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BEST PRACTICES FOR ASSESSING AND MANAGING MARINE MAMMAL BYCATCH

Summary of findings and products of the Marine Mammal Bycatch Working Group

INTRODUCTION

Bycatch in marine fisheries is the leading source of human-caused mortality of marine mammals globally. Under the Marine Mammal Protection Act (MMPA), U.S. managers, fishermen and other stakeholders have been working for decades to reduce bycatch. To help stem further declines, and in fairness to U.S. fisheries competing in a global seafood marketplace, the National Oceanic and Atmospheric Administration (NOAA) in 2016 issued the MMPA Import Provisions, which require nations that export fish and fish products to the U.S. to adhere to bycatch standards comparable in effectiveness to those in the U.S. By January 2023, nations must apply for and receive a "comparability finding" for each of their fisheries to continue exporting fish and fish products into the U.S.

Developing quantitative assessments and monitoring programs would enable nations to determine where, how, and the rates at which marine mammal bycatch is occurring, thereby enhancing the effectiveness of potential mitigation measures. Approaches and methods for evaluating the significance of marine mammal bycatch rely on estimates of abundance and bycatch levels, which are necessary to calculate bycatch reference points and to determine conservation status. With this information, nations could prioritize mitigation measures in fisheries where bycatch injury and mortality most significantly impact populations.

Marine Mammal Bycatch Working Group: An international team of experts

With initiation of the MMPA Import Provisions, the Ocean Modeling Forum convened the Marine Mammal Bycatch Working Group, an international team of experts, to assist nations in their efforts to assess marine mammal bycatch. Over the last several years, the Working Group has produced a suite of products and tools that explore how to:

- understand which fisheries have a bycatch problem;
- collect the best data to quantify marine mammal abundance and bycatch;
- develop reference points for setting measurable conservation or recovery goals; and
- monitor progress towards such goals.

In particular, the Working Group is keenly aware that many nations will be designing and conducting assessments for the first time. Thus, it provided guidance that can be used in a variety of conditions in terms of data availability and resources.

MARINE MAMMAL BYCATCH WORKING GROUP

- André Punt, Co-Chair, University of Washington, U.S.
- Tessa Francis, Co-Chair, University of Washington Tacoma, U.S.
- Rob Williams, Co-Chair, Oceans Initiative, U.S.
- Philip Hammond, University of St Andrews, U.K.
- Dennis Heinemann, Marine Mammal Commission, U.S.
- Kristy Long, NOAA Office of Protected Resources, U.S.
- Jeffrey Moore, NOAA Southwest Fisheries Science Center, U.S.
- Randall Reeves, Okapi Wildlife Associates, Canada
- Maritza Sepúlveda, Universidad de Valparaíso, Chile
- Guðjón Már Sigurðsson, Marine and Freshwater Research Institute, Iceland
- Margaret Siple, NOAA Alaska Fisheries Science Center, U.S.
- Gísli Víkingsson, Marine and Freshwater Research Institute, Iceland
- Paul Wade, NOAA National Marine Mammal Laboratory, U.S.
- Alex Zerbini, NOAA National Marine Mammal Laboratory, U.S.

FLOW CHART TO QUANTIFY ABUNDANCE AND BYCATCH

Step through the main components of bycatch assessment, including the products of the Marine Mammal Bycatch Working Group.

See Wade, Long et al. 2021. Best practices for assessing and managing bycatch of marine mammals. https://doi.org/10.3389/fmars.2021.757330

PLAN

Describe fisheries
- Gear type
- Area(s) of operation
- Target species
- Known marine mammal bycatch

Characterize marine mammals
- Species lists
- Population structure
- Distribution and abundance

Prioritize data collection
- High risk gear
- Export fisheries
- Marine mammal populations at risk

No assessment

COLLECT/ESTIMATE

Estimate abundance
- Hammond et al. 2021. Estimating abundance. https://doi.org/10.3389/fmars.2021.735770

Estimate bycatch
- Moore et al. 2021. Estimating bycatch. https://doi.org/10.3389/fmars.2021.752356

