DAM REMOVAL – A META-ANALYSIS OF EFFECTS ON MACROINVERTEBRATE COMMUNITIES

Peter Carlson
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Projekt Ekoliv

SLU
Swedish University of Agricultural Sciences

Kort om KLIV

- **Kraft och liv i vatten (KLIV)**

  (Power and life in water)

- **Energiforsk**

  (the Swedish Energy Research Centre)

- **Energimyndigheten**

  (Swedish Energy Agency)

- **HaV**

  (Swedish Agency for Marine and
  Water Management)

Kort om KLIV

Syfte:	Vattenkraftföretag och myndigheter samverkar för att ta fram kunskap och metoder som krävs för att komma ett steg närmare visionen.
Vision:	Mer kraft och liv i våra vatten
Programstart:	Sommar 2014 (Projektstart våren 2015)
Programslut.	Hösten 2017 (projektslut maj 2017)
Bakgrund:	Utmaningar på miljö- och energiområdet → KLIV kan bidra med svar och vägledning för att hantera dessa utmaningar med hjälp av forskning och utveckling.

Forsknings- och utvecklingsprojekt

Framtagande av relevant och användaranpassad samhällsekonomisk modell för miljöåtgärder för kraft och liv i vatten (FRAM-KLIV)

Projektledare:
Tore Söderqvist, Enveco Miljöekonomi AB

Miljöförbättringar i utbyggda älvar: en arbetsgång för att prioritera mellan åtgärder. (PRIO-KLIV)

Projektledare:
Roland Jansson, Umeå Universitet.

Ekologiska och ekonomiska strategier för optimering av vattenkraftsrelaterade miljöåtgärder (EKOLIV)

Projektledare:
Leonard Sandin
Institutionen för Vatten & Miljö, SLU, Uppsala

EKOLIV

- Leonard Sandin vid SLU Uppsala
- Analysera ekologiska och samhällsekonomiska effekter av redan genomförda miljöåtgärder kopplade till vattenkraft.
- I projektet kommer de att arbeta utifrån ett ekosystemperspektiv och inkludera ekosystemfunktioner och ekosystemtjänster kopplat till de socioekonomiska beräkningarna.

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Study aim: revealing spatiotemporal response trends across systems and regions

Understand and make predictions of the range, magnitude, trajectory, and duration of macroinvertebrate response to small dam removal.

Unravel influence of additional factors:

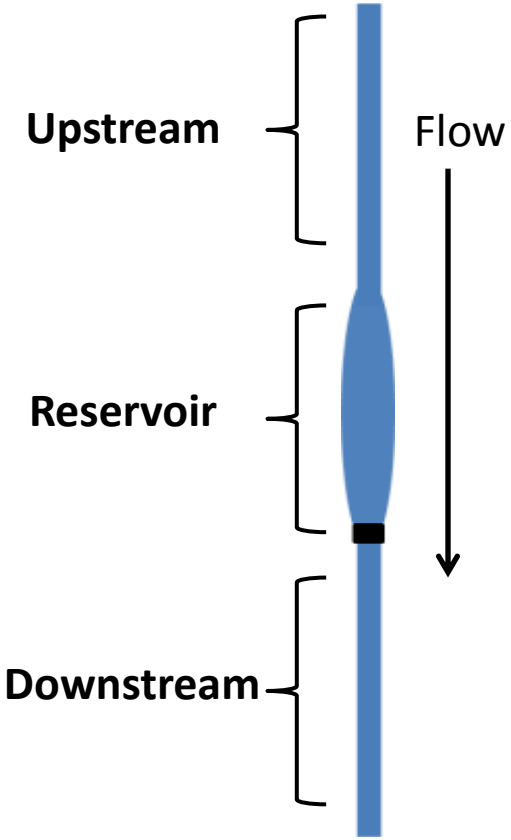
-Landuse

-Stream characteristics

-Dam characteristics

Disturbance and ecological improvement after dam removal

Evaluated at three sections:



Alterations:
- hydrology
- sediment loading
- temperature regimes
- connectivity

Processes:
- sediment exposure, erosion, redistribution
- shifts in hydrology and temperature

