Cetacean Spatial Analysis: Needs and Solutions

NMFS Protected Toolbox Mini-Symposium III
March 1-2, 2018

Presenter: Charlotte Boyd (AFSC)

Contributors:

Penny Ruvelas (WCR), Karin Forney(SWFSC), Jessica Redfern (SWFSC), Elizabeth Becker (SWFSC).

Dave Gouveia (GARFO), Debi Palka (NEFSC), Doug Sigourney (NEFSC), Dave Miller (NEFSC)

Jean Higgins (PIRO), Erin Oleson (PIFSC)

Kristin Mabry (ARO), Kim Shelden (AFSC), Nancy Friday (AFSC), Amy Kennedy (AFSC)

Lance Garrison (SEFSC)

NOAA FISHERIES

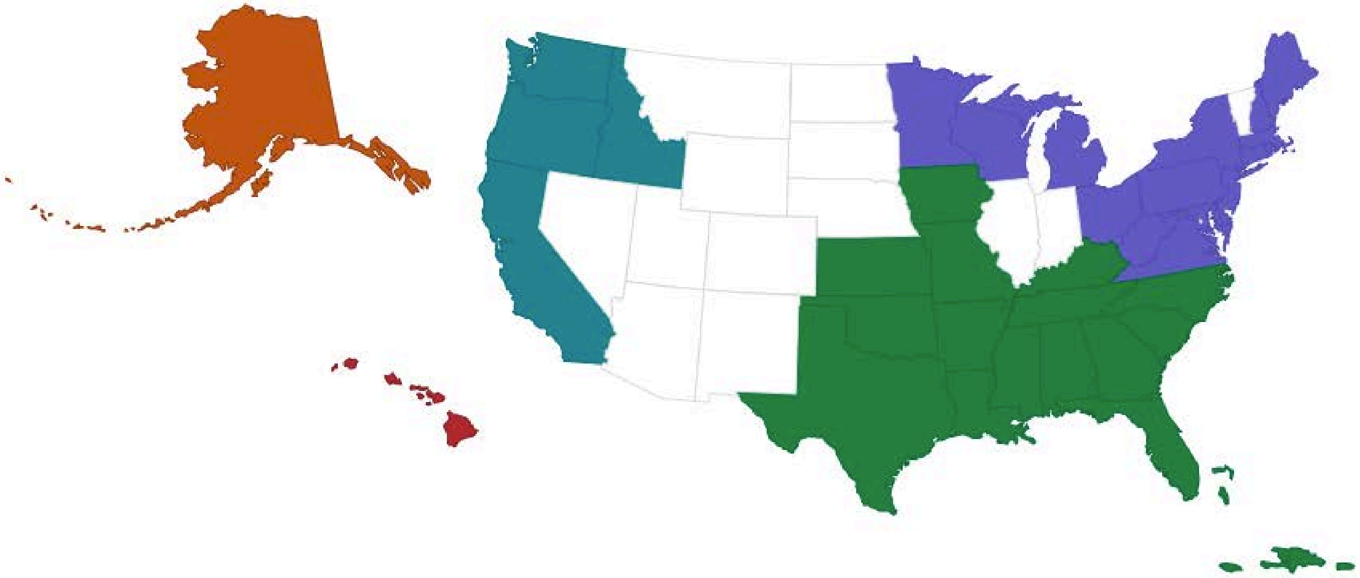
Cetacean Spatial Analysis Webinar Series

Objectives:

- review management questions/needs for each region;
- review data sources and methods being used to address these questions in each region;
- identify gaps and need for further development of analytical tools or other tools to meet management needs.

Regions

- Alaska
- New England/Mid-Atlantic
- Pacific Islands
- Southeast
- West Coast
- International



Protected Species Management and Science Drivers

Marine Mammal Protection Act

- Stock Assessment Reports
- Estimation of Serious Injury and
- Stranding response and UME investigation
- Take Reduction Planning and Implementation
- Incidental Take Authorizations

Endangered Species Act

- Section 7 consultations
- Jeopardy analysis and Biological Opinions
- Critical habitat identification
- Recovery planning

Management Tasks

1. Identifying conservation/management units
2. Status assessment
3. Impact/risk assessment
4. Identification of important sites
5. Broad-scale marine spatial planning or dynamic ocean management

