MONITORING ENVIRONMENTAL IMPACTS OF

OFFSHORE WIND FARMS

IN THE BELGIAN PART OF THE NORTH SEA

TOP PREDATORS

- Dick Botteldooren, Robin Brabant, Wouter Courtens, Elisabeth Debusschere, Steven Degraer, Luc Dekoninck, Valérie Dulière, Jan Haelters, Kris Hostens, Alain Norro, Thierry Onkelinx, Bob Rumes, Eric Stienen, Sofie Vandendriessche, Marc Van de Walle, Nicolas Vanermen, Timothy Van Renterghem, Hilbran Verstraete, Laurence Vigin, Magda Vincx
- Presented by: Jan Haelters and Nicolas Vanermen






LEARNING FROM THE PAST TO OPTIMISE

FUTURE MONITORING

NOISE, FISH, PORPOISES AND SEABIRDS

Construction phase

Above water noise

Underwater noise

- Effects on marine mammals
- Effects on fish

Operational phase

Above water noise

Underwater noise

- Effects of the presence of operational wind turbines on seabirds

CONSTRUCTION PHASE: ABOVE WATER NOISE

- During piling (jacket foundation): 145 dB(A) @ 284 m: can be heard up to 10 km away during calm weather conditions
- No effects investigated / observed on seabirds

CONSTRUCTION PHASE: UNDERWATER NOISE

Source level

SPL

L_{p-p}

Pa

dB

dB_{RMS}

L_{p-p}

SEL

Received level

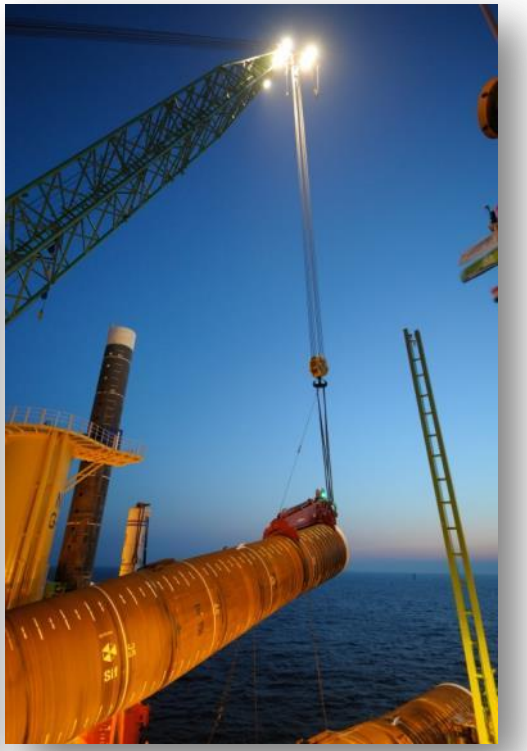
DIFFICULT TO INTERPRET AND COMPARE

CONSTRUCTION PHASE: UNDERWATER NOISE

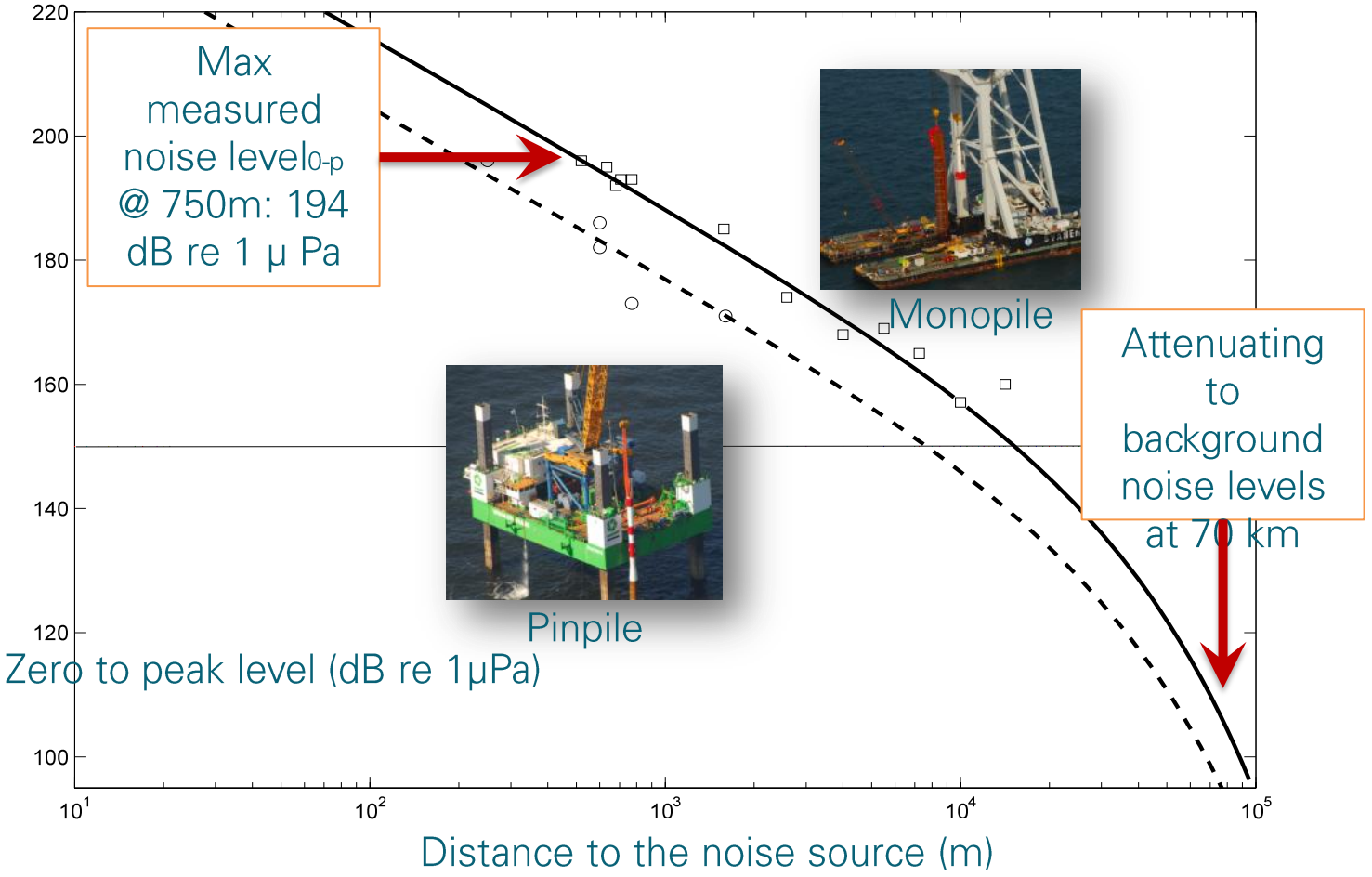
- Shipping, dredging, cable, scour protection,…:
  - Noise levels similar to existing activities

CONSTRUCTION PHASE: UNDERWATER NOISE

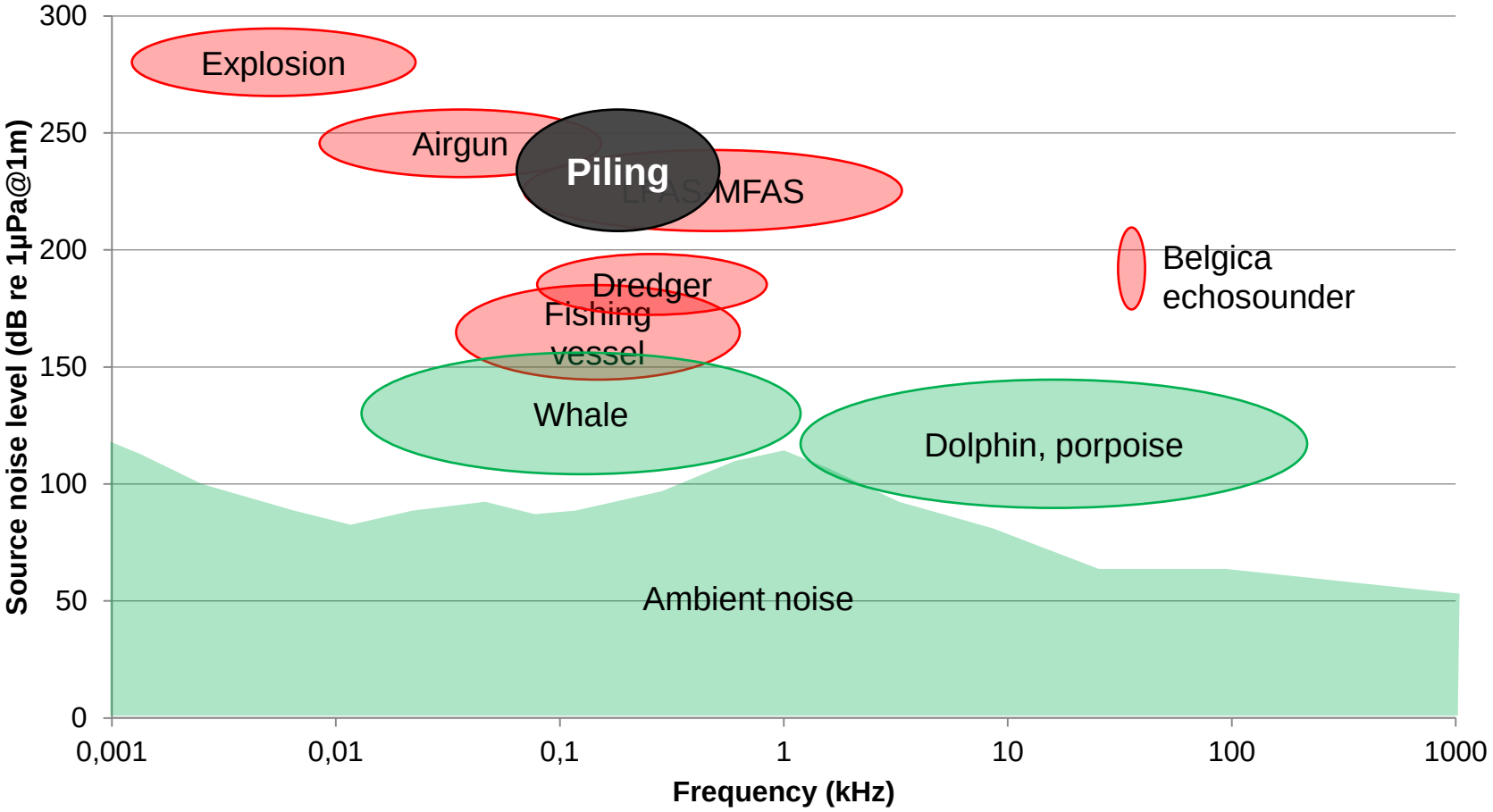
- Piling:
  - Very high noise levels
  - Wider-ranging effects?



