Presentation at the Second Plenary Meeting of the Advisory Committee on Acoustic Impacts on Marine Mammals

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Mitigating the risks to marine mammals from acoustic operations

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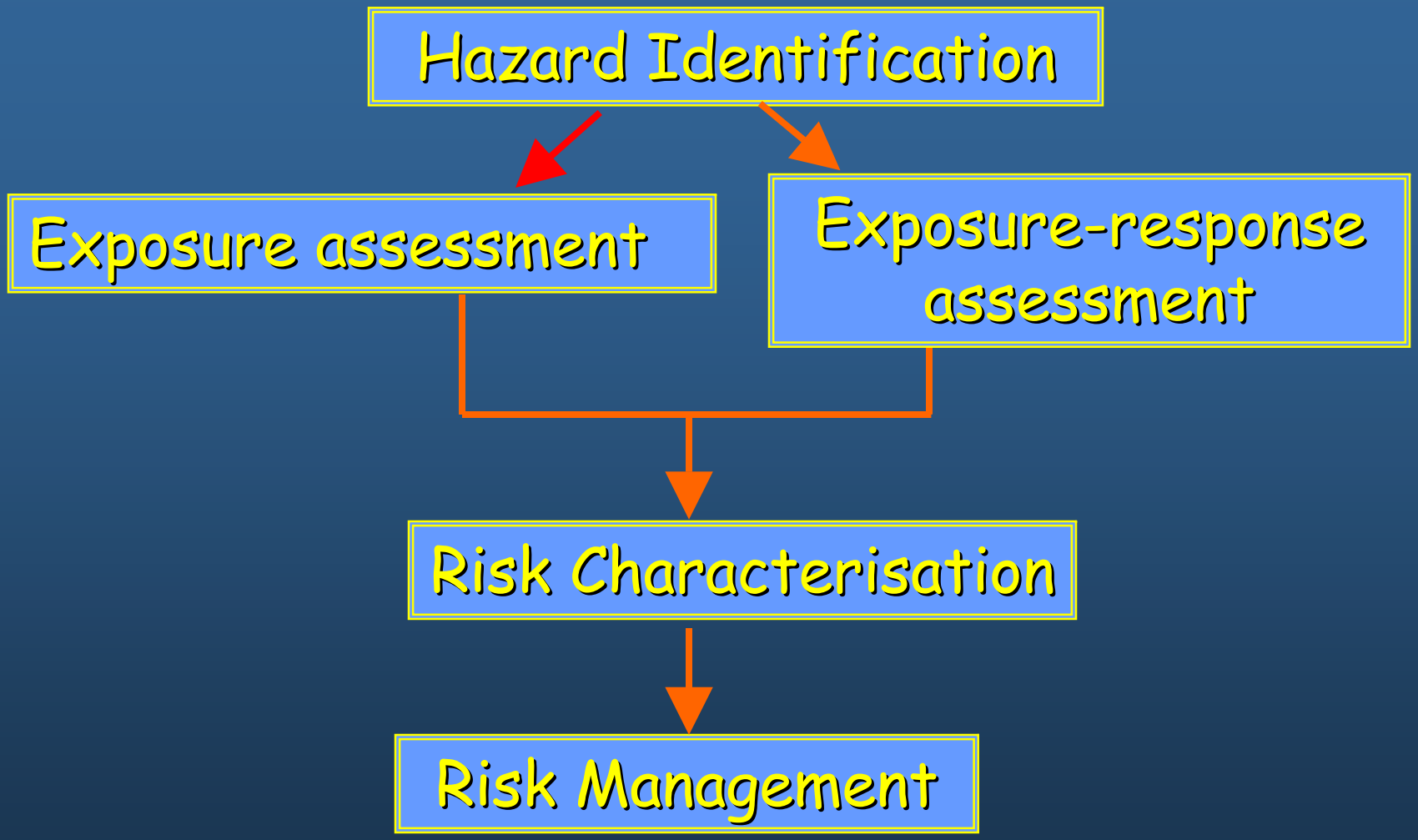
EPA framework



The classic approach to environmental (and human) risk mitigation uses a framework initially developed by the US Environmental Protection Agency

Uncertainty and risk

- Risk is the **probability** that something undesirable (the hazard) will happen
- Most risk assessment attempts to “minimize” risk. Does this mean that the probability a bad thing will happen is zero?
- No. We are usually willing to accept some (undefined) low probability that the undesirable event will occur.
- How low should it be?
- If this is not obvious or is likely to vary with circumstances, we need a **quantitative** risk assessment

Exposure assessment

- Depends on the combination of the emissions from the acoustic source and their attenuation, and the distribution in three dimensions of all marine mammal species.
- I will focus entirely on the second of these.