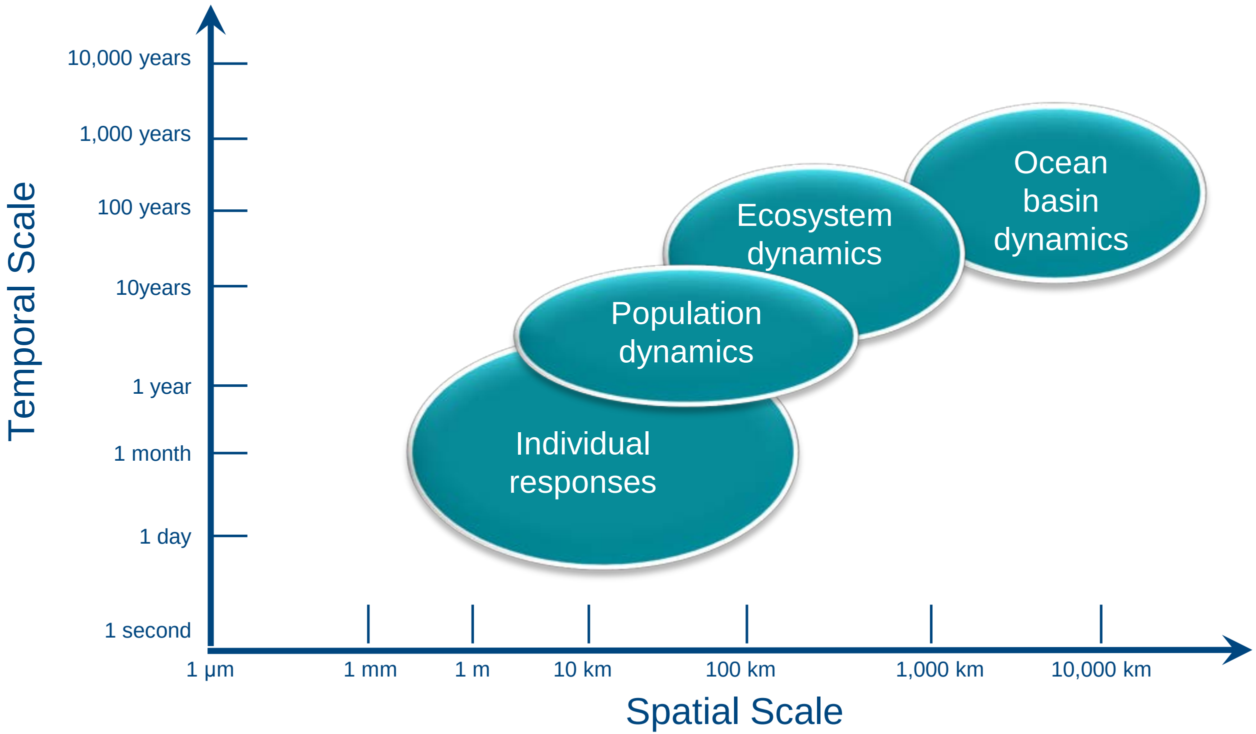
Cetacean Spatial Analysis Questions

- Who's out there? And when?
- Where might they be, or where are they likely to be?
- What are they doing in that area?
- Where are they going?
- How will those distributions change over time (years or seasons or even weeks)?
- How certain are you?
- How comfortable are you with the consequences of these predictions?

Data Types

- Surveys → Occurrence & distribution
- Acoustics → Occurrence & distribution
- Photo-id → Stock structure, life history
- Biopsy → Stock structure, life history
- Satellite tagging → Movements & habitat use
- Historical reconstructions → Stock assessment
- Multi-disciplinary work → Habitat/process studies
- Modeling → Abundance, habitat, …

Spatial and Temporal Scales



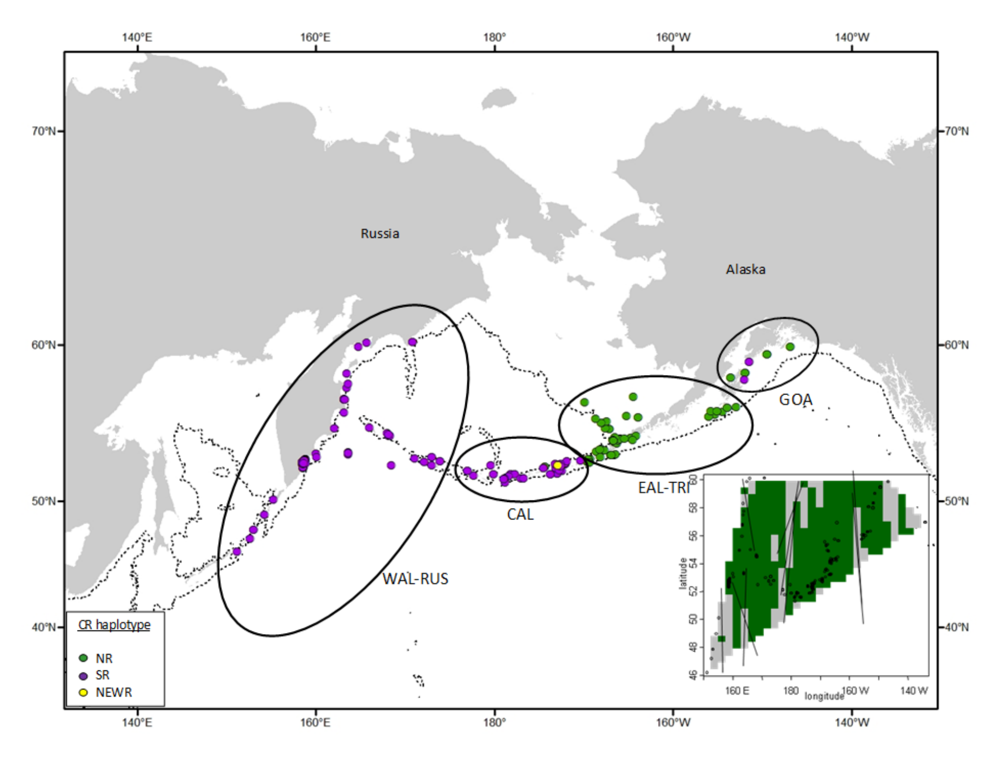
1. Identifying conservation/ management units

- Genetic differentiation among samples from different locations:
    - DNA from biopsies (e.g. killer whales)

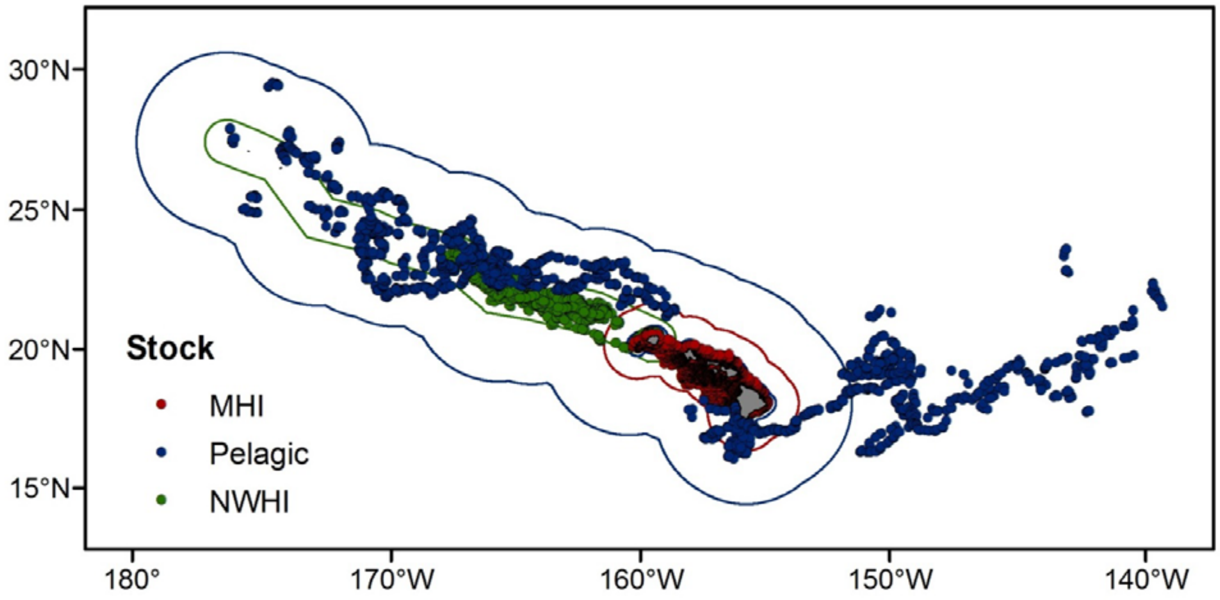
- Geographic discreteness:
    - telemetry data (e.g. false killer whales)
    - individual mark-recapture data
    - habitat selection models based on distance sampling data? (e.g. harbor porpoise?)

