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REPORT OF THE MEETING ON THE USE OF MULTIPLE LINES OF EVIDENCE TO DELINEATE DEMOGRAPHICALLY INDEPENDENT POPULATIONS

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Southwest Fisheries Science Center

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EXECUTIVE SUMMARY

The NMFS Southwest Fisheries Science Center hosted a meeting to improve delineation of demographically independent populations under the MMPA from August 19-21, 2014. The meeting included representation of nearly all NMFS Science Centers, all Regional Scientific Review groups, and some representatives from NMFS Regional Offices and outside expertise (List of Participants, Agenda, Appendix 1).

The impetus for the effort to improve stock delineation came from the 2011 meeting to revise the Guidelines for Assessing Marine Mammal Stocks (GAMMS III) where it was documented that the ranges of most of the stocks set forth in the 1994 Stock Assessment Reports (SARs) encompassed large geographic areas and that stock revisions had been made only for species with genetic data available. Although the GAMMS report notes that lines of evidence other than genetics can be used, guidance on using other lines of evidence are not given and examples are not available. Consistency and accuracy in delineating stocks for species with limited data would be improved if both guidelines on the strengths of different lines of evidence and guidance on how to evaluate multiple lines together were available. A steering group was formed to organize this effort. The steering group scheduled presentations and discussions on each line of evidence listed in the GAMMS. The summaries of those discussion groups formed the basis for the meeting described in this report.

The meeting participants agreed that the best way to provide guidance on the use of multiple lines of evidence when delineating demographically independent populations (DIPs) for marine mammals was to produce a Stock Delineation Handbook that can serve as a guide for future DIP delineation efforts. The Handbook will be analogous to the 'Viable Salmonid Populations' Technical Memorandum (McElhaney et al. 2000) used for delineating and assessing salmon stocks. Participants identified several components that are needed for the Handbook:

1. Review each line of evidence and identify factors that should be considered when collecting, analyzing, and interpreting data for that line of evidence.
2. Assess the strength of the evidence when positive results are found and sampling is adequate.
3. Assess data availability for different lines of evidence for each existing stock in order to describe 'best available science' for stock delineation attainable for different stocks.
4. Consider methods to integrate multiple lines of evidence for stock delineation.

1. Review of Lines of Evidence

The MMPA directs NMFS to prepare stock assessment reports for each marine mammal stock using the best scientific information available. The MMPA defines 'population stocks' or 'stocks' as "a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature." The term 'population stock' has no common meaning in the scientific community, nor is the definition sufficiently clear as to be unambiguous. The agency therefore has discretion to interpret the term, consistent with the statute.

NMFS has developed guidance for applying the MMPA definition (NMFS 2005, aka GAMMS II), which was made available for public comment. The guidance states that a stock is a "demographically isolated biological population." (The most recent guidance, GAMMS III [NMFS 2011], which is not final, clarifies that the test should be stated as demographic "independence" rather than "isolation.") GAMMS II notes that "reproductive isolation is proof of demographic isolation" and that "[e]vidence of morphological or genetic differences in animals from different geographic regions indicates that these populations are reproductively isolated." GAMMS II also recognizes that many types of information can be used to identify demographic isolation, including "distribution and movements, population trends, morphological differences, genetic differences, contaminants and natural isotope loads, parasite differences, and oceanographic habitat differences." GAMMS II does not provide further guidance on how to consider or weigh these lines of evidence.

The discussion groups reviewed the utility of the following lines of evidence for delineating DIPs in marine mammals:

1. Acoustics
2. Movements
3. Stable isotopes and fatty acids
4. Contaminants
5. Morphology
6. Life history
7. Trends in abundance
8. Physiographic and oceanographic differences in habitat
9. Distributional hiatuses and low density areas
10. Association data (e.g., from social network analyses)

Each of the discussion groups began with presentations on the strengths and weaknesses of that LoE for identifying DIPs and examples of cases where it had been applied to marine mammals. The presentations were typically given by scientists with expertise in the LoE under discussion. Additional experts in the LoE were also invited to attend and participate in the discussion. The summaries of the discussion groups provide detailed information about the use of each line of evidence for DIP delineation and the many factors that have to be taken into account when evaluating the strength of a particular data set or analysis. The discussion group summaries will form the basis for much of the Stock Delineation Handbook and are available upon request. We did not hold a discussion groups to review genetic data because the utility of genetic data in stock delineation has been well documented. However, genetic data will be included as a Line of Evidence in the Stock Delineation Handbook.