PILING: UNDERWATER NOISE LEVELS



CONSTRUCTION NOISE



After Seiche, 2002; ACCOBAMS/ASCOBANS, in prep.

CONSTRUCTION NOISE





DIRECTIVES

DIRECTIVE 2008/56/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 17 June 2008

establishing a framework for community action in the field of marine environmental policy (Marine

THE EUROPEAN
EUROPEAN UNIO

8. 'pollution' means the direct or indirect introduction into the marine environment, as a result of human activity, of substances or energy, including human-induced marine underwater noise, which results or is likely to result in deleterious effects such as harm to living resources and marine ecosystems, including loss of biodiversity, hazards to human health, the hindering of marine activities, including fishing, tourism and recreation and other legitimate uses of the sea, impairment of the quality for use of sea water and reduction of amenities or, in general,

(11) Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment.

EFFECTS ON HARBOUR PORPOISES

- By far the most common marine mammal in Belgian waters
- Small endotherm in cold water: constant foraging!
- Very sensitive to underwater noise

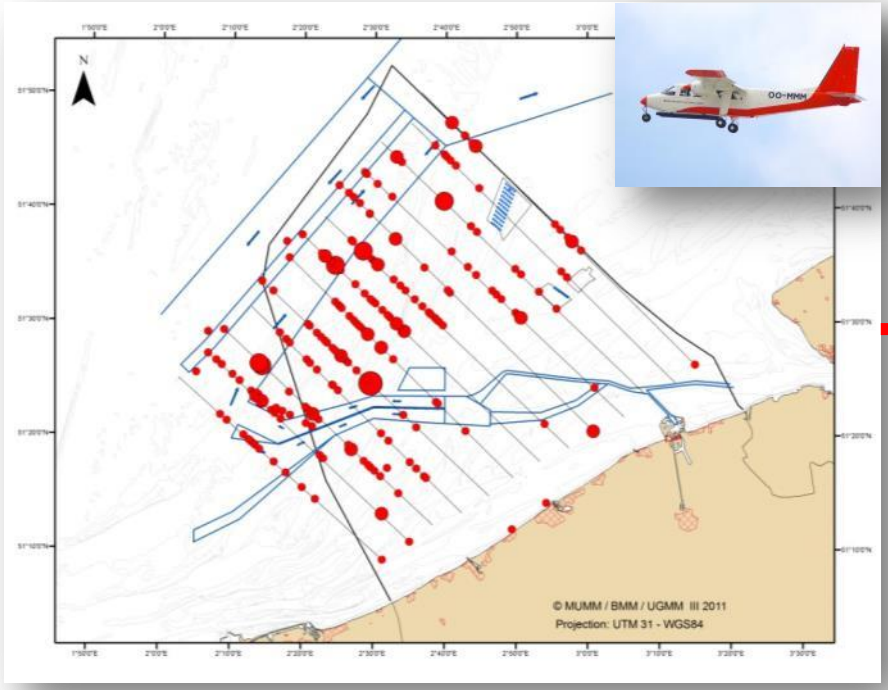
CONSTRUCTION NOISE: EFFECTS

EFFECTS OF PILING ON HARBOUR PORPOISES

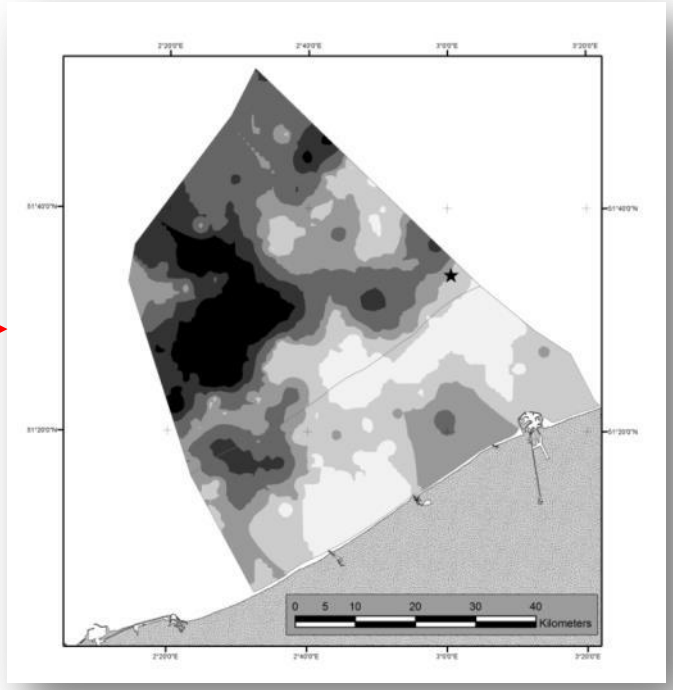
- Aerial line transect surveys before, during and after piling
- Modelling effects on the basis of literature and UW noise measurements