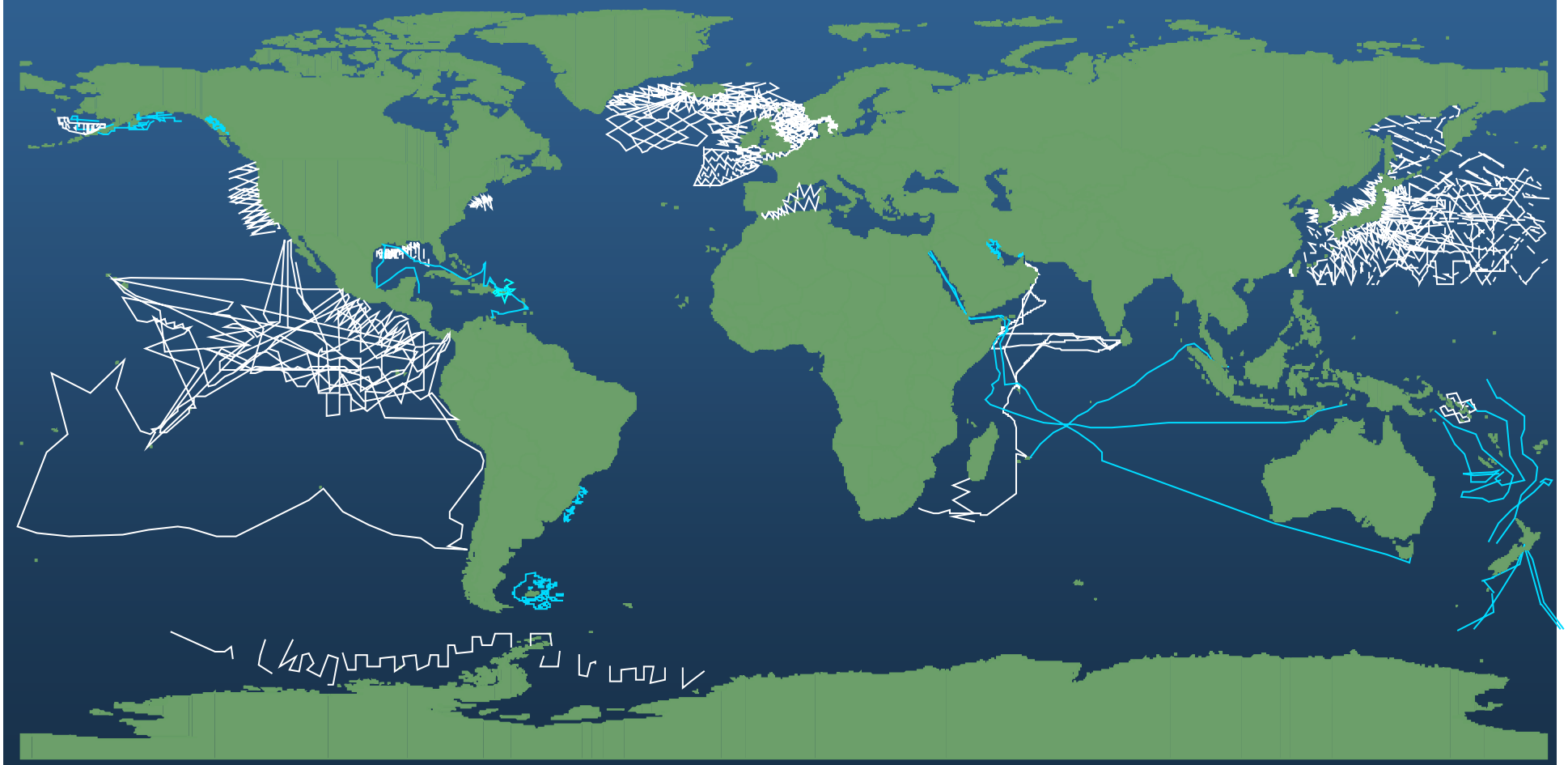
Types and Sources of Marine Mammal Data

TYPES

DEDICATED	OPPORTUNISTIC	STRANDINGS	TELEMETRY
Density Abundance Distribution	Occurrence Relative Abundance Distribution	Occurrence Seasonality	Movements Behaviour
SCANS NASS NILS IDCR	Joint Cetacean Database Whaling records (eg. JSV)	Natural History Museum	Sea Mammal Research Unit Woods Hole Inst.

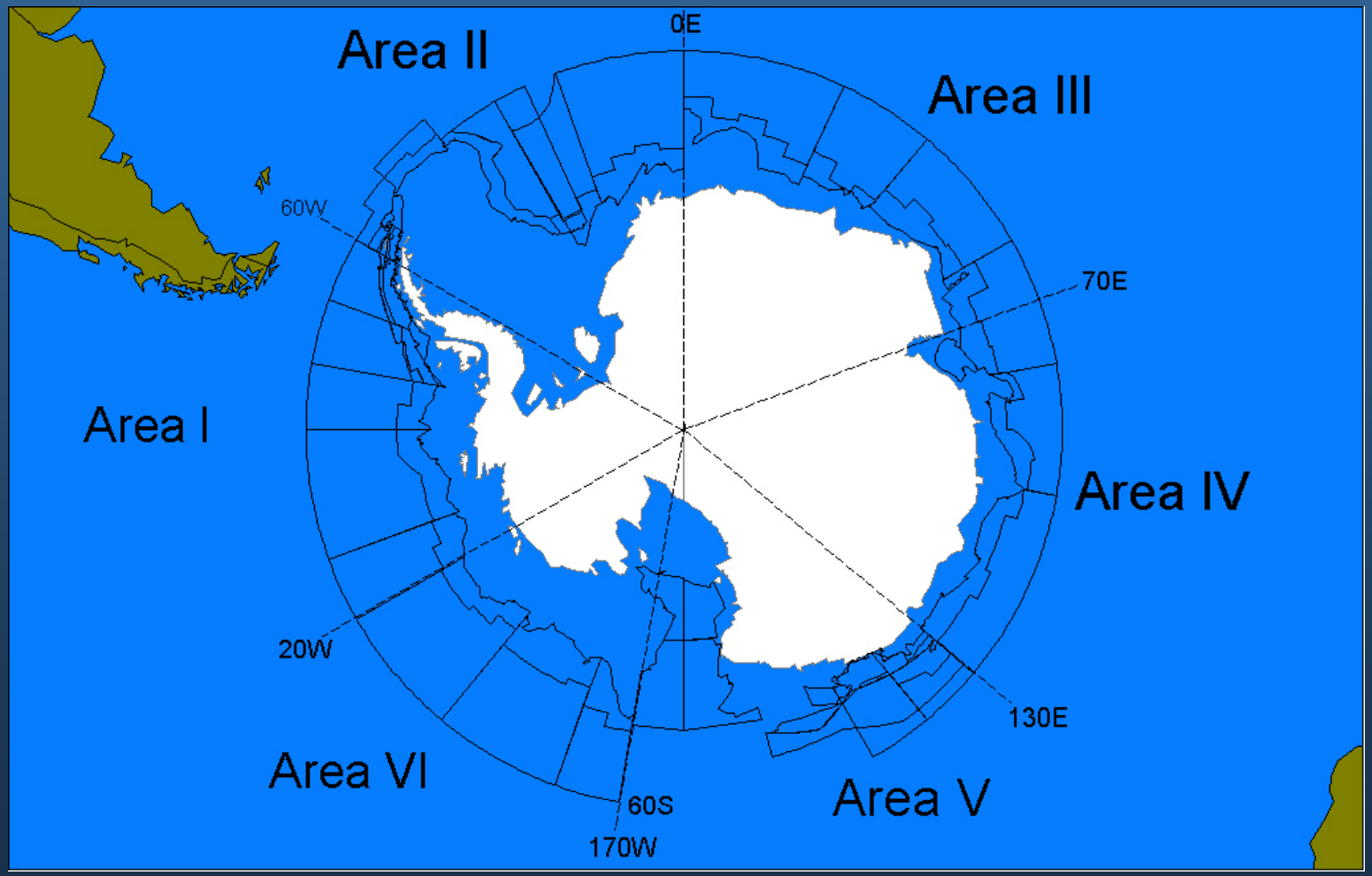
Cetacean Sightings Surveys

- Opportunistic surveys: distribution, occurrence and relative abundance
- Dedicated surveys: density and absolute abundance

