The impact of anthropogenic ocean noise pollution: a risk to prey species and food supply

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Impacts of Noise on Marine Animals

Most marine animals use sound for vital functions

130+ marine species impacted by underwater noise

- 30 species of marine mammals
- 66 species of fish
- 36 species of invertebrates

Recently, studies on fish and invertebrates show impacts extend beyond *individual* species to include *communities* of species and how they interact, ecosystem, and ecological services

Noise Impacts on Ecosystem and Ecological Services

- Pile driving noise caused valve closure in mussels, energetically costly behavior, disrupting breathing, heart rate and excretion, halving oxygen concentrations and doubling CO_2 levels in 3 hrs *(Roberts et al. 2015)*
  - Growth and body condition likely to suffer, with ecosystem and commercial consequences

Noise Impacts on Ecosystem and Ecological Services

- Ship noise suppressed oyster activity and volume of water flowing over their gills, decreasing food uptake, causing slower fat metabolism and growth rate, greater oxidative stress *(Charifi et al. 2018)*
  - The slowdown in growth constitutes “a potentially massive risk in terms of ecosystem productivity”

Noise Impacts on Ecosystem and Ecological Services

- A seismic survey caused reef fish abundance to decline by 78% in the evening when fish habitat use was highest *(Paxton et al. 2017)*
  - Such reactions of an entire community of species means fish lose opportunities to aggregate, forage, or mate

Temperate coral reef 1 day before seismic

Response occurred across fish species

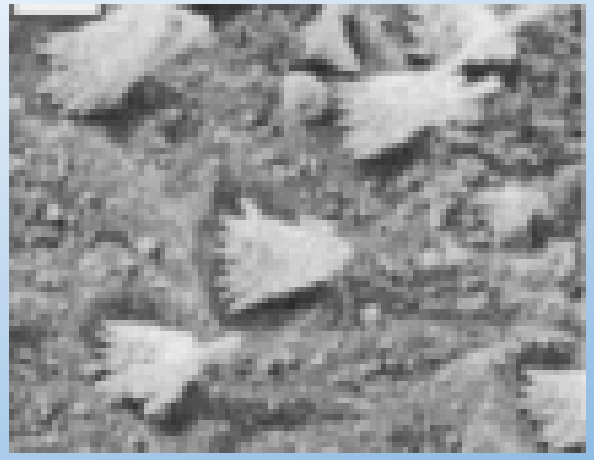
Same reef with seismic 8 km away

Impacts of Noise on Invertebrates

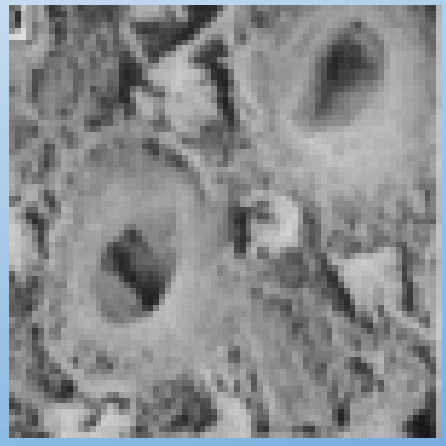
- Seismic airgun noise caused chronic impairment of immune competency and nutritional condition in lobsters up to 120 days post-exposure *(Fitzgibbon et al. 2017).*
- Developmental delays in scallop larvae in tanks; 46% with body malformations *(Aguilar de Soto et al. 2013)*

Noise Impacts on Invertebrates & Fish

- LF sound caused substantial, permanent, cellular damage to statocysts and neurons in squid, cuttlefish, octopus, jellyfish *(André et al. 2011; Solé et al. 2013a, 2013b, 2016, 2017)*
- "…massive acoustic trauma, not compatible with life…" *(André et al. 2011)*
- Extensively damaged caged snapper fish ears in the field. No recovery after 58 days *(McCauley et al. 2003)*



Before



After

McCauley et al. 2003

Impacts of Noise on Invertebrates & Fish

- Increased stress hormones and indicators in bass, sea bream, cod, carp, perch, gudgeon, kelpfish, goldfish, shrimp, crabs, mussels, scallops, lobsters, sea horses *(Bruintjes et al. 2017; Buscaino et al. 2010; Day et al. 2017; Filiciotto et al. 2016; Fitzgibbon et al. 2017; Graham and Cooke 2008; Lagardère 1982; Nichols et al. 2015; Régnault & Lagardère 1983; Santulli et al. 1999; Sierra-Flores et al. 2015; Smith et al. 2004; Spiga et al. 2016; Wale et al. 2013; Wale et al. 2016; Wysocki et al. 2006)*
  - Cortisol increased 99% in the perch, 81% in the carp, and 120% in the gudgeon for shipping noise playback *(Wysocki et al. 2006)*