EFFECTS OF PILING ON HARBOUR PORPOISES

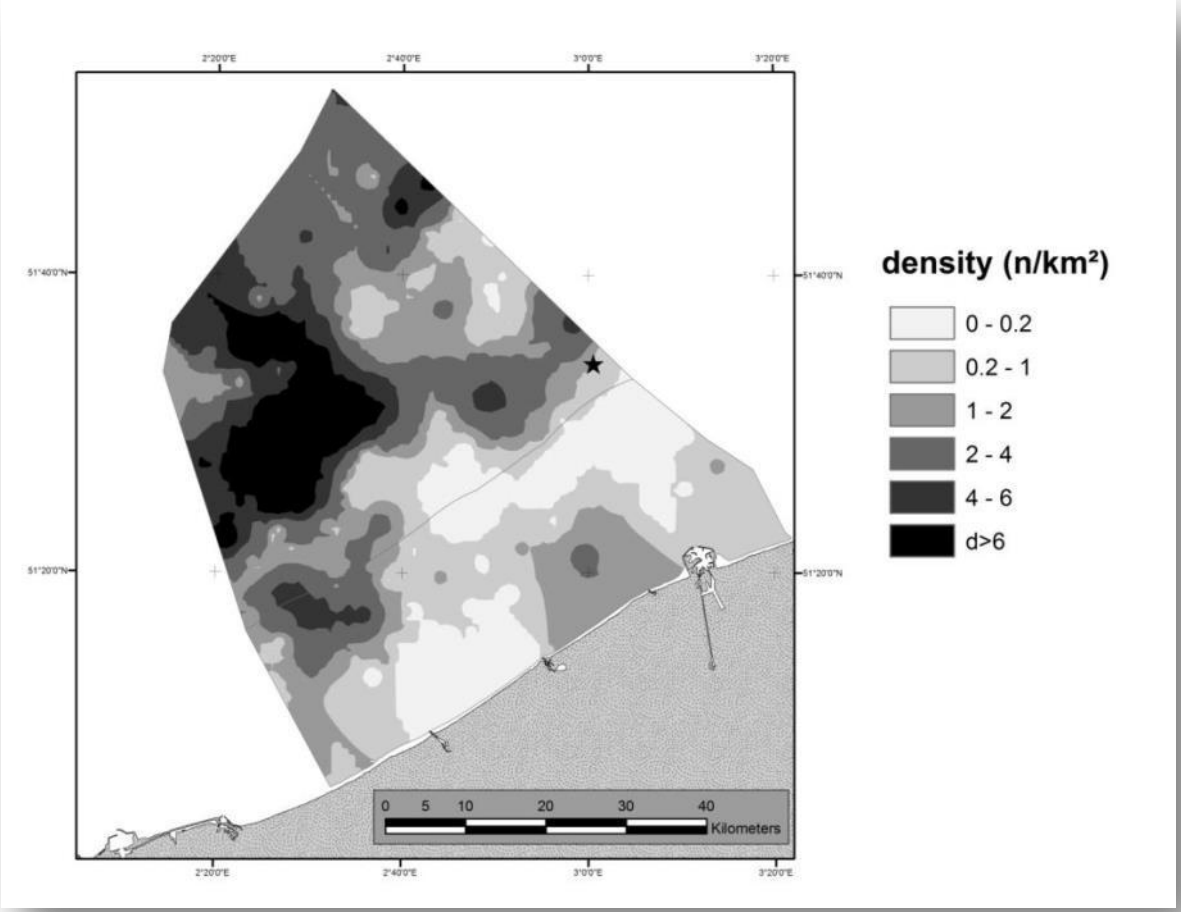
Observations



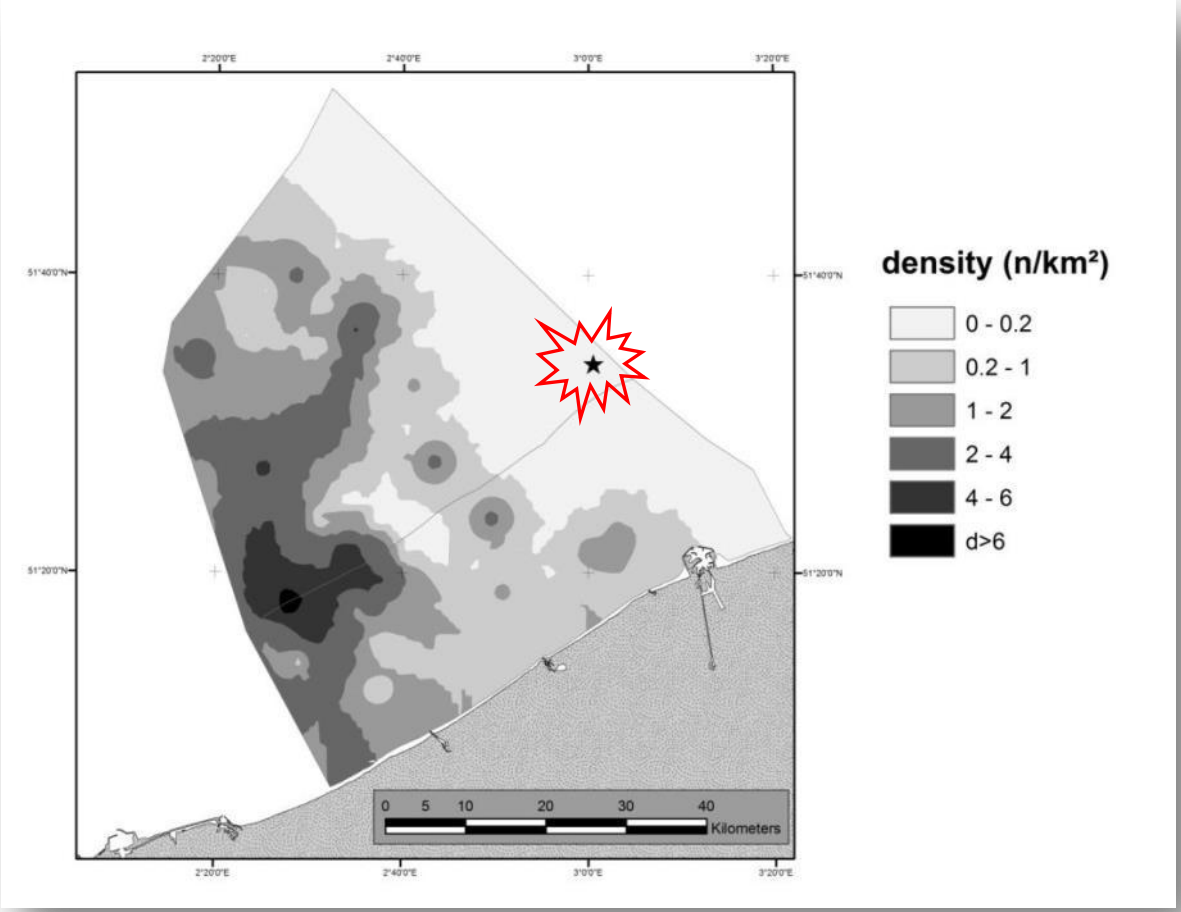
Density



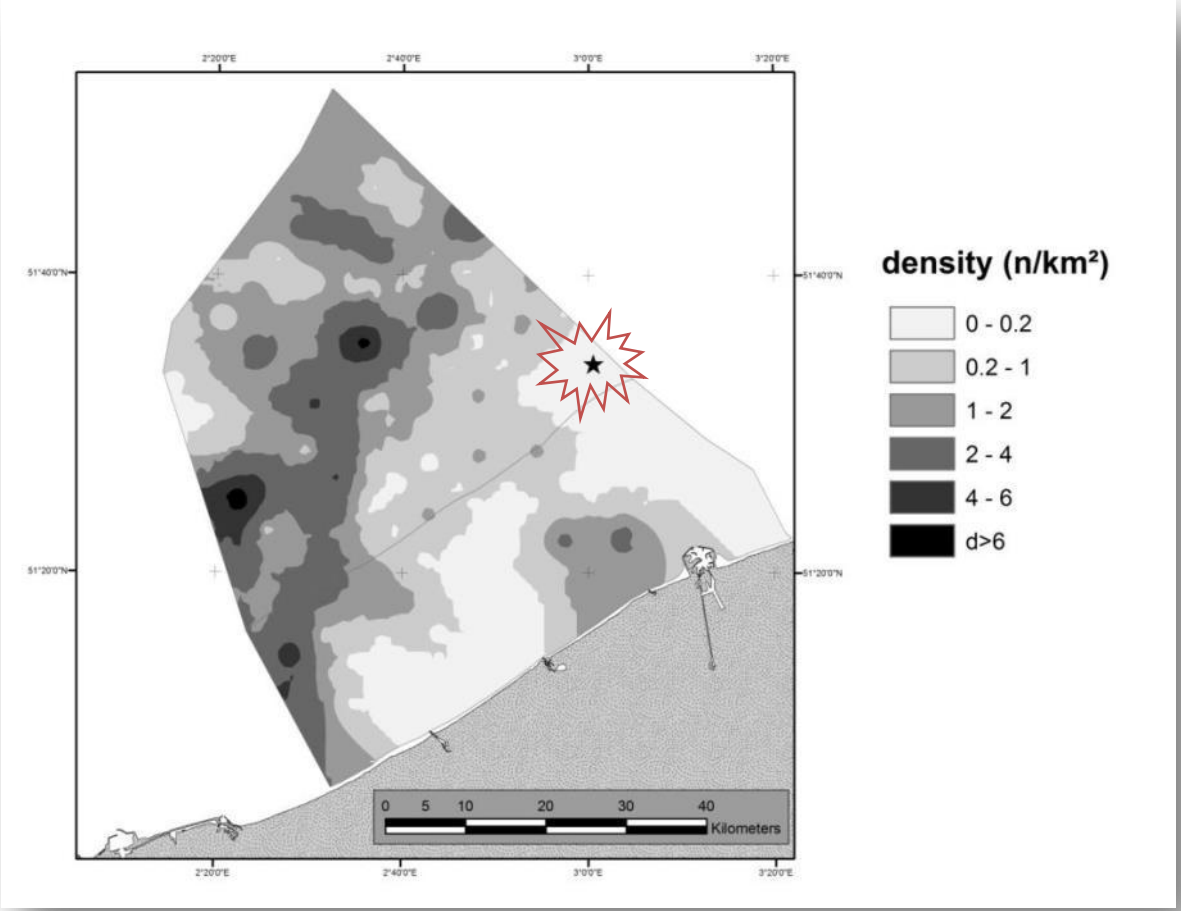
DENSITY BEFORE PILING



DENSITY DURING PILING

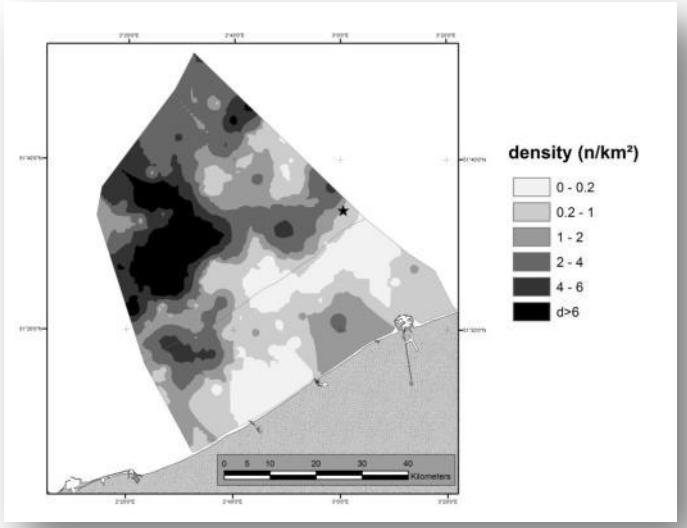


DENSITY 1 DAY AFTER PILING

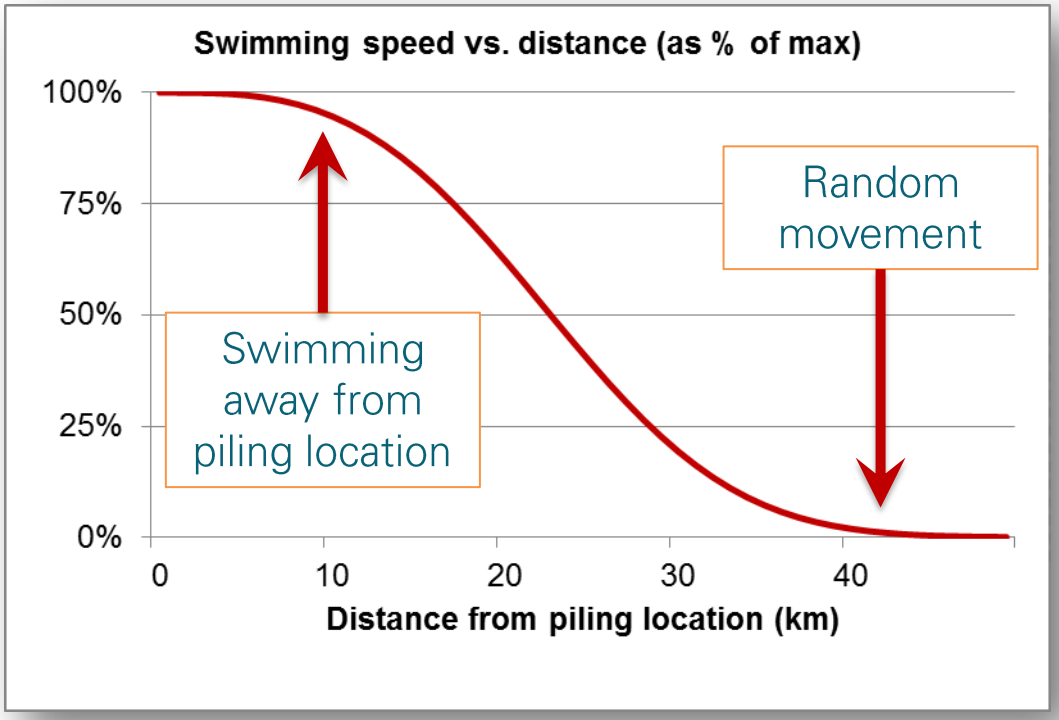


PORPOISE REDISTRIBUTION MODEL

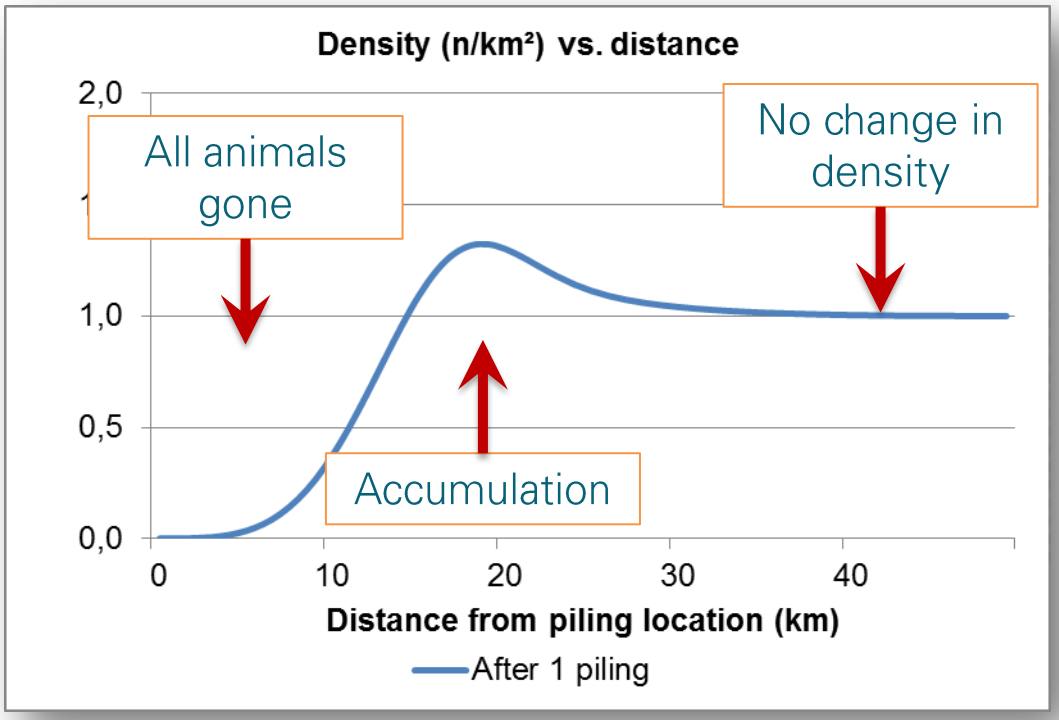
- Existing reference situation
- Development of an impact model
- Application of the model to hypothetical data (1 animal/km²)
- Application of the model to the reference situation: predicted redistribution



