Cumulative Human Impacts on Marine Predators

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Importance of cumulative impacts and marine predators

1. Marine predators important ecologically and economically

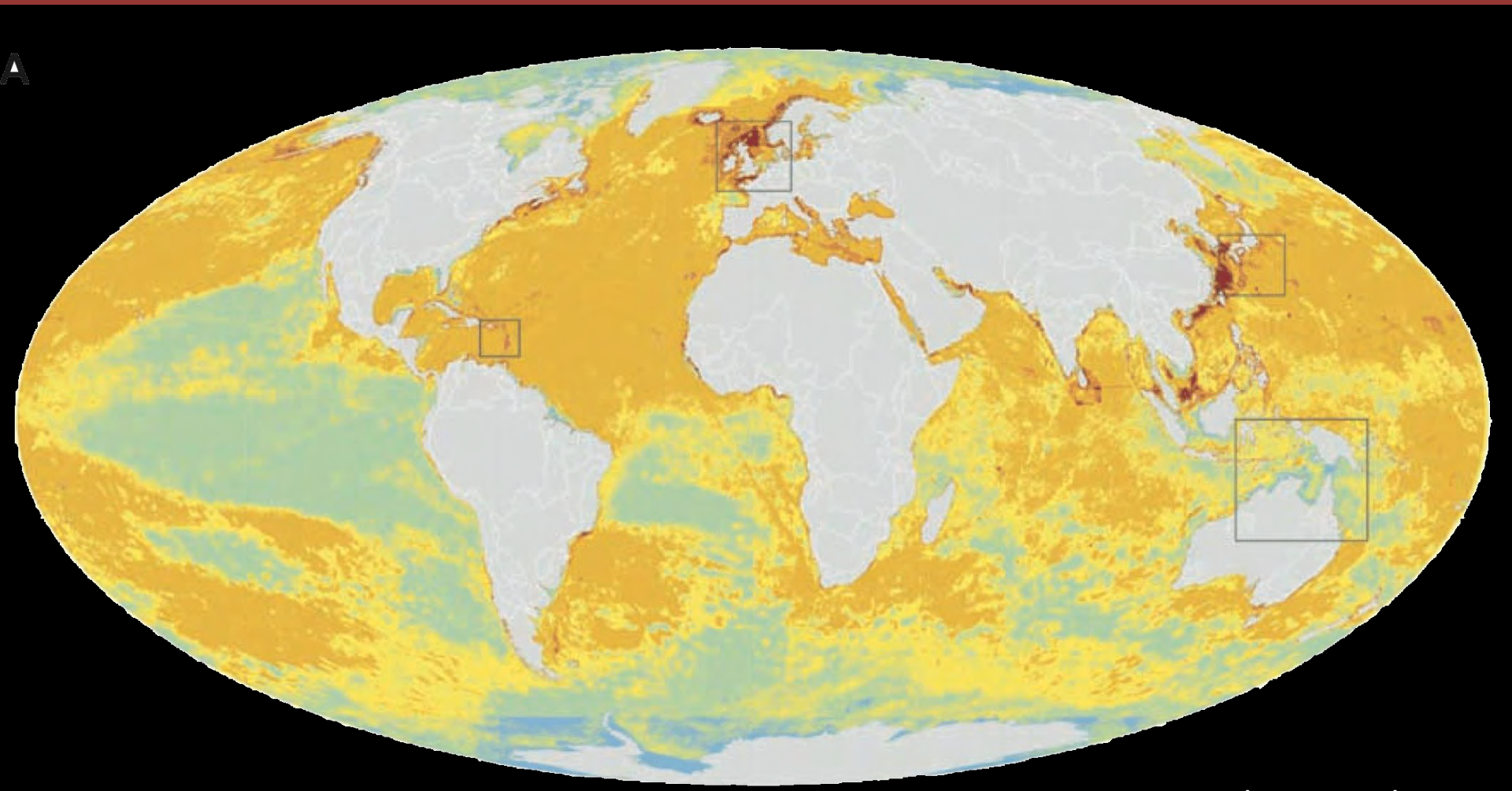
   (Furness & Camphuysen 1997, Estes et al. 2011, Wilmers et al. 2012)

2. Predators important for ecosystem-based management

   (Foley et al. 2010, Hooker et al 2011)

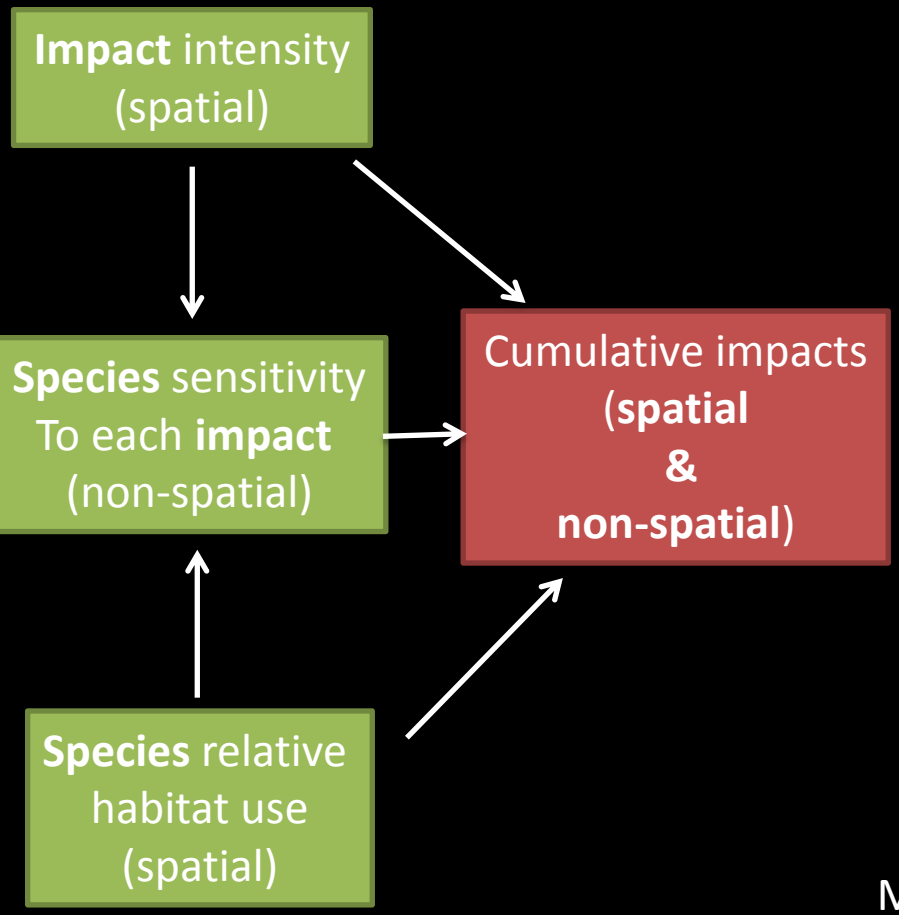
3. Cumulative impacts part of MMPA, ESA, etc.