Hassel et al. 2004

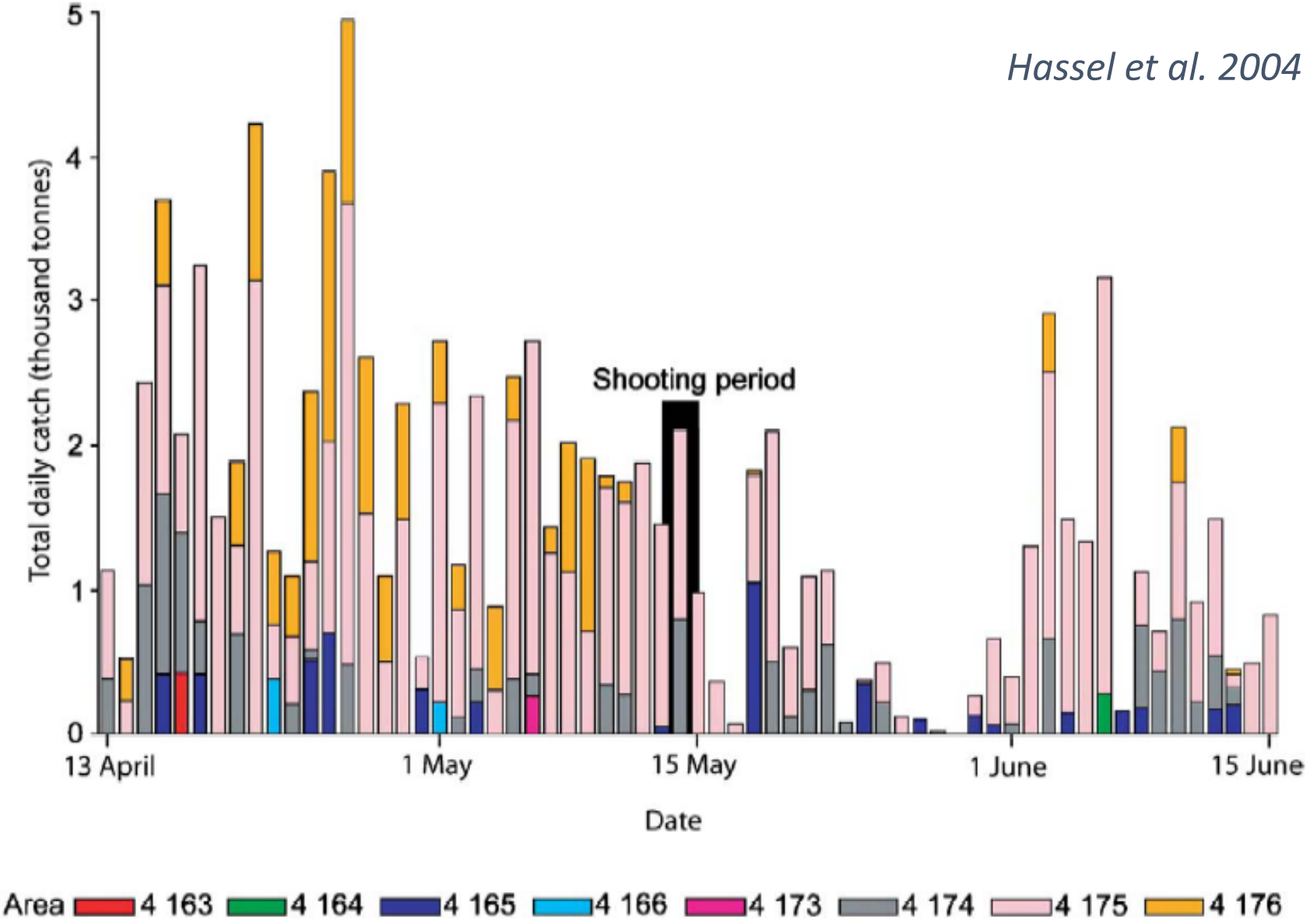


Figure 7. Daily landed sandeel catches in thousand tonnes for the different geographical fishing areas close to the shooting ground. The shooting period was from 13 May (10:30)–15 May (18:13), indicated by the width of the black rectangle. The dates are landing days, and the reported catches were captured about 4–6 days before the day of landing.