➢ Multiple strands of evidence

Parsons et al (2013): four genetic subdivisions in resident-type killer whales from the Gulf of Alaska to Russia



Data from 43 individuals from 3 stocks of false killer whales in Hawaii - primarily contributed by research partners (Cascadia)



2. Status assessment

- Abundance/trend estimation:
    - o individual mark-recapture data.
    - o line transect data:
        - standard distance sampling methods and broad spatial strata (e.g. California Current surveys);
        - 2-stage distance sampling + GAM models ~ fine-scale environmental covariates (Sigourney?);
        - hierarchical distance sampling methods ~ fine-scale environmental covariates (Dall's porpoise).

➢ Rapidly evolving methods -> incorporating habitat information can lead to more precise estimates.

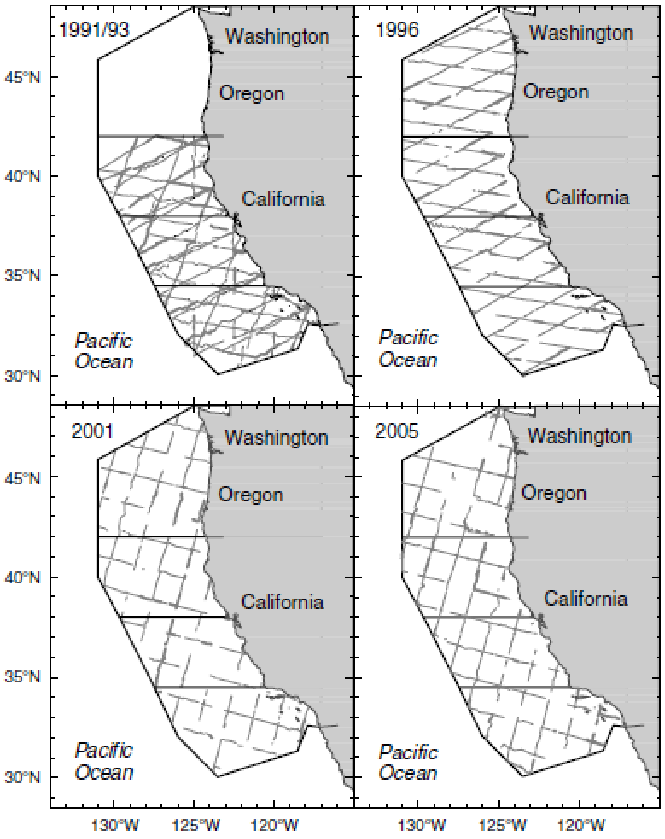
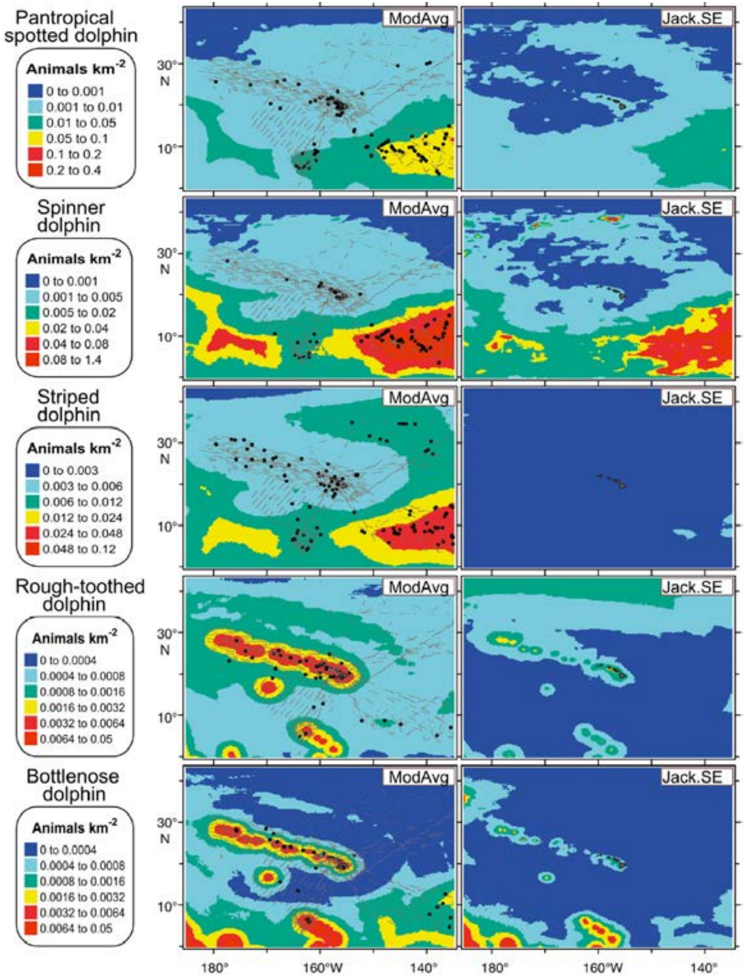
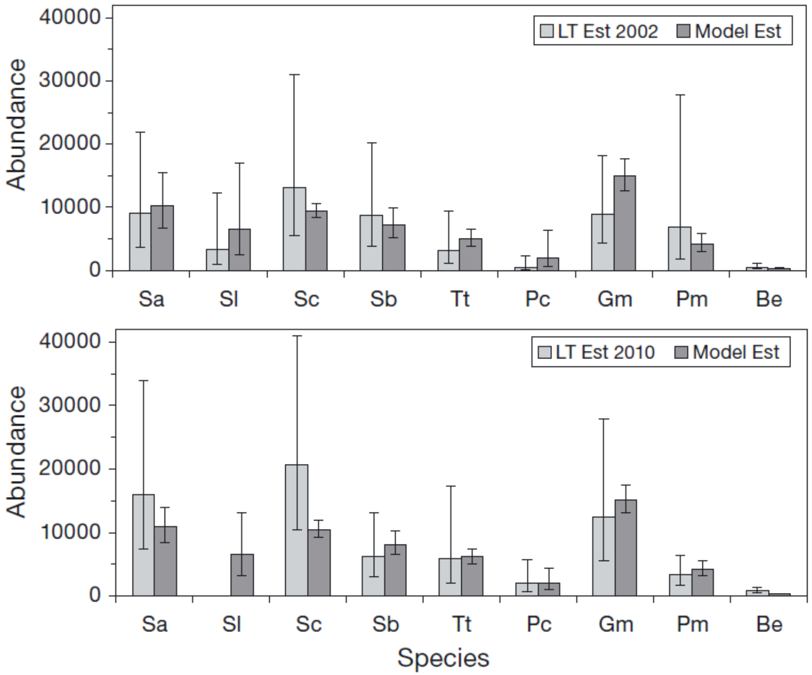


