Photo: NEAq under DFO SARA permit

Multiscale monitoring of endangered North Atlantic right whales

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Photo: NEAq under DFO SARA permit

Outline

Background

- Ecology and conservation

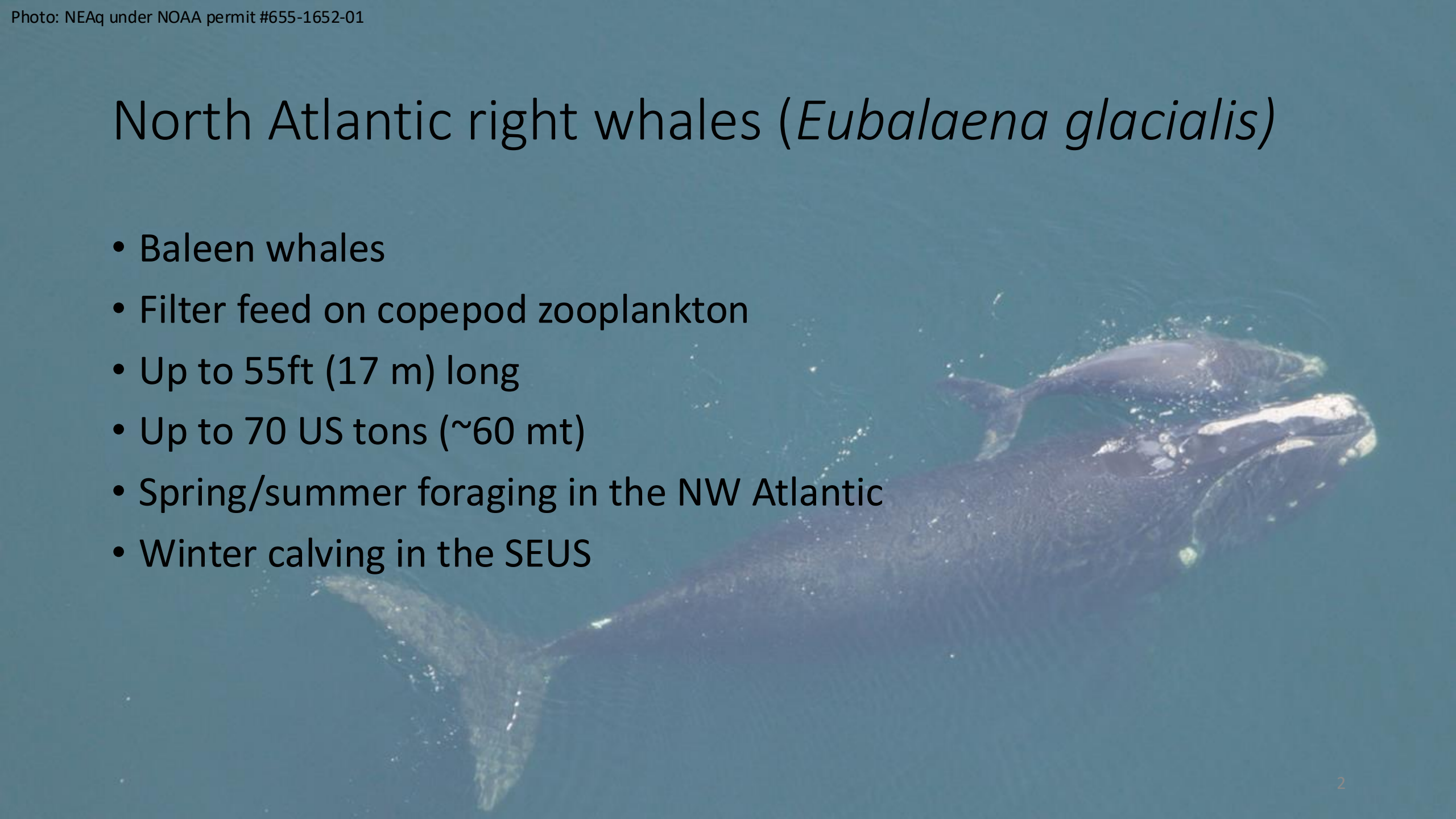
Research

- Individual health
- Near real-time monitoring

Photo: NEAq under NOAA permit #655-1652-01

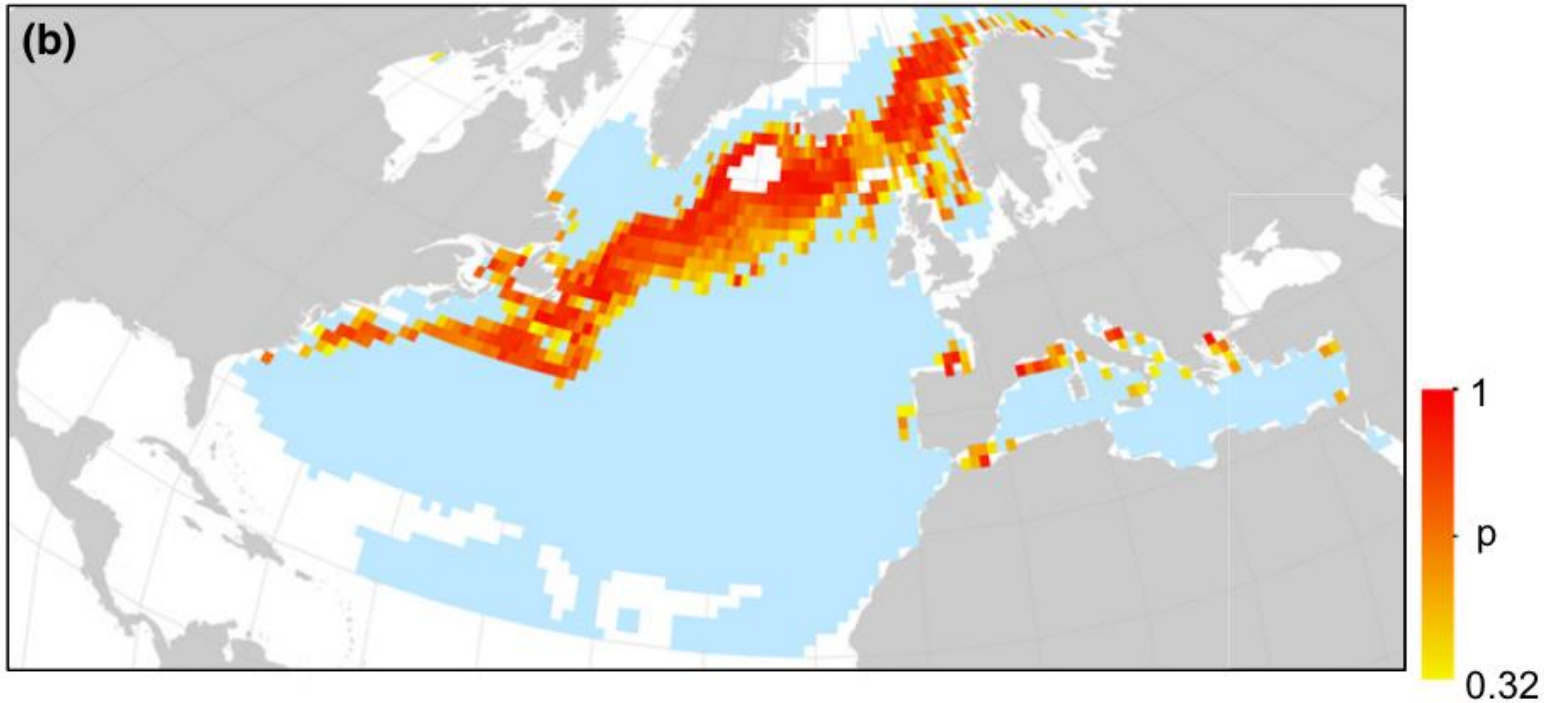
North Atlantic right whales (*Eubalaena glacialis)*