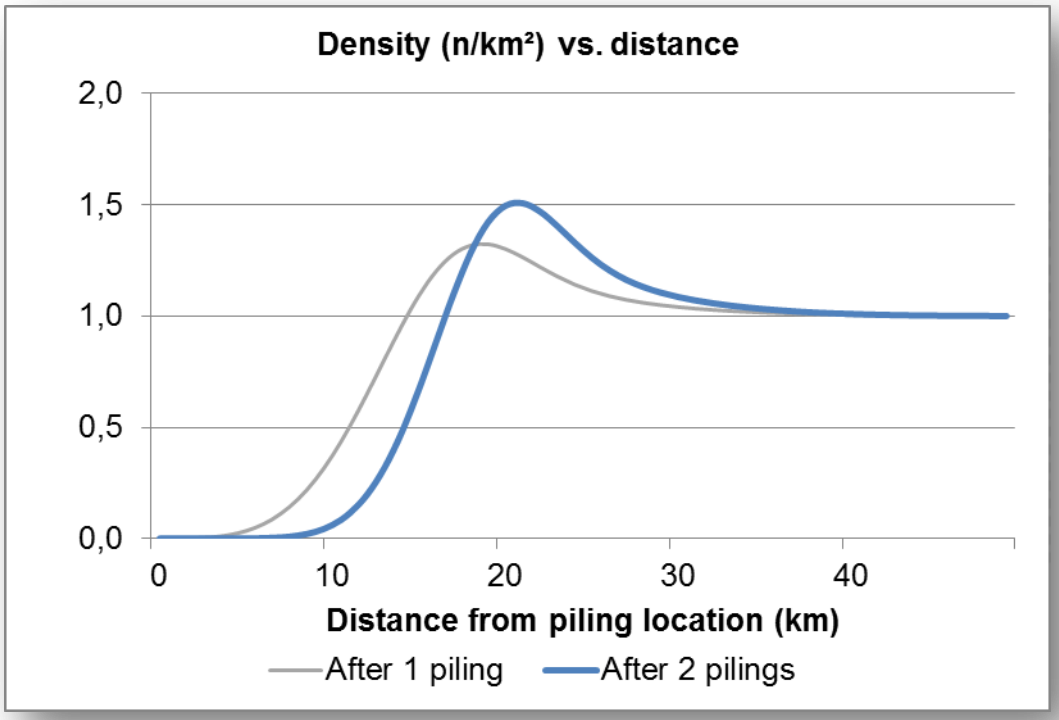
CONSTRUCTION NOISE: MODEL



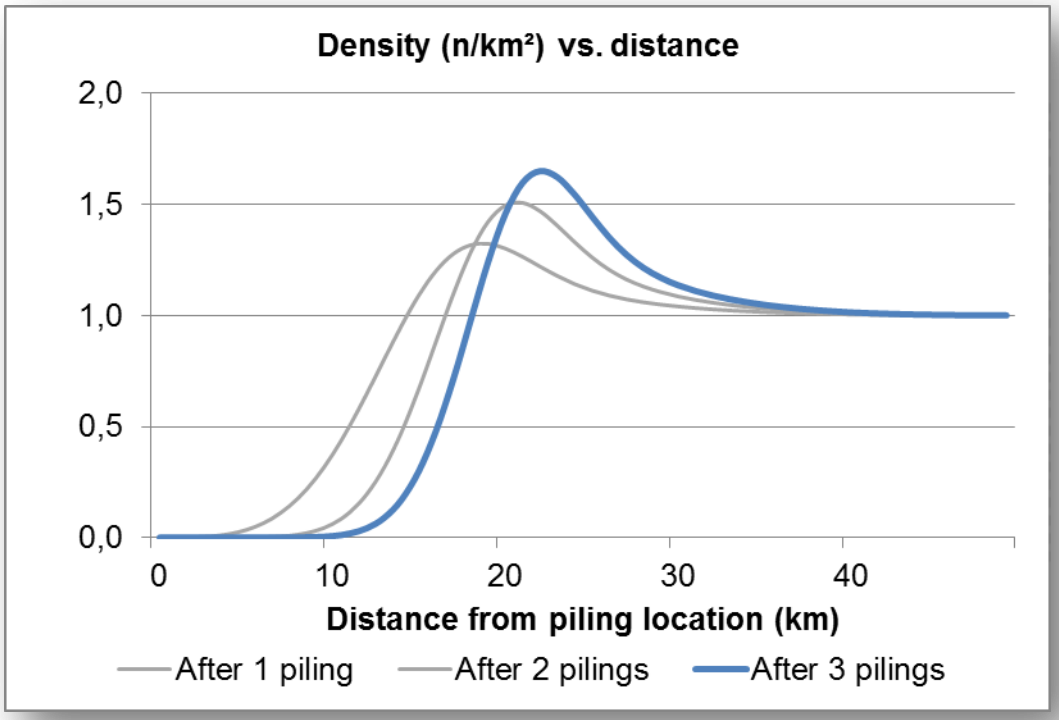
CONSTRUCTION NOISE: MODEL



CONSTRUCTION NOISE: MODEL

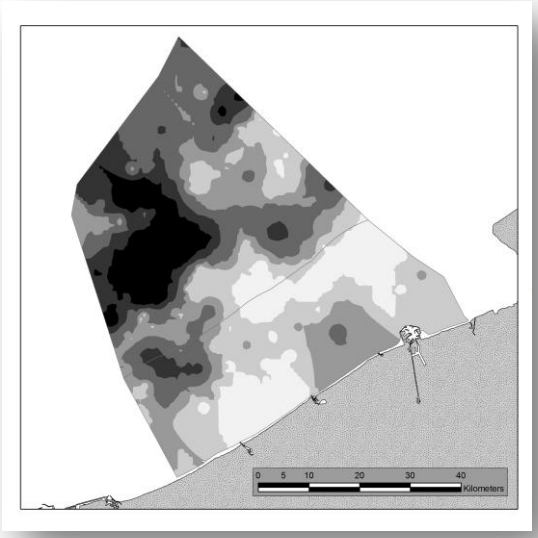


CONSTRUCTION NOISE: MODEL

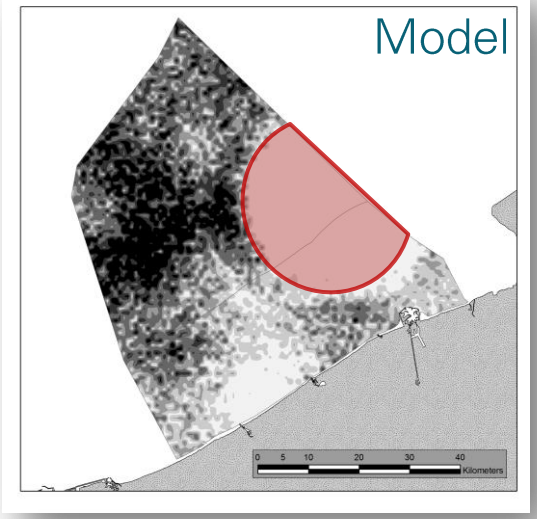


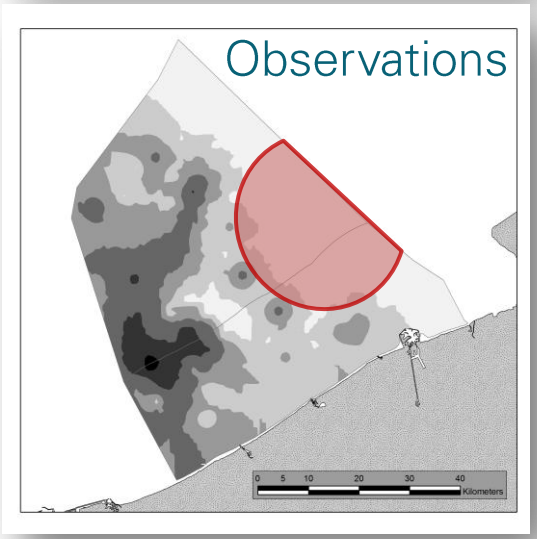
CONSTRUCTION NOISE: MODEL

Reference situation

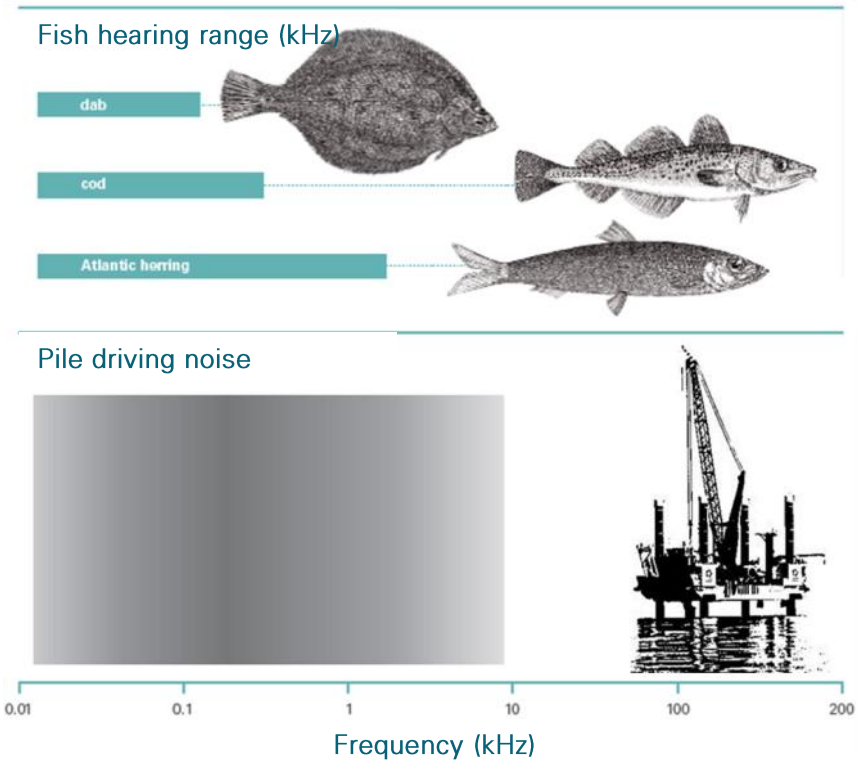


Situation during piling

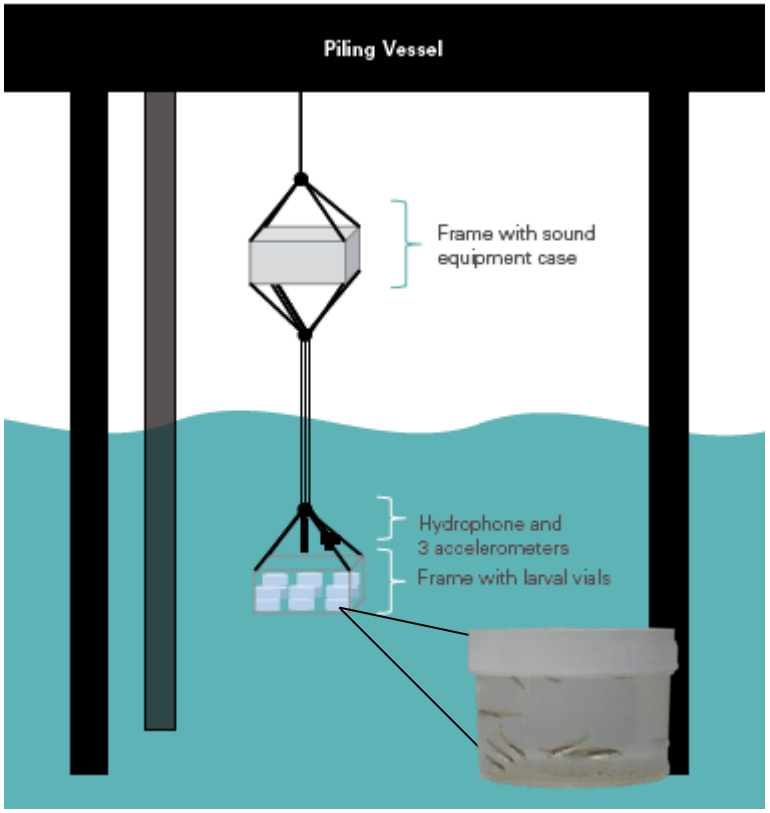




EFFECTS ON FISH



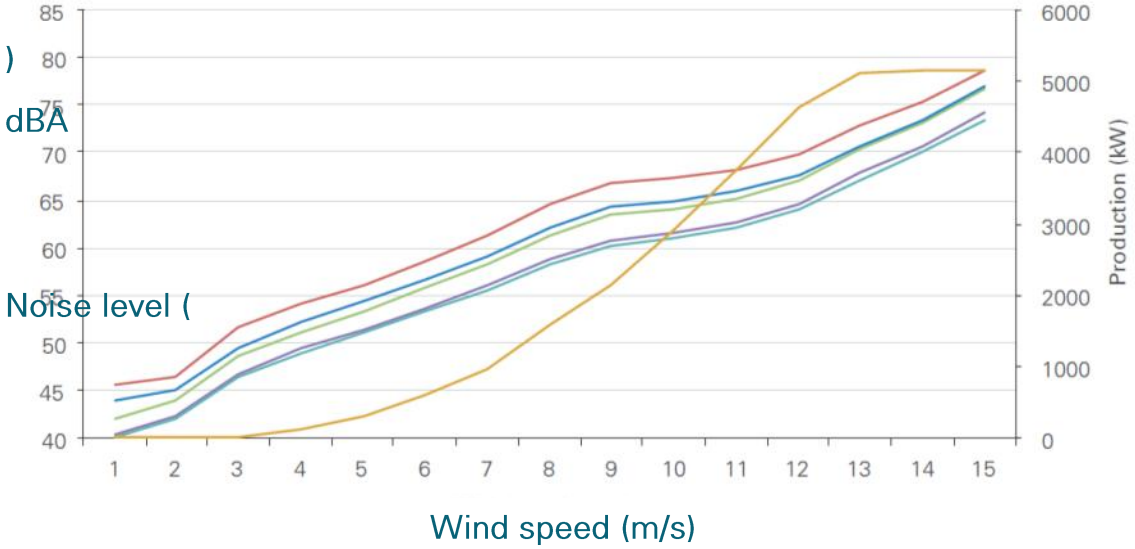
[Based on Slabbekoorn et al., 2010]



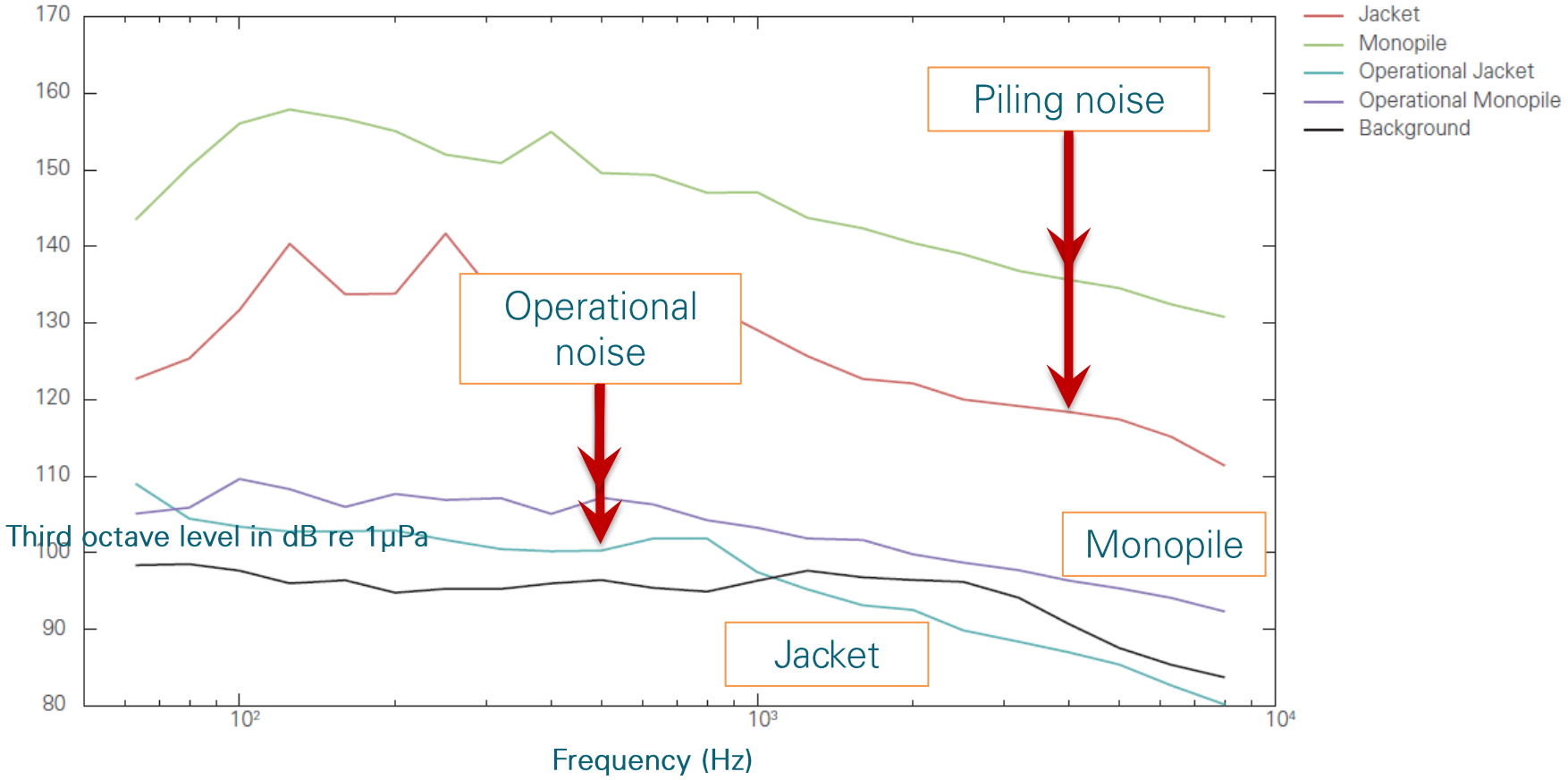
First results indicate no immediate or delayed mortality in young sea bass due to piling

OPERATIONAL PHASE: ABOVE WATER NOISE LEVELS

Operational noise levels: function of wind speed; can be heard up to a few km away



OPERATIONAL PHASE: UNDERWATER NOISE LEVELS



CONCLUSIONS ON NOISE AND PORPOISES

- Construction phase
  - Above water noise: little concern
  - Underwater noise: piling of concern, with porpoises displaced over 20 (+?) km