Figure 1

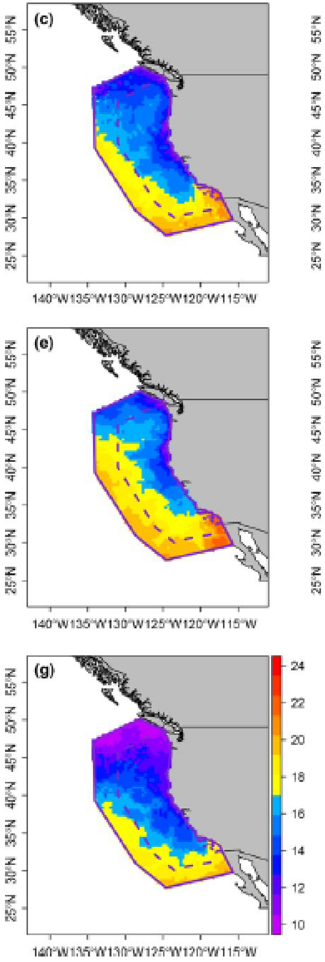
Transect lines (gray) surveyed during 1991 and 1993, 1996, 2001, and 2005 surveys. Thick transect lines were surveyed in Beaufort sea states of 0–2 and thin lines in Beaufort sea states 3–5. Black lines on all maps indicate the boundaries of the four geographic regions.

Barlow & Forney. *Fish. Bull.* 2007





Forney *et al. End. Spp. Res.* 2015



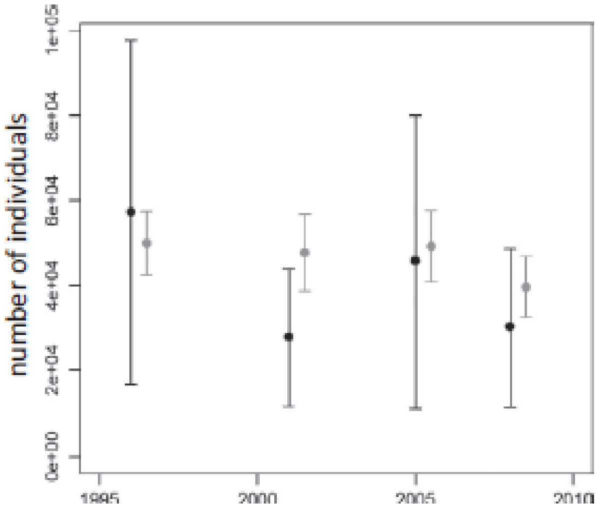


FIGURE 5 Comparison of previous estimates of the population size of Dall's porpoise in the California Current Ecosystem survey region in 1996, 2001, 2005 and 2008 (Barlow, 2016, table 8) shown in black versus estimates based on the full habitat restricted range integrated population-redistribution model shown in grey. Points indicate the mean abundance estimate in each year; error bars indicate ± 1 *SD*

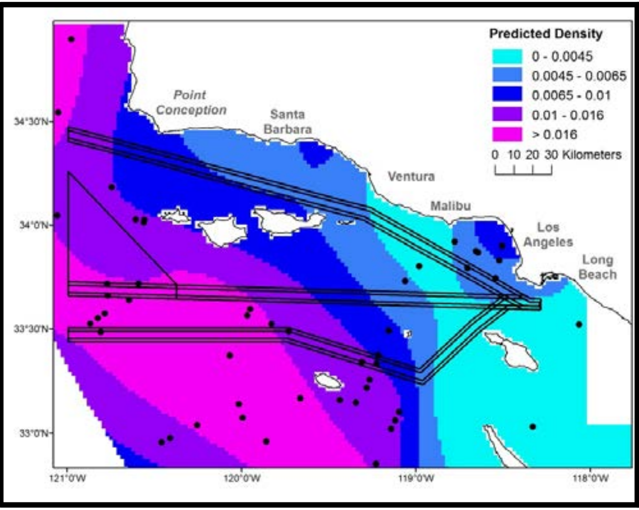
Boyd *et al. Div. & Dist.* 2018

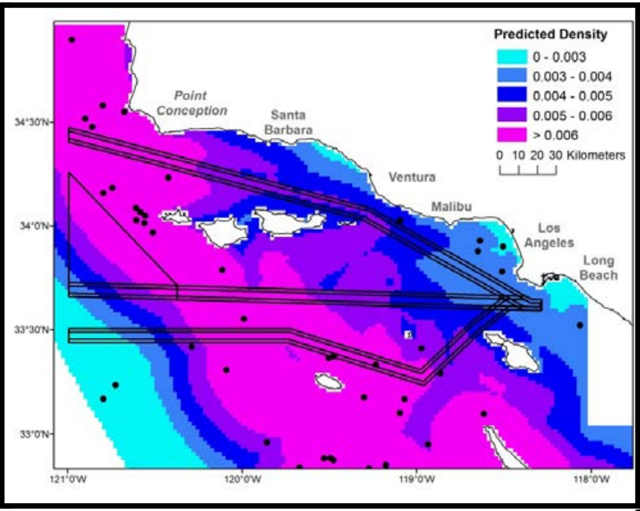
3. Impact/risk assessment

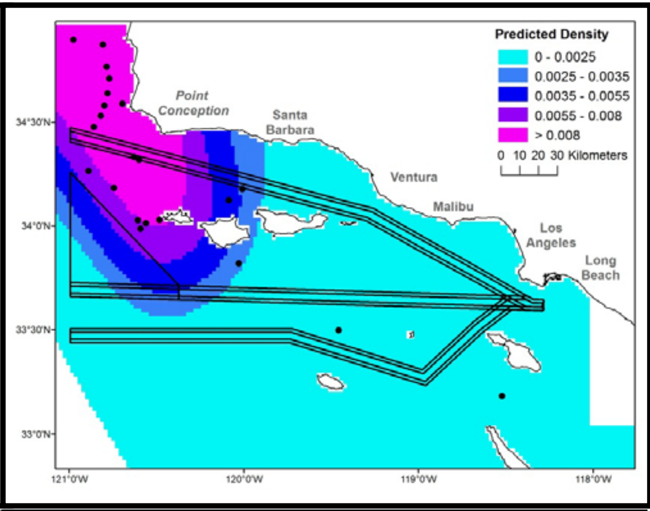
- Ship strikes
- Fisheries interactions
- Tourism
- Oil & gas development
- Naval operations
- UME investigations

➢ Range of approaches from relatively simple co-occurrence models to much more complex analysis of the population-level consequences of individual-level disturbance.