2. Strength of Lines of Evidence

We used the information presented to the SDGI discussion groups, together with input from the meeting participants, to evaluate the strength and weaknesses of different lines of evidence (LoE) for delineating DIPs for marine mammals. We did this by designing and completing the LoE Strength Table, which is an expansion and refinement of a similar table that was completed by SDGI Steering Committee members and invited experts during the SDGI discussion groups. We completed the table for every cetacean and pinniped species currently listed in the SARs so that we could characterize variation among species with respect to the utility and availability of different LoEs. For species that have separate coastal/insular and pelagic populations (e.g., bottlenose dolphins), we evaluated the coastal and pelagic populations separately, as both the utility of a LoE and the feasibility of collecting data could vary between them. We did not include any species managed by the U.S. Fish and Wildlife Service (sea otters, polar bears, manatees, and walruses) because we lacked the necessary expertise among the meeting participants. The complete list of species considered is in Appendix 2.

The LoE Strength Table posed the question "Assuming that you have robust data that show a difference among two or more groups of animals in the line of evidence concerned, then, based upon the current state of knowledge of that species, how useful would you rate this line of evidence as a means of delineating separate populations?" 'Robust data' means that there has been appropriate evaluation of all relevant factors (e.g., age and sex difference, sample size, analytical methods, etc.) such that the observed difference is real, not a sampling or analytical artifact.

For each species, each LoE was coded as follows:
'-': Utility of this LoE for this species unknown, meaning there are no data for this species or a similar species from which generalizations can be made
0: This LoE is not informative or potentially misleading
1: Weak; this LoE must be combined with multiple additional LoEs
2: Moderate; this LoE must be combined with at least one other LoE
3: Strong; this LoE can be used alone to delineate DIPs

After completing the table, we summarized the strength of each LoE within each of three broad taxonomic groups – large whales, odontocetes, and pinnipeds (Table 1). For most LoEs, we found that their strength did not vary substantially between species or across taxonomic groups. Robust data demonstrating genetic or morphological differences between two groups were uniformly judged to be strong evidence of demographic independence, regardless of the species. Movement data were also judged to constitute a strong line of evidence supporting demographic independence for nearly all species. The exceptions were a few species of migratory whales and odontocetes with strong social structure that could be mistaken for population structure. In those cases movement data were considered to be moderate, meaning that additional data would have to be considered in order to determine whether the differences observed from movement data truly reflected demographically independent populations.

Distributional hiatuses or low-density areas were judged to be of medium strength for nearly all species. Stable isotope and fatty acid differences were uniformly considered to be weak to misleading as evidence of demographic independence due to the fact that there are many possible causes for differences in stable isotope signatures, such as differences in individual diet preferences, prey switching, and within and between year changes in background isotope profiles. Contaminant data were judged to be somewhat stronger (i.e., moderate to weak) indicators of demographic independence, largely because contaminant loads are integrated over the lifetime of an animal rather than representing a short (one to six month) snapshot of an animal's diet, as is the case with stable isotopes and fatty acids. Differences in trends or life history parameters between two groups were judged to represent weak evidence of demographic independence for most species, largely due to the large amount of other data needed in order to properly interpret results from these LoEs.

Rankings for the utility of physiographic or oceanographic differences in habitat and association data varied among the three broad taxonomic groups, but were relatively consistent within a taxonomic group. Acoustic data were the only LoE for which the utility for delineating DIPs was judged to be very species specific.

Table 1. Strength of different lines of evidence for evaluating demographic independence. These evaluations are predicated on the assumption that a difference among two or more groups of animals has been found for that line of evidence, and that there has been an appropriate evaluation of all relevant factors to ensure that the observed difference is not a sampling or analytical artifact.