  - Repopulation after 1 day without piling
  - Effects on individuals or population unknown
- Operational phase
  - Above water noise: little concern
  - Underwater noise: effects on porpoises to be examined, but likely to be minor

BIRD MONITORING

BIRD MONITORING

Belgian part of the North Sea:

- Important wintering area for northern breeding seabirds
- Foraging habitat for local tern and gull populations
- Major migration corridor for 1-1,3 million seabirds

Offshore wind farm development may lead to…

- … habitat loss and barrier effects hampering migration & local flight movements due to avoidance behaviour
- … increased bird mortality due to collisions, catalysed by attraction effects

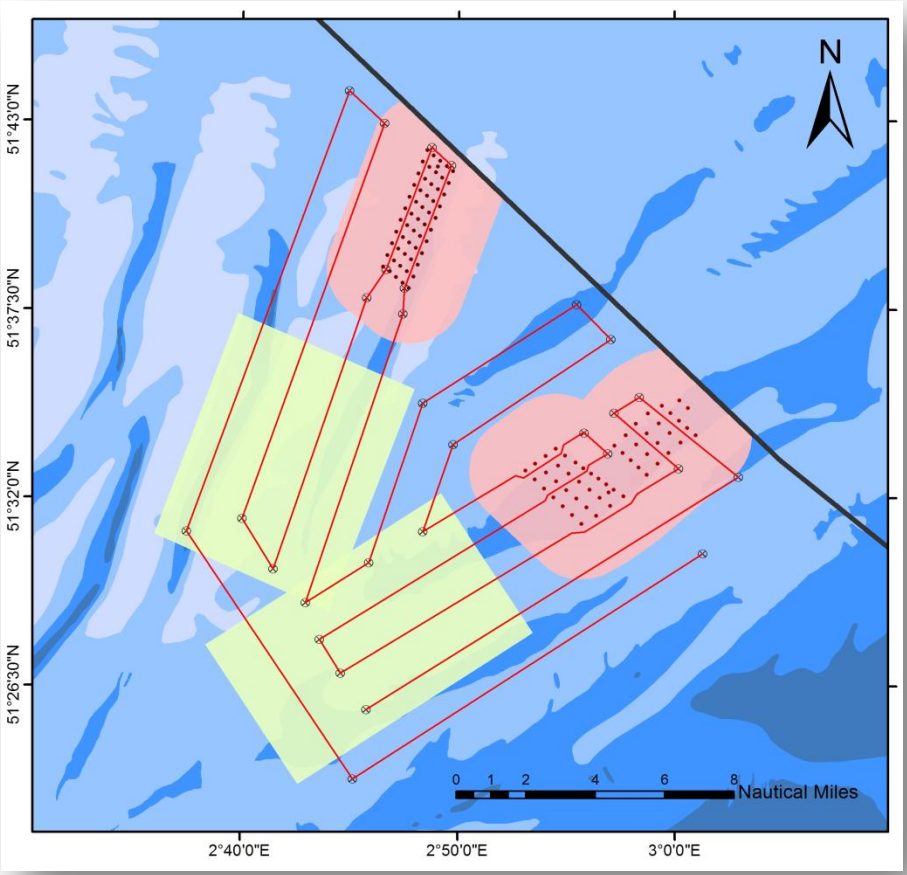
BIRD MONITORING: Methods

Ship-based seabird surveys

- BACI-designed monthly surveys through impact & control areas
  → output ~ bird densities
- Primary goal: seabird displacement assessment
  → habitat loss versus attraction effects
- Results on densities of flying birds may also serve as input in collision risk modelling (CRM, Band 2012)