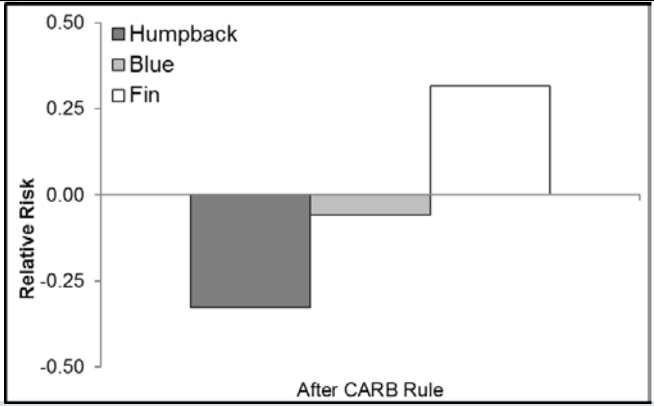
Fin Whales | Blue Whales | Humpback Whales

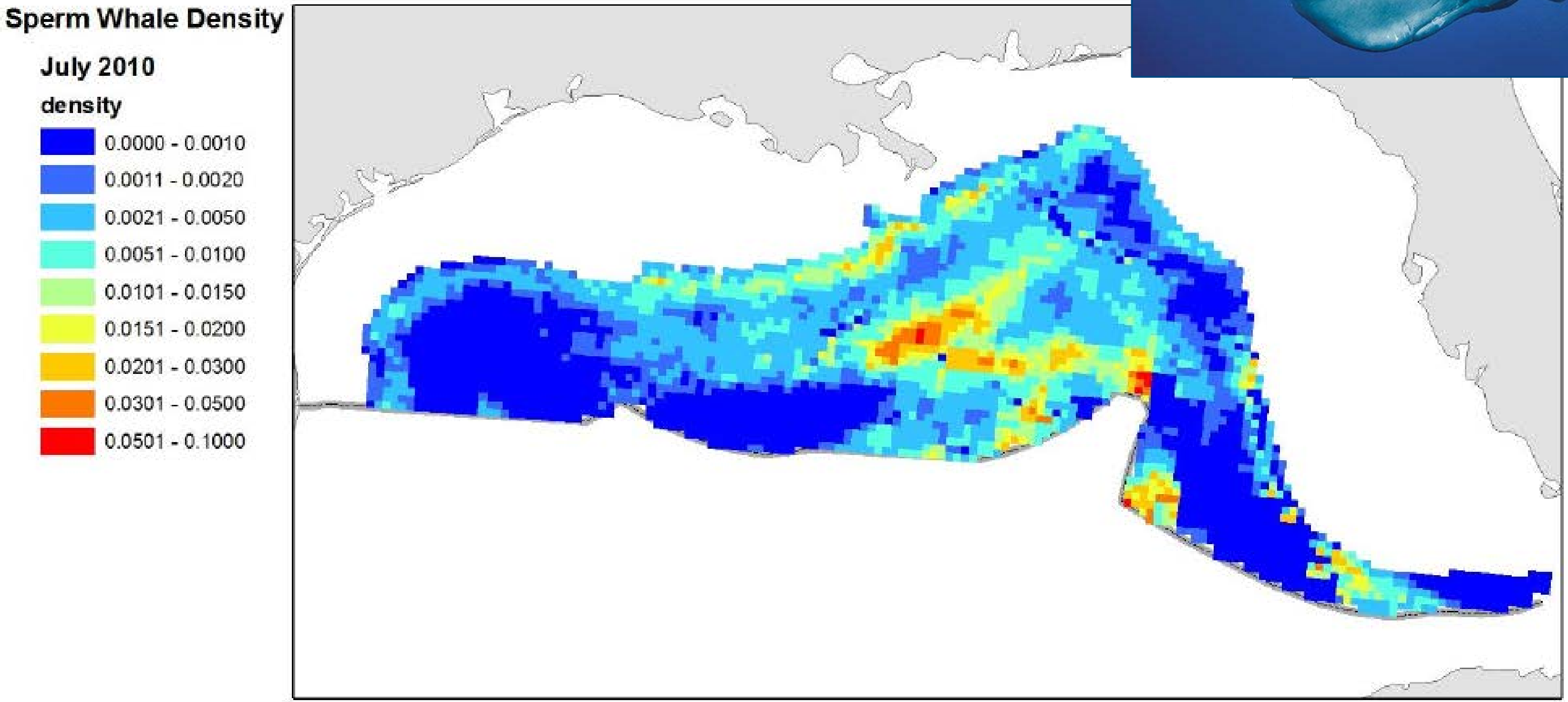






Redfern *et al. Cons. Biol.* 2013




Sperm Whale Density
July 2010
density
0.0000 - 0.0010
0.0011 - 0.0020
0.0021 - 0.0050
0.0051 - 0.0100
0.0101 - 0.0150
0.0151 - 0.0200
0.0201 - 0.0300
0.0301 - 0.0500
0.0501 - 0.1000

4. Identification of important sites

Critical habitat:

- aerial/vessel-based survey data (e.g. Cook Inlet beluga; N Atlantic right whale)
- telemetry data (e.g. MHI false killer whales)

Biologically important areas:

- telemetry data,
- photo-identification data
- acoustic data
- aerial, vessel, land-based survey data
- Traditional ecological knowledge

➢ Multiple data sources

➢ How to categorize into important vs not important?