Line of Evidence	Large whales	Odontocetes	Pinnipeds
Morphology	Strong	Strong	Strong
Genetics	Strong	Strong	Strong
Movements	Strong	Strong	Strong
Distributional hiatuses or low density areas	Medium	Medium	Medium
Contaminants	Medium/Weak	Medium/Weak	Medium/Weak
Stable isotopes and fatty acids	Weak/Not Informative	Weak	Not Informative
Life history	Weak	Weak	Weak
Trends in abundance	Weak	Weak	Weak/Not Informative
Physiographic or oceanographic differences in habitat	Not informative	Medium	Weak
Association data	Not Informative	Medium/Weak	Unknown
Acoustics	Species Specific	Species Specific	Species Specific

3. Best Scientific Information Available

GAMMS II cautions that the absence of evidence for demographic independence does not mean that demographic independence does not exist, and that in cases where geographically concentrated human mortality occurs, serious consideration should be given to identifying defensible management units. GAMMS II further states that "Examples of such management units include distinct oceanographic regions, semi-isolated habitat areas, and areas of higher density of the species that are separated by relatively lower density areas."

The MMPA directs NMFS to use the best scientific information available when preparing SARs. The original SARs published in 1995 identified stocks at very large scales, commensurate with the limited information of population structure at that time. For some species the agency has since delineated smaller stocks, but with 20 years of accrued data since the first SARs, the process of stock revision would benefit from further guidance regarding what constitutes "best scientific information available," particularly for stocks for which data are limited and where human-caused mortality may be a concern.

Over the past 20 years, many new data have been generated to allow calculation of PBR in the SARs. Revisions of stocks have primarily occurred for species where strong lines of evidence have been attainable. For example, tissues obtained from observer programs in California fisheries provided the genetic samples that revealed that stocks of harbor porpoise existed on a finer scale than previously realized. Those genetic data, together with distributional data, were used to delineate two new stocks of harbor porpoise. Areas of lower density guided placement of stock boundaries. Similarly, data from harbor seals in Alaska, including genetics, abundance and trends, and satellite tagging showing movement patterns, revealed that finer-scale stocks than had been previously recognized occurred there. Those data, along with traditional subsistence hunting boundaries, were used to delineate 12 stocks where there had only been three. Later, the new stock boundaries were noted to correspond well to fine-scale ecoregions described for Alaska (Piatt and Springer 2007). Similarly, multiple lines of evidence for bottlenose dolphins along the Atlantic coast and for Hawaiian insular false killer whales revealed previously unrecognized stocks. All these cases had genetics and movement data available, which are each considered strong lines of evidence.

In contrast, there have been no stock revisions for species where genetic or movement data (through tagging or photo-identification) are particularly difficult to obtain. Many such species have largely inaccessible distributions, including some of the ice seals and many beaked whales. Other species are difficult to obtain biopsy samples from (e.g., harbor porpoise, minke whales, and most deep diving cetaceans). Photographic-identification is impractical for species of high abundance (e.g., common dolphins, pelagic dolphin species generally) or that have too few (e.g., harbor porpoise) or too many (e.g., harbor porpoise) markings. Satellite tagging is expensive and is thus not a practical method to gather sufficient movement data from which to draw inference for many species with moderate to high abundance. Consequently, there are many species that have few or no data for LoEs that are considered strong for stock delineation. There is also little prospect of attaining such data in the near future (5 years).

It is clear that availability and suitability of different LoEs will vary among species, and thus stock delineation must be based on different LoEs to meet the MMPA language to use the best available scientific information. Workshop participants have therefore undertaken to document what data are available for currently defined stocks. The Data Availability Table asks the question, "Are results currently available from this LoE that are sufficiently robust to determine whether there are multiple stocks present within a currently defined stock? If not, are results likely to be available within the next five years?" The Data Availability Table was completed for every stock of cetacean and pinniped, using the stocks listed in the 2012 Stock Assessment Reports.

For each species, each LoE will be coded as follows:
'-': Not applicable; this LoE is not useful for stock delineation for this stock/species
0: Not feasible to collect or analyze data within five years
1: Feasible to collect data or analyze samples within five years, but no plans to do so
2: Sufficient results for reviewing stock delineation expected within five years
3: Sufficient results for review of stock delineation are currently available

We were unable to complete the entire table due to time constraints and because in some cases meeting participants did not have enough information to complete the table. However, we completed the table for three example species (CA/OR/WA offshore bottlenose dolphins, bearded seals, and NE Pacific fin whales) in order to ensure a consistent understanding of the exercise. Input on the table will be solicited from relevant personnel at each Science Center, and the final table will be included in the Stock Delineation Handbook.