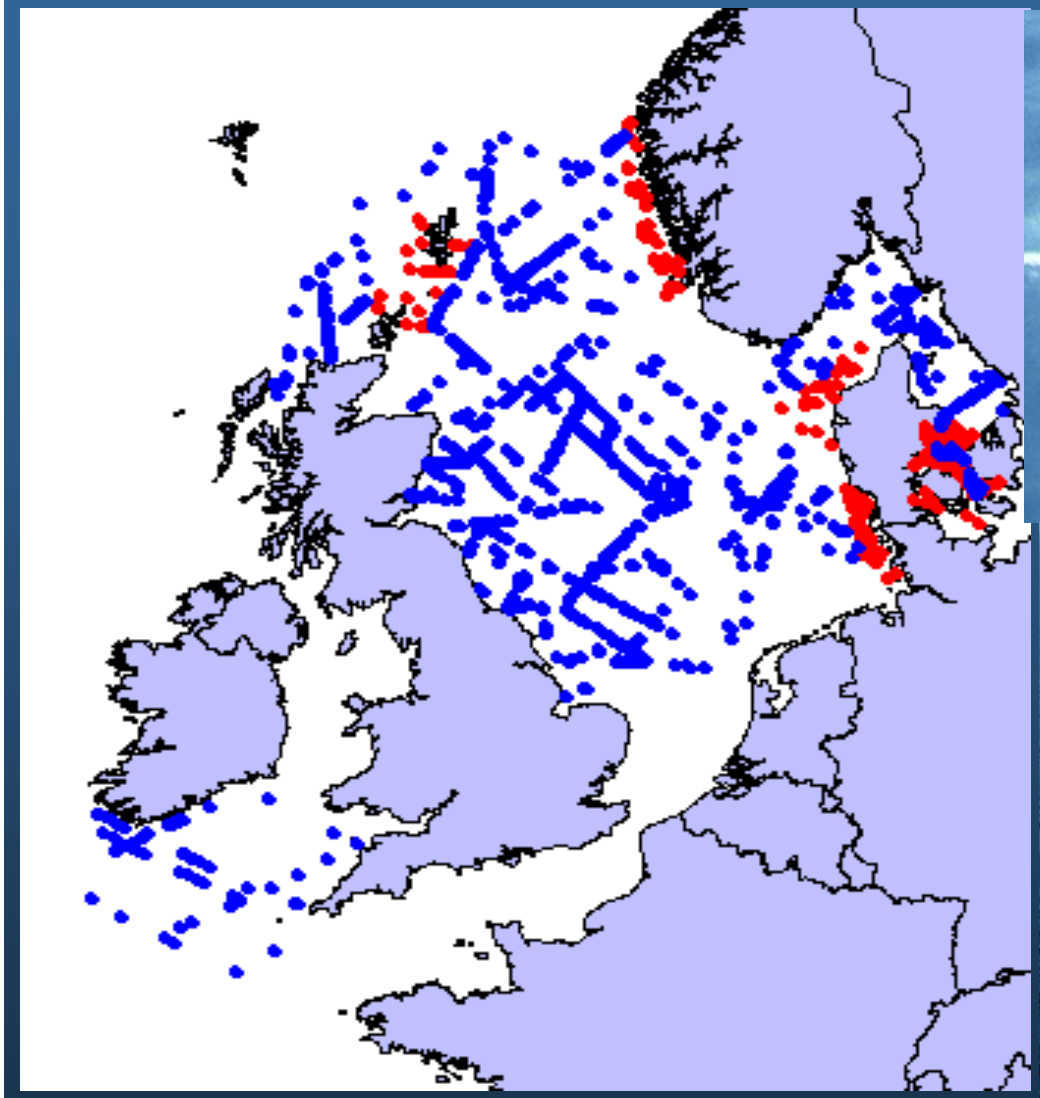


This map doesn't include IWC/IDCR surveys in the Southern Ocean

International Whaling Commission/ International Decade(s) of Cetacean Research Survey Coverage – 3 circumpolar surveys