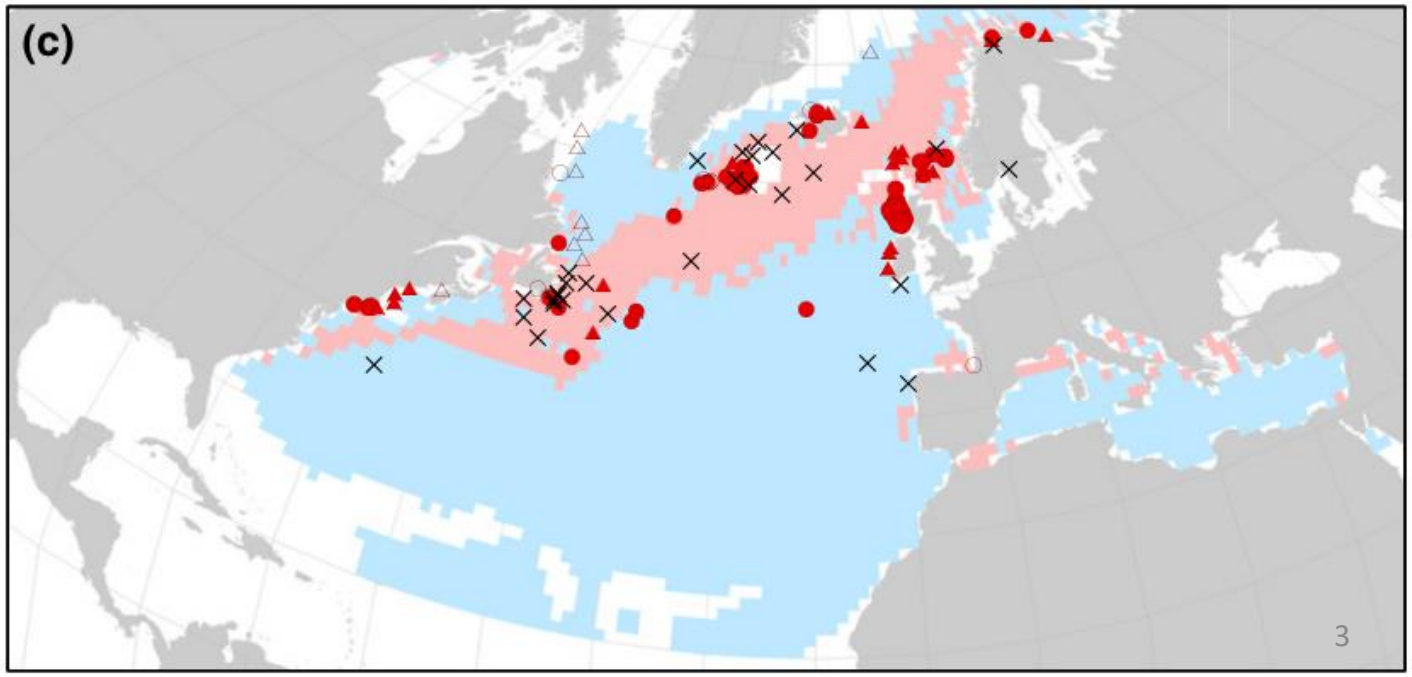
- Baleen whales
- Filter feed on copepod zooplankton
- Up to 55ft (17 m) long
- Up to 70 US tons (~60 mt)
- Spring/summer foraging in the NW Atlantic
- Winter calving in the SEUS



Pre-whaling

- Historical distribution likely spanned the Atlantic
- Modeling estimates population of 9,000-21,000
- Driven nearly to extinction by commercial whaling
- Right whale hunting banned in 1935

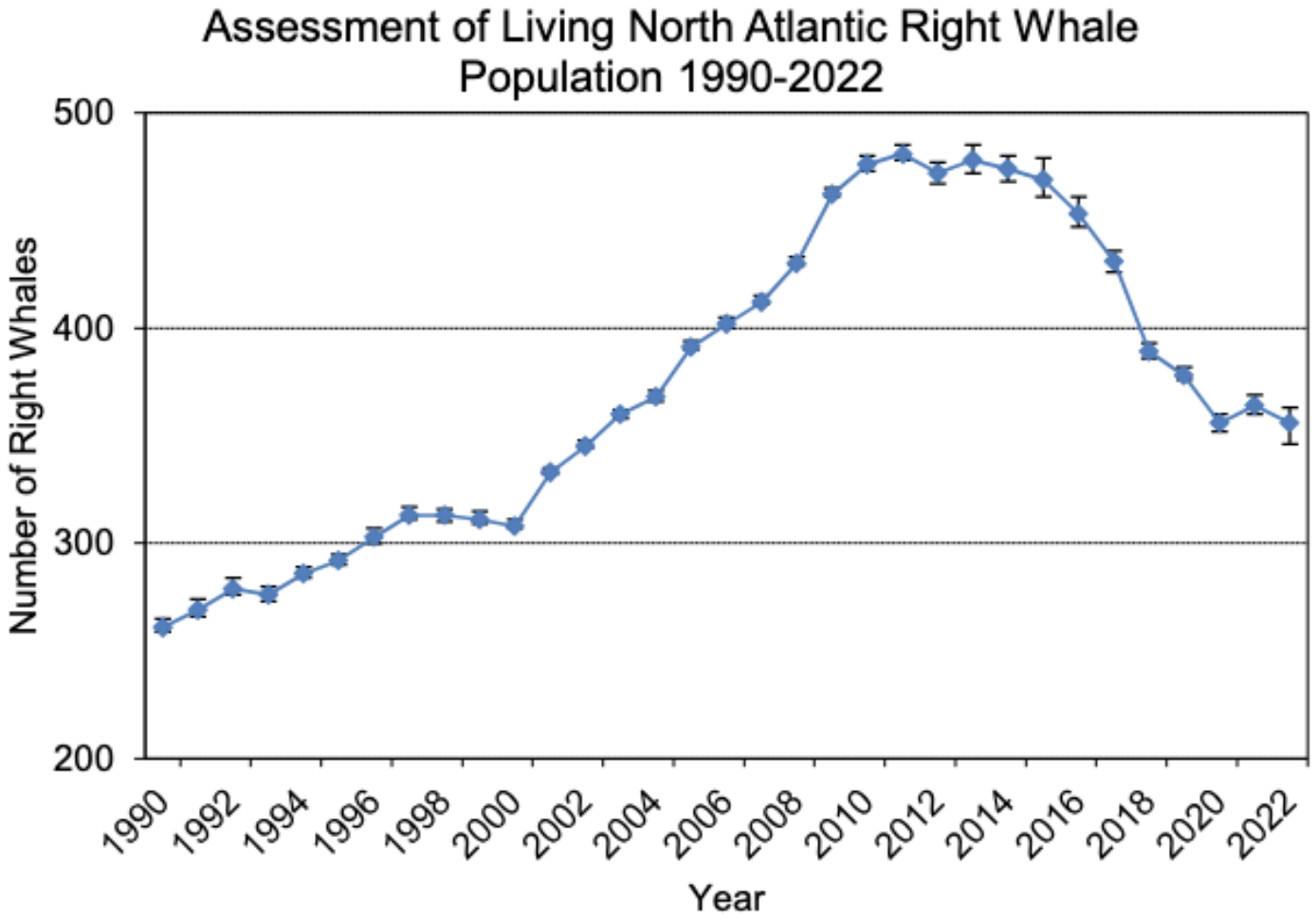




Monsarrat S, Pennino MG, Smith TD, Reeves RR, Umr C (2015) Historical summer distribution of the endangered North Atlantic right whale (Eubalaena glacialis): a hypothesis based on environmental preferences of a congeneric species. Biodiversity Research:1–13.

Current status

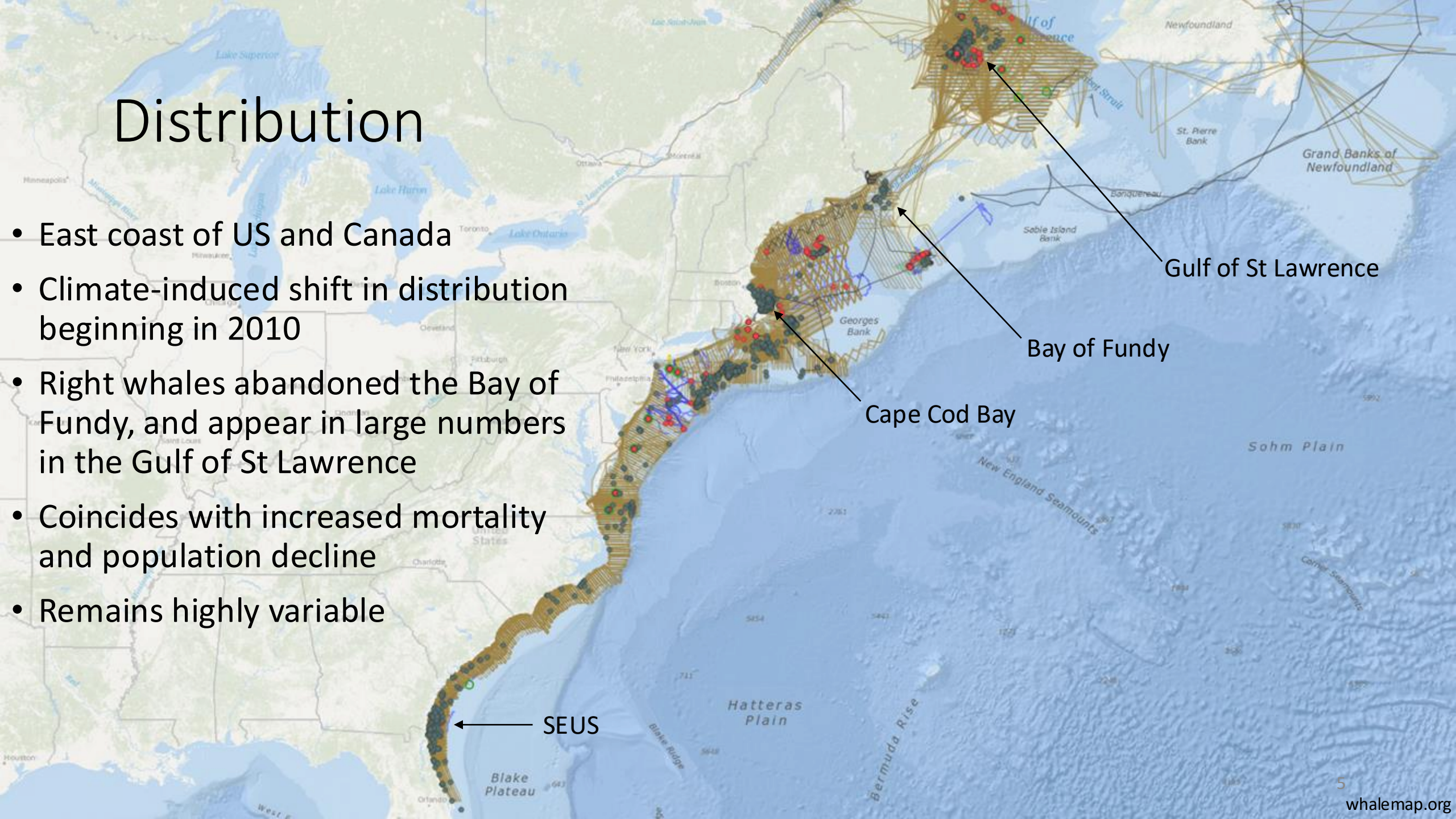
- Distribution is restricted to east coast of US and Canada
- Less than 300 whales when NEAq research program began in 1980
- Increase until ~2010, followed by steep decline
- Current estimate is **356** (+7/-10)



Pettis, H.M. and Hamilton, P.K. 2024. North Atlantic Right Whale Consortium 2023 Annual Report Card. Report to the North Atlantic Right Whale Consortium.