Managing for cumulative impacts



Halpern et al. 2008

Managing for cumulative impacts

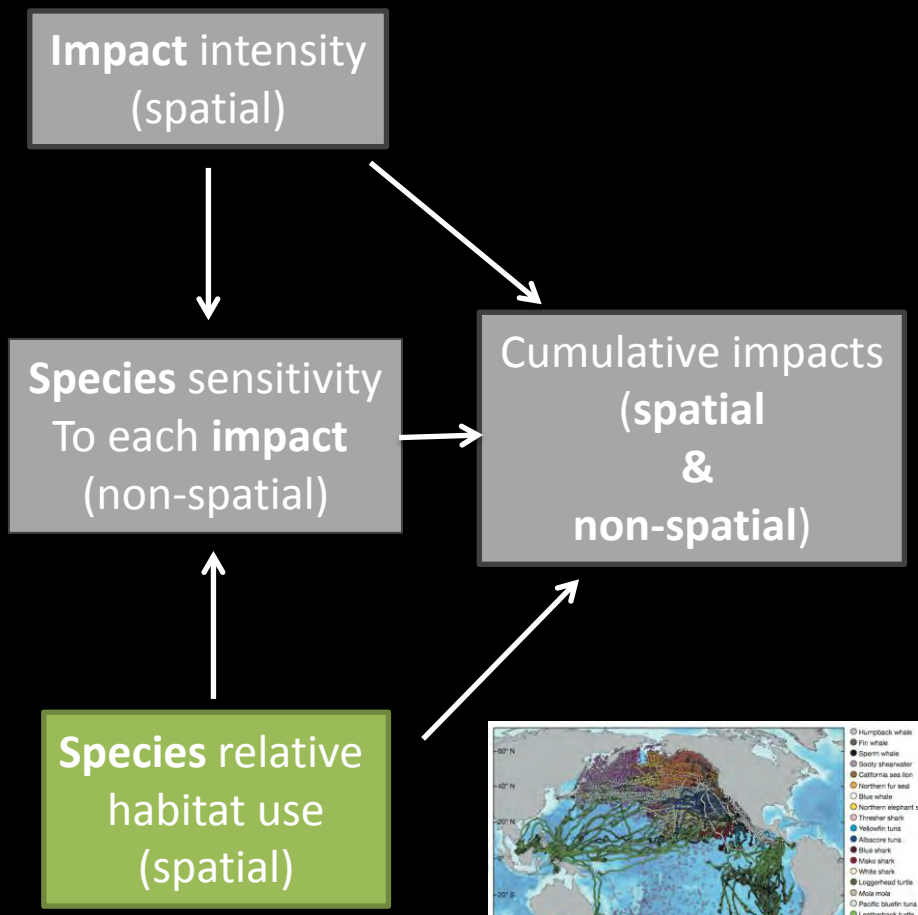


Maxwell et al. *in press* Nature Communications

Methods: Relative Habitat Use (Tracking)

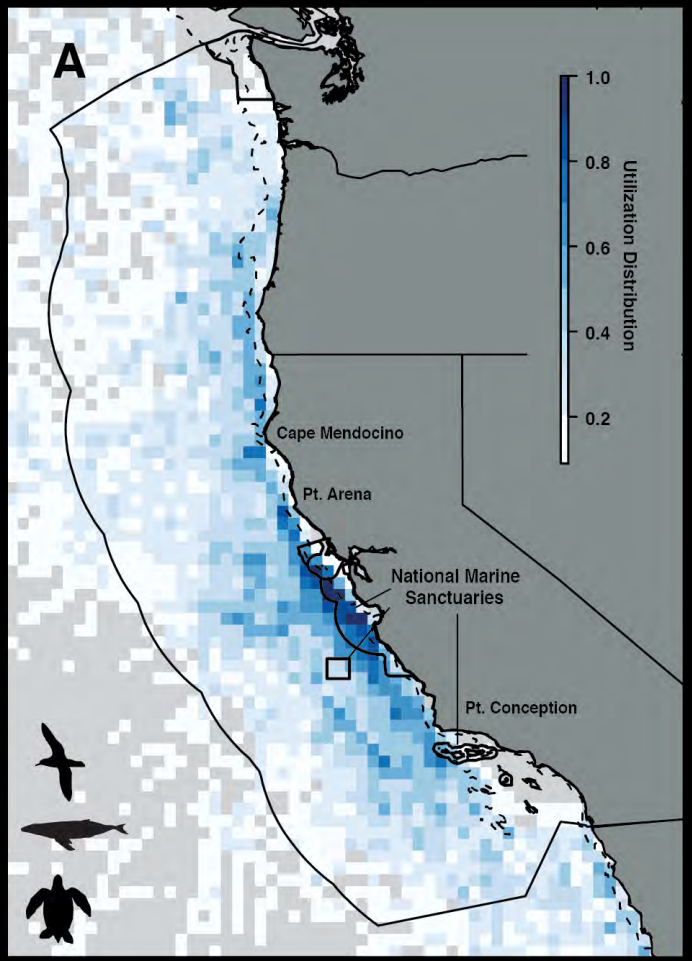
685 individuals from 8 species:

- Seabirds (n=3)
  - Laysan albatross
  - Black-footed albatross
  - Sooty shearwater
- Sea turtles (n=1)
  - Leatherback sea turtle
- Marine mammals (n=4)
  - California sea lions
  - Northern elephant seals
  - Blue whales
  - Humpback whales



Relative habitat use: Gridded utilization distribution (home range)

Methods: Relative Habitat Use (Tracking)

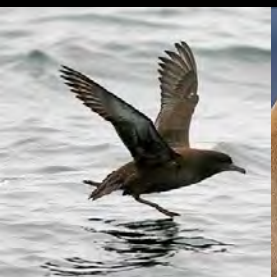


Impact intensity (spatial)

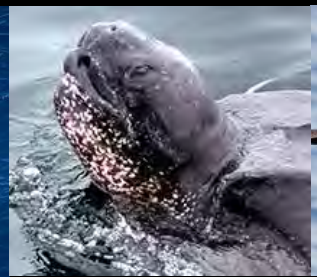
Species sensitivity To each **impact** (non-spatial)

Cumulative impacts (**spatial & non-spatial**)

Species relative habitat use (spatial)



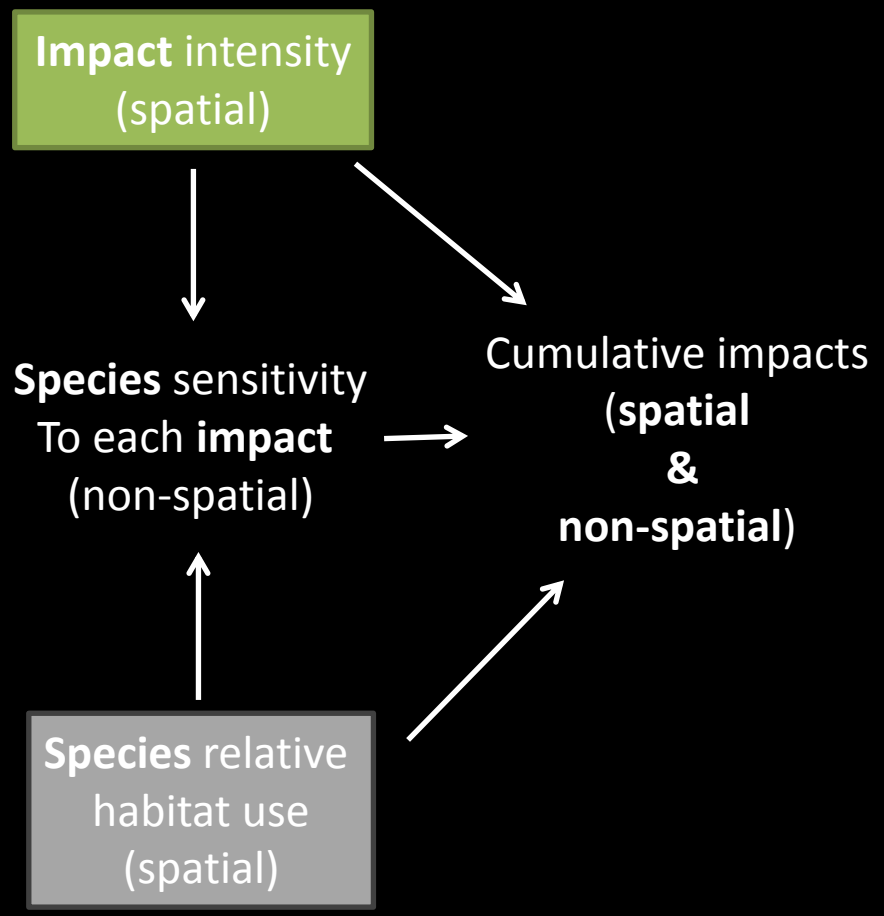




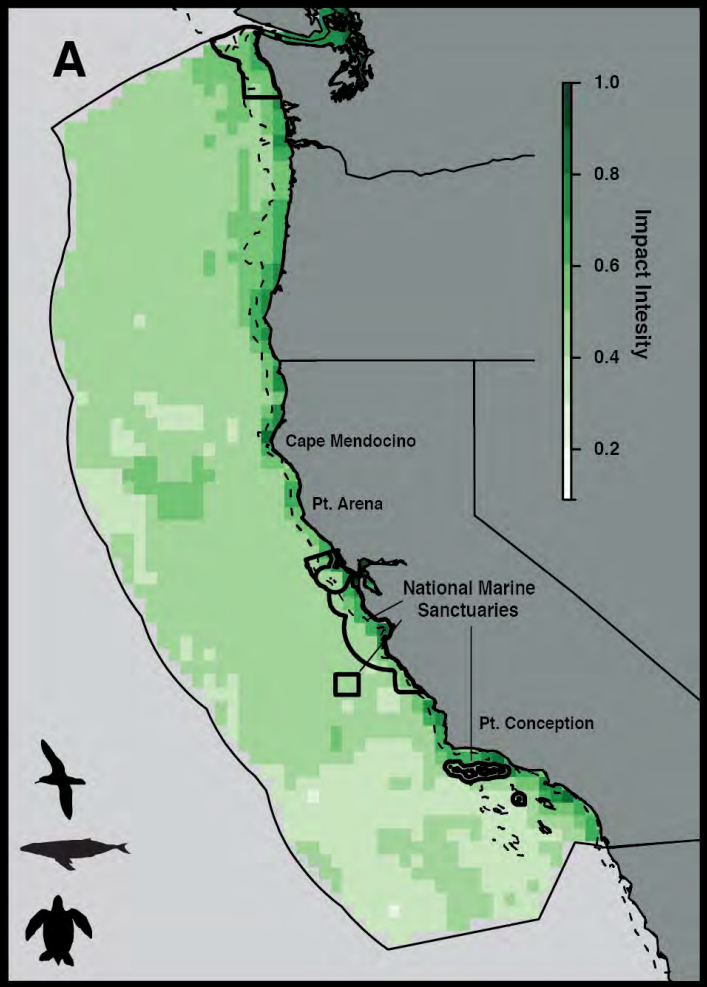
Methods: Impact Intensity

24 drivers from Halpern et al. 2009 (*Cons Letters*):