BIRD MONITORING: Methods

Ship-based seabird surveys



BIRD MONITORING: Methods

Radar research

- Horizontal radar:
  - Tracks bird flights in a horizontal pane …
  - … primarily to assess barrier effects and macro-avoidance rates

- Vertical radar:
  - Measures bird flux through a vertical pane …
  - … and serves as input for CRM

BIRD MONITORING: Methods

Radar research

BIRD MONITORING: Seabird displacement

Modelling SAS data

Ship-based seabird survey count results:

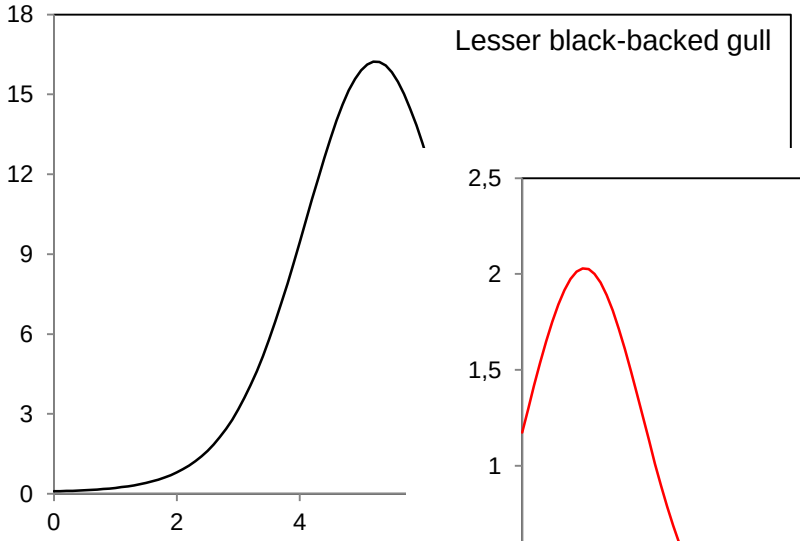
- Data aggregation to day totals per area (control / impact) to avoid autocorrelation
- Zero-inflated negative binomial modelling to incorporate high variance and excess in zero-counts

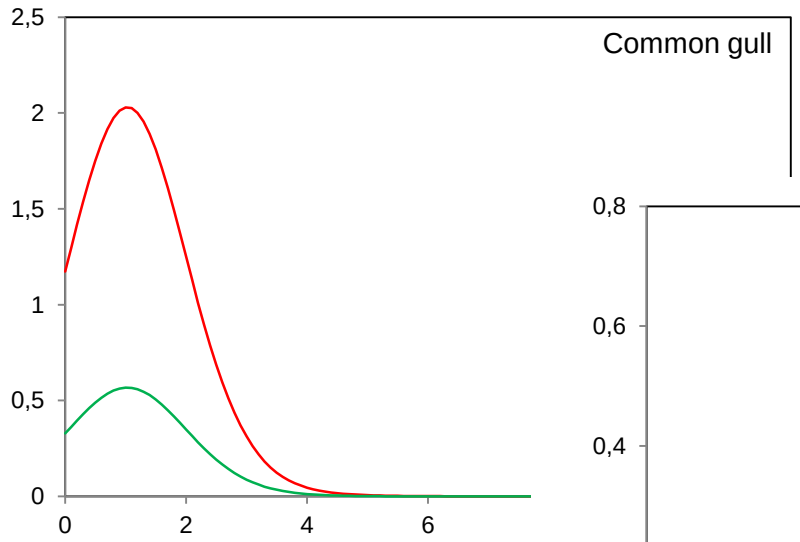
Model covariates:

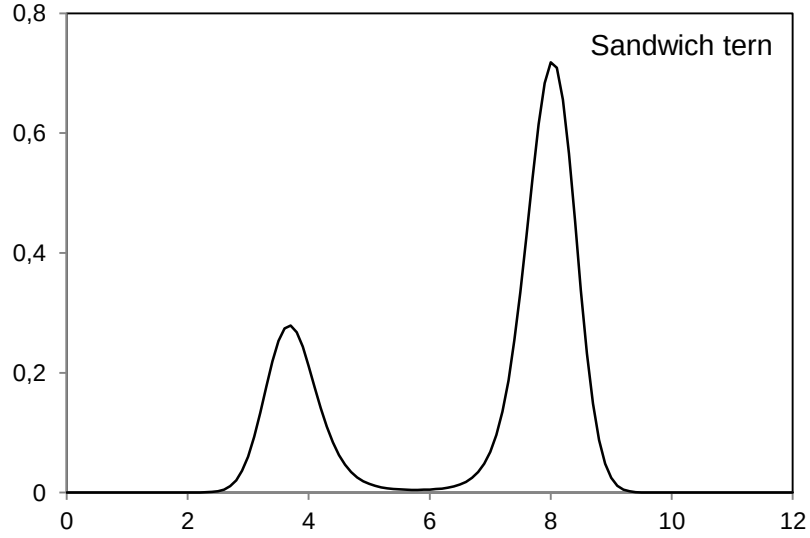
- Seasonality: modelled as a sine curve
- Period: two-level factor variable **BA** (before-after)
- Area: two-level factor variable **CI** (control-impact)
- Displacement effect: interaction between **BA** & **CI**