Distribution

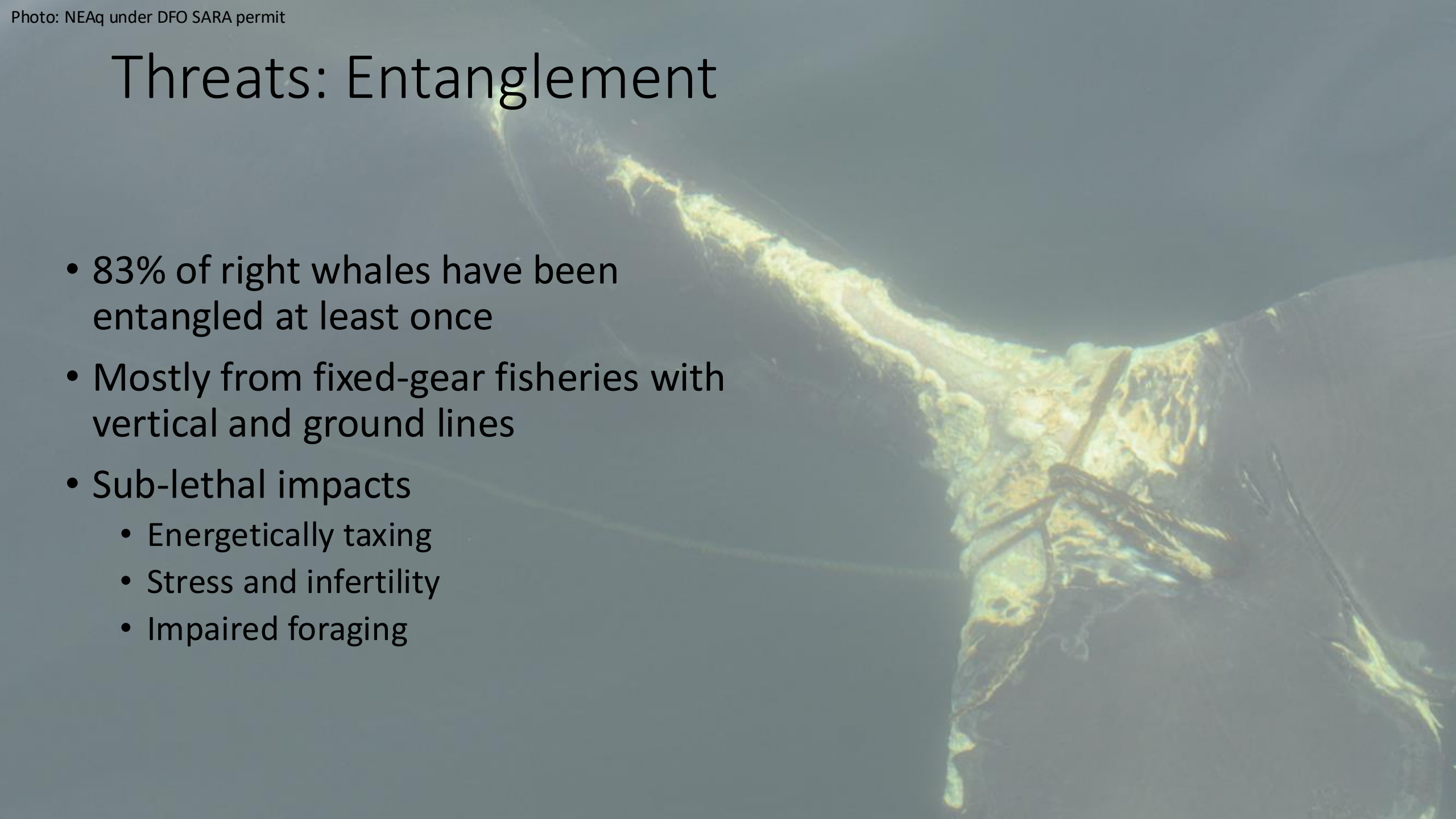
- East coast of US and Canada
- Climate-induced shift in distribution beginning in 2010
- Right whales abandoned the Bay of Fundy, and appear in large numbers in the Gulf of St Lawrence
- Coincides with increased mortality and population decline
- Remains highly variable



whalemap.org

Photo: NEAq under DFO SARA permit

Threats: Entanglement



- 83% of right whales have been entangled at least once
- Mostly from fixed-gear fisheries with vertical and ground lines
- Sub-lethal impacts
  - Energetically taxing
  - Stress and infertility
  - Impaired foraging

Threats: Vessel Strike

- Most often struck large whale
- Difficult to quantify
- Probability of lethality increases with vessel speed and size

Photo: NEAq under NOAA permit #655-1652-01

Threats: Climate Change

- Climate-induced changes in availability of prey
- Increased energetic costs
- Shift distribution into regions with unmitigated risks

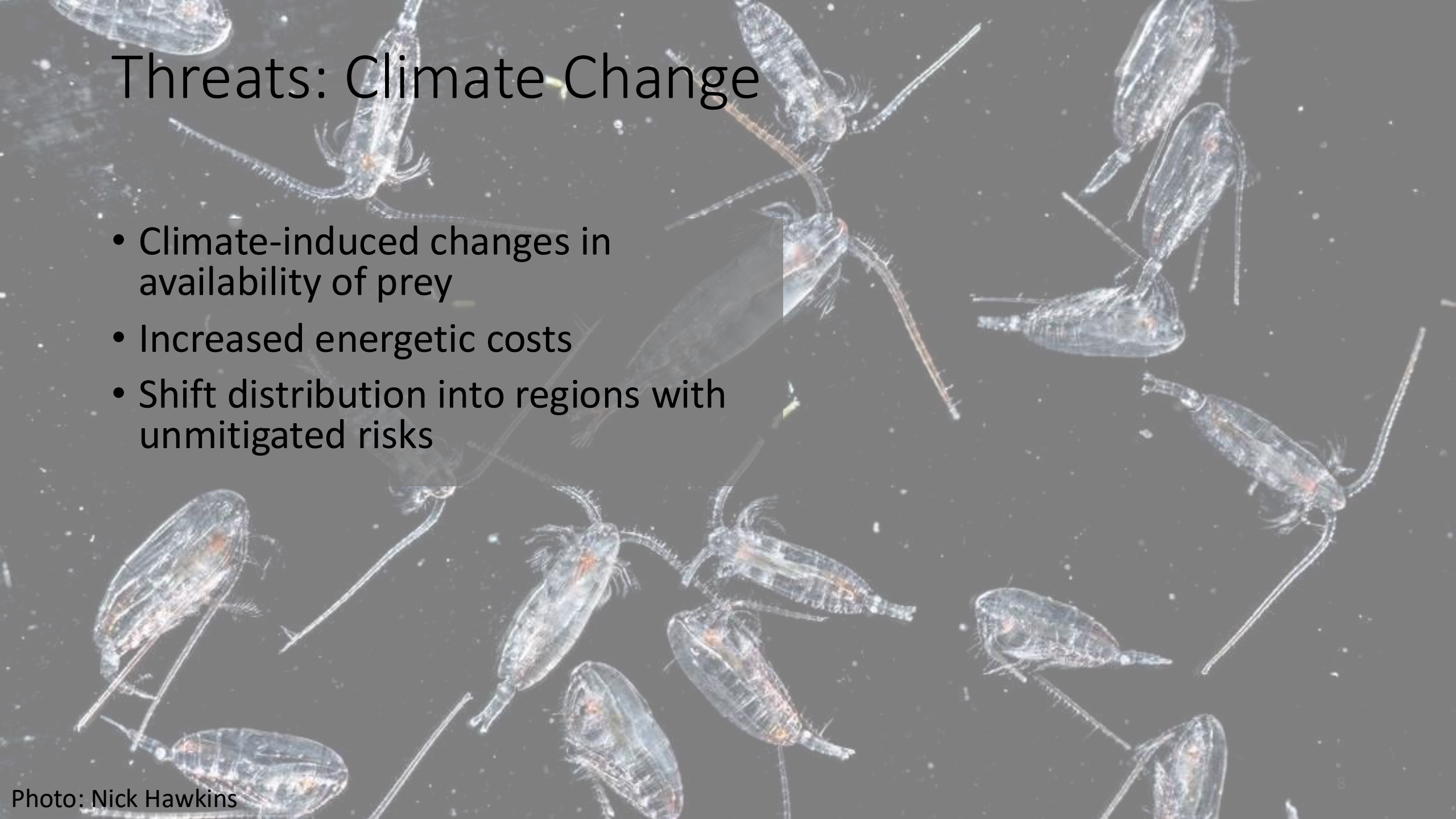


Photo: Nick Hawkins

Photo: NEAq under DFO SARA permit

Conservation

Entanglement

- Reduce effort in times/places with whales
- Use alternative technology

Ship strike

- Reduce vessel speed
- Divert or re-route traffic

Conservation relies on:

- Knowledge of whale distribution (where and when to manage?)
- Population monitoring (is management effective?)

