Photo: Stefan Wermuth

Offshore wind energy development: known and potential effects on marine mammals

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innovative wildlife science

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- Mark Swingle, Virginia Aquarium
- Susi von Oettingen, US Fish and Wildlife Service
- Kristopher Winiarski, University of Massachusetts Amherst

- Other workshop attendees and regulatory, development and environmental advisory groups (for 2011 workshop and related efforts)

Potential hazards

Hazard	Effect	Development Phases		
		Pre-constr. & Assess.	Con-struction	Operation & Maint.
Direct effects	Collisions with vessels	■	■	■
	Other direct injuries	■	■	
Indirect effects (mediated by behavioral response)	Disturbance from seismic surveys	■		
	Disturbance from construction		■	
	Disturbance from vessels	■	■	■
	Disturbance from structures			■
Indirect effects via changes in habitat/prey distributions	Direct habitat change		■	
	Changes in prey distrib. (displacement or reef effects)			■
	Changes in fishing patterns			■
	Changes to air/water quality		■	

Data sources

- European offshore wind energy development
- Other anthropogenic activities in the marine environment

Photo: Mike Page

Direct effects: Injuries from construction activities

- Pile driving noise
- Predicted injury potential suggested to occur within a radius of about 100m from the source
- Other European studies??
- More generally, similar types of noise have the potential to cause temporary or permanent damage to hearing
    - Elevated noise levels → temporary hearing loss, elevated cortisol and other physiological changes

Read 2013b, Bergström et al. 2014, Bailey et al. 2010, Southall et al. 2007, Nowacek et al. 2007, Romano et al. 2004, Bailey et al. 2010

Disturbance: construction activities

- Highest impact activity for marine mammals (Bergström et al. 2014)
- Observed effects at European OW facilities:
  - Displacement (variable distances observed)
  - Behavioral changes

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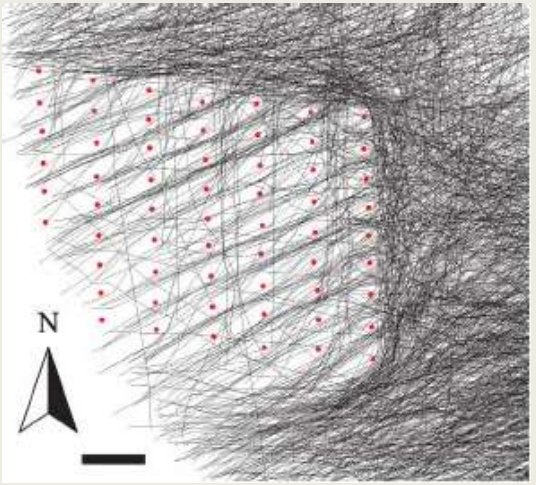
Thomsen et al. 2006, Madsen et al. 2006, Nowacek et al. 2007, Malme et al. 1984, Tougaard et al. 2009a, Thompson et al. 2010, Brandt et al. 2011, David 2006, Clark et al. 2009, Teilmann et al. 2006a, 2006b, Lindeboom et al. 2011, Kastelein et al. 2013

Disturbance: Operational turbines



- Low levels of underwater noise
- Potential effects: displacement and avoidance
  - Displacement: effective habitat loss, potential for displacement into areas with other risks
  - Cumulative avoidance during migration → increased energetic demands? (Masden et al. 2009 study on birds)
- Seals have not demonstrated avoidance or displacement behavior
- Harbor porpoise results are contradictory (activity levels down 0-71%)
- Several reviews have suggested little or no change in behavior

Tourgaard et al. 2009b, Edren et al. 2010, Teilmann et al. 2006b, Teilmann et al. 2008, Scheidat et al. 2011, Lindeboom et al. 2011, Teilmann and Carstensen 2012, Peterson and Fox 2007, Madsen and Boertmann 2008, Desholm and Kahlert 2005, Masden et all. 2009, Schuster et al. 2015

Changes to habitat/prey: Effects of pile driving

- Potential for direct and indirect effects on fish populations
- Long-term reductions in local fish abundance occurred after pile-driving during critical spawning periods (Atlantic herring)

Popper and Schilt 2008, Slabbekoorn et al 2011, Wardle et al. 2001, Dalen and Knutsen 1987, McCauley et al. 2000 , Engas et al. 1996, Hirst and Rodhouse 2000, Bergström et al. 2014, Kikuchi 2009, McCauley et al. 2003, Gregory and Wood 1999, Consten et al. 2001, Perrow et al. 2011

Changes to habitat/prey: Operations

- Potentially significant changes to local pelagic habitat
- Reef effects
- Changes to fishing patterns
- Noise or hydrodynamic effects on fish populations

Petersen and Malm 2006, Boswell et al. 2010, Bergström et al. 2014, Wilhelmsson et al. 2006, Todd et al. 2009, Teilmann and Carstensen 2012, Connell 1997, Wahlberg and Westerberg 2005, Slabbekorn et al. 2010, Musial and Ram 2010, Thomsen et al. 2006, Andersson et al. 2007, Andersson 2011, Russell et al. 2014, Schuster et al. 2015, Mackinson et al. 2006, Lindeboom et al. 2011, van Deurs et al. 2012

Data sources

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Photo: Mike Page

Other potential effects

- Vessel collisions (all development phases)
- Effects from seismic surveys
  - Injuries, displacement, behavioral changes
  - Possible effects on both marine mammals and prey
- Electromagnetic fields
- Changes to air and water quality

Waring et al. 2011, Wilson et al. 2007, Van Waerebeek et al. 2007, Laist et al. 2001, Jensen and Silber 2004, Bexton et al 2012, BOEM 2012a, Samuel et al. 2005, NOAA 2012, Weilgart 2007, Tyack et al. 2006, Cox et al. 2006, Southall et al. 2007, Tyack et al. 2011, McCauley et al. 2000, Castellote et al. 2012, Madsen et al. 2002, Goold 1996, Gordon et al. 2003, Bergström et al. 2014, MMS 2007, Popper and Schilt 2008, Slabbekoorn et al 2011, Wardle et al. 2001, Dalen and Knutsen 1987, McCauley et al. 2000 , Engas et al. 1996, Hirst and Rodhouse 2000, Perrow et al. 2011

Take home messages

- Behavioral effects of seismic surveys and construction noise require further investigation
- Displacement during operations? Little or no data available for many taxa (especially baleen whales); harbor porpoise data is inconsistent
- Effects on habitat and prey communities will occur, but the net effect of such changes is unclear
- Need more info on large whale populations, distributions/ movements, and their responses to OW
    - Collision mortality with vessel traffic, at all phases

Inger et al. 2009, Slabbekorn et al. 2010, Gill et al. 2012, Lindeboom et al. 2011, Macreadie et al 2011, Perrow et al. 2011

Thank you!

- Participants at 2011 workshop (Portland, Maine) that led to the development of many of these ideas
- Regulatory, development and environmental advisory groups for 2011 workshop and related efforts
- Support for 2011 workshop:
  - Oak Foundation
  - Davis Foundation
  - Horizon Foundation