ASSESS

Assessment Applications
1. Punt et al. 2021. Evaluating strategies in Iceland. https://doi.org/10.1139/cjfas-2019-0386
2. Punt et al. 2021. Assessing bycatch in Chile. https://doi.org/10.1016/j.fishres.2020.105816

Reference points (i.e., PBR)

or

PBR alternatives
- Punt et al. 2020. Robustness of PBR in management. https://doi.org/10.1093/icesjms/fsaa096
- Punt et al. 2021. Bycatch in low data environments. https://doi.org/10.1111/1365-2664.13816

Does bycatch exceed the reference point, possibly preventing conservation?

No action — No

Yes

ACT

Prioritize fisheries
- Siple et al. 2022. Bycatch impacts exploration tool. https://doi.org/10.21105/joss.03888

Mitigate

PLANNING FOR AN ASSESSMENT OF BYCATCH

The goal is to identify fisheries that use high bycatch-risk fishing gear or spatially and temporally overlap with marine mammal populations. The combination of these components is a strong indicator of a bycatch problem.

PLAN

Describe fisheries

Characterize marine mammals

Prioritize data collection

Step 1: Describe fisheries that interact with marine mammal populations

Start by summarizing what is known about fishing gear used in an area. It is important to describe fisheries by target species and gear type and synthesize information about participants, number of boats, and fishing effort. Enough is known about marine mammal bycatch worldwide to characterize which types of fishing gear likely pose risks to marine mammals that co-occur where those fisheries operate. Finally, there is a need to collect existing information about bycatch incidence.

METHOD OPTIONS:

- Synthesize public information and data
- Use previous literature to identify high-risk gear
- Examine records of bycatch and strandings
- Collect media reports and anecdotes
- Interview fishermen or conduct other dockside surveys

Step 2: Characterize marine mammal populations

Create a list of the marine mammal species that co-occur with the fisheries of interest and, to the extent possible, describe (a.) their population structure, or number and boundaries of each population within a species; (b.) known sources of human-caused mortality; and (c.) their management and conservation status (e.g., any endangered or depleted species, relevant management plans or legislation).

METHOD OPTIONS:

At a minimum, characterize species that occur in a region. Beyond that, synthesize available information on:

- Habitat preferences and distribution
- Abundance and population trends
- Stock structure and genetics
- Movement
- Life history
- Management and conservation status

Step 3: Prioritize data collection

Once existing data on fisheries and the marine mammal community have been compiled, develop data collection programs to fill key gaps. Data on marine mammal abundance and bycatch are essential to understand and address bycatch problems. If little or no data exist, use criteria based on the information synthesized in Steps 1 and 2 concerning the distribution of fishing effort in time and space and the occurrence of marine mammal populations to rank fisheries from high to low bycatch risk. Areas of co-occurrence between fisheries and marine mammals can then be prioritized for data collection.

METHOD OPTIONS:

To understand co-occurrence:

- Use NOAA's List of Foreign Fisheries (LOFF) to identify at-risk fisheries
- Rank fisheries with bycatch into high (e.g., gillnet fisheries), medium (e.g., longline fisheries), and low (e.g., hook-and-line fisheries) risk categories
- Apply GIS-based decision frameworks – e.g., Bycatch Risk Assessment (ByRA) toolbox (see Box 1)

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BOX 1. USING THE BYCATCH RISK ASSESSMENT (ByRA) TOOLBOX IN CHILE

The ByRA toolbox is a geographic information systems-based toolbox that can generate visualizations, or "risk maps," of potential bycatch using a broad range of data types and amounts. In a separate project—Marine Mammal Bycatch Risk Assessment in Chile—that in part stemmed from the Working Group, Dr. Maritza Sepúlveda, Universidad de Valparaíso, Dr. Ellen Hines, San Francisco State University, and Dr. Carlos Montenegro Silva, Instituto de Fomento Pesquero, are leading a team of researchers and fisheries managers to produce risk maps for the Chilean coast.