Literature search: published, grey, and raw data (October 2015 to April 2016)

Web of Science **Search terms**: TS=(dam* OR weir* OR reservoir* OR impoundment*) AND TS=(remov* OR deconstruct* OR destruct* OR undam*) AND TS=(invertebrate* OR benthic* OR macroinvertebrate* OR "aquatic insect*" OR zoobentho*) **WITH**: *Sort by relevance*, *Doc types:* no patents, *Research Area:* Environmental Science/Ecology

Web search engines **Search terms:** All possible combinations of the search terms listed above

Citations and references of all relevant literature

Contact with entities associated with dam removals

Criteria for inclusion:

- **-pre- and post-dam removal data**
- **-sampling distance and time**
- **-dam height <15 m**

Literature search results

35 dam removals scattered across the United States,
but also studies from Sweden, Taiwan, and Korea

2736 effect sizes, 10 metrics:

Biotic Index
LIFE Index
Shannon diversity
Simpson diversity
Total density
Richness
EPT density
EPT richness
%EPT density
%EPT richness

9 predictor variables:

Dam height
Dam elevation
Stream gradient
Stream width
Stream discharge
Catchment area
Catchment area % undisturbed
Catchment area % arable
Catchment area % urban

Studies on response of macroinvertebrates to small dam removal

- Few published studies relative to the number of dam removals
- Limited by inadequate spatial and temporal replication

  - long-term studies are rare

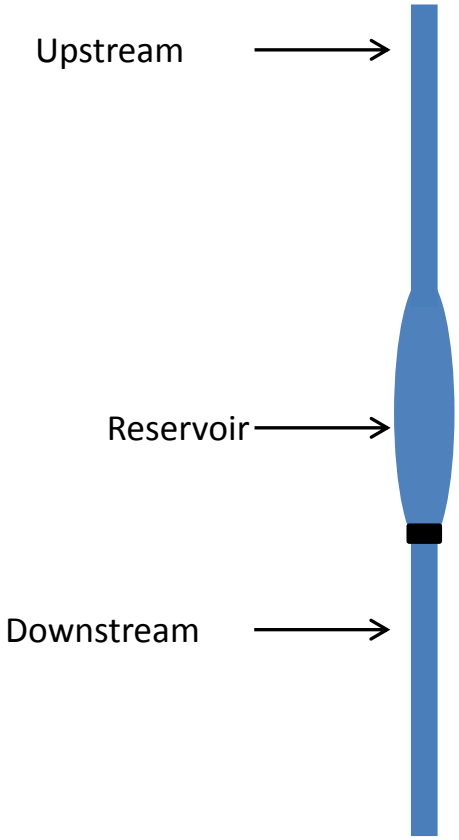
  - short-term studies can be largely dependent on sampling time and distance from dam removal

- Often excluded one or more sections (i.e., upstream, reservoir, or downstream)

Studies on response of macroinvertebrates to small dam removal

- Utilization of “reference” up- or down-stream sections with an untested assumption that response is minimal or nonexistent (often BACI designs)
- Pre-removal data are often lacking making it difficult, if at all possible, to assess changes from pre-removal conditions
- Selection of metric/s utilized often differ among studies

Framework of analyses



$$\ln\left(\frac{\text{Before removal } (N_b)}{\text{After removal } (N_a)}\right)$$