Photo: NEAq under DFO SARA permit

Kraus Marine Mammal Conservation Program

Two current research areas are:

1. Monitoring individuals
2. Near real-time monitoring

Photo: NEAq under DFO SARA permit

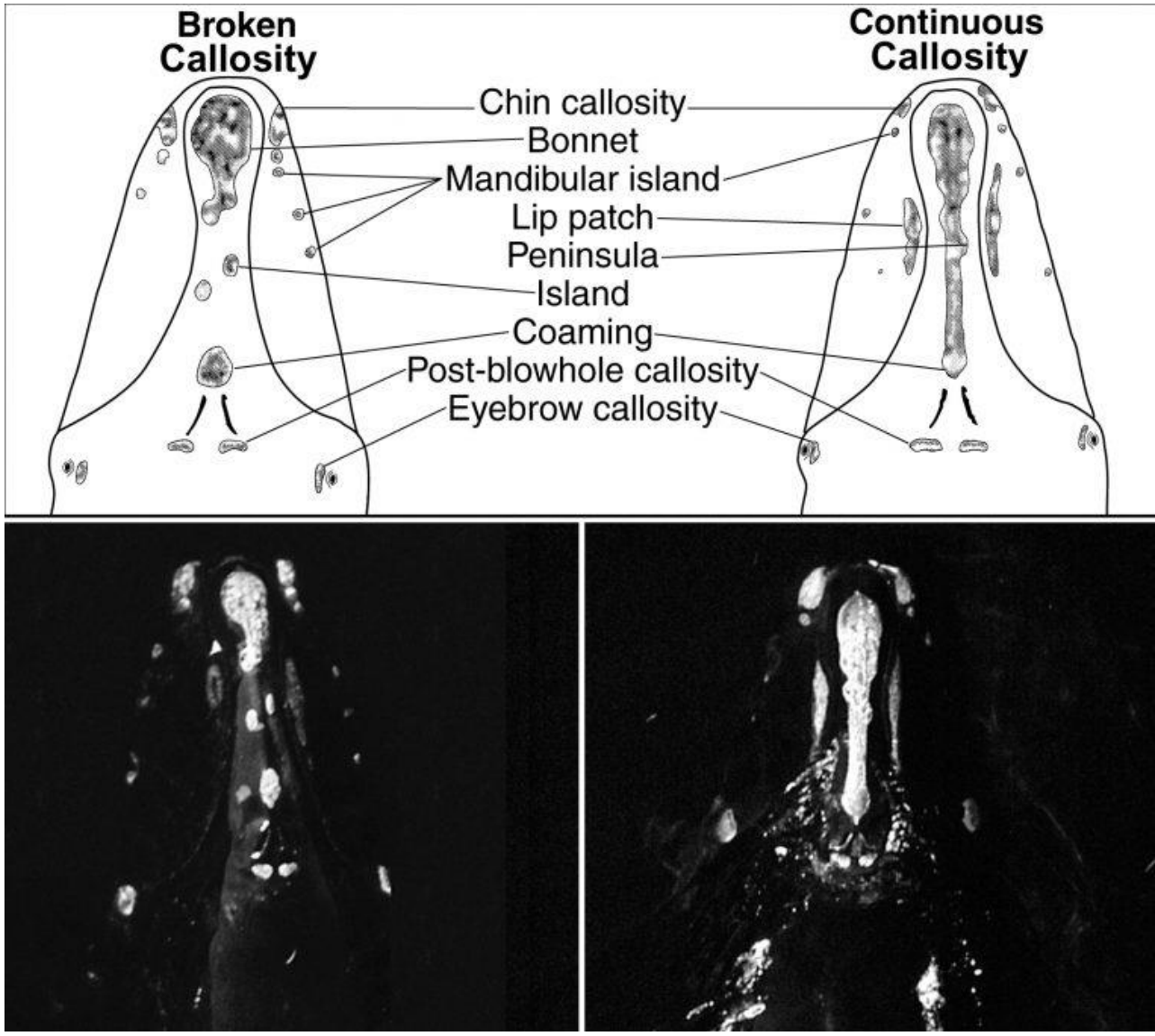
Monitoring individuals

- Vessel-based photo-ID surveys in high-use habitats (Cape Cod Bay, Gulf of St Lawrence, etc.)
- Collect identification images of all individuals
- Document behaviors, other species, etc.
- Biological sampling (biopsy, feces)
- Drone-based data collection

Photo-ID Catalog

- >2 million images since 1935
- >95,000 sightings of 817 individuals
- >650 contributing organizations
- 2,000 - 5,000 sightings from 50,000 - 250,000 images submitted every year

- Submitted data are reviewed to
  - Select high-quality images
  - Identify individuals
  - Code behaviors
  - Assess health (scarring, body condition, etc.)



NEAq

Photo: NEAq under DFO SARA permit

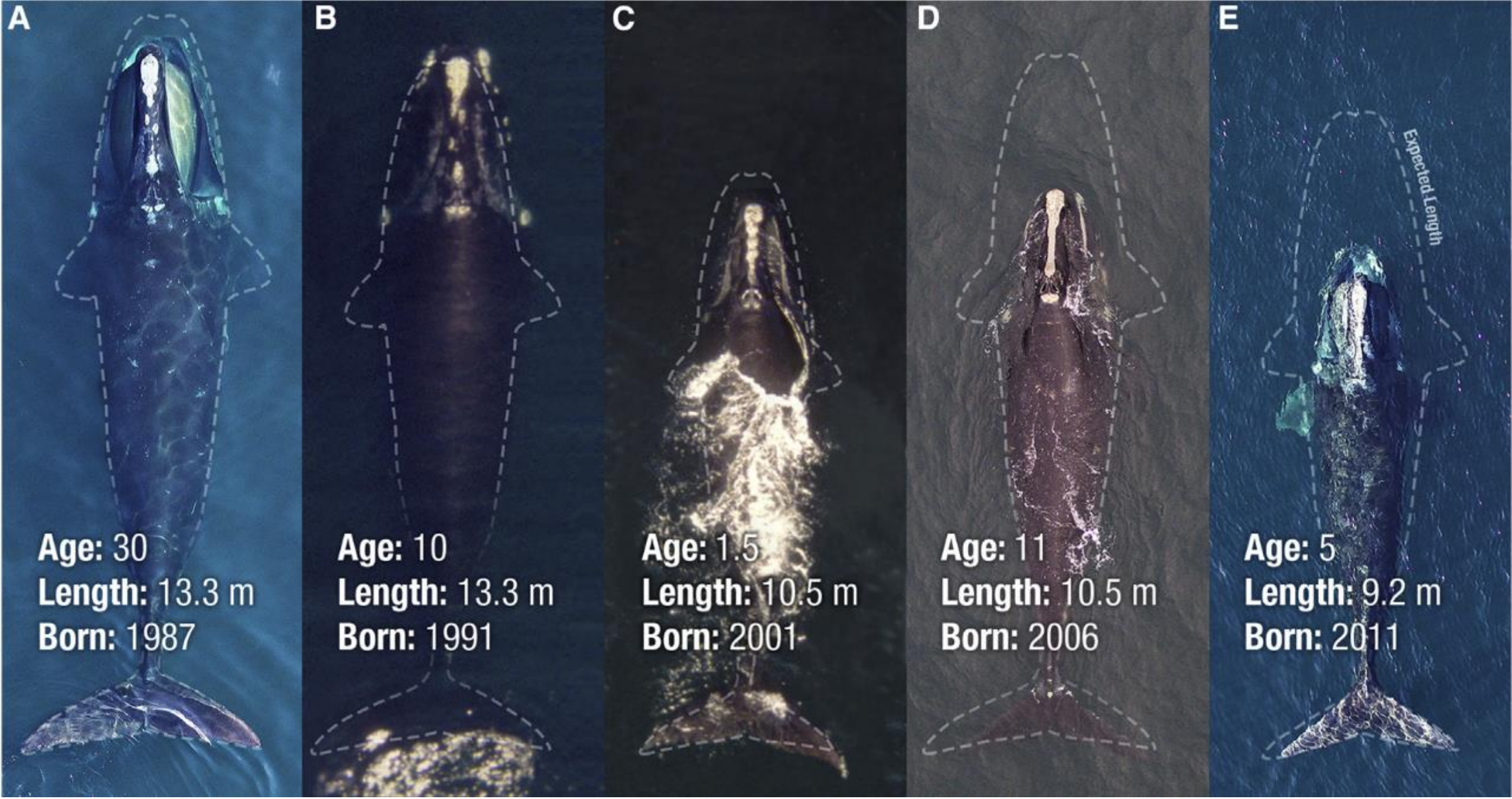
Catalog data

- Data made available via the North Atlantic Right Whale Consortium (NARWC)
- Used to inform a wide range of scientific analyses of:
  - Population abundance
  - Distribution and movement
  - Injury rates
  - Health and body condition