The team is engaging with local scientists and stakeholders to identify sites and fisheries with bycatch risk and to compile all available data sources. They are using the ByRA toolbox to calculate the likelihood of a species interacting with a particular gear type. Then the team is using ByRA scenarios to understand what could happen to populations under various bycatch rates, ocean conditions, increases or decreases in the number of observers, or the use of different mitigation strategies. The outputs will be maps that show bycatch risk for each site, fishery, and field season.

COLLECTING THE APPROPRIATE DATA AND ESTIMATING BYCATCH

COLLECT/ESTIMATE

Estimate abundance

Estimate bycatch

The goal here is to estimate the magnitude of bycatch with respect to the size of marine mammal populations. Managers can then set conservation or recovery goals to guide bycatch mitigation measures. This involves quantifying the abundance of marine mammal populations, describing fishing operations and collecting bycatch and fishing-effort data to estimate bycatch rates as well as the total amount of bycatch.

Step 1: Estimate abundance of marine mammal populations

A nearly unbiased estimate of absolute abundance is the most useful means of assessing the conservation status of a marine mammal population. The Working Group through *Estimating the abundance of marine mammal populations* (Hammond et al. 2021) provides a comprehensive guide, including minimum requirements and best practices for obtaining credible estimates of abundance. The techniques and methods used are based on the marine mammal species and regions of interest. See the decision tree in Appendix 1 to navigate options for estimating abundance.

METHOD OPTIONS:

To collect abundance data:

- Counts of pinniped pups or all-age animals
- Tags or photo-identification of individuals (to track capture histories)
- Transect surveys (aerial, small boat or ship)

To analyze data:

- Extrapolate counts (using multipliers, life tables, population models or haul-out proportions)
- Mark-recapture analysis of capture histories (including correction for unidentifiable animals)
- Distance analysis of survey data (including correction for availability and/or perception bias)

Step 2: Estimate marine mammal bycatch

The standard way to quantify bycatch is to (a.) observe fishing operations and bycatch for a portion of the fishery; and (b.) collect effort data for the fishery. With these data, it is possible to estimate the bycatch rate for the observed portion of the fishery and to quantify total marine mammal bycatch for the entire fishery. In *Estimating bycatch mortality for marine mammals: Concepts and best practices* (Moore et al. 2021), the Working Group provides step-by-step guidance on how to quantify bycatch under a variety of data conditions, including data requirements (e.g., the proportion of fishing effort that needs to be observed) and how to collect the data. See Appendix 2 for a decision tree that walks through estimating bycatch.

METHOD OPTIONS:

To characterize fishing operations:

- Onboard observer programs and/or camera systems
- Observer programs from secondary platforms
- Logbook records
- Structured fishermen interviews

- Dockside surveys

To analyze data:

- Simple ratio estimators
- Design-based methods (assuming observed bycatch can be extrapolated to the whole fishery)
- Model-based estimators (when monitoring for bycatch cannot be assumed to be representative)

Jeremy Bishop/Unsplash

CONDUCTING A BYCATCH ASSESSMENT

Scientists and managers rarely have enough data to assess depletion levels of bycaught species. Further, what is needed is not just a way to assess current depletion, but also knowing whether bycatch is high enough to eventually hinder population recovery or lead to depletion. The simplest approach is to develop a bycatch reference point based especially on abundance data.

ASSESS

Reference points (i.e., PBR)

PBR alternatives

Calculating reference points: Potential biological removal (U.S. example)

In the U.S., the 1994 amendments to the MMPA mandated the use of a reference point, known as the potential biological removal (PBR) level, to assess the impact of mortality on marine mammal populations from human causes. The overall goal is to prevent populations from dropping below their Optimum Sustainable Population, defined as being between the Maximum Net Productivity Level (MNPL) and the maximum number of individuals the environment can support. PBR is how scientists calculate a level of bycatch below which populations will be able to rebuild and stay above their MNPLs.