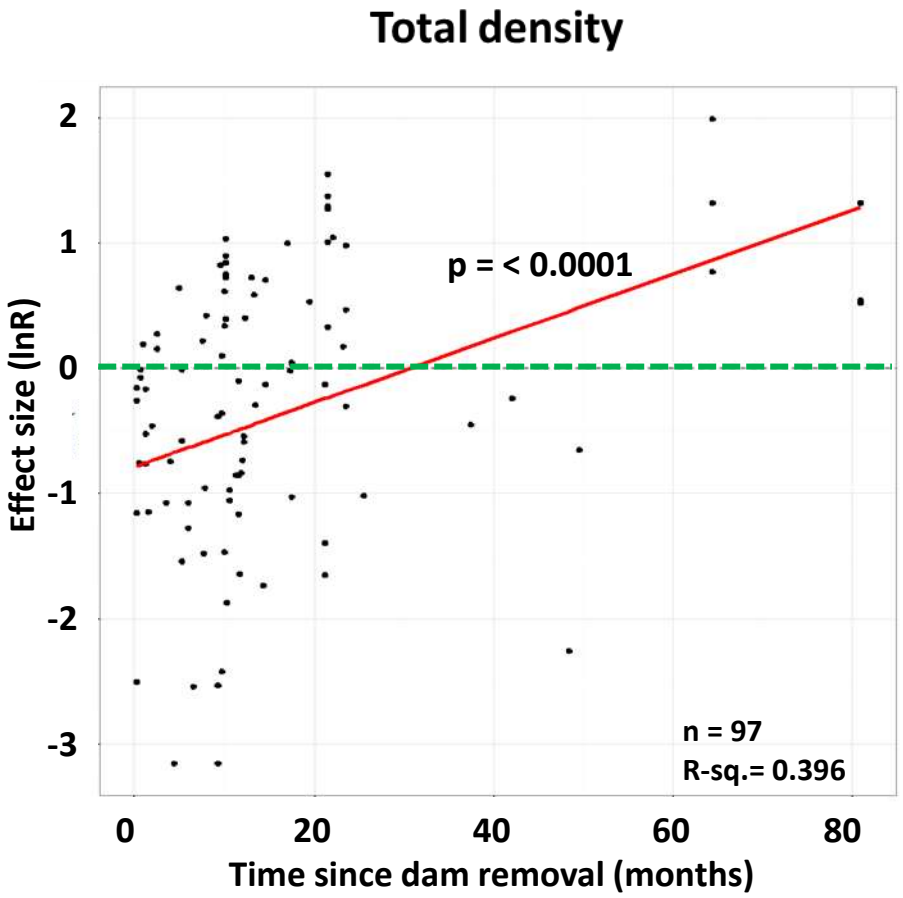
Effect size = Response ratio = change after dam removal = $\Delta r = \ln(N_a/N_b)$

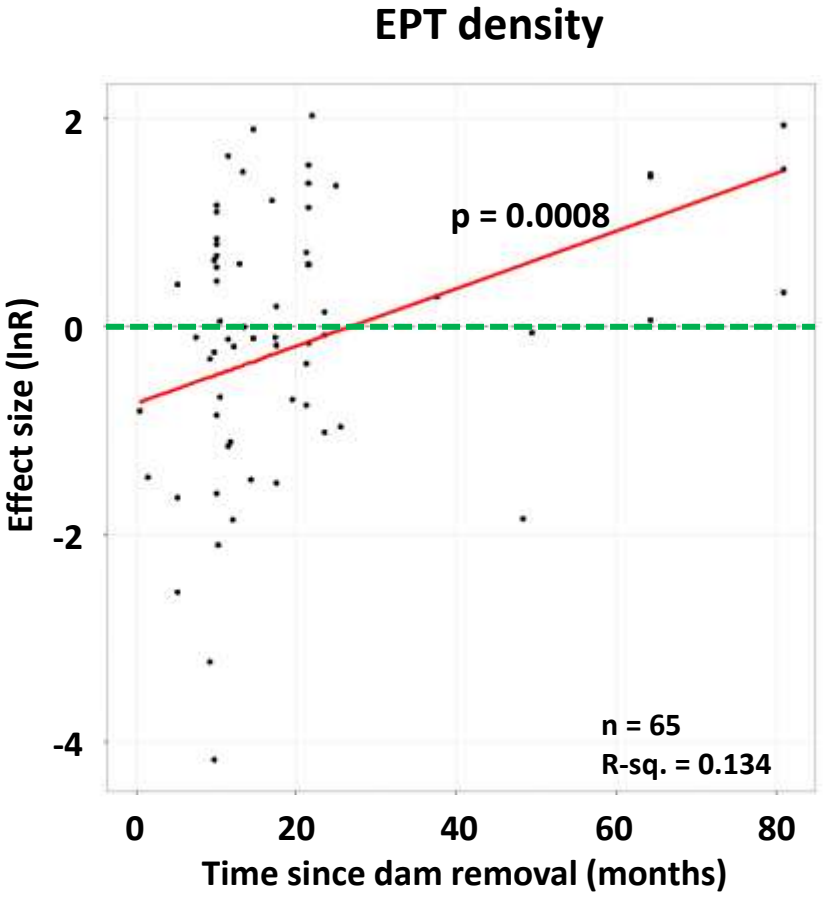
Suitable for statistical analysis of spatiotemporal change in the metric values across studies