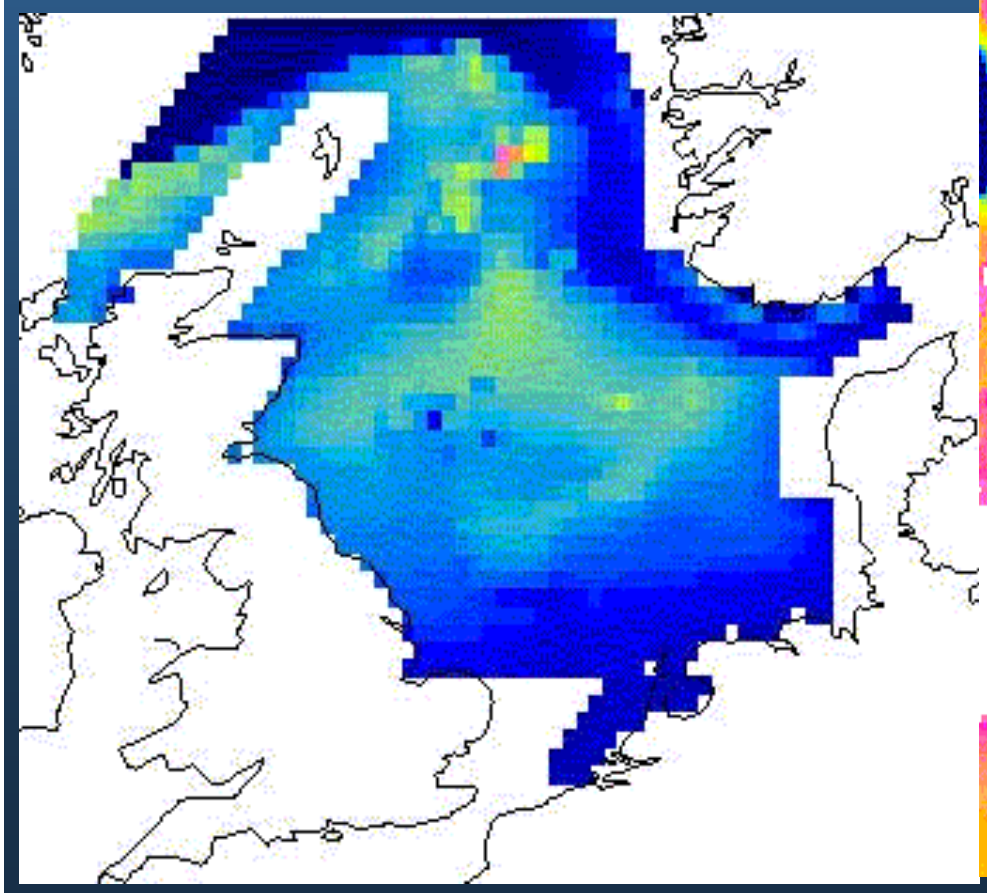


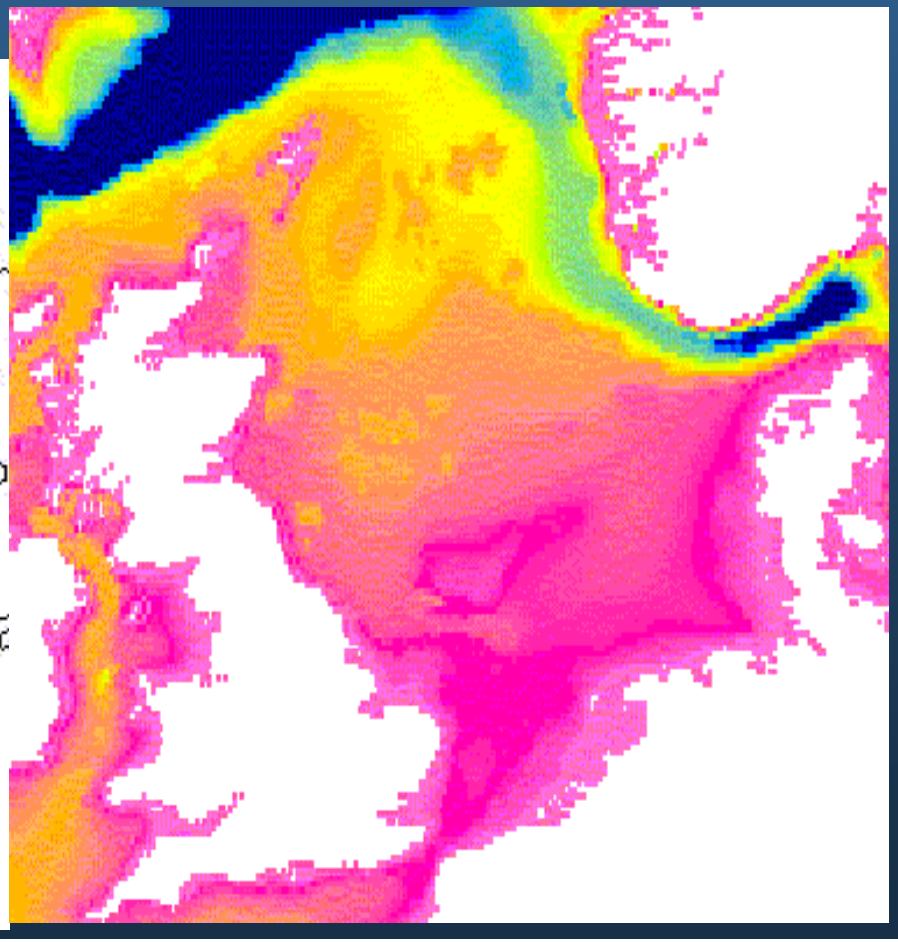
SCANS survey results for harbour porpoise



Results of these surveys are usually analysed using DISTANCE software (developed by CREEM) to provide estimates of total abundance.
However, they can be used with more sophisticated statistical techniques to provide detailed spatial information.

In this case, water depth was the best predictor of porpoise density.
Analysis conducted by Louise Burt (CREEM) for QinetiQ





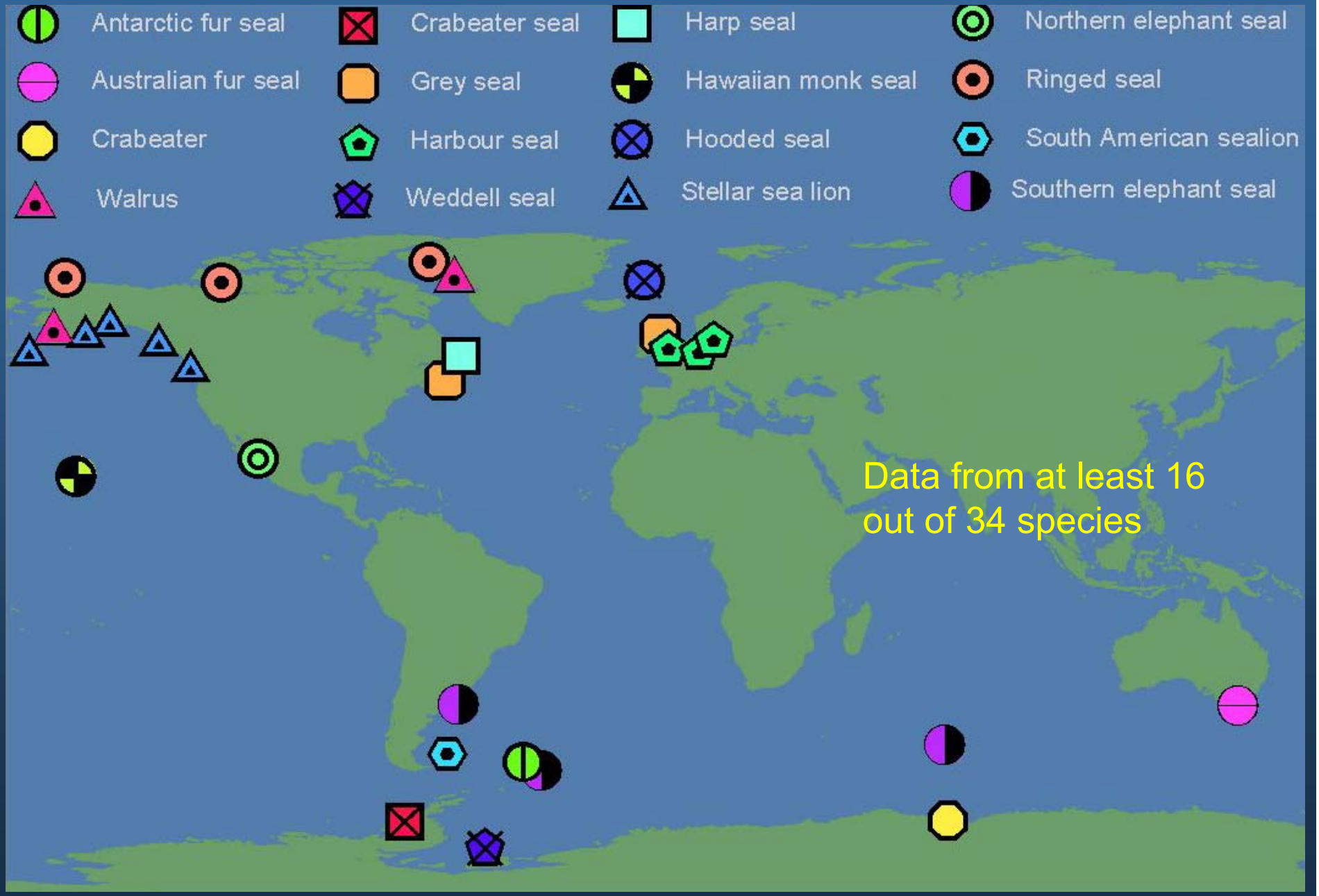
What about areas for which there are no good abundance and distribution data?