Photogrammetry

- Make calibrated measurements using a drone—based camera system
- Monitor changes in growth rate and body condition over time and space
- Currently collecting data to compare body condition and growth rates between different habitats

NEAq



Stewart et al., Decreasing body lengths in North Atlantic right whales, Current Biology (2021), https://doi.org/ 10.1016/j.cub.2021.04.067

Photo: NEAq under NOAA permit #25739

Blow sampling

- Collect whale blow on drone equipped with petri dishes
- Analyze for DNA, microbiome, and hormones
- Currently collecting blow to assess stress and pregnancy hormones

Video: NEAq under DFO SARA permit

Shelagh (#4510) after a severe entanglement

Photo: NEAq under DFO SARA permit

Individual monitoring

- Photo-ID surveys provide valuable data for abundance and individual health
- Opportunistic biological sampling
- Drones offer new perspective and data collection

Near real-time monitoring

- Climate-induced shifts in whale distribution
- Whales in areas with unmitigated risk
- Static research and management cannot accommodate
- Need for more dynamic methods
- Our team has been involved in facilitating and evaluating aspects of near real-time monitoring

Photo: NEAq under NOAA permit #655-1652-01

Definition

Near real-time monitoring is:

1. Detecting
2. Classifying
3. Localizing
4. Reporting

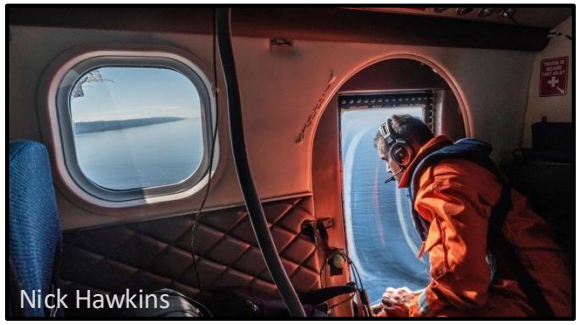
… whales in less than ~24 hours

Monitoring methods

Visual - vessel

- Survey at 10-25 km/h
- Limited by daylight and sea state
- Collect abundance, images/demographics, acoustics, drones, environmental

Brown MW, et al. (2007) Surveying for discovery, science and management. In: *The urban whale: North Atlantic right whale at the crossroads*. Harvard University Press, Cambridge, MA, p 105–137



Visual - aerial

- Survey at 150-200 km/h
- Limited by endurance, daylight and sea state
- Collect abundance, images/demographics, limited acoustics

O'Brien O, et al. (2022) Repatriation of a historical North Atlantic right whale habitat during an era of rapid climate change. Sci Rep 12:12407.

Acoustic - mobile

- Survey at ~1 km/h
- Persistent monitoring 24/7 for weeks to months
- Collect presence-only, environmental

Baumgartner MF, et al. (2020) Slocum Gliders Provide Accurate Near Real-Time Estimates of Baleen Whale Presence From Human-Reviewed Passive Acoustic Detection Information. Front Mar Sci 7.

Acoustic - stationary

- Do not move
- Persistent monitoring 24/7 for months to years
- Collect presence-only, limited environment

Baumgartner MF, et al. (2019) Persistent near real-time passive acoustic monitoring for baleen whales from a moored buoy: System description and evaluation. Methods in Ecology and Evolution 0:1–14.

Monitoring methods

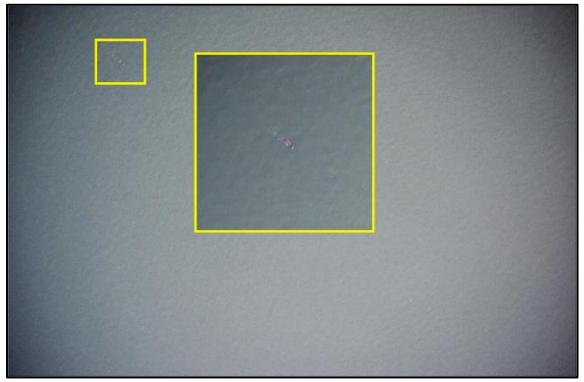


Image detection - aerial

- Image collection from piloted or remotely piloted aircraft
- Can collect aerial data without observers
- Limited by weather and detection range

Ferguson MC, et al. (2018) Performance of manned and unmanned aerial surveys to collect visual data and imagery for estimating arctic cetacean density and associated uncertainty. J Unmanned Veh Sys 6:128–154.

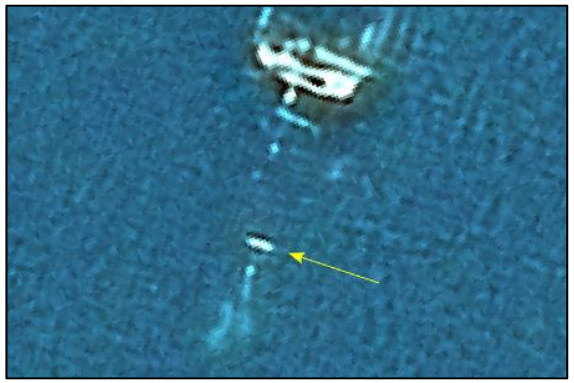
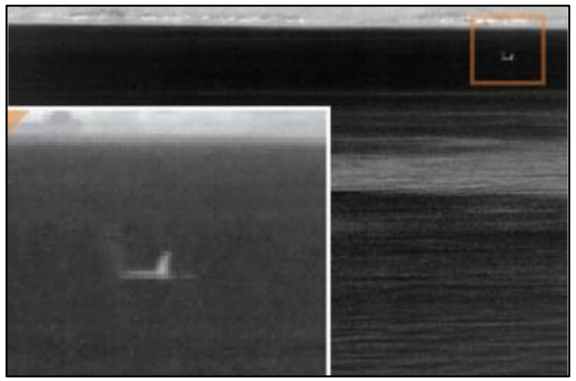


Image detection - satellite

- Image collection from satellite
- Can remotely survey large areas
- Limited by data availability and weather

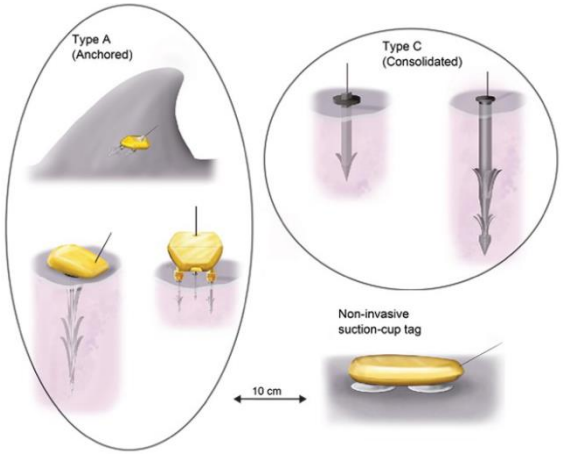
Hodul M, et al. (2023) Individual North Atlantic right whales identified from space. Marine Mammal Science 39:220–231.



Thermal detection

- Thermal image collection from vessel or stationary platform
- Can operate 24/7
- Limited by weather

Baille L & Zitterbart D (2022) Effectiveness of surface-based detection methods for vessel strike mitigation of North Atlantic right whales. Endang Species Res 49:57–69.