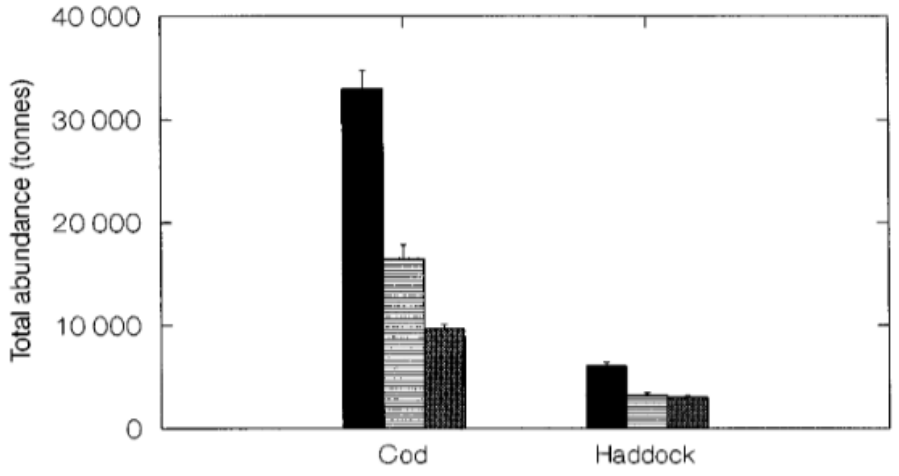
Noise Reduces Catch and Abundance of Commercially Important Fish

5 days after seismic:

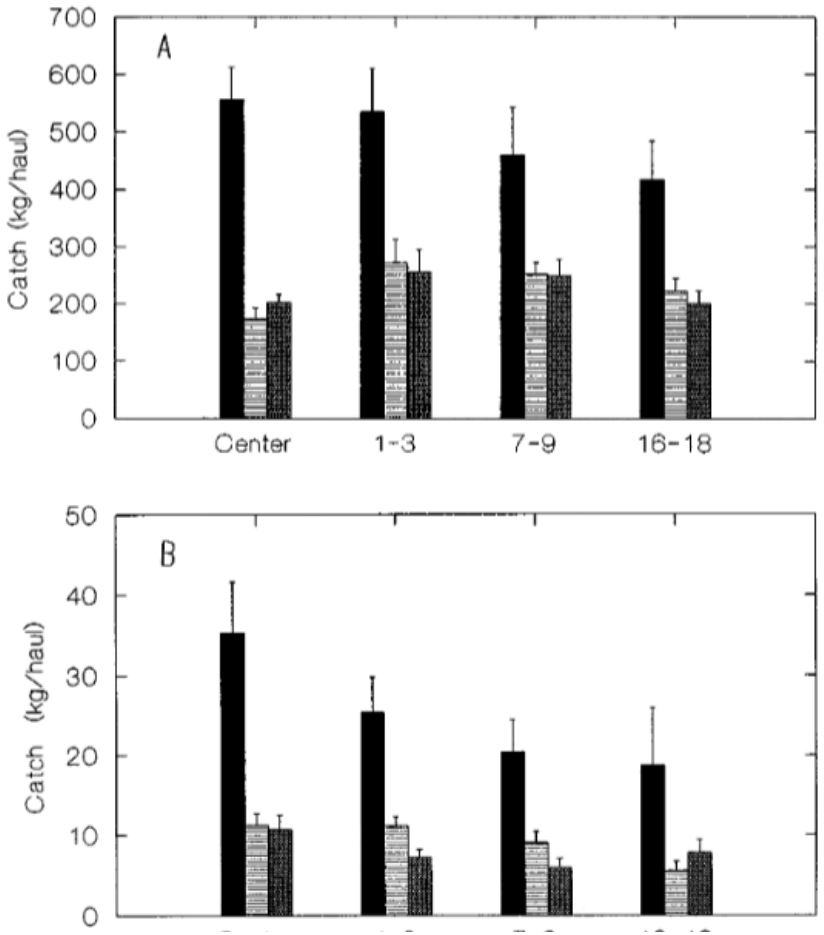
- Commercial trawl cod catch↓69%
- Longline cod catch ↓45%
- Longline haddock catch ↓67%

↓ 52% in CPUE for rockfish hook-and-line fishery

- 50% average economic loss



Total quantity of cod and haddock by mass B (solid), D (striped), A (gray) seismic



Trawl catch rates of cod (A) & haddock (B) B (solid), D (striped), A (gray) seismic, by distance (nm) from seismic

Engås et al. (1996), Skalski et al. 1992

Summary

- Most marine fauna very dependent on sound
- 130+ species shown to be impacted
- Impacts include decreased growth, body condition, feeding, metabolism, productivity, abundance, immune competency and nutrition, catch rates.
- Noise caused permanently damaged ears and sensory organs, developmental delays and malformations, and increased stress hormones and indicators
- Impacts extend beyond *individual* species to include *communities* of species and how they interact, ecosystem, and ecological services