- Techniques used to **inter**polate distribution between survey track lines can be used to **extra**polate distribution.
- Several projects underway to do this funded by SERDEP, ONR and UK

What about finer scale and three-dimensional distribution?

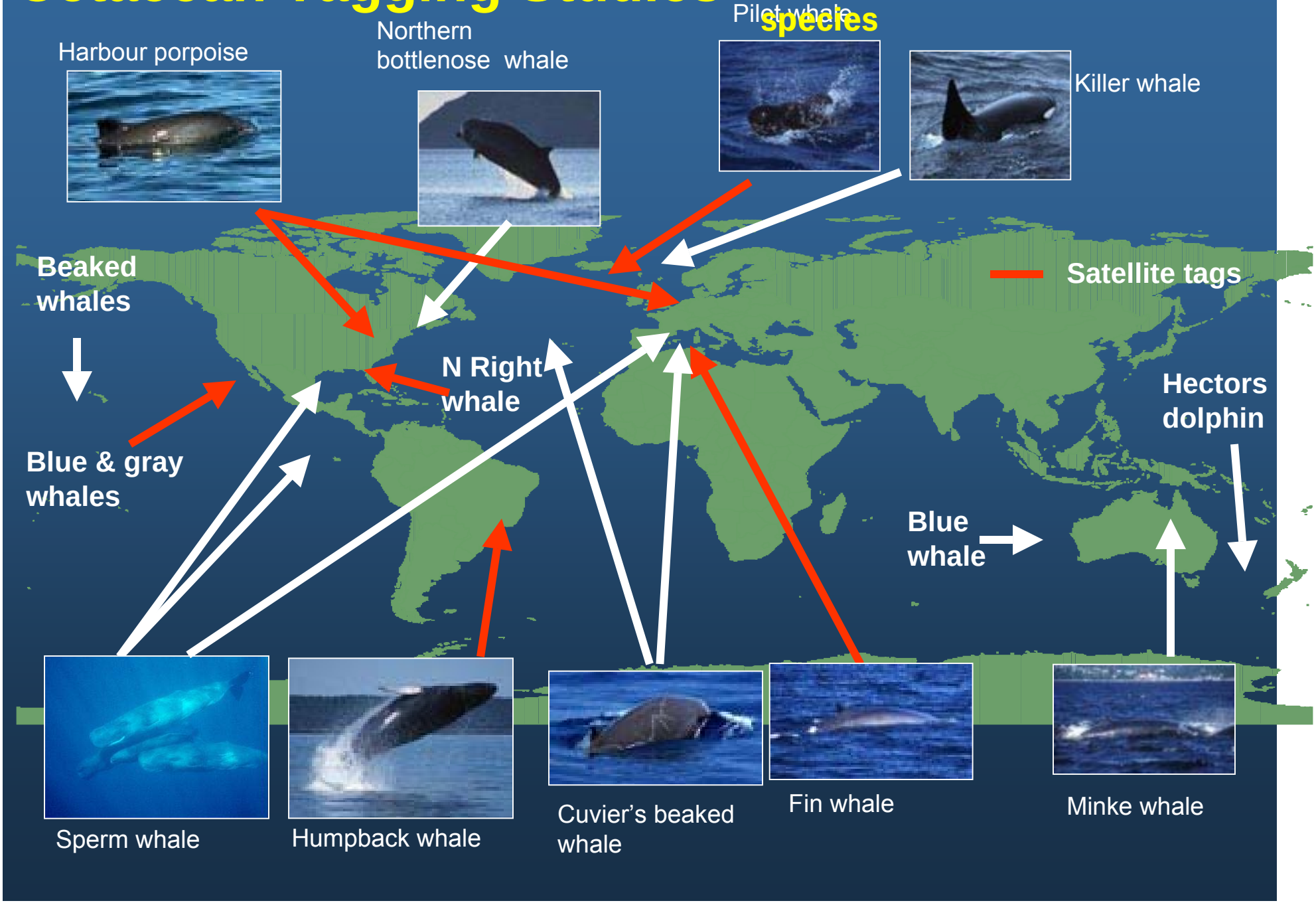
- Telemetric studies of individual animals
- VHF and archival tags provide large amounts of detailed information over short time periods
- Satellite-linked data loggers provide limited amounts of data (including location) over longer time periods