Regression analyses of effect sizes

- Time up to 80 months
- Distance downstream 0-3 km
- Distance upstream of reservoir 0-3 km
- Reservoir all distances
- Predictor variables included in the model:
  - dam height
  - discharge
  - % catchment area undisturbed

Results downstream



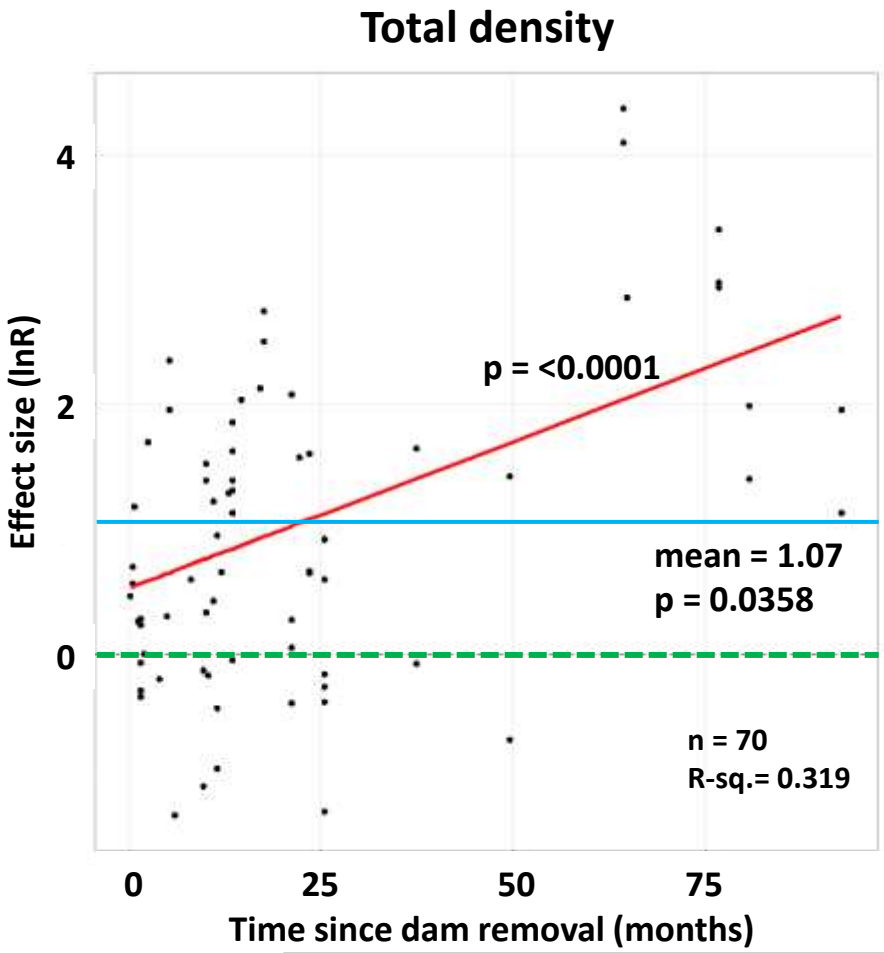


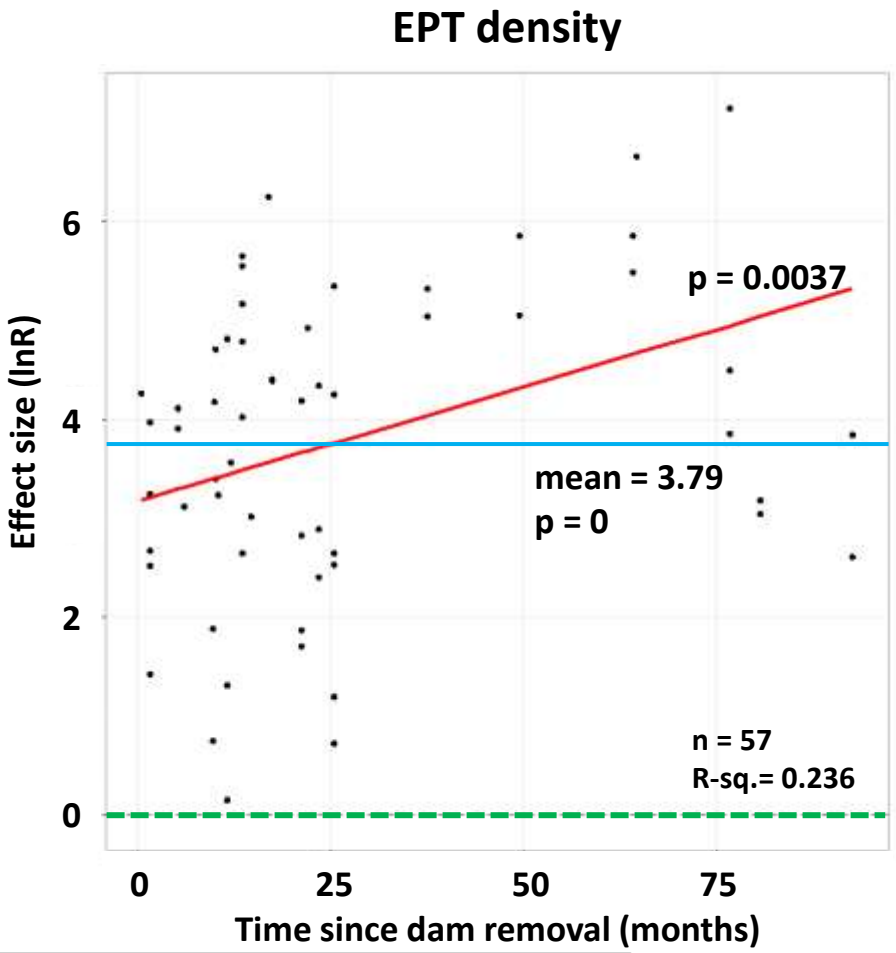
% EPT density

Mean effect size significantly increased after dam removal, but did not change with time