Satellite tag

- High resolution data on individual movement
- Limited by potential health risks and only provide data on the tagged individual

Marine Mammal Commission. 2024. North Atlantic right whale tagging workshop report. Final report, Marine Mammal Commission. Bethesda, MD. 37 pages

Reporting: WhaleMap

WhaleMap was designed to:

- Incorporate whale detection and survey effort from all survey methods in near real-time
- Allow survey teams to easily contribute and retain complete control over their data
- Provide the latest data in an accurate, user-friendly, and publicly accessible format
- Operate transparently using open-source tools and with limited supervision

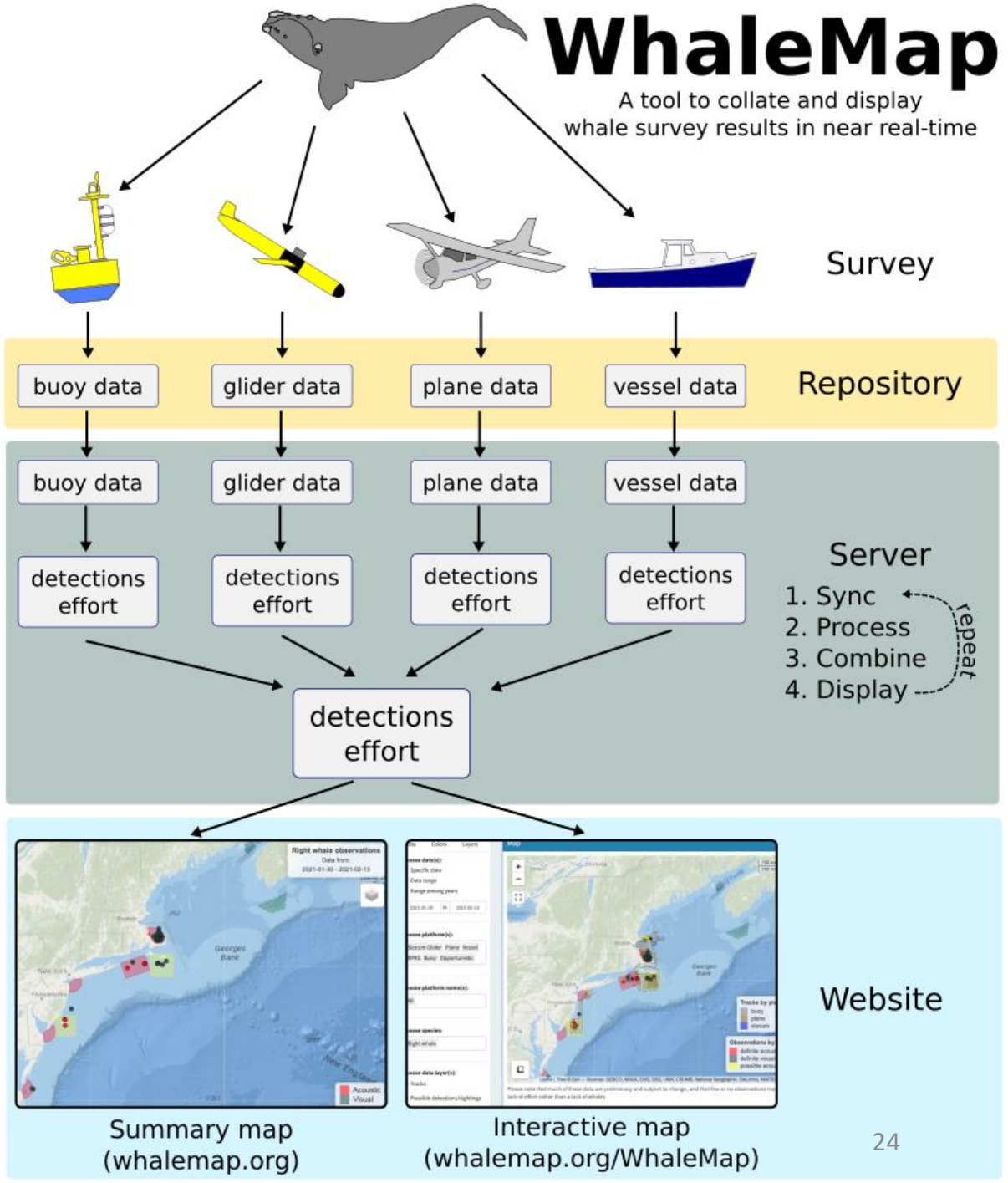
WhaleMap does **NOT**:

- Perform significant quality-control, or take responsibility for verifying contributions
- Provide a long-term database for survey results
- Allow access to raw or processed data without appropriate permission

How it Works

1. Survey data are uploaded to a remote repository (e.g., Google Drive)
2. Data are copied to the WhaleMap server
3. Custom code extracts detections and effort
4. Data are combined, displayed online, and made available for management

Entire process repeats every 15 minutes

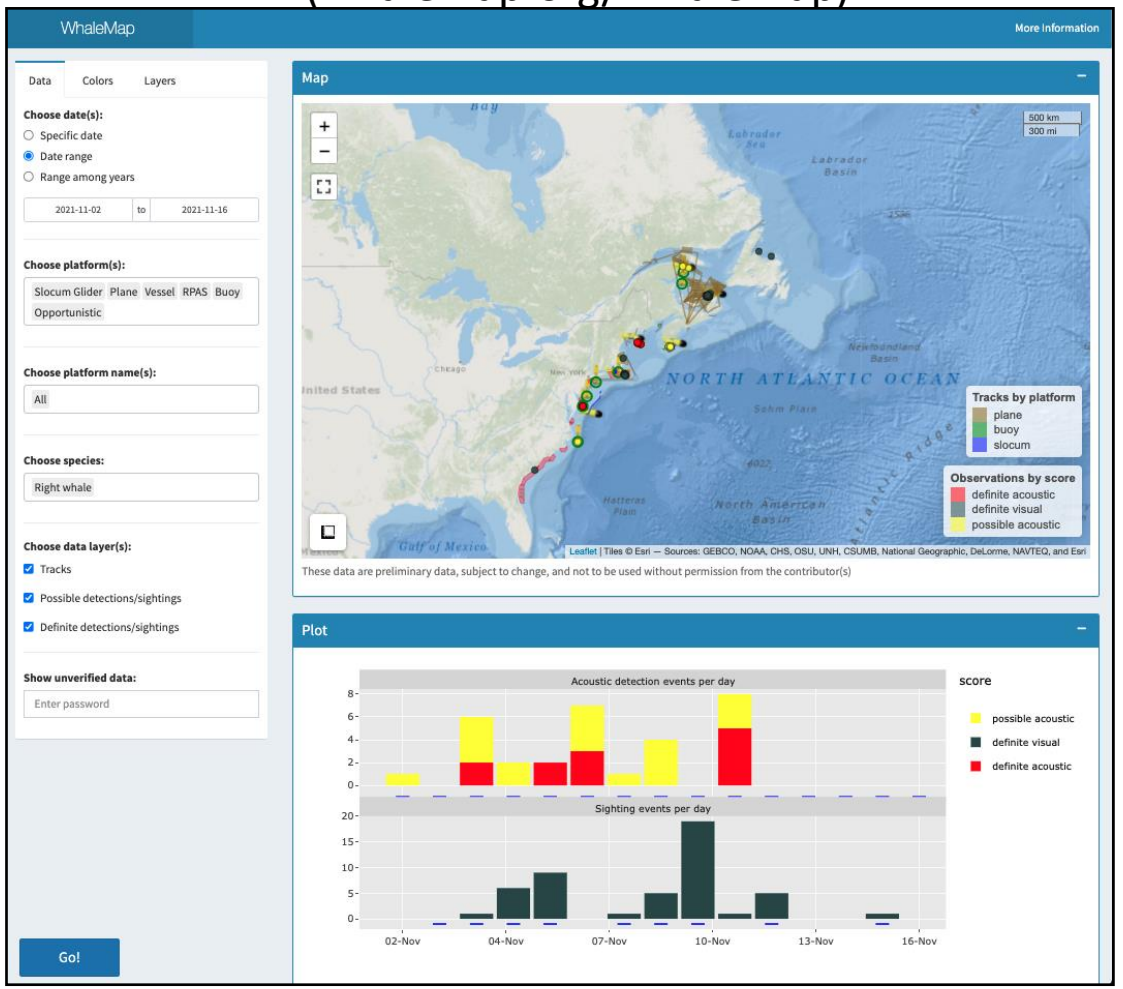


Johnson H, Morrison D, Taggart C (2021) WhaleMap: a tool to collate and display whale survey results in near real-time. Journal of Open Source Software 6:3094.