Pinniped Satellite Tagging Studies

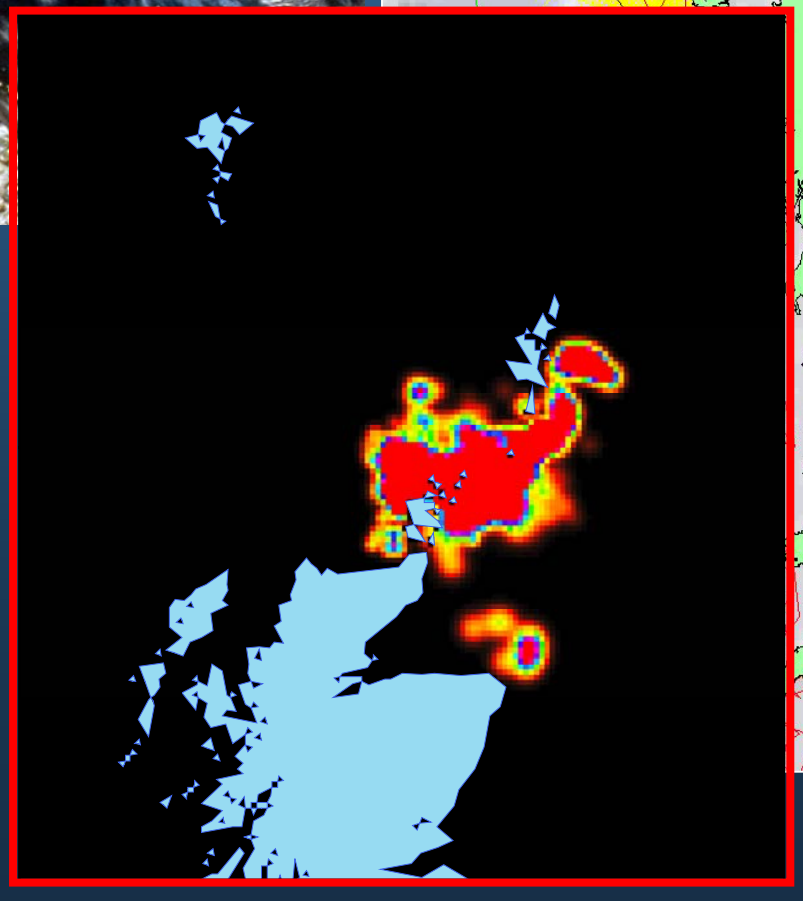


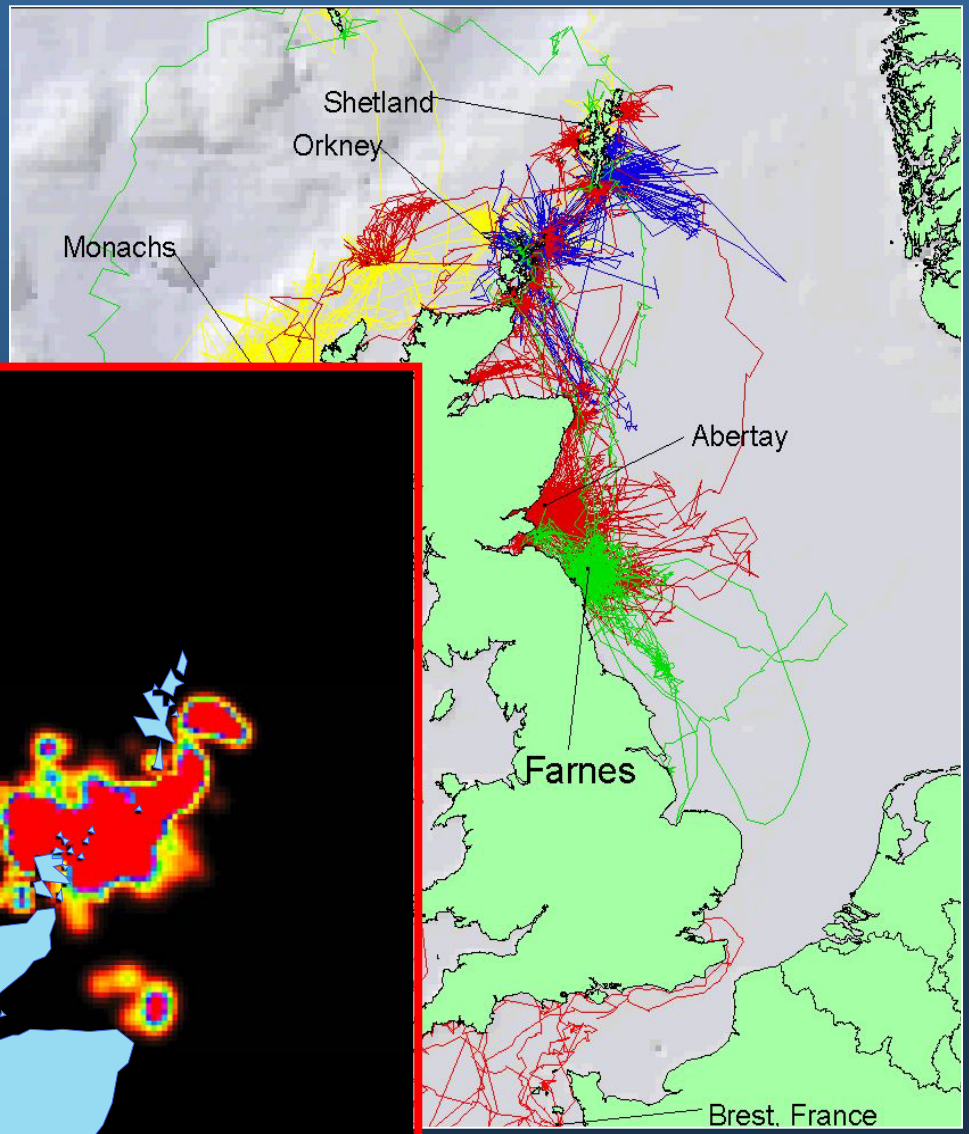
Cetacean Tagging Studies

- Data from 19 out of ~80 species



UK grey seals





Exposure response

- For humans or (small) terrestrial species, we know something about the relationship between exposure and hazardous effects
- We can then do experiments to refine the dose response curve
- We haven't been able to do this for marine mammals
- Focus has been on identifying some threshold response (eg TTS)
- OK for physiological effects, but probably not appropriate for behavioural responses, which are often context dependent

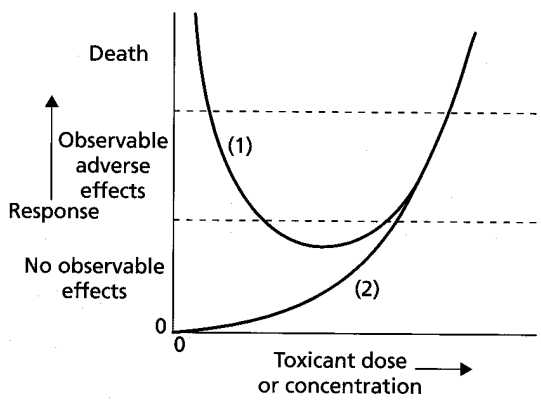


Fig. 6.1 Biological responses to differing doses or concentrations of (1) essential substances which become toxic at higher than essential levels and (2) nonessential toxic substances.