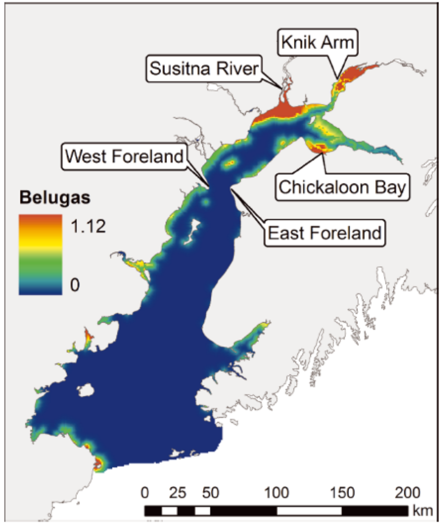
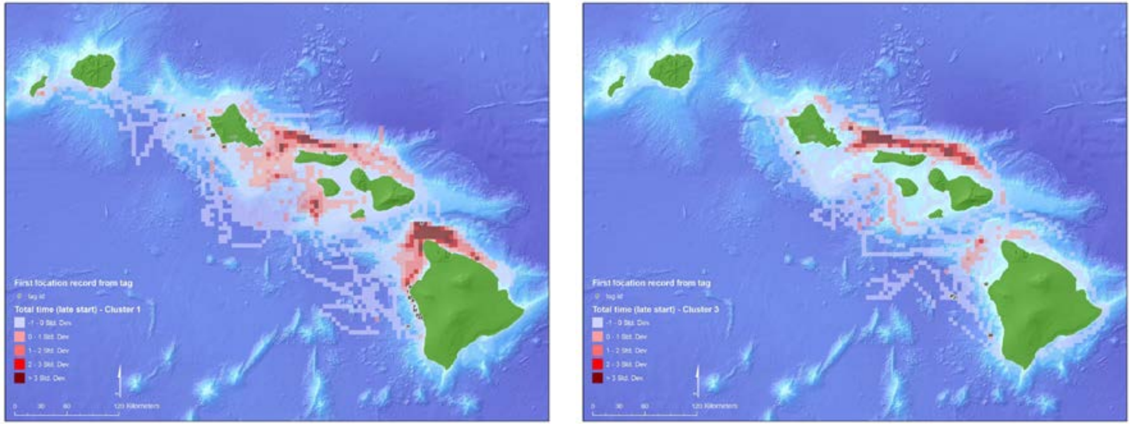
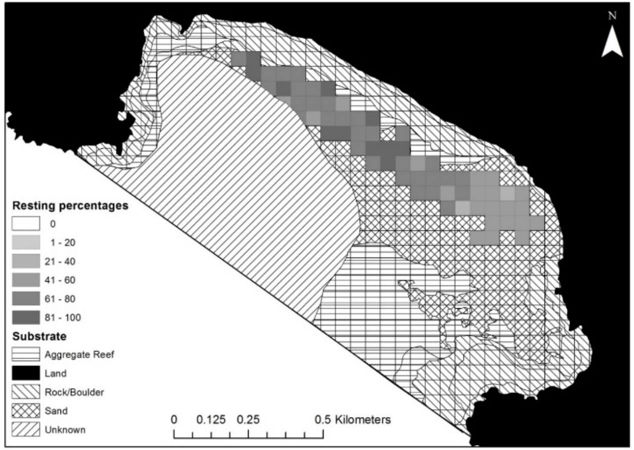


Fig. 6. *Delphinapterus leucas*. Expected number of belugas in each habitat unit (1 km^2 cell) derived as the product (i.e. multiplication) of the probability of beluga presence and the expected number of belugas when they are present

Goetz *et al. End. Spp. Res.* 2012



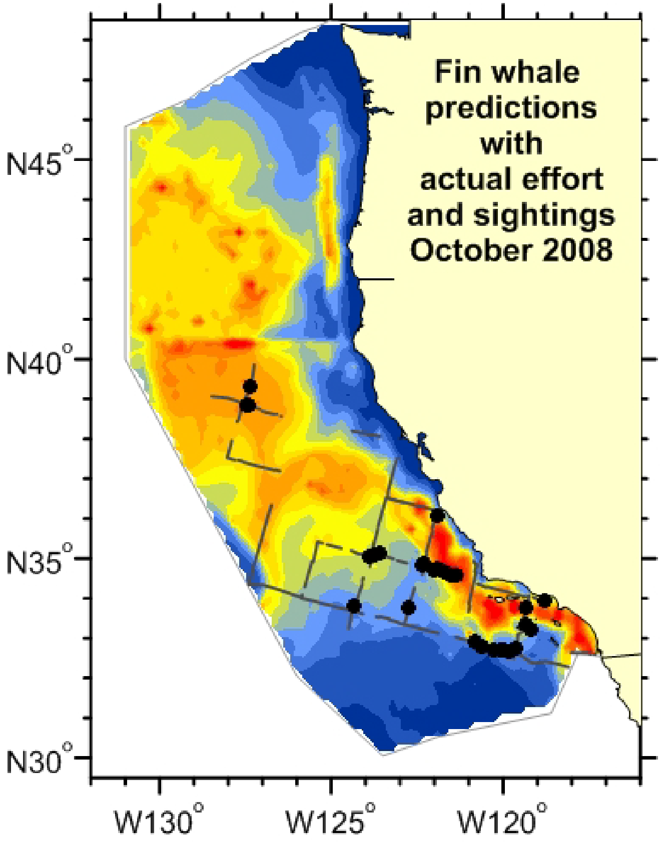
Baird *et al. End. Spp. Res.* 2012

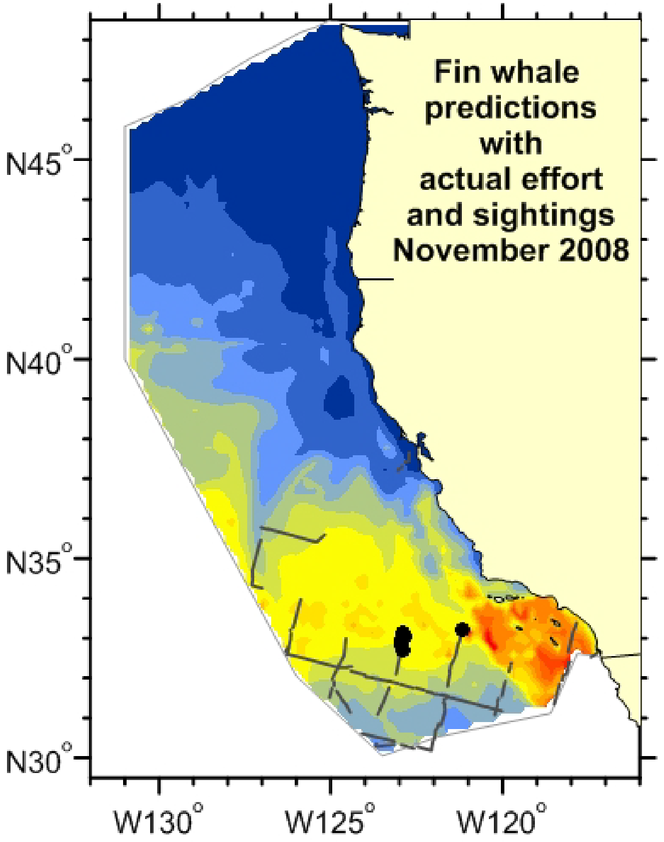


Tyne *et al. J. App. Ecol.* 2015

5. Broad-scale marine spatial planning

- Marine spatial planning
  - e.g. permanent and/or seasonal management areas for N Atlantic right whales
- Dynamic ocean management
  - e.g. dynamic area management for N Atlantic right whales