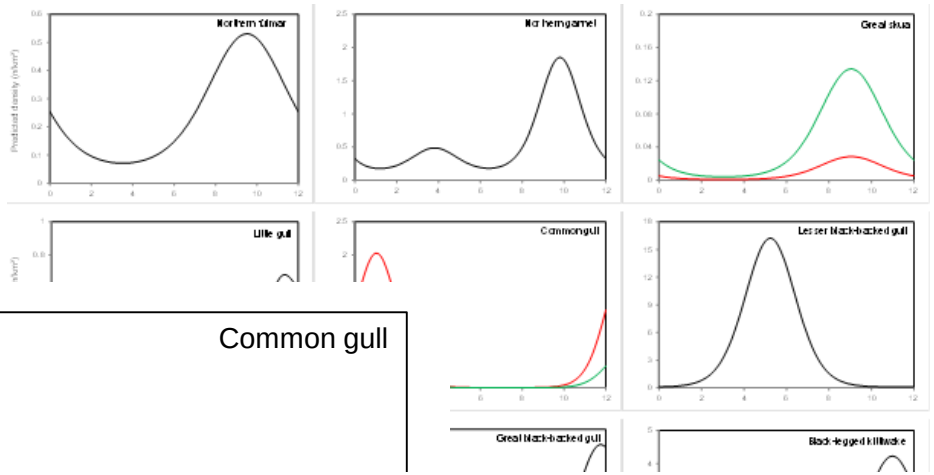
BIRD MONITORING: Seabird displacement

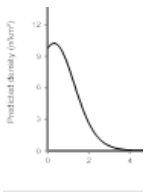
Reference modelling





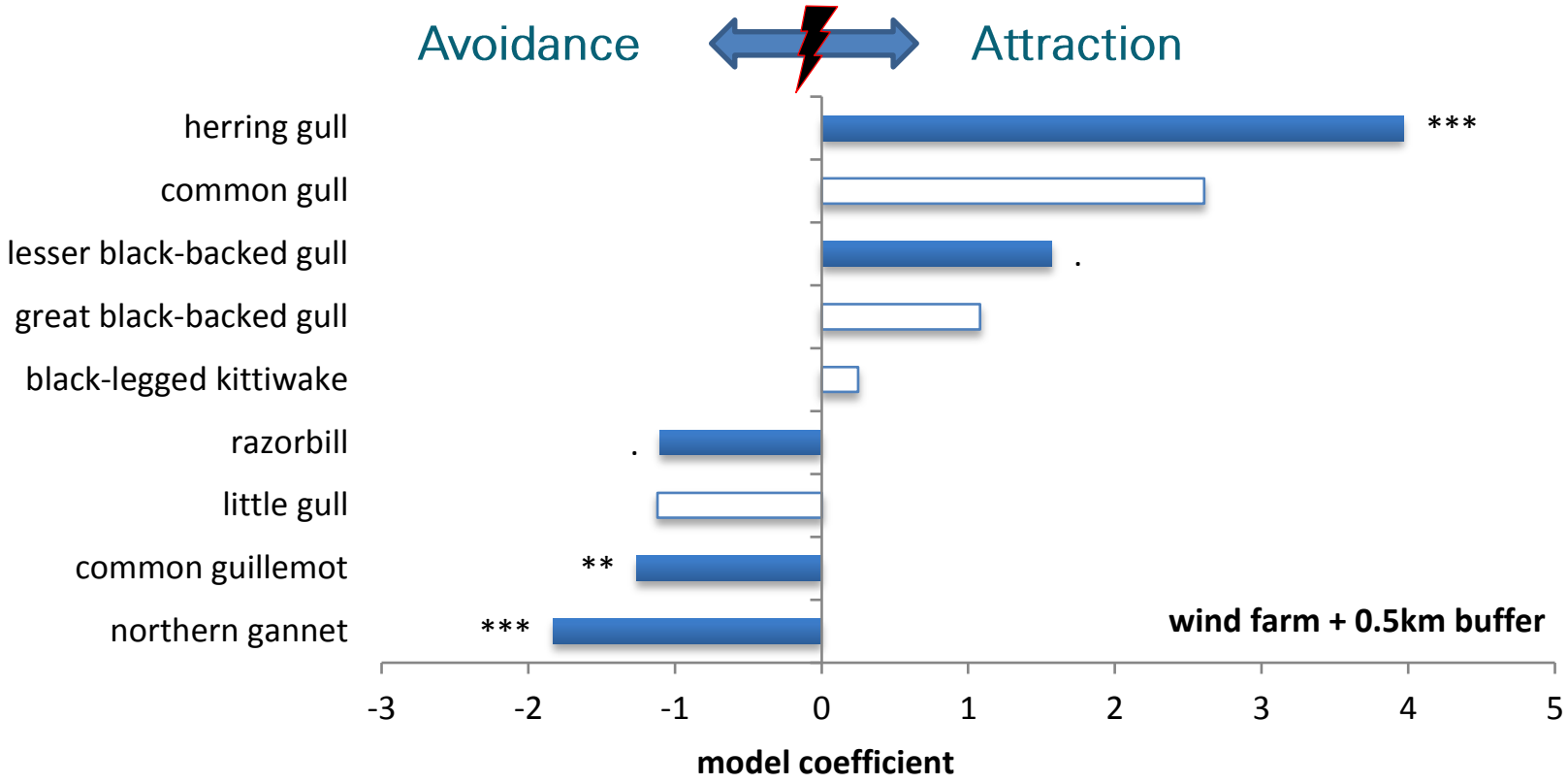






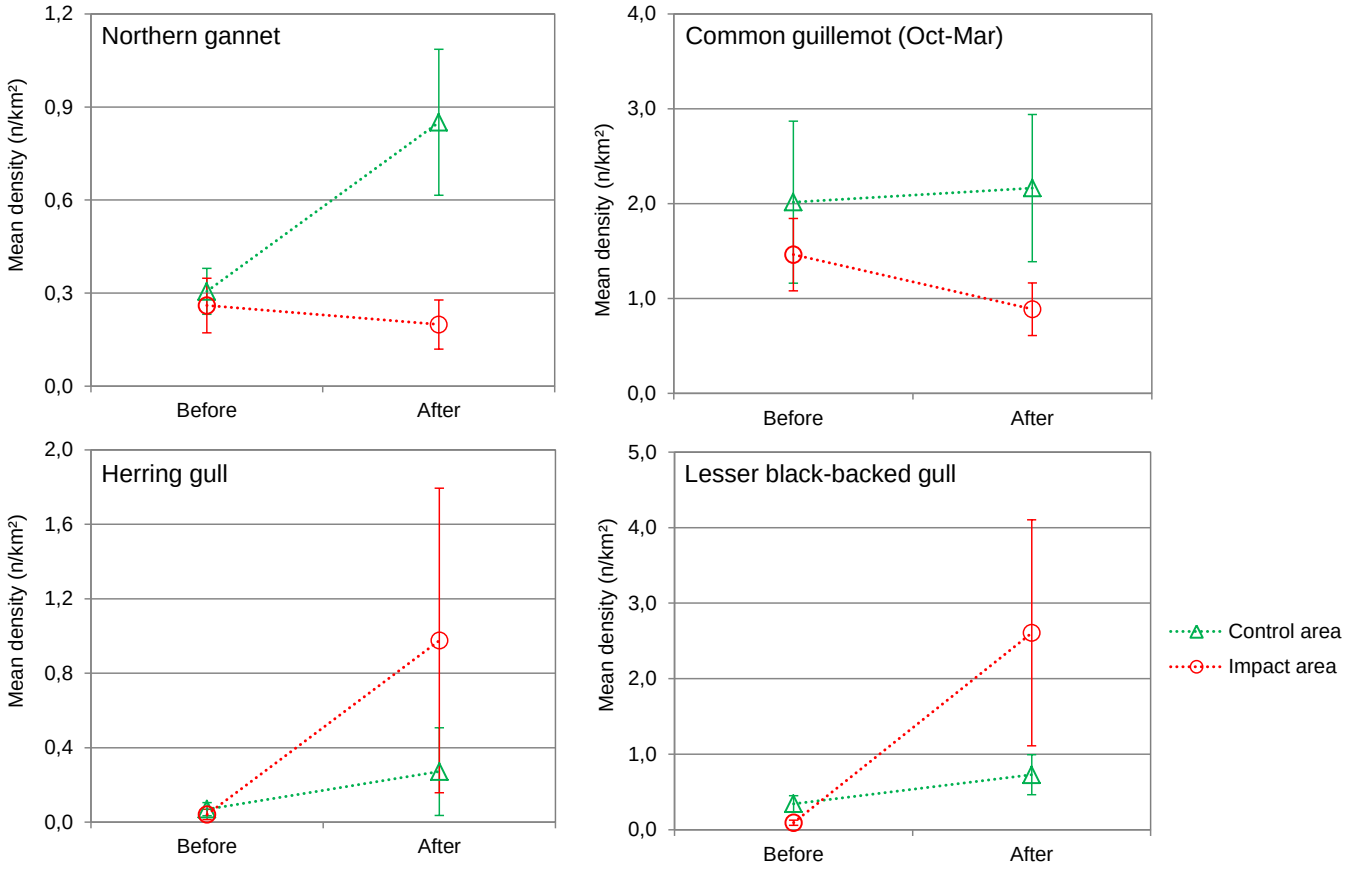
BIRD MONITORING: Seabird displacement

Impact modelling Blighbank



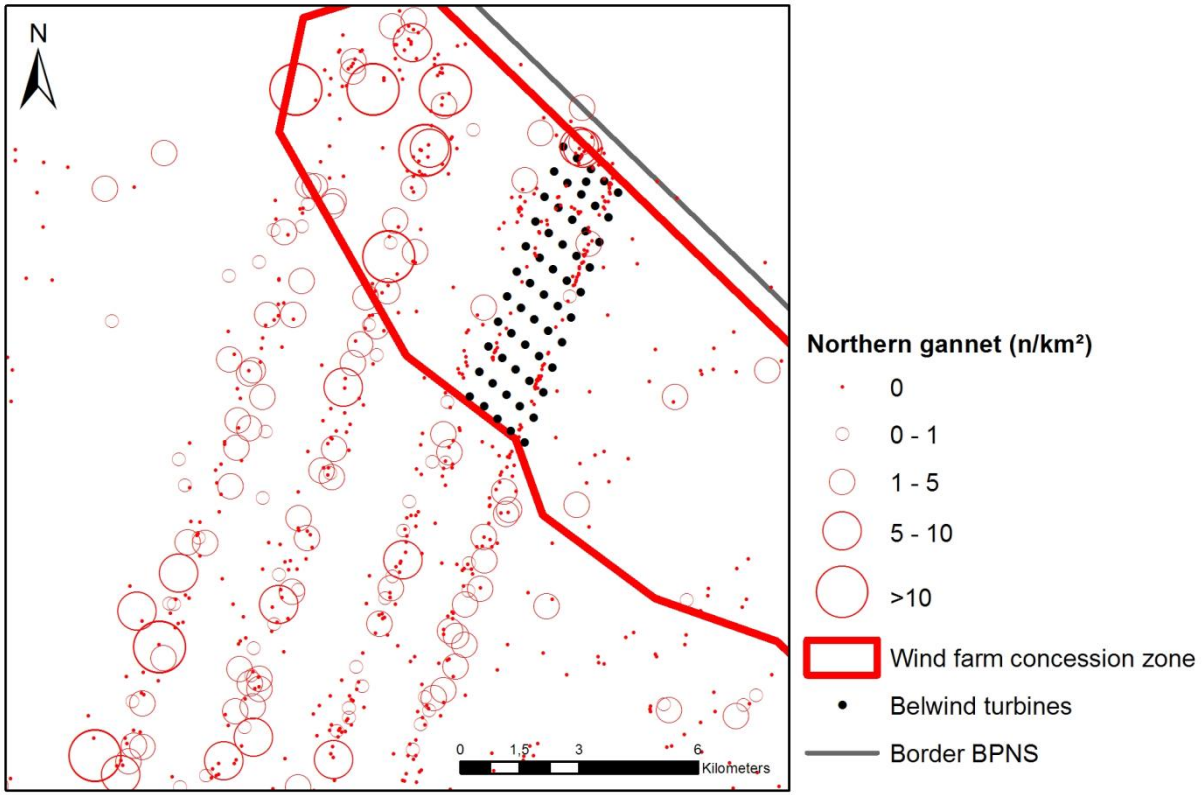
BIRD MONITORING: Seabird displacement

BACI graphs Blighbank



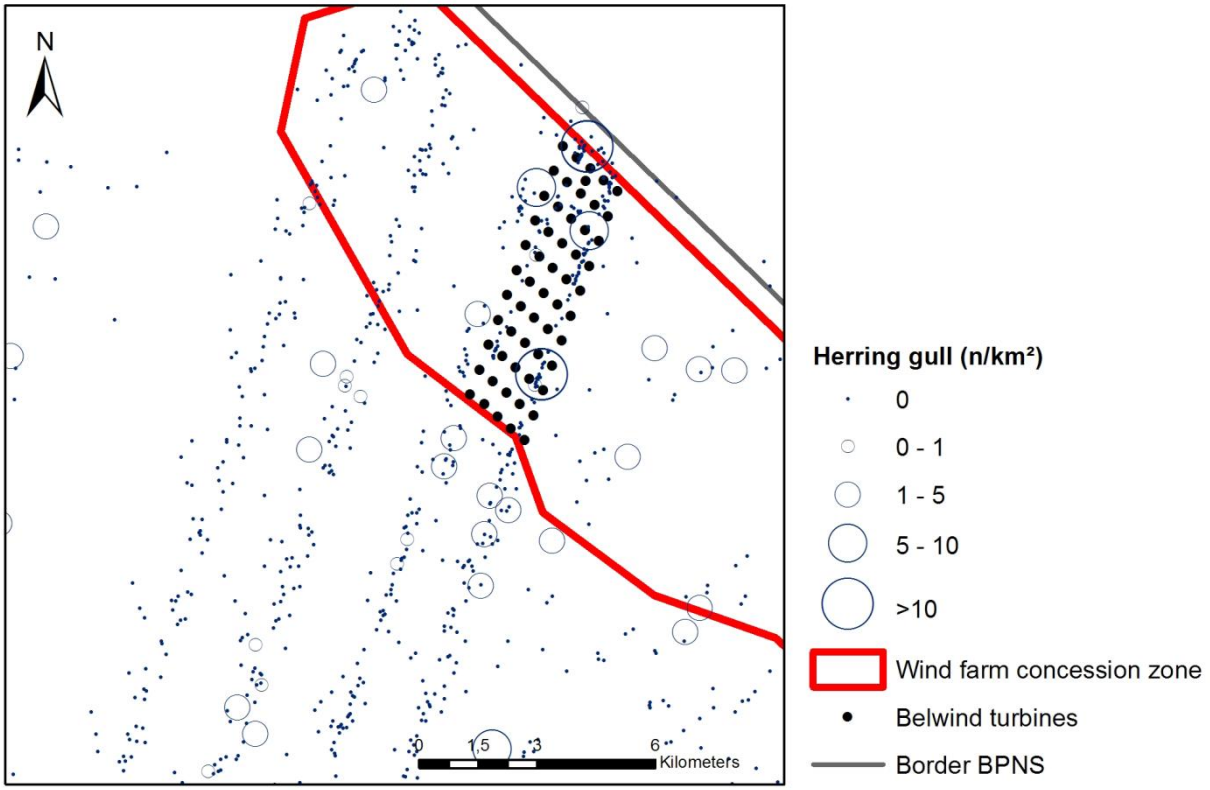
BIRD MONITORING: Seabird displacement

Distribution northern gannet: avoidance



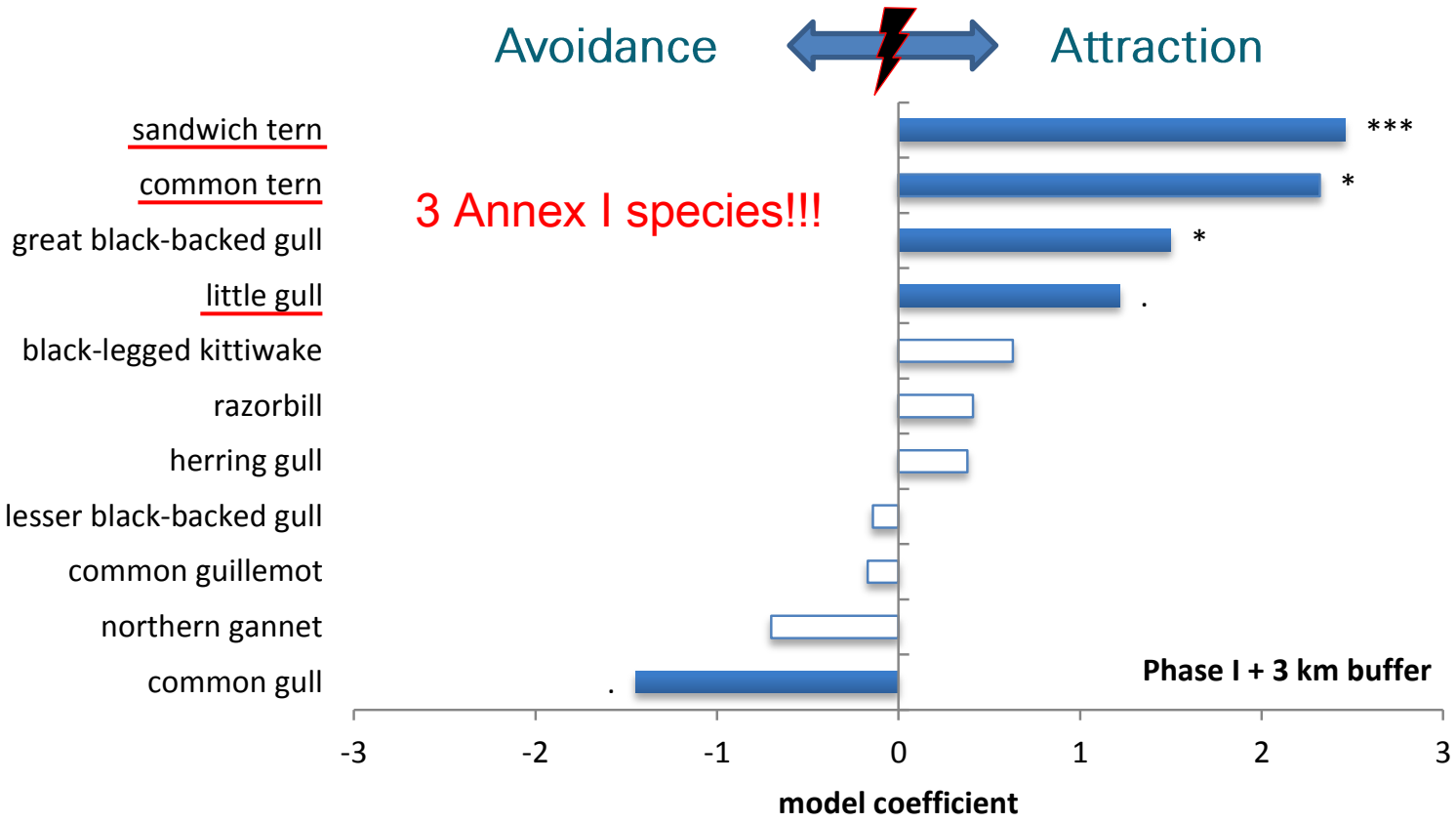
BIRD MONITORING: Seabird displacement

Distribution herring gull: attraction



BIRD MONITORING: Seabird displacement

Impact modelling Thorntonbank



BIRD MONITORING: Collision rate

Estimated through Collision Risk Modelling (Band, 2012):

→ Results based on densities of flying birds inside the Bligh Bank WF:

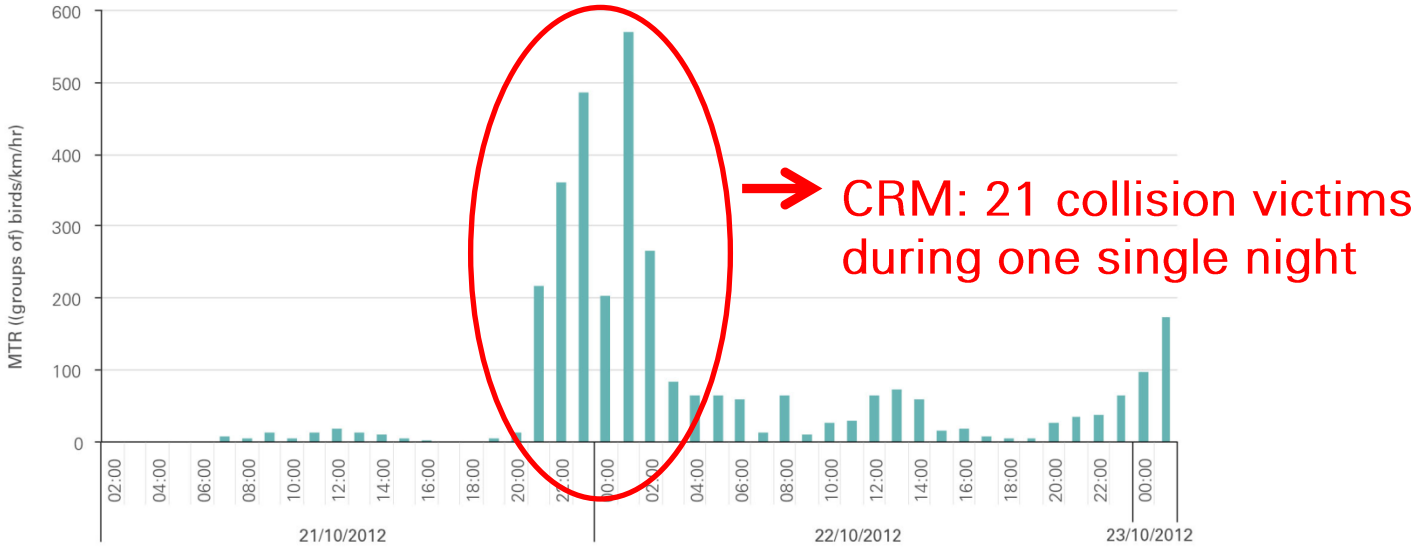
	Northern gannet	Common gull	Lesser black-backed gull	Herring gull	Great black-backed gull	Black-legged kittiwake
Winter	0	3	0	3	3	19
Spring	0	0	40	3	4	10
Summer	0	0	22	0	0	0
Autumn	1	0	3	0	21	3
Number/year	**1**	**3**	**65**	**6**	**28**	**32**
Number/(turbine*year)	**0.02**	**0.05**	**1.18**	**0.11**	**0.51**	**0.58**

→ 2,4 collisions by gulls per turbine per year at the Bligh Bank

BIRD MONITORING: Collision rate

Radar research

- Persistent technical problems hampered adequate data collection!!
- First results based on limited time frames, e.g. 21-22/10/2012