- Climate: UV radiation, ocean acidification
- Pollution: ocean pollution, organic and inorganic pollution, nutrient deposition, coastal waste
- Shipping: shipping lanes, invasive species
- Fishing: pelagic, demersal, high and low bycatch, destructive and non-destructive
- Coastal: beach access, ocean engineering, fish farming, power plants, sediment runoff



Methods: Impact Intensity



Impact intensity (spatial)

Species sensitivity To each **impact** (non-spatial)

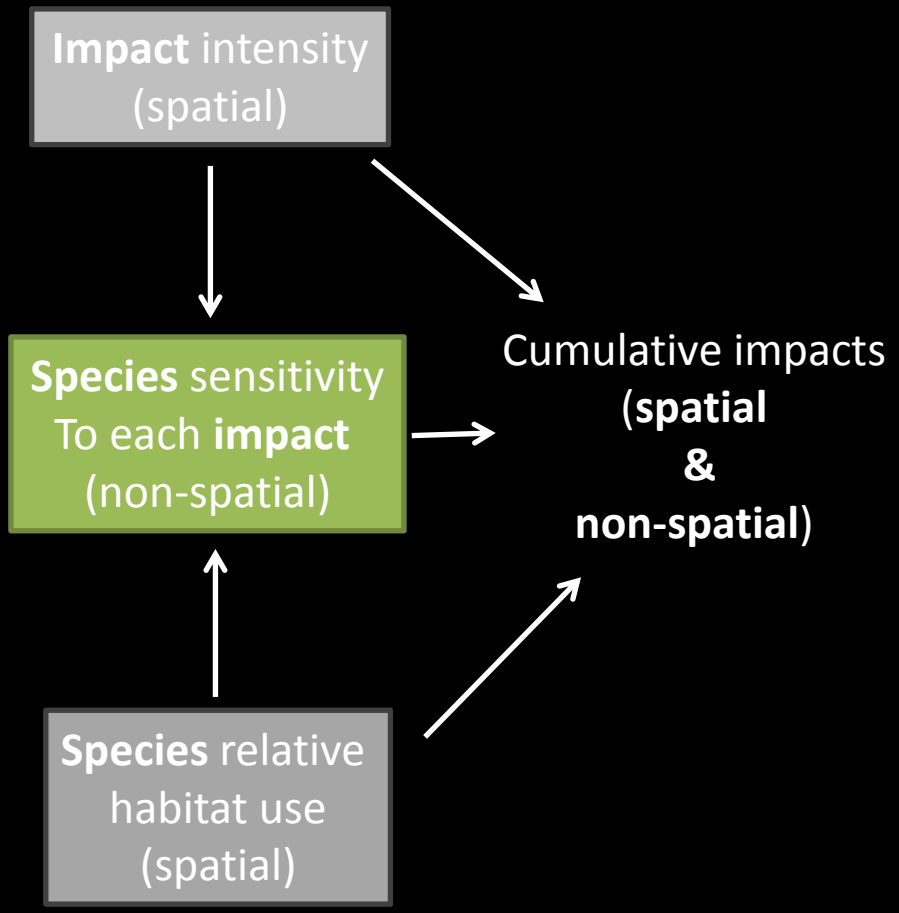
Cumulative impacts (**spatial & non-spatial**)

Species relative habitat use (spatial)

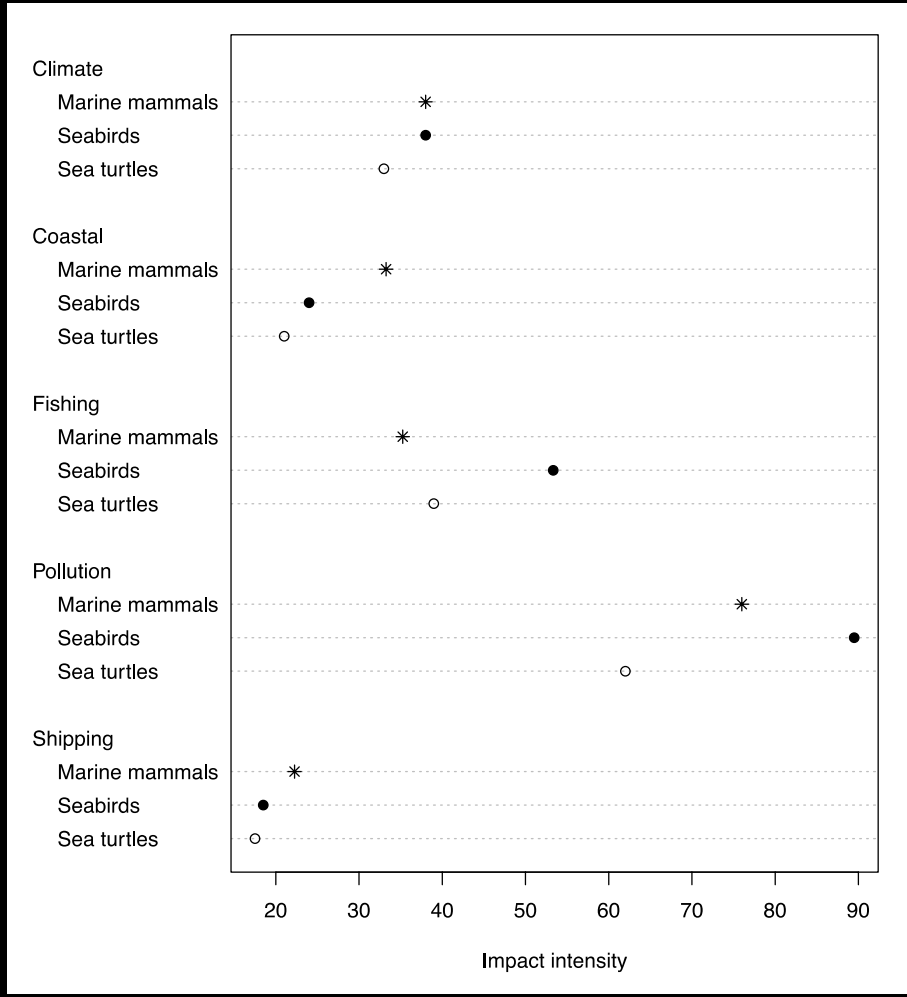
Methods: Species Sensitivity to Impacts

Vulnerability Measures:

1. Frequency
2. Direct vs. indirect impact
3. Resistance (likelihood of mortality)
4. Recovery time of individual
5. Reproductive impacts
6. Population effects



Methods: Species Sensitivity to Impacts



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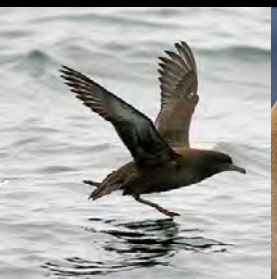
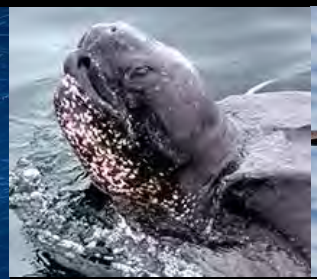






Methods: Species Sensitivity to Impacts

$$CUI = \sum_{i=1}^{n} \sum_{j=1}^{m} D_i \times S_j \times u_{i,j}$$

Impact intensity (spatial)

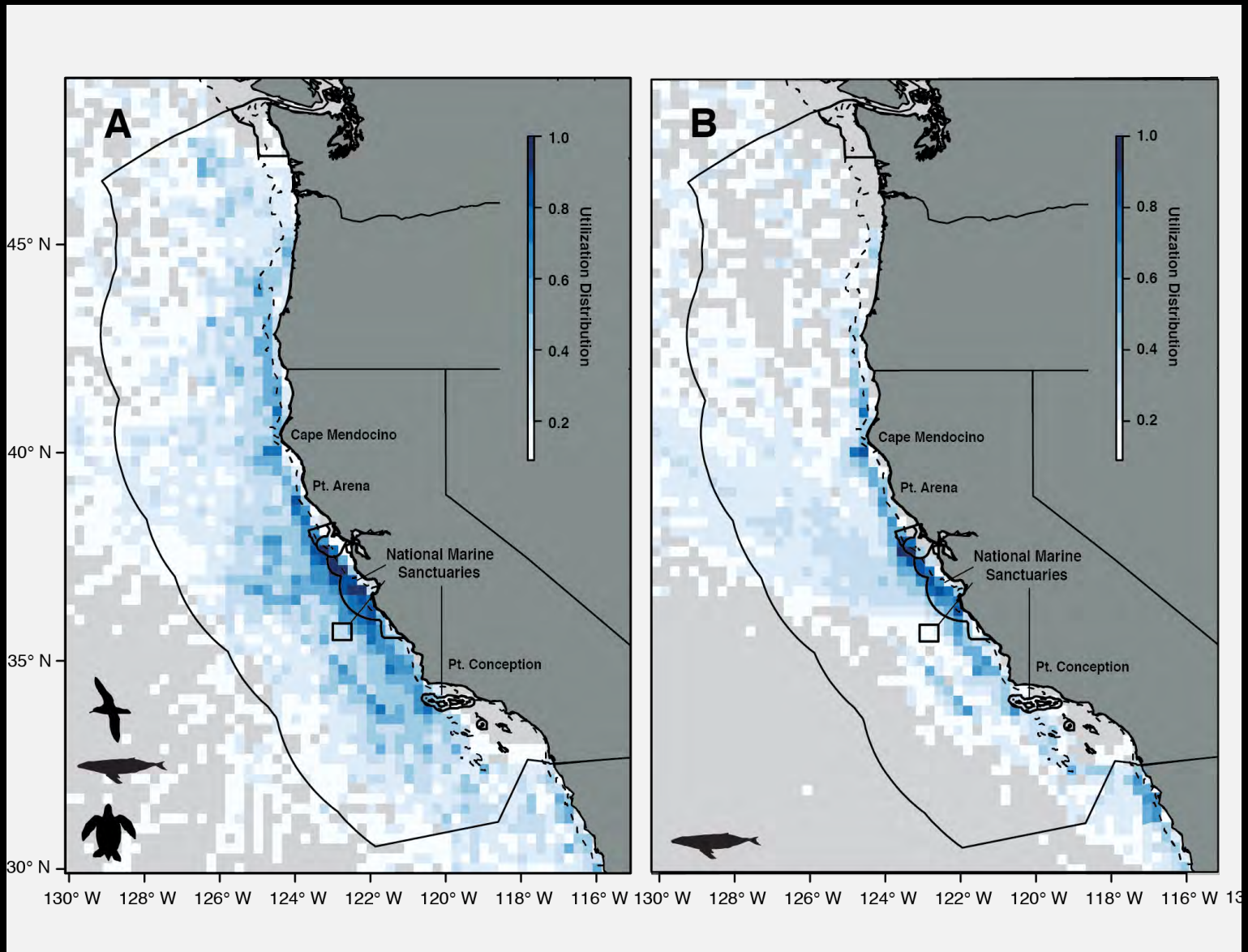
Species sensitivity To each **impact** (non-spatial)

Species relative habitat use (spatial)

Cumulative impacts (**spatial & non-spatial**)