From: Connell, D. et al. 1999 Introduction to Ecotoxicology

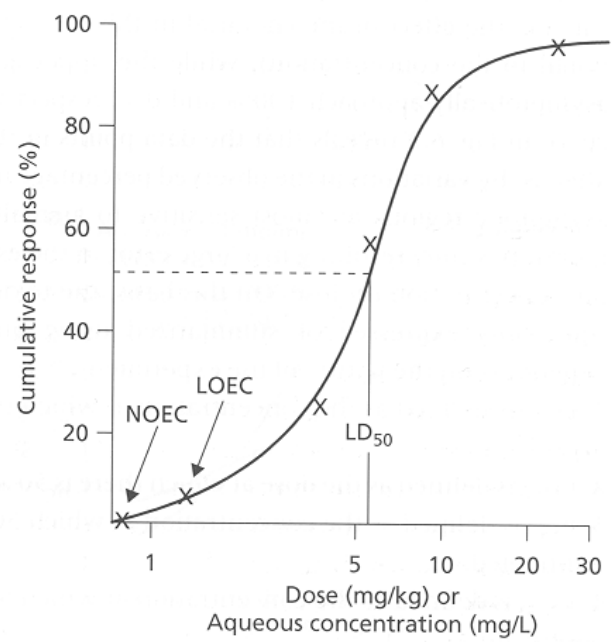
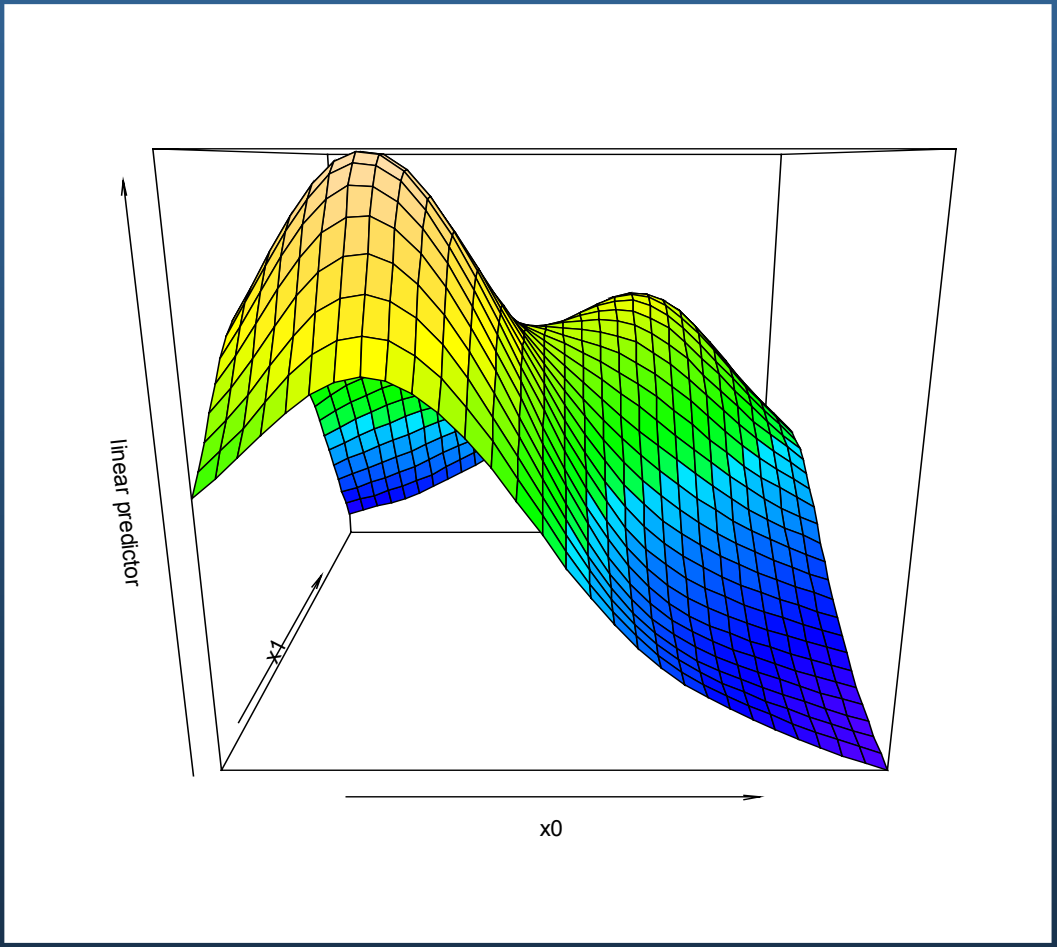


Fig. 6.2 Cumulative dose–response curve. In a lethality experiment the response is the cumulative percentage of animal mortalities with the actual data points indicated as crosses. Lowest observable effect concentration (LOEC) and no observable effect concentration (NOEC) are indicated.

Risk characterization

- Combining information on sound propagation with marine mammal distribution, abundance and behaviour (using models like ESME) →
- a **hazard exposure surface** for **each** species for the area where acoustic operations are planned
- Can be turned into a risk exposure surface for each species if threshold exposure values are agreed
- But use of mean values will result in the threshold being exceeded 50% of the time
- Therefore we need to account for uncertainty



The nature of uncertainty

- 'Reports that say that something hasn't happened are always interesting to me because, as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns—the ones we don't know we don't know'

This statement, by US Secretary of Defense Donald Rumsfeld, won a UK award for "the most baffling statement by a public figure" earlier this year

It's actually a rather good description of the major sources of uncertainty

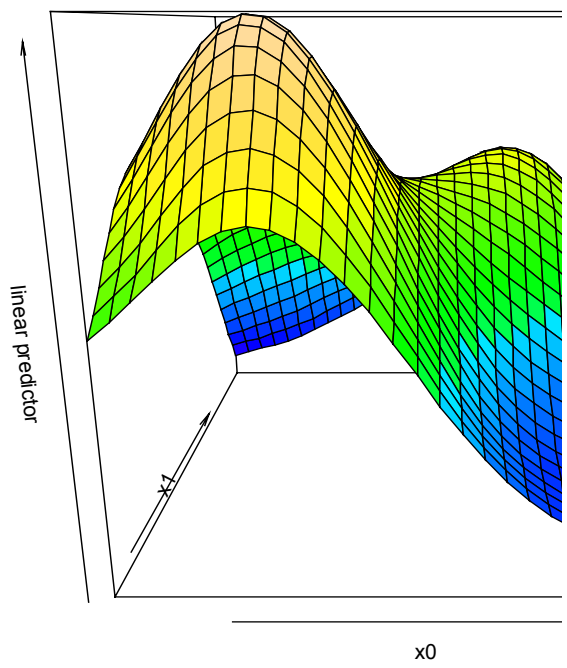
- "things we know we do not know"
- **Random effects**
- **Observation error** (measurement error + estimation error)
- **Implementation error** (Murphy's law)
- "the ones we don't know we don't know"
- **Model error**
- **Ignorance**