Becker *et al. End. Spp. Res.* 2012

Major challenges: science -> management questions

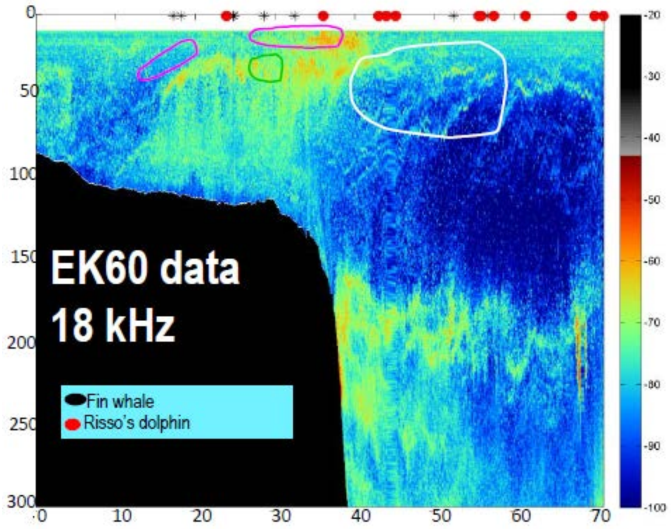
- Multiple strands of evidence -> different conclusions:
  - integrated analysis of various data sources;
  - ensemble modelling;
  - structured expert decision-making.

- Representing uncertainty:
  - scientists -> managers;
  - managers -> public.

Emerging Scientific Directions

- Rapidly evolving methods:
  - o esp. analysis of line transect data;
  - o integrated analysis of various data types;
  - o more process-based approaches?

- New technologies
  - o new tools for passive acoustic monitoring?
  - o UAV data?

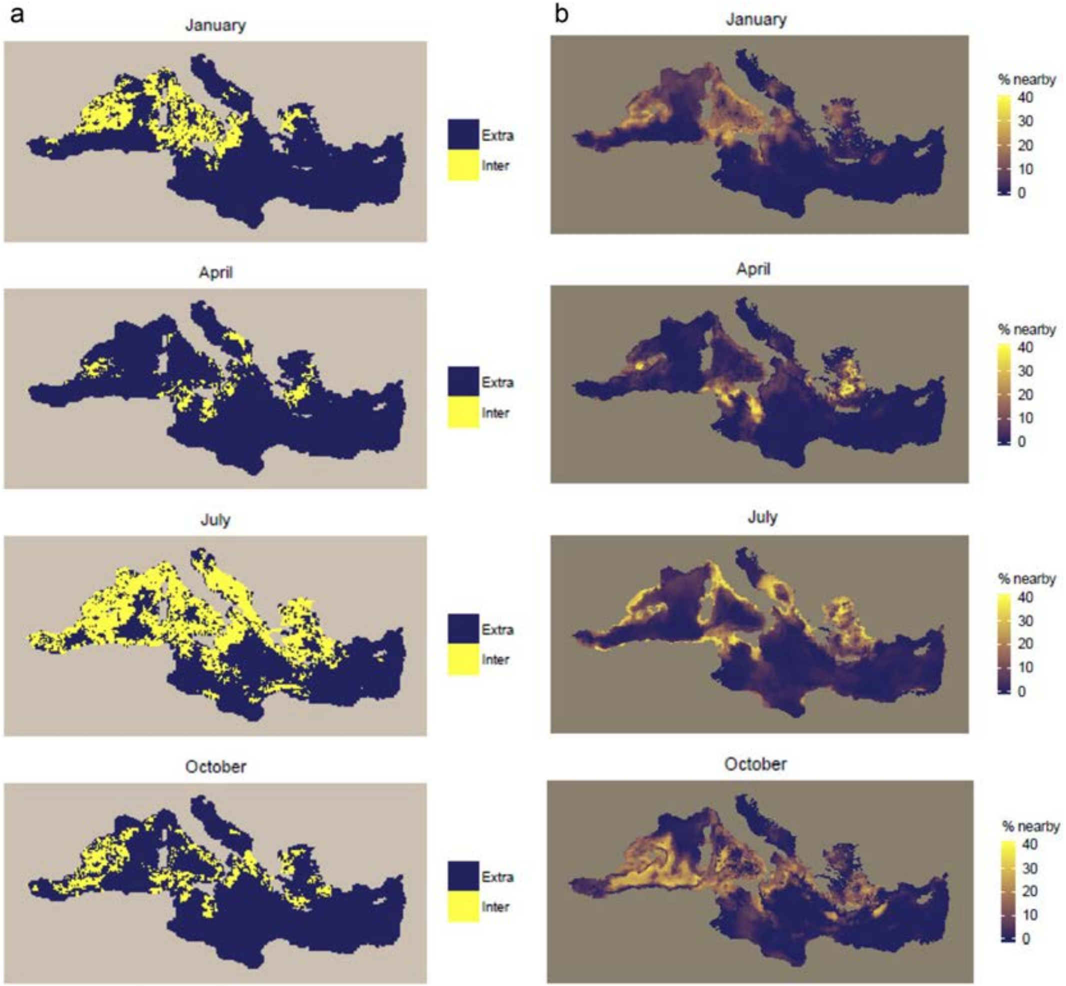


Integrating distributions of lower trophic levels with cetacean distributions

Key Unresolved Questions

- Estimating turnover (i.e. how many distinct individuals at a location for how long?)
  - individual mark-recapture and telemetry data

- Year-round distribution patterns?
  - extrapolation of line transect data? (Mannocci et al. 2017)
  - non-summer surveys?
  - passive acoustic monitoring (fixed or transient)?
  - long-term telemetry data?



Mannocci *et al. Nature.* 2018

Figure 8. (**a**) Extent of extrapolation (dark blue) *versus* interpolation (yellow), and (**b**) proportion of prediction points near available data points in the multivariate environmental space defined by all considered static and dynamic covariates if a model including all static and dynamic covariates calibrated on the available survey data was used for prediction across the Mediterranean Sea. In (**b**), dark blue/yellow represents areas where predictions would potentially be unreliable/reliable. Results for January, April, July, and October, corresponding to the middle month of solar seasons, are shown. Results for all months are shown in Supplementary Figs S13 and S14. The definition of neighborhood in multivariate environmental space is provided in the Methods. The maps were generated with R (https://www.r-project.org/) (version 3.1.1).