The first step is understanding the structure of marine mammal stocks, or independent (and manageable) populations of marine mammals. Then, PBR can be calculated via a mathematical equation involving a minimum estimate of abundance, an estimate of the population's maximum rate of increase and a recovery factor. U.S. managers define the minimum abundance estimate as the 20th percentile of an abundance estimate. Based on this threshold, populations that experience mortality at or below the level of the calculated PBR should stay at or recover to MNPL with 95% probability. A population is designated as "Strategic" in the U.S. if the level of annual human-caused mortality exceeds PBR, potentially subjecting fisheries to requirements to reduce bycatch.

Alternative assessment methods

In *Can we manage marine mammal bycatch effectively in low-data environments?* (Punt et al. 2021), the Working Group explores alternative methods for calculating bycatch reference points that can be used in different scenarios. In data-poor situations, alternative reference points—albeit lower and more variable than PBR—can be calculated based on trends in abundance (vs. estimates of abundance). In data-rich situations, PBR can be made more robust by incorporating multiple abundance estimates.

ACTING ON ASSESSMENT RESULTS TO GUIDE BYCATCH REDUCTION

ACT

Prioritize fisheries

Mitigate

The results of marine mammal bycatch assessments can help to set priorities for bycatch mitigation. Management plans can then be developed and implemented, and their progress in enabling depleted populations to recover can be monitored over time.

Step 1: Prioritize fisheries for bycatch reduction

Prioritizing fisheries for bycatch reduction is critical given most nations (including the U.S.) lack the resources to address all bycatch problems simultaneously. In the U.S., for example, high priority is assigned to fisheries where bycatch mortality exceeds PBR. Medium-priority fisheries are those where bycatch levels are more than 50% of PBR (but still less than PBR). Additional considerations are given to marine mammals with already small population sizes, as well as those that are being depleted more rapidly.

BOX 2. MARINE MAMMAL BYCATCH IMPACTS EXPLORATION TOOL (MMBIET)

The Working Group recognizes that in many places there is an absence of high-quality data on abundance and bycatch to inform priorities. The Working Group developed the *Marine Mammal Bycatch Impacts Exploration Tool (MMBIET)* (Siple et al. 2022), a web-based app and accompanying software package that enables managers to project marine mammal population trends under various bycatch levels. Projections can be used to better understand risk in terms of expected depletion levels and long-term population recovery. The values it provides will only be as robust as the data inputs, but the MMBIET allows users to explore various bycatch scenarios given their goals.

Step 2: Mitigate marine mammal bycatch

Once priorities are identified, managers must set measurable goals for reducing bycatch. A reasonable goal is to reduce bycatch below the reference point. However, an important factor in goal setting is taking into account uncertainty around estimates of abundance and bycatch. In the U.S., for example, while the immediate goal is to reduce bycatch below PBR, the long-term goal is to reduce it even further (at least to 10% of PBR) to ensure population recovery. In *Robustness of potential biological removal to monitoring, environmental, and management uncertainties* (Punt et al. 2020), the Working Group expands understanding of the management consequences of uncertainties, such as catastrophic changes in abundance and spatial differences in PBR implementation.

It is also possible to mitigate without having conducted a bycatch assessment. The main challenge here is determining how much mitigation is needed if there is no reference point for comparison. Finally, managers must put in place monitoring to assess whether mitigation has been successful in meeting conservation or recovery goals. Key to

designing monitoring programs are timing and sample size needed to detect changes in the bycatch rate. Effectiveness of mitigation measures should then be assessed at regular intervals to ensure continued bycatch reduction over time.

METHOD OPTIONS:

In selecting mitigation options, managers must weigh many factors that can vary by species, fishery, and location, including their potential effectiveness, possible displacement of marine mammal populations, feasibility and cost of implementation and enforcement, and the safety of fishermen:

- Time/area closures (of "hotspots" of overlap between fisheries and marine mammals)
- Banning high-risk gear types
- Gear switching from high- to low-risk gear
- Modifying fishing gear to eliminate or lessen the threat (e.g., adding acoustic alarms to deter marine mammals)


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CONCLUSION

The sheer magnitude of managing bycatch globally can seem daunting. But looking forward, the MMPA Import Provisions create the opportunity for significant conservation advances for marine mammal populations worldwide. This Working Group has provided practical guidance that enables managers to evaluate abundance and bycatch and set priorities, and a framework for reducing bycatch like that used in the U.S. We hope these products contribute to the development and spread of effective bycatch mitigation measures to reduce the leading source of human-caused mortality of marine mammals.