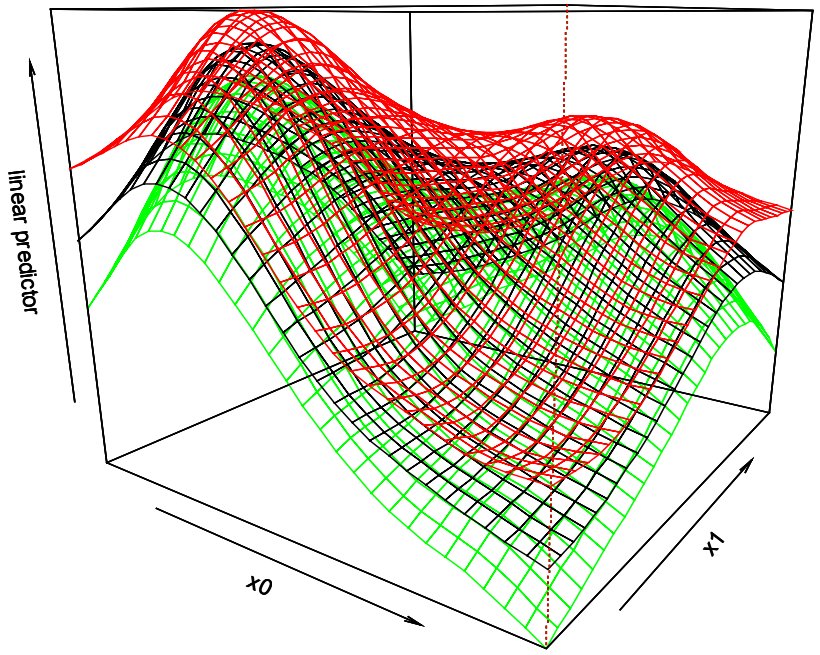
ELSEVIER Opinion TRENDS in Ecology and Evolution Vol.18 No.12 December 2003 617

Coping with uncertainty in ecological advice: lessons from fisheries

John Harwood[1] and Kevin Stokes[2]

If we take account of these uncertainties, we end up with a probability surface that will allow us to account for risk in a precautionary way





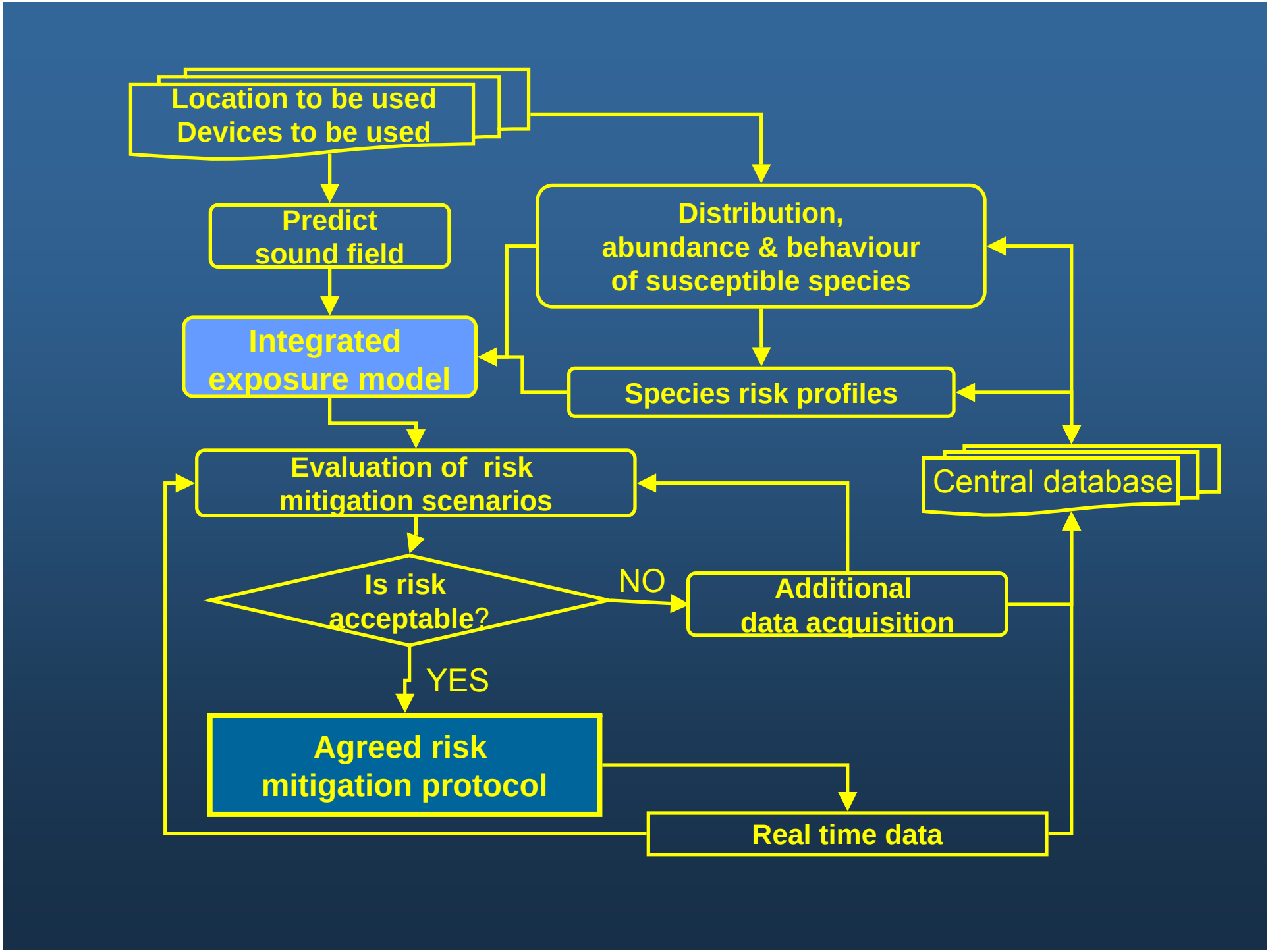
red/green are +/- 2 s.e.

This approach is essentially a quantitative version of a standard Environmental Impact Assessment

- If risk level is acceptable, then proceed
- If not, consider a range of different risk mitigation scenarios and evaluate their effects on the risk surface
- Chose one that provides the best balance between costs and benefits
- Results in an agreed protocol for a particular application

Adopted risk mitigation strategy is likely to be based on data with high levels of uncertainty

- Events may be quite different
- We need some way to incorporate data collected in real (or near real time) into the risk assessment
- For example, how does the sighting of one cetacean at the start of operations affect the overall risk?


Location to be used
Devices to be used
Predict sound field
Integrated exposure model
Distribution, abundance & behaviour of susceptible species
Species risk profiles
Central database
Evaluation of risk mitigation scenarios
Is risk acceptable?
NO
Additional data acquisition
YES
Agreed risk mitigation protocol
Real time data

Summary

- The hazard posed to marine mammals by marine acoustic operations are complex and can't be "minimized"
- Some form of quantitative risk assessment is needed to evaluate the effectiveness of different mitigation strategies
- Some, but by no means all, of the data and most of the analytical techniques are available now
- Large geographical areas are still unsurveyed
- "Dose response" relationships, particularly those involving behavioural responses. are poorly understood.

ACKNOWLEDGEMENTS: Photographs courtesy of Dylan Walker (WildGuides), Graeme Cresswell (Norfolk CC), International Fund for Animal Welfare(IFAW). Southern elephant seal map: Martin Buiw; UK seals: Bernie McConnell