Taming the Intractable

how to control the cormorant and other unmanageable wildlife

Sten Zeibig

supervisors: PD Dr. K. Frank, Prof. H. Malchow

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Background story: the conflict

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Background story o●ooo	From the special to generity		Appendix 0000

The conflict

- Fishery suffers losses by cormorants
- Cormorant is a protected species



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The conflict

Numbers of cormorants is increasing



T. Bregnballe et al.

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Background story 000●0	From the special to generity		Appendix 0000
The conflic	t		

Standard approach for reduction is to cull, but culling is dodgy





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Lessons learnt oo Appendix

The buffer structure

Breeding cormorant



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The buffer structure

Some mature cormorants do not breed (floaters)



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The buffer structure

Floaters can fill vacancies in breeding sites



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The buffer structure

Floaters can fill vacancies in breeding sites



Ecosystem functioning influences regulation effectiveness

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From the special to generity the relevance of buffer structure

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A common structure

Floaters are known from many species



Spanish imperial eagle

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A common structure

Floaters are known from many species



Otter

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A common structure

Floaters are known from many species



Some lizard species

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A common structure

Floaters are known from many species



Badger

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A common structure

Floaters are known from many species



Raven

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A common structure

Floaters are known from many species



Mink

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A common structure

Floaters are known from many species



Canada goose

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Why not try to get a general understanding of the buffer structure?

Of special interest: the context of regulation

- conserving viability
- being effective
- being efficient

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What are the dynamical effects of the buffer structure?

- Given a buffer stock is to be regulated, how could this be done in an effective and efficient way?
 - Are there any principle limitations or pitfalls?
 - Are there rules of thumb?
- How can the cormorant be regulated?

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A model of the buffer structure



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A model of the buffer structure



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A model of the buffer structure



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Stock regulation



time

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Stock regulation



time

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Stock regulation



time

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Stock regulation



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Stock regulation



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Ways to regulate a stock

Culling of adults

- Egg oiling, chicks suffocate before hatching
- Reducing environmental capacity for breeders

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Ways to regulate a stock

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Question reminder

- What are the dynamical properties of the buffer structure?
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 - Are there any principle limitations or pitfalls?
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- How can the cormorant be regulated?

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Result: buffer structure and resilience

The bigger the buffer, the faster breeders recover from catastrophes



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Result: buffer structure and resilience

The bigger the buffer, the faster breeders recover from catastrophes



 \Rightarrow The buffer structure is a resilience mechanism.

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Question reminder

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Result: culling and buffer destruction

Slightly increased culling destroys the buffer



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Image: A matrix

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Result: culling and buffer destruction

Slightly increased culling destroys the buffer



⇒ Loss of resilience!

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Result: buffer types and achievable targets

Sluggishness of buffer response to breeders loss determines achievable regulation targets



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Result: buffer types and achievable targets

Sluggishness of buffer response to breeders loss determines achievable regulation targets



\Rightarrow Margin for normative decisions is limited.

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Result: working regulation strategies Reducing environmental capacity for breeders



Broad range of target sizes ecologically possible

- Buffer structure is conserved
- Low fluctuations in stock size, i.e. regulation effort well predictable

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Result: working regulation strategies

Reducing environmental capacity for breeders



- Broad range of target sizes ecologically possible
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Buffer structure provides a resilience mechanism

- Regulation should not alter system structure to maintain resilience
- There are limitations for achievability of normative settings
- Understanding ecosystem functioning as basis for design of conflict reconciliation strategies
- Thus, need for structurally explicit dynamic models

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- Understanding ecosystem functioning as basis for design of conflict reconciliation strategies
- Thus, need for structurally explicit dynamic models

Thank you for your attention!









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Conceptional model

Logistic growth dynamic of the reproductive part

$$N_{t+1} = N_t + r_t N_t \left(1 - \frac{N_t}{\kappa}\right)$$

Simple cut-off dynamic of the buffer

$$P_{t+1} = \min\{\kappa, P_t - \delta P_t\}$$

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Conceptional model

Flux into the buffer

$$f_{rb}(N_t) = \lambda max\{0, (1+r_t)N_t - K\}$$

Flux forth the buffer

$$f_{br}(N_t, P_t) = \beta(P_t - \delta P_t) \frac{\max\{0, (K - N_t)\}^2}{k^2 + (K - N_t)^2}$$

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Conceptional model

First calculation of gross growth

$$N_{g,t} = r_t N_t - f_{rb}(N_t) + f_{br}(N_t, P_t)$$
 $N_{t+1} = N_t + N_{g,t} \left(1 - rac{N_t}{K}
ight)$

Buffer dynamic

$$P_{t+1} = \min\{\kappa, P_t - \delta P_t + f_{rb}(N_t) - f_{br}(N_t, P_t)\}$$

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Regulation strategies



"bang-bang"-strategy with "stop-loss-rule"

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Regulation strategies: achievable targets, costs, risk



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Regulation strategies: achievable targets, costs, risk



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Regulation strategies: achievable targets, costs, risk



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Regulation strategies: achievable targets, costs, risk



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1. If risk of catastrophes is unknown, conserve the buffer

- 2. If possible, reduce environmental capacity for breeders
- 3. If not, breeders number may be reduced carefully
- 4. Medium reductions of breeders number lead to strong fluctuations and thus are risky
- 5. Stronger breeders reduction removes the buffer
- 6. Manipulating the buffer directly or the reproduction rate is not effective

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Rules of thumb for regulation

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