REFERENCED PRODUCTS OF MARINE MAMMAL BYCATCH WORKING GROUP

Summarizing best practices

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Estimating abundance and bycatch

Hammond, P.S., Francis, T.B., Heinemann, D., Long, K.J., Moore, J.E., Punt, A.E., Reeves, R.R., Sepúlveda, M., Sigurðsson, G.M., Siple, M.C., Víkingsson, G., Wade, P.R., Williams, R., Zerbini, A.N. (2021). *Estimating the abundance of marine mammal populations.* Frontiers in Marine Science. https://doi.org/10.3389/fmars.2021.735770

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Calculating reference points and bycatch scenarios

Punt, A.E., Siple, M.C., Francis, T.B., Hammond, P.S., Heinemann, D., Long, K.J., Moore, J.E., Sepúlveda, M., Reeves, R.R., Sigurðsson, G.M., Vikingsson, G.A., Wade, P.R., Williams, R., Zerbini, A.N. (2020). *Robustness of potential biological removal to monitoring, environmental, and management uncertainties.* ICES Journal of Marine Science. https://doi.org/10.1093/icesjms/fsaa096

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Siple, M. C., Punt, A. E., Francis, T. B., Hammond, P. S., Heinemann, D., Long, K. J., Moore, J., Sepúlveda, M., Reeves, R. R., Sigurðsson, G. M., Víkingsson, G.A., Wade, P.R., Williams, R., & Zerbini, A. N. (2022). *mmrefpoints: Projecting long-term marine mammal abundance with bycatch.* Journal of Open Source Software, 7(71), 3888. https://doi.org/10.21105/joss.03888

Case study applications: Iceland and Chile

Punt, A.E., Siple, M.C., Sigurðsson, G.M., Vikingsson, G., Francis, T.B., Granquist, S.M., Hammond, P.S., Heinemann, D., Long, K.J., Moore, J.E., Sepúlveda, M., Reeves, R.R., Wade, P.R., Williams, R., Zerbini, A.N. (2020). *Evaluating management strategies for marine mammal populations: an example for multiple species and multiple fishing sectors in Iceland.* Canadian Journal of Fisheries and Aquatic Sciences. https://doi.org/10.1139/cjfas-2019-0386

Punt, A.E., Sepúlveda, M., Siple, M.C., Moore, J.E., Francis, T.B., Hammond, P.S., Heinemann, D., Long, K.J., Oliva, D., Reeves, R.R., Sigurðsson, G.M., Víkingsson, G.A., Wade, P.R., Williams, R., Zerbini, A.N. (2021). *Assessing pinniped bycatch mortality with uncertainty in abundance and post-release mortality: A case study from Chile.* Fisheries Research. https://doi.org/10.1016/j.fishres.2020.105816