  - → massive thrush migration
  - → flux up to 570 (groups of) birds/(km*hr))

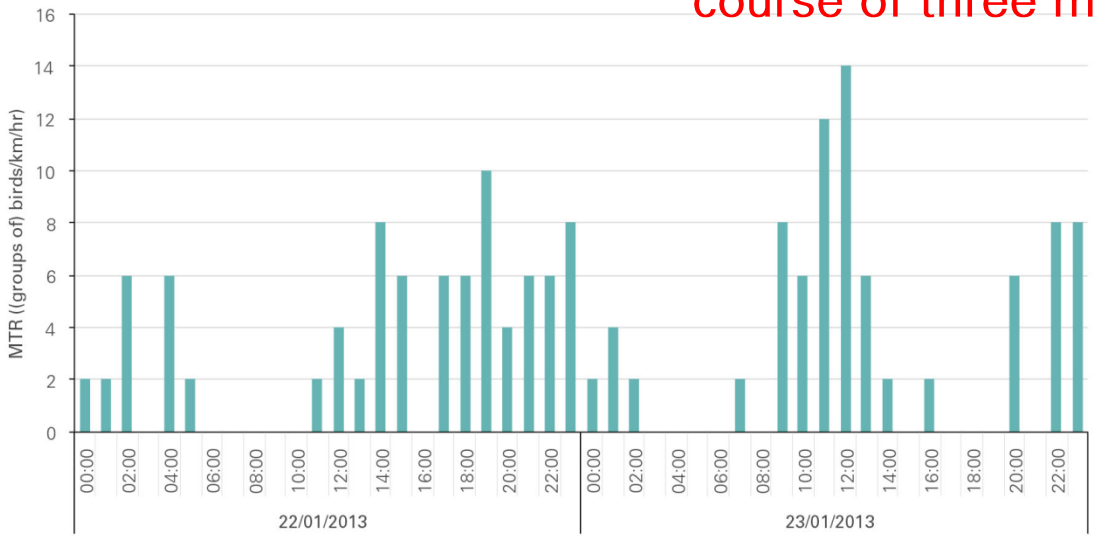


BIRD MONITORING: Collision rate

Radar research

- 2nd example: 22-23/01/2013
  - → illustrating movements of local (wintering) gulls
  - → flux up to 14 (groups of) birds/(hr*km)

CRM: 58 collision victims in the course of three months



FUTURE MONITORING

- Noise
  - Measurements piling (dimensions increase - mitigating measures?)
  - Measurements using moored hydrophones
- Harbour porpoises
  - Continuation of research into disturbance and effects
  - Validation and fine-tuning of the model
  - Effects of operational wind farms
- Fish
  - Effects of piling on different fish species at different life stages
  - Effects of operational noise on different fish species at different life stages

FUTURE MONITORING

- Seabirds
  - Continuation of the radar monitoring program to…
    - further improve radar signal in collaboration with radar developers
    - assess bird fluxes over a wide range of conditions to improve CRM results
    - perform a before-after study of the Norther concession zone to assess barrier effects and macro-avoidance behaviour
  - Need for accurate assessment of actual number of collisions to calibrate the theoretical CRM
  - Upscaling of additional mortality to a population level
  - Continuation of the baseline BACI monitoring of local seabird densities, and further reveal attraction-avoidance effects through enhanced power