4. Integrating Multiple Lines Of Evidence

A clear conclusion of the SDGI discussion groups was that there is no quantitative way to combine multiple LoEs in order to delineate DIPs. Consequently, the overall strength of data in stock delineation reviews will always have to be evaluated on a case-by-case basis. Such evaluations need to be documented using a repeatable, transparent process. This could be accomplished by requiring the publication of a Technical Memorandum (Tech Memo) or peer-reviewed publication to accompany every stock delineation revision. The Tech Memo should provide a clear and concise explanation of the data and analyses that were used to determine the number of demographically independent stocks and to identify the boundaries of those stocks. The existence of DIPs is often more clear than where the boundaries exist between them. An important function of the Tech Memo will be to explain the rationale behind boundary placement. The Stock Delineation Handbook will provide detailed guidelines regarding the preparation, review, and dissemination of the Tech Memo in order to promote consistency across Science Centers.

In cases where the best scientific information available regarding the presence of DIPs comes from weak LoEs or limited data sets, or where robust data sets from strong LoEs indicate that it is a borderline case, a formal decision-making framework should be used in stock delineation reviews. Structured Expert Decision Making (SEDM) is such a framework that has been used in a review of stock structure for gray whales (Weller et al. 2013), as well as in numerous status reviews under the Endangered Species Act (ESA) (e.g., Krahn et al. 2002, Oleson et al. 2010). In SEDM, lines of evidence for demographic independence, as well as potential threats and other factors, are evaluated by experts using categorical or numerical scoring. Evaluations consider the inference quality of the data (e.g., how useful are stable isotope data for evaluating stock structure in a particular species or population?), as well as the data quality (e.g., how robust are the available data and analyses?). SEDM is particularly useful in identifying weaknesses in data and differences in data interpretation for borderline cases for which many data are available but definitive conclusions are difficult (e.g., the gray whale Pacific Coast Feeding Group) and for identifying inconsistencies in approach across species or stocks.

In order to facilitate the use of SEDM in future stock delineation reviews, meeting participants agreed to develop a set of example questions for use in an SEDM framework. The Report of the NMFS Gray Whale Stock Identification Workshop (Weller et al. 2013) presents useful examples for a case that is data-rich, but borderline with respect to demographic independence. The meeting participants agreed to develop example questions for cases where the best scientific information available comes from weak LoEs or limited data sets. Because the SEDM process relies on several rounds of drafting and answering questions, discussing the answers, and then revising the questions to make them clearer, the only feasible way to develop example questions is by applying SEDM to example cases. This activity will be pursued by a subset of meeting participants.

5. Further Considerations

NMFS Protected Resources personnel at the Regional Offices and at Headquarters are working to develop criteria and a process for prioritizing stocks for stock delineation review. Meeting participants were briefed on that effort and asked for their ideas from a scientific perspective. The discussion generated the following suggestions that should be considered when prioritizing stock delineation review efforts:

- Higher priority should be given to stocks where there are geographically concentrated threats, whether they are authorized or unauthorized. These include fishery interactions, ship strikes, anthropogenic sound, and habitat degradation, as well as emerging threats such as marine renewable energy.
- Higher priority should be given to cases where DPS delineations under the ESA and stock delineations under the MMPA do not align (e.g., North Pacific humpback whales). Because DPSs and stocks are not defined based on the same criteria, there are likely cases where it is appropriate for them to differ. Nonetheless, these cases should be reviewed and the misalignment of the DPSs and stocks either corrected through revision or clearly justified.
- Higher priority should be given to cases where the abundance of the currently delineated stocks is believed to differ substantially from the abundance of the actual DIPs.

- Stocks of naturally rare species should receive higher priority than high abundance stocks because they can be driven to near-extirpation more rapidly.
- Stocks with increasing trends in abundance should have lower priority.
- Lower priority should be given to stocks for which delineation has already been thoroughly reviewed.

Participants noted that stocks can be grouped into three categories – those for which the necessary data have already been collected and analyzed, those for which additional data are needed and are attainable with reasonable effort, and those for which there is little prospect of obtaining robust data from strong LoEs in the near future – and that these categories may need to be prioritized separately. For the last category of 'data poor' stocks, one possibility is to hold a workshop or series of taxonomically-focused workshops to review the best scientific information available and recommend stock delineation revisions as necessary. Such an approach would be analogous to the efforts of the NMFS Data Poor Assessment Methods Working Group, which focuses on assessments of fish stocks.