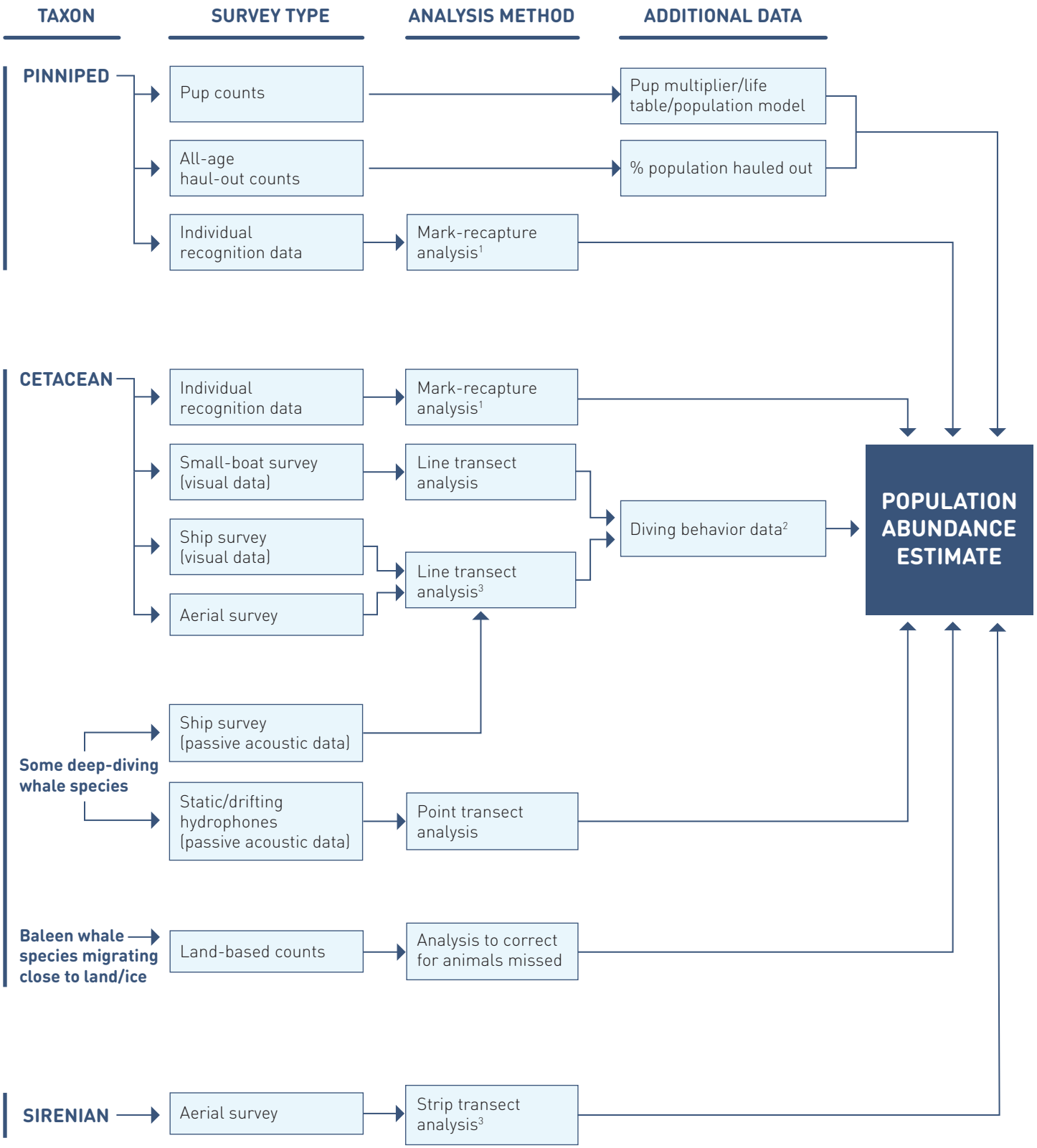
Key Webpages

Ocean Modeling Forum: https://oceanmodelingforum.org/working-groups/marine-mammal-bycatch-working-group/

Lenfest Ocean Program: https://www.lenfestocean.org/en/research-projects/developing-recommendations-to-estimate-bycatch-for-the-marine-mammal-protection-act