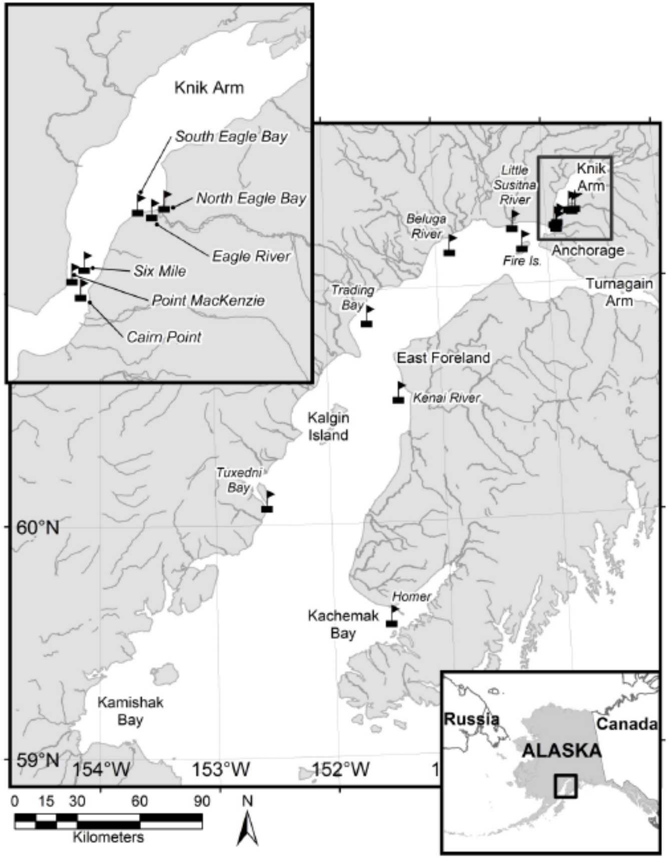


Figure 1. Locations where acoustic moorings were deployed to monitor for beluga whales from July 2008 to May 2013, in Cook Inlet, Alaska. The Knik Arm insert shows the six overwinter deployment sites for that area.

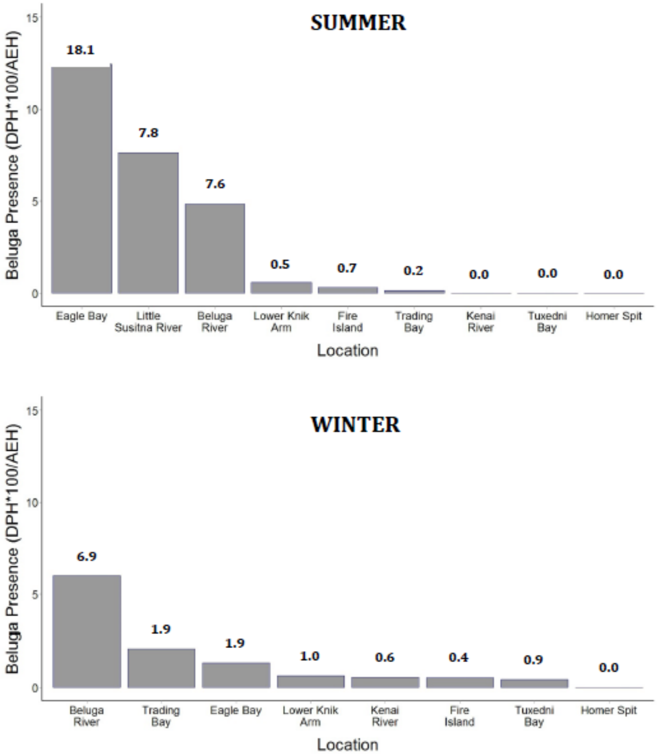


Figure 5. Beluga acoustic presence (%DPH), calculated as percent detection positive hours (DPH) over total acoustic effort hours (AEH), during summer (May to October) and winter (November to April) for all locations sampled during the CIBA research program in Cook Inlet, Alaska, July 2008 to May 2013. Locations are ordered by decreasing %DPH in both seasons, and the standard deviation is shown above the %DPH.

Castellote *et al. Wild. Res. Rep.* 2016

Key Unresolved Questions

- Estimating turnover (i.e. how many distinct individuals at a location for how long?)
  - individual mark-recapture and telemetry data

- Year-round distribution patterns?
  - extrapolation of line transect data? (Mannocci et al. 2017)
  - non-summer surveys?
  - passive acoustic monitoring (fixed or transient)?
  - long-term telemetry data?

- Future projections under climate change:
  - combining line transect data with ROMS (e.g. Becker et al. YY)
  - extrapolation of line transect data? (Mannocci et al. 2017)
  - ➢ need for more process-based modeling approaches.

Potential useful spatial toolboxes

- Tools that use a variety of models/methods to estimate spatially- and temporally-explicit abundance or bycatch estimates (along with associated trends and uncertainty) for entire US coast and/or for areas or characteristics of interest
- Tools to standardize output from a variety of models/methods that could then be used, for example to create ensemble estimates or input to ecosystem models or ocean planning layers, etc.
- Tools to integrate data from line transect surveys, individual tag movements, passive acoustic bottom mounted arrays, bycatch, etc. to, for example, describe the spatial/temporal distribution of a species
- Tools to use these types of data and others to evaluate potential management mitigation scenarios
- Tools that use a variety of measures to identify areas of concern

Spatial analysis tool box needs

- Tools that allow us to easily overlay disparate data and integrate information
- Tools that allow us to analyze time and seasonality associated with data

- More resources to collect data!

Spatial analysis tool box needs

- Systems for the aggregation/ display of multiple data types incl. both animal density/habitat use and human stressors;
- Representations of uncertainty/risk
- Integration of climate models and long-term projections.

Spatial analysis tool box needs

This PDF was later amended to make the document 508 compliant.

- Inventory of what spatially explicit data is already available
- Tools/infrastructure to properly use those datasets
- Seasonal density (distribution) maps for all species
- Ship-strike risk assessment models for humpback and Northern right whale
- Abundance and migratory routes in all oil spill planning areas
- Marine Spatial Planning framework that includes sensitive areas and time for these species?