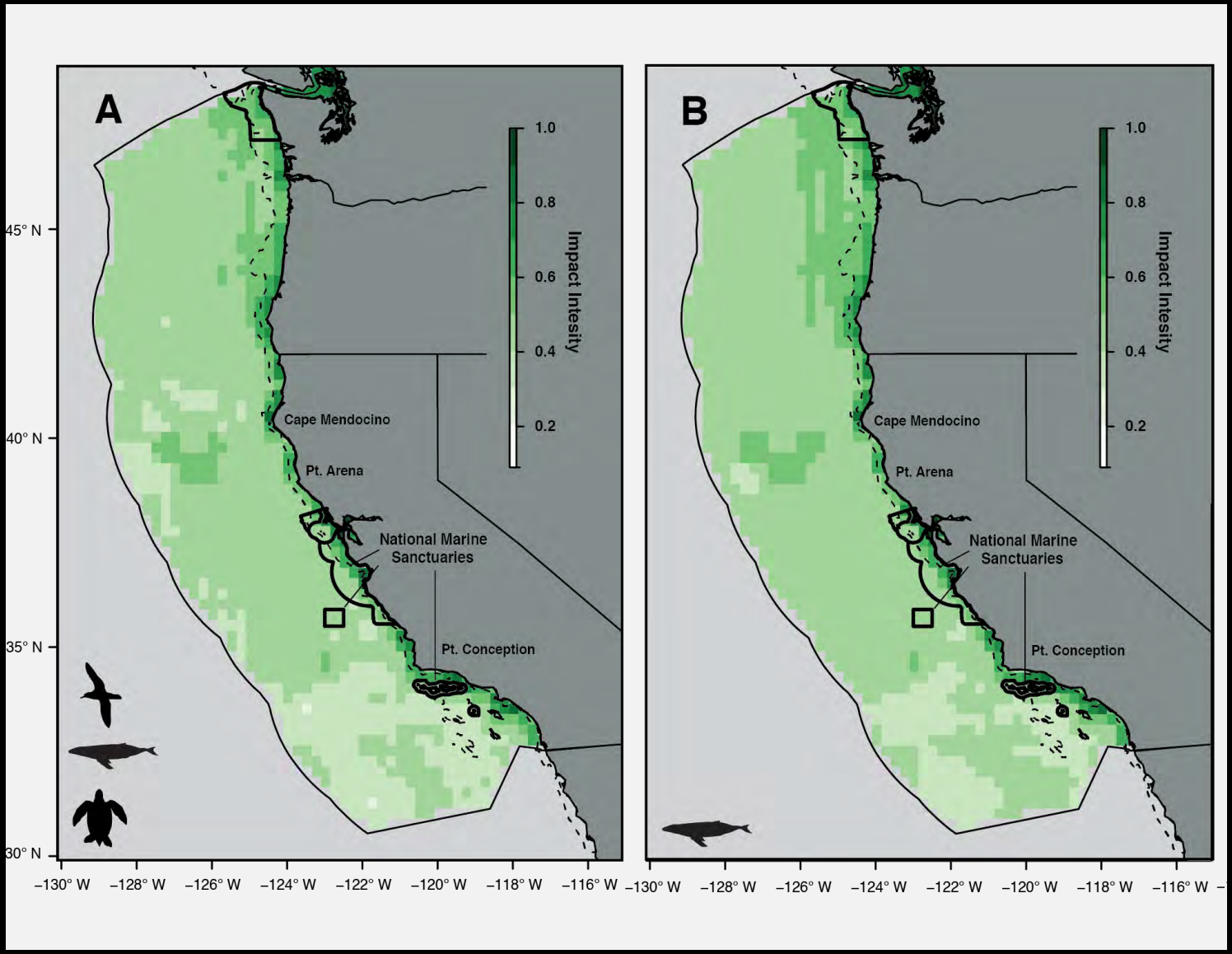
Results: Relative Habitat Use

1. Greater habitat use on the continental shelf and in National Marine Sanctuaries (NMS)



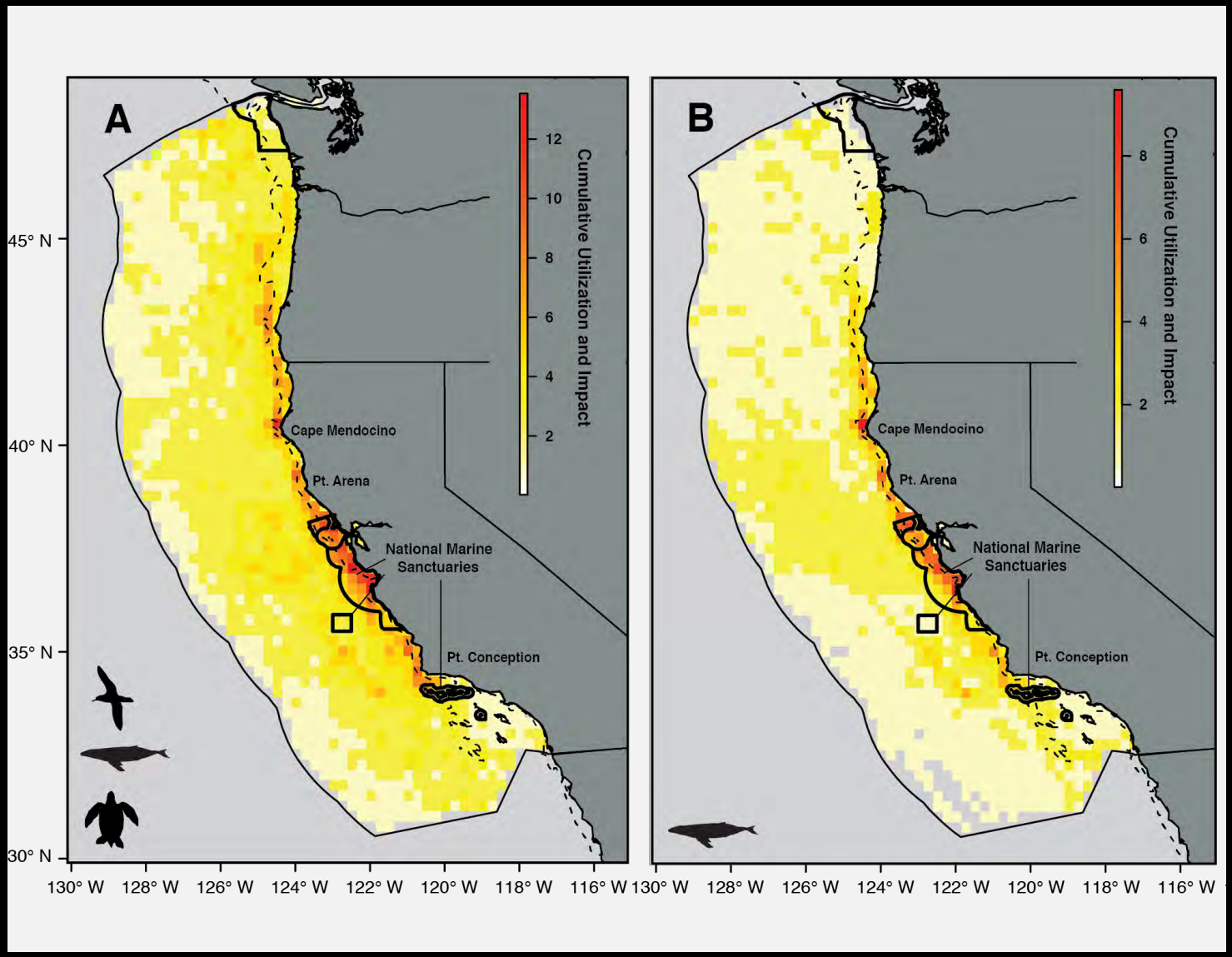
Results: Stressor intensity

2. Stressors in greater density on the continental shelf and in NMS



Results: Cumulative Utilization and Impact (CUI)

3. CUI also greater on the continental shelf and in NMS



*Note different scales