APPENDIX 1. DECISION TREE TO ESTIMATE ABUNDANCE

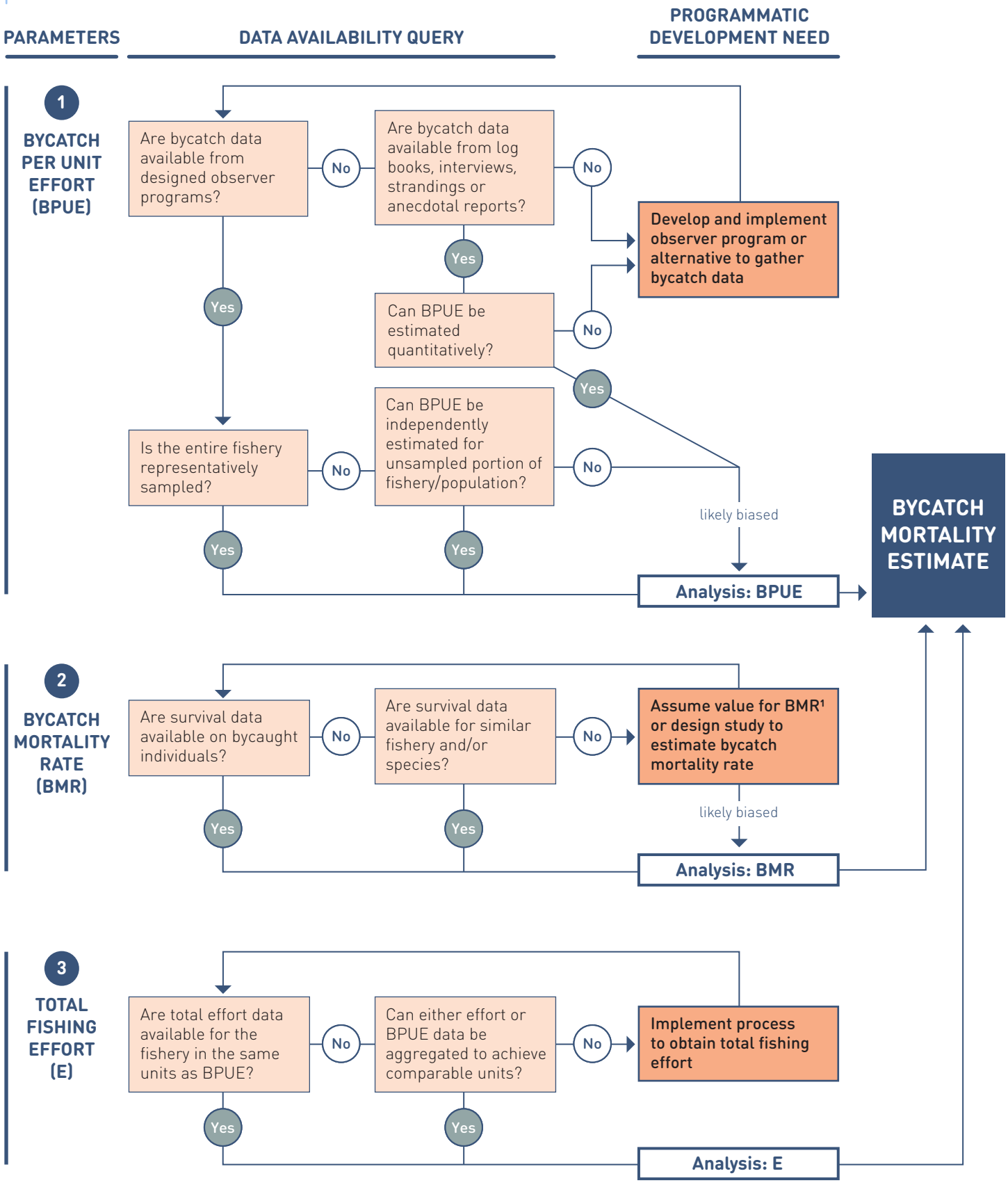
Based on Hammond et al. 2021, the flow of information and activities to estimate abundance of marine mammal populations.



1. Correct for proportion identifiable in the population, as appropriate.
2. To correct for availability bias, as appropriate.
3. Can incorporate corrections for perception bias (with double observer teams) and availability bias (method dependent).

APPENDIX 2. DECISION TREE TO ESTIMATE BYCATCH MORTALITY

Based on Moore et al. 2021, how to estimate the components of bycatch mortality: Bycatch per unit effort (BPUE), bycatch mortality rate (BMR), and total fishery effort (E).



1. Use a precautionary value, typically 1.0.