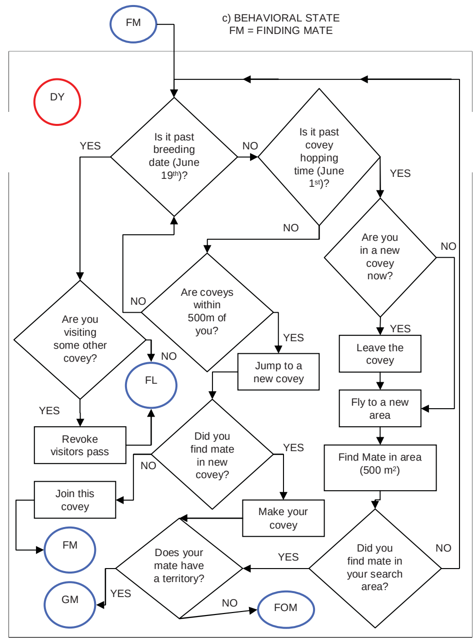
The study landscape



Real 10x10 km Danish landscape by Bjerringbro, 1-m resolution

Legend
- Main road
- Roadside verge
- Permanent grass
- Unmanaged grassland
- Rotational field (same colours for all crops)
- Coniferous forest
- Deciduous forest

Agent specification



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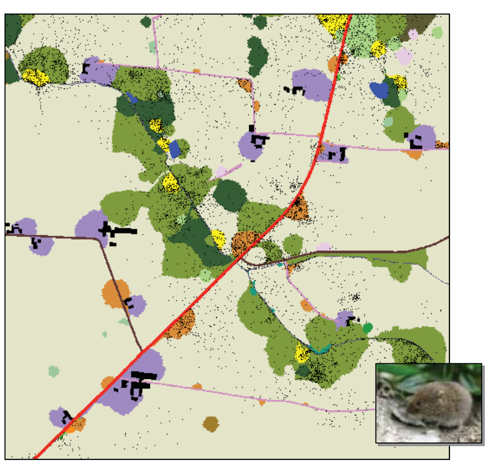
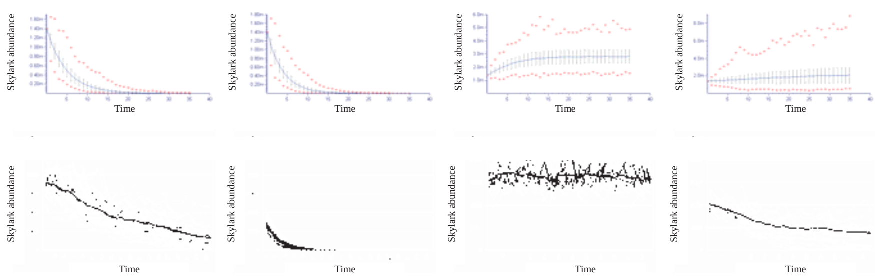


Spatially explicit model of animal behaviour of the vole

Population dynamics emerge as result of local interactions

Dynamic landscape with crop rotation and weather-dependent plant growth

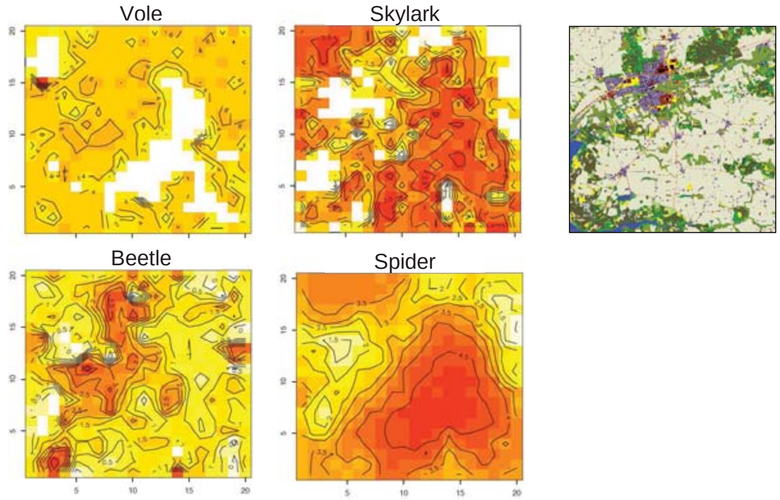
Winter Wheat No Insecticide | Winter Wheat With Insecticide | Broad Habitats No Insecticide | Broad Habitats With Insecticide



The York approach: five steps to population risk assessment

- toxicity endpoints in the lab
- extrapolate between species
- assess exposure in the field
- extrapolate from lab to field
- evaluate effects on populations of woodmice and skylarks

Variation in carrying capacity (K)=



White areas have N=0.=

Summary

- Endpoints are abundance and population growth rate
- Stress and density can be measured in springtails
- Ecological niche relates lab and field
- Microarrays will one day predict growth reproduction and survival
- Individual based models

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