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Appendix 1.

Meeting on the Use of Multiple Lines of Evidence to Delineate Demographically Independent Populations

Southwest Fisheries Science Center, La Jolla, CA
19-21 August, 2014

List of Participants

Karen Martien (chair), Aimée Lang, Barbara Taylor, Karin Forney, Jim Carretta (SWFSC); Erin Oleson, Amanda Bradford (PIFSC); Paul Wade, Phil Clapham, Peter Boveng (AKFSC); Brad Hanson (NWFSC); Patricia Rosel (SEFSC); Donna Darm, Chris Yates (WARO); Shannon Bettridge (OPR); Samantha Simmons (MMC); Michael Scott (Pacific SRG); Lloyd Lowry (Alaska SRG); Randall Wells (Atlantic SRG); Robin Baird (Cascadia Research Collective)

Final Agenda

1 INTRODUCTORY ITEMS

1.1 Welcome and opening remarks
1.2 Review and adoption of agenda

2 REVIEW OF LINES OF EVIDENCE (SDGI-01)

2.1 Acoustics
2.2 Movements
2.3 Stable Isotopes
2.4 Contaminants and Fatty Acids
2.5 Morphology
2.6 Life History
2.7 Trends in Abundance
2.8 Oceanography and Distribution
2.9 Social Structure and Association Data

3 INTEGRATING MULTIPLE LINES OF EVIDENCE

3.1 Review of past stock delineation revisions (Table 3 of SDGI-02)
3.2 How to weight different lines of evidence
3.3 Do we need different standards for data-rich versus data-poor species (SDGI-03)
3.4 Structured expert decision-making for data poor species (SDGI-04)

4. FUTURE STOCK REVISIONS

4.1 Discuss criteria for prioritizing future revisions
4.2 Identify high priority stocks (from SDGI-05)

Appendix 2. List of species included in the LoE Strength Table.

Taxonomic group	Species	Taxonomic group	Species
pinniped	Bearded seal	odontocete	Baird’s beaked whale
pinniped	California sea lion	odontocete	Cuvier’s beaked whale
pinniped	Gray seal	odontocete	Gervais beaked whale
pinniped	Guadalupe Fur Seal	odontocete	True's beaked whale
pinniped	Harbor seal	odontocete	Sowerby's beaked whale
pinniped	Harp seal	odontocete	Longman's beaked whale
pinniped	Hooded seal	odontocete	Blainville’s beaked whale
pinniped	Monk Seal	odontocete	Northern bottlenose whale
pinniped	Northern Elephant Seal	odontocete	Pygmy sperm whale
pinniped	Northern fur seal	odontocete	Dwarf sperm whale
pinniped	Ribbon seal	odontocete	Killer whale, Resident
pinniped	Ringed seal	odontocete	Killer whale, Offshore
pinniped	Steller sea lion	odontocete	Killer whale, Biggs
pinniped	Spotted seal	odontocete	Pilot whale, long-finned
odontocete	Risso’s dolphin	odontocete	Pilot whale, short-finned
odontocete	Dall’s porpoise	odontocete	False killer whale
odontocete	Harbor porpoise	odontocete	Pygmy killer whale
odontocete	Pantropical spotted dolphin	odontocete	Melon-headed whale
odontocete	Pacific white-sided dolphin	odontocete	Beluga whale
odontocete	Striped dolphin	odontocete	Narwhal
odontocete	Fraser’s dolphin	large whale	Blue whale
odontocete	Northern right whale dolphin	large whale	Bowhead whale
odontocete	Spinner dolphin, island	large whale	Bryde’s whale
odontocete	Spinner dolphin, pelagic	large whale	Fin whale
odontocete	Atlantic spotted dolphin	large whale	Gray whale
odontocete	Atlantic white-sided dolphin	large whale	Humpback whale
odontocete	White-beaked dolphin	large whale	Minke whale
odontocete	Clymene dolphin	large whale	North Atlantic right whale
odontocete	Common dolphin, long-beaked	large whale	North Pacific right whale
odontocete	Common dolphin, short-beaked	large whale	Sei whale
odontocete	Rough-toothed dolphin	large whale	Sperm whale
odontocete	Bottlenose dolphin, pelagic		
odontocete	Bottlenose dolphin, coastal		
odontocete	Bottlenose dolphin, BSE		