Mean effect size = 2
n = 47
R-sq.= 0.254
p (>|t|) = 0.0221

Results reservoir



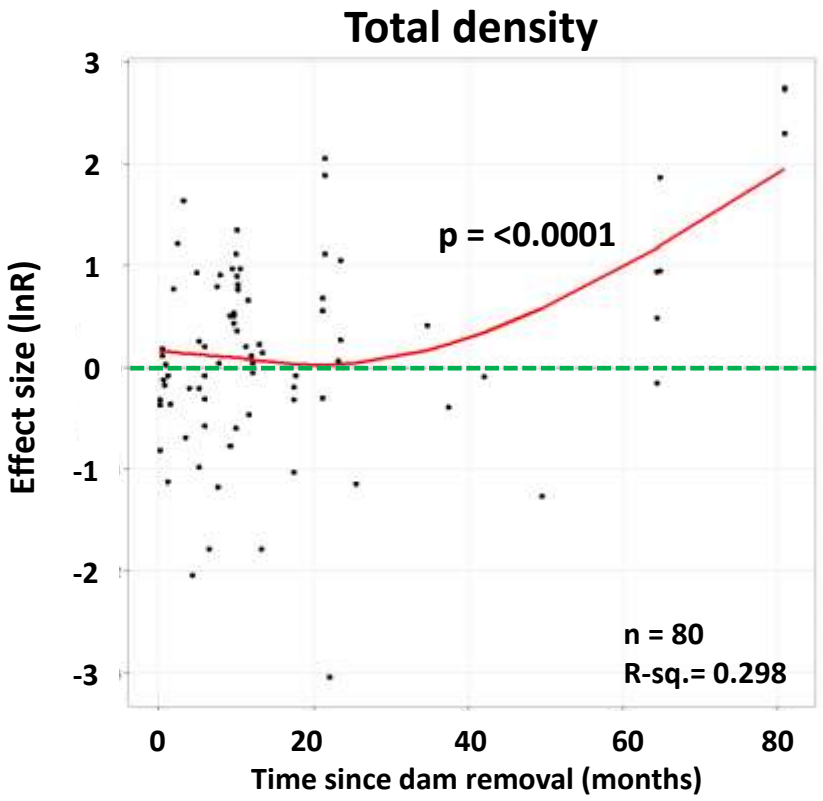


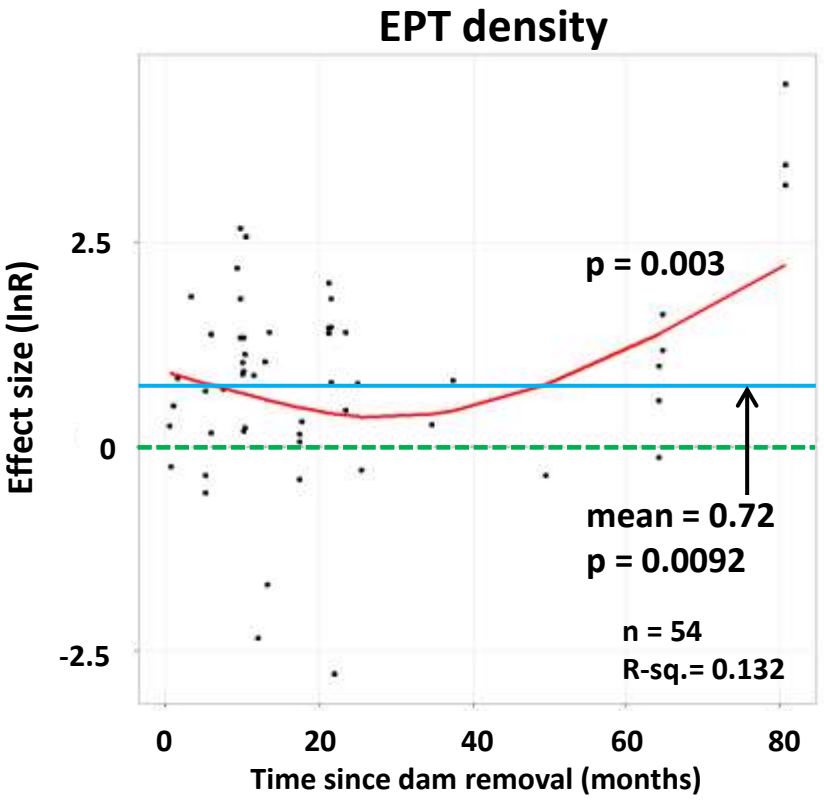
% EPT density

Mean effect size significantly increased after dam removal, but did not change with time

Mean effect size = 2.25
n = 65
R-sq.= 0.18
p (>|t|) = 0.0084

Results upstream !!





Conclusions

- Dam removal is an effective ecological restoration measure
- Time is the most important predictor of response with changes still occurring after at least five years
- Total density, EPT density, and %EPT density have high potential as metrics utilized across systems and regions in predicting and evaluating ecological response to small dam removal
- Using up- or down-stream reaches as reference sites is unlikely appropriate (i.e., BACI designs)

Projekt Ekoliv

Acknowledgements

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- **Kraft och liv i vatten (KLIV)**
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- **Energimyndigheten**
  (Swedish Energy Agency)
- **HaV**
  (Swedish Agency for Marine and Water Management)
- **Vattenmyndigheterna**
  (Sweden's five water authorities)

Vattenfall Vattenkraft AB
Fortum Generation AB
Sydkraft Hydropower AB
Statkraft Sverige AB
Skellefteå Kraft AB
Holmen Energi AB
Jämtkraft AB
Umeå Energi AB
Tekniska Verken i Linköping AB
Mälarenergi AB
Sollefteåforsens AB
Karlstads Energi AB
Jönköping Energi AB
Härjeåns Kraft AB