Displays

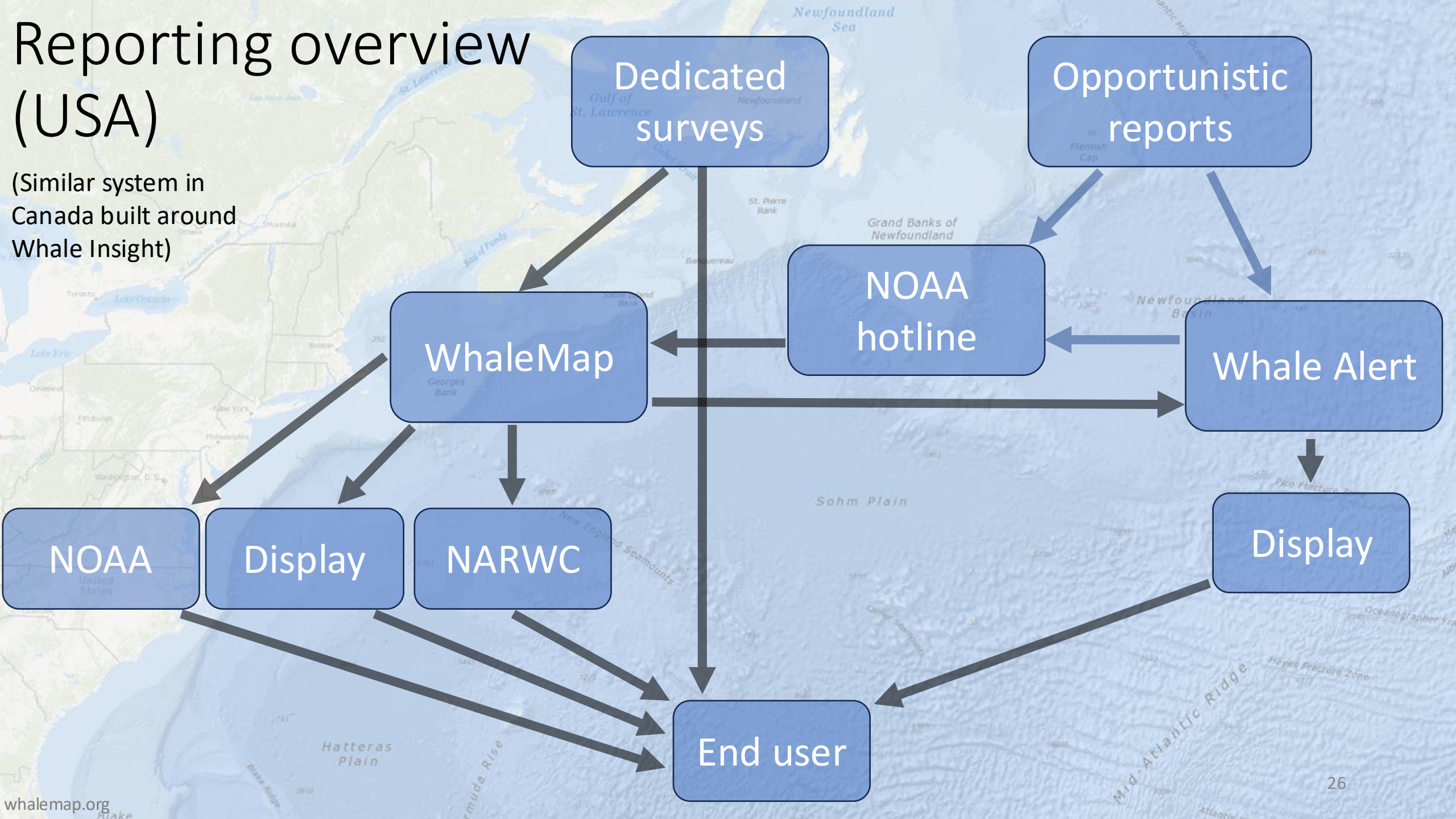
Summary map
(whalemap.org)

Dashboard
(whalemap.org/WhaleMap)



Reporting overview (USA)

(Similar system in Canada built around Whale Insight)



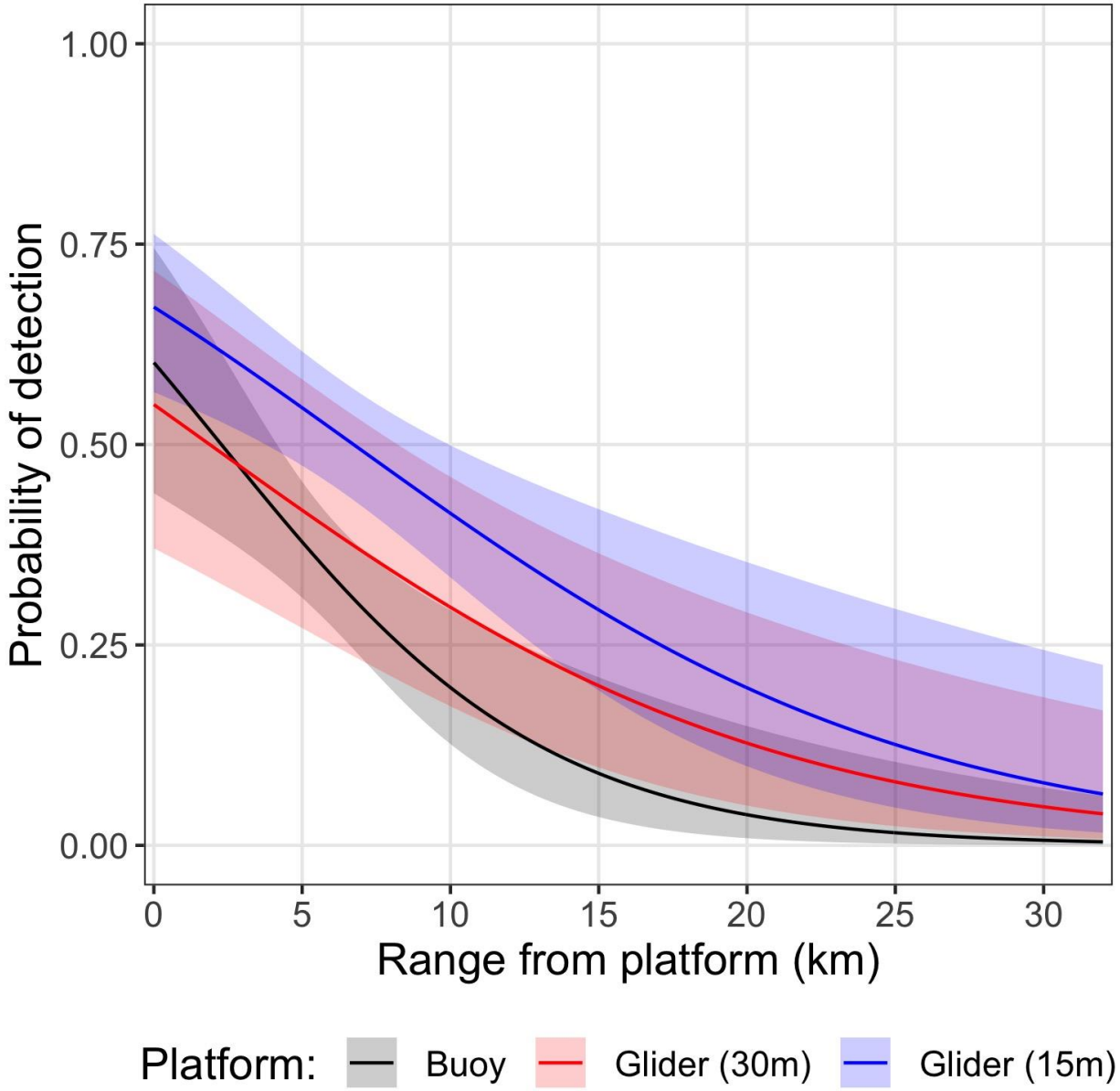
Limitations

- Detector performance
- Whale movement
- Survey effort

Detector performance

- Performance should be characterized, peer-reviewed, and reported
- Detection is virtually never 100%, regardless of method, and influenced by a variety of factors

Detection results are a minimum estimate of whale presence

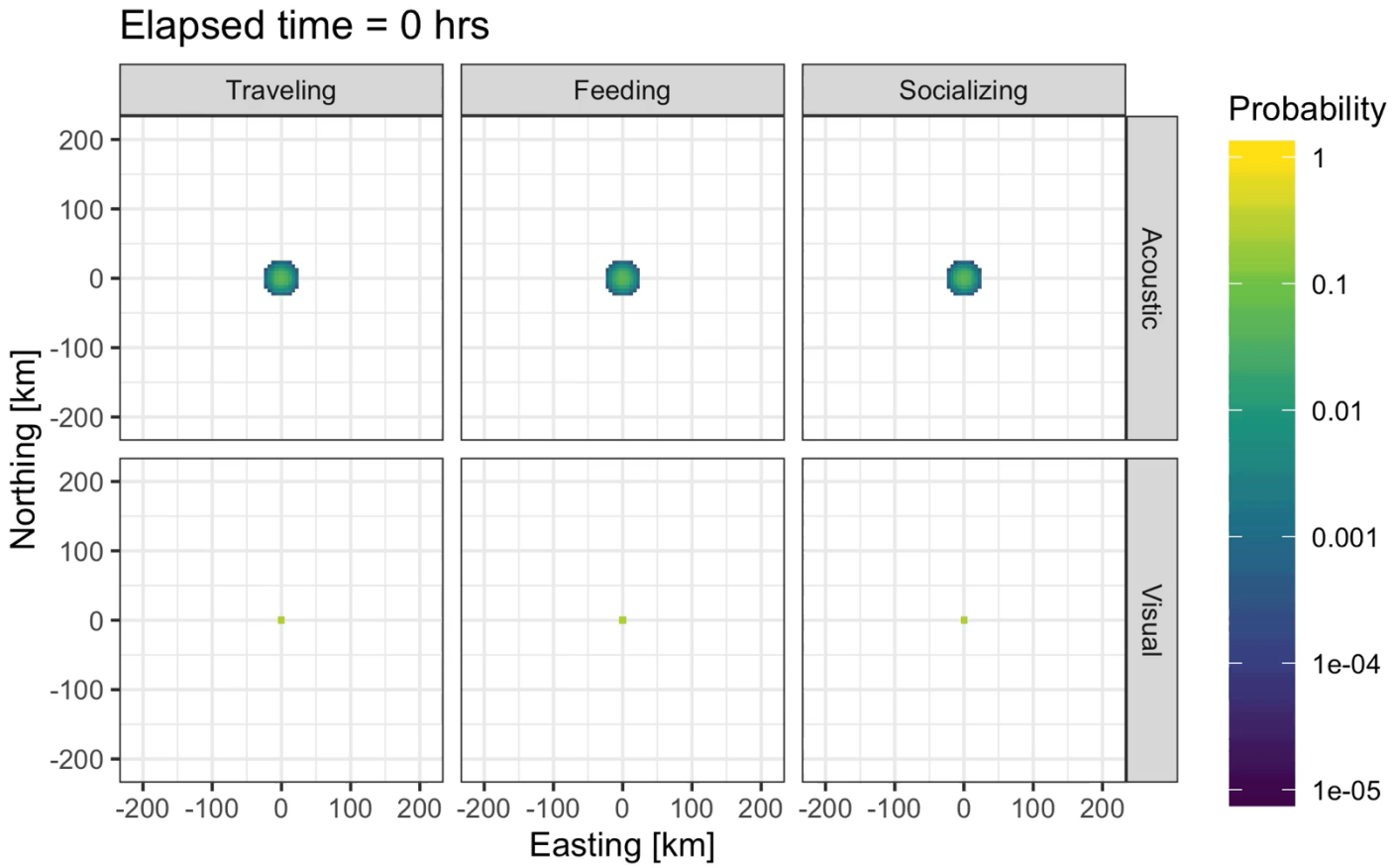


Johnson HD, et al. (2022) Acoustic detection range of right whale upcalls identified in near-real time from a moored buoy and a Slocum glider. The Journal of the Acoustical Society of America 151:2558–2575.