Results: Sensitivity to Stressors

4. Different species influenced differently – spatially as well

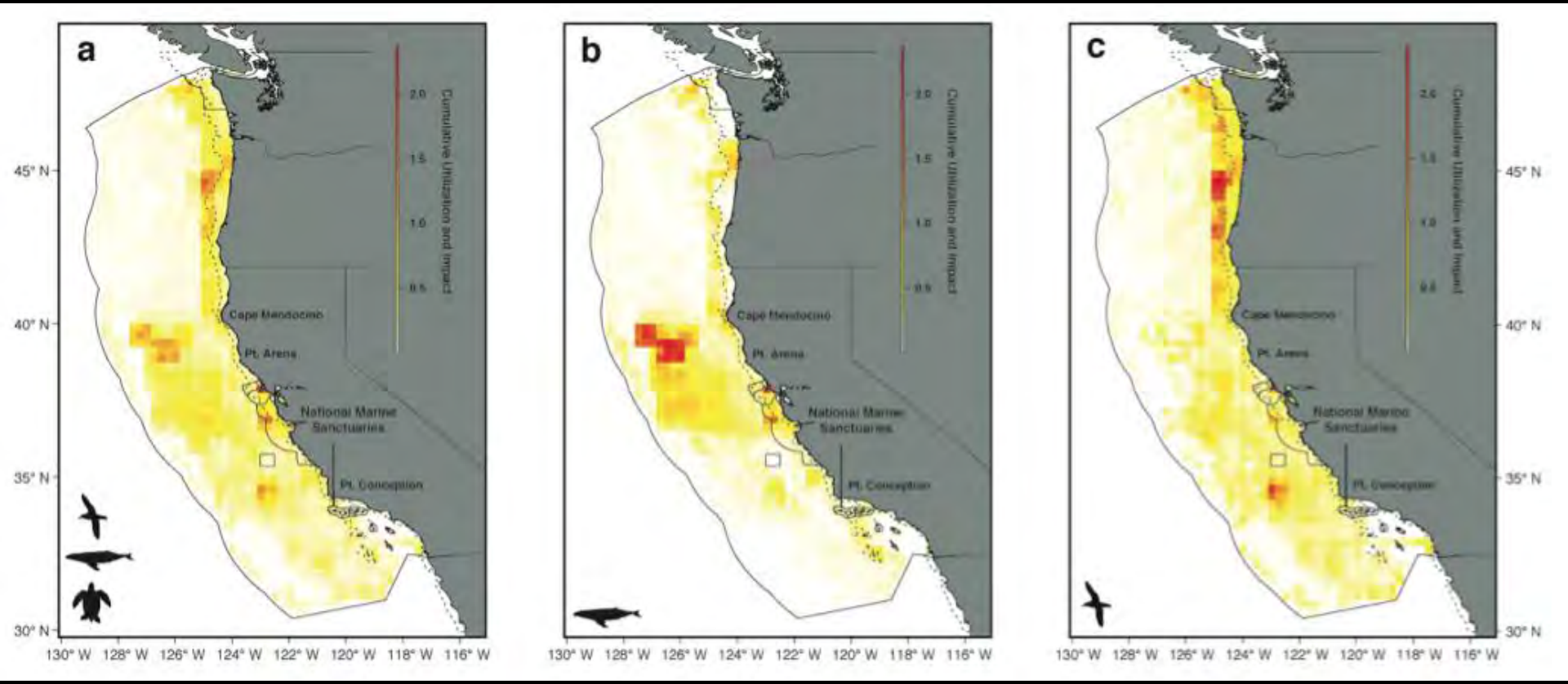
Applications to management:

- Know where activities can be conducted safely
- Can reduce areas in need of management
- Identify broad-scale problems versus localized issues

Results: Sensitivity to Stressors

4. Different species influenced differently – spatially as well

Fishing CUI across species groups:

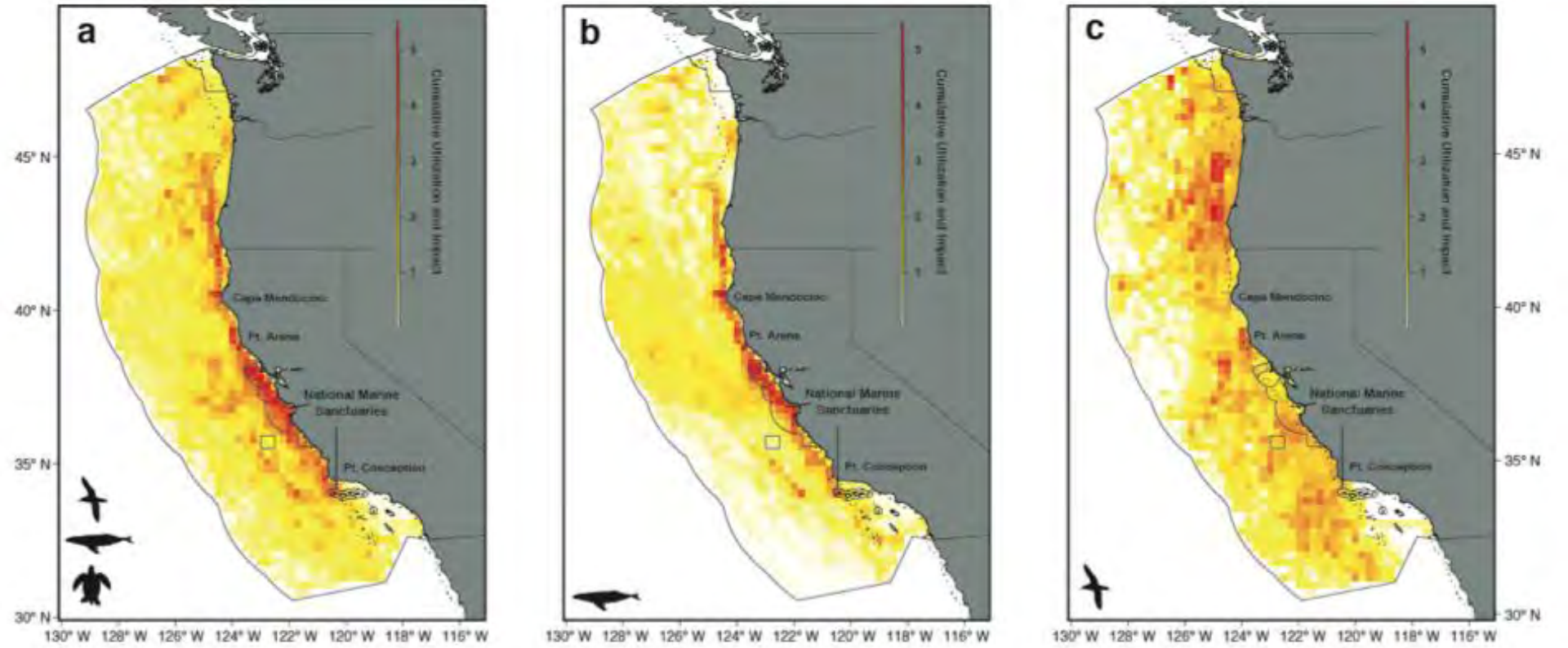


Fishing mitigation: time-area closures, bycatch reduction devices, modification of fishing methods

Results: Sensitivity to Stressors

4. Different species influenced differently – spatially as well

Climate CUI across species groups:

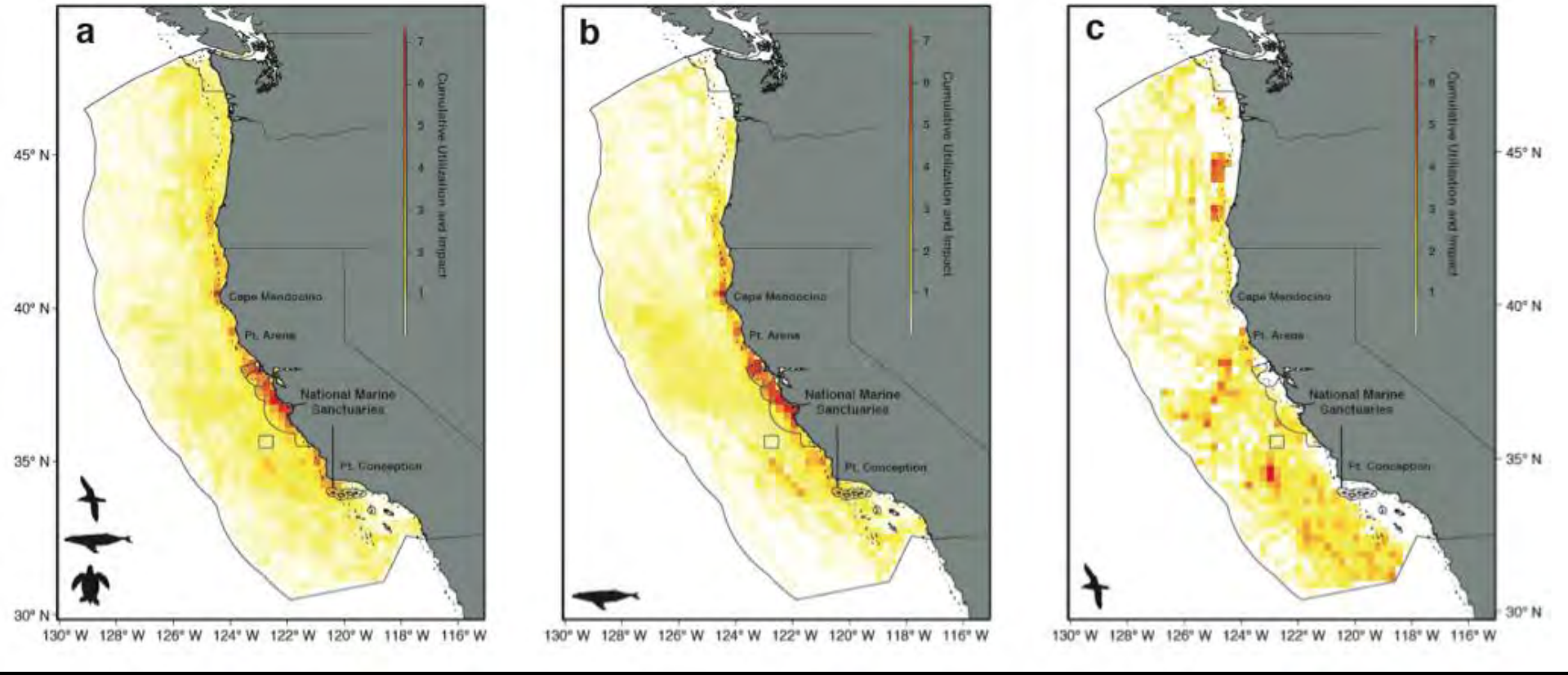


Climate mitigation: protection of micro-refugia habitat or prey resources, adaptive management

Results: Sensitivity to Stressors

5. Sanctuaries are areas of high CUI

Even when just direct impacts:



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