Whale movement

- Right whale movement is highly variable (0 – 100 km / day) and depends on behavior
- Detection locations become increasingly uncertain over time

Points on a map may not represent the current whale location

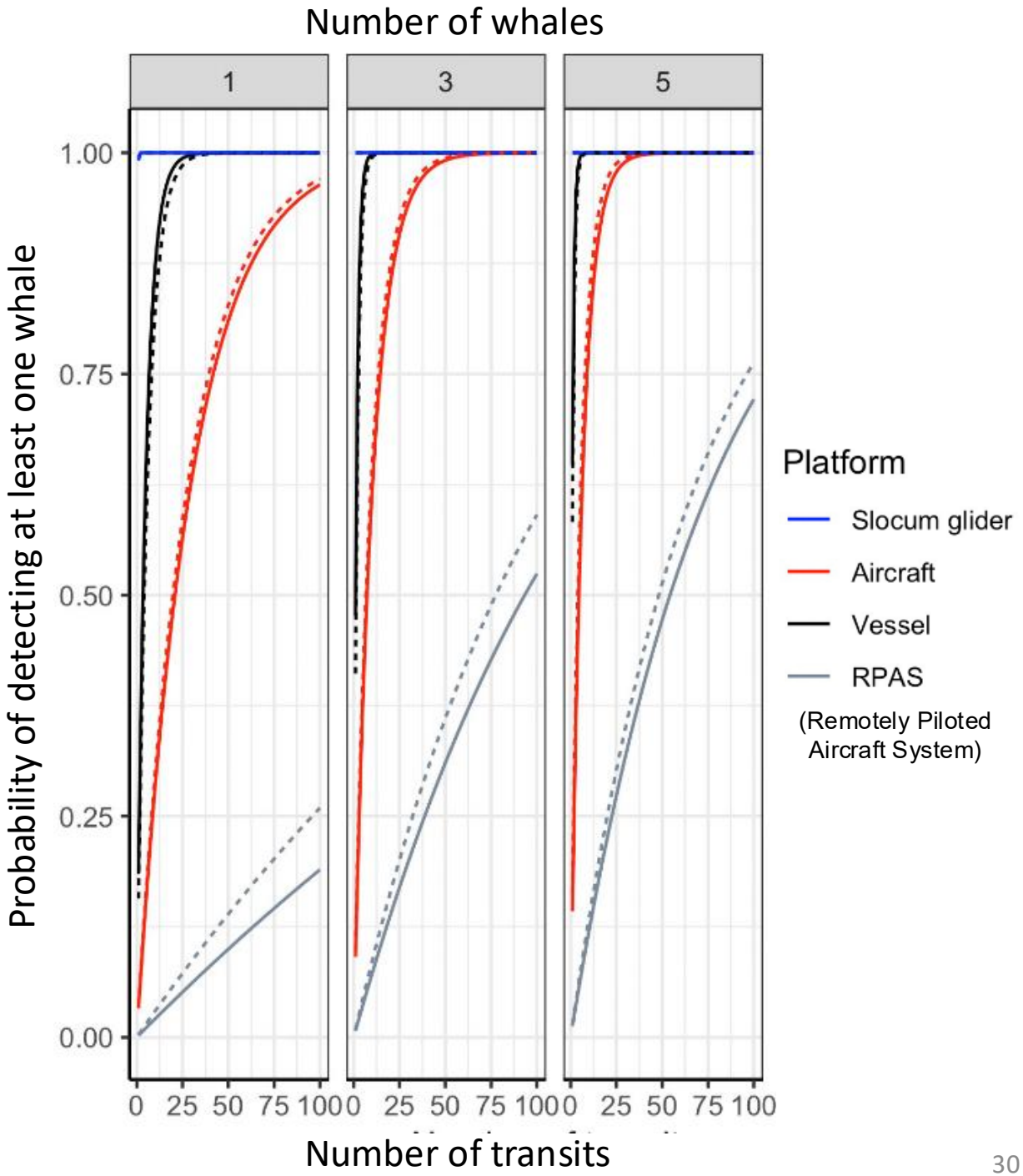


Johnson HD, et al. (2020) Estimating North Atlantic right whale (*Eubalaena glacialis)* location uncertainty following visual or acoustic detection to inform dynamic management. Conservation Science and Practice 2:e267.

Survey effort

- Not feasible to monitor the location of every whale all the time
- Need to choose time/space scales and monitoring method(s) carefully
- Can use simulations to evaluate monitoring strategies

Near real-time distribution of whales depends on survey effort



Ceballos V, et al. (2023) Comparison of visual and acoustic surveys for the detection and dynamic management of North Atlantic right whales (*Eubalaena glacialis*) in Canada. Conservation Science and Practice 5:e12866.

Photo: NEAq under NOAA permit #25739

Near real-time monitoring

- Several operational methods and reporting pipeline
- Valuable for communicating survey results and coordinating research
- Limitations
  - Imperfect detection
  - Uncertainty in whale location
  - Distribution depends on effort
- Must be considered when designing surveys or interpreting results

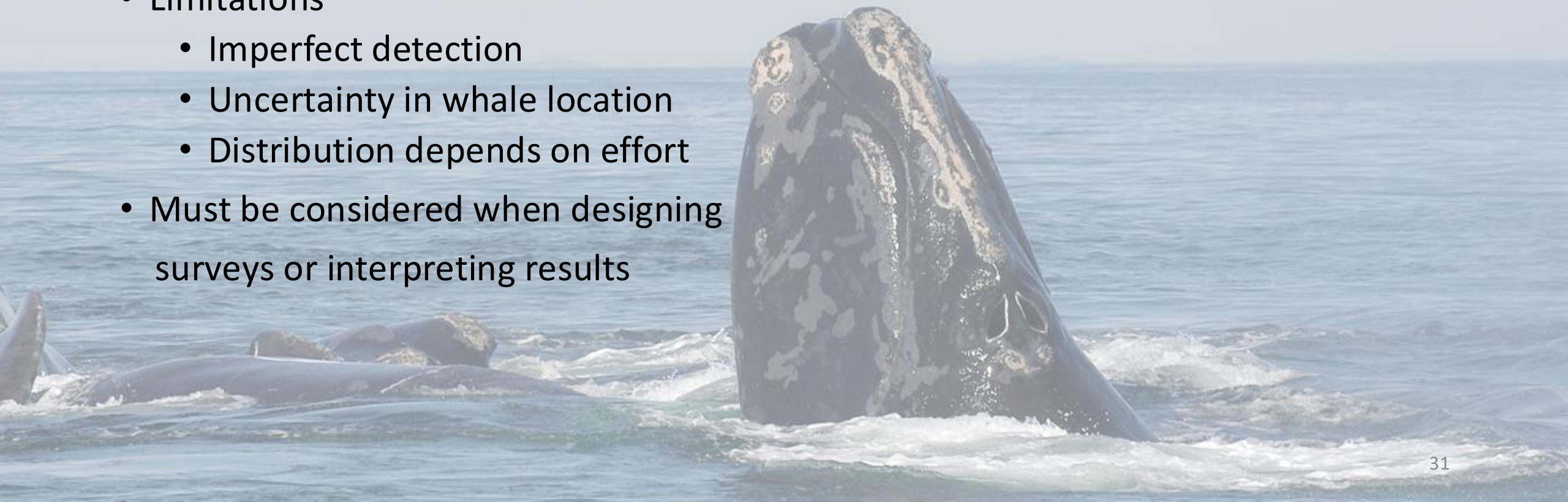


Photo: NEAq under DFO SARA permit

Summary

- Right whales face threats from entanglement, ship strike, and climate change
- Our team has been studying right whales for over 40 years
- Currently, much of our research is focused on:
  1. Monitoring individuals to assess changes in abundance and health
  2. Facilitating and evaluating near real-time monitoring efforts
- We hope our work contributes to improved conservation outcomes

Thank you!

Questions?

Ask or email me at
hjohnson@neaq.org

New England Aquarium

Protecting the blue planet