INDEPENDENT ADVISORY TEAM FOR MARINE MAMMAL ASSESSMENT

Final Report – Phase I

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1. Purpose

The Independent Advisory Team for Marine Mammal Stock Assessment (IAT) is a think-tank dedicated to identifying, developing, and promoting research to help reduce uncertainty associated with marine mammal (MM) stock assessments. The IAT will review the scientific basis for assessment and conservation of MM stocks, particularly in relation to fisheries management, identify research priorities, and seek to develop and promote proposals for research meant to address those priorities. To this end, the IAT will seek to network with MM stock assessment scientists, fisheries managers and industry representatives.

The objectives of Year 1 of the IAT project were to: 1) Establish the team; 2) Attend relevant MM meetings to network, disseminate information about the project, increase the team's understanding of the issues, and seek advice on opportunities for collaboration; 3) Review key MM stock assessment literature; and 4) Use 2) and 3) to make recommendations to the science agenda of SCeMFiS.

2. Background

As part of efforts to conserve marine mammal (MM) stocks in US waters, managers rely on the calculation of Potential Biological Removal (PBR) levels, which are also used to classify fisheries according to the extent to which they cause incidental mortality and serious injury (M/SI) of MMs. Estimates of abundance are a key input in calculating PBR. However, the precision and/or accuracy of estimates of abundance may be lower than the standards recommended by regulatory agencies. In some cases, current estimates may not be available. Similarly, estimates of mortality may be lacking for some MM stocks or may not meet the precision standards set by the regulatory agencies.

Uncertainty is generally regarded as undesirable regardless of one's priorities or perspective. It can impede conservation (i.e. increase the risk of underprotection) or unnecessarily limit opportunities for the sustainable exploitation of fish stocks (i.e. increase the risk of overprotection). As the Marine Mammal Commission (MMC) has pointed out, "the precautionary principle requires relatively restrictive measures to address fishery interactions, whether direct (bycatch) or indirect (predator-prey relationship)" when survey data and other information is inadequate for calculating PBR, or when large uncertainty surrounds values used in the PBR calculation (MMC, 2014b, p22).

2.1. MMPA Requirements

Two primary goals of the Marine Mammal Protection Act (MMPA) are to ensure that marine mammal species or populations do not:

- "[…] diminish beyond the point at which they cease to be a significant functioning element in the ecosystem […]" or
- "[…] diminish below their optimum sustainable population."

The optimum sustainable population (OSP) for a given stock is defined as "[…] the number of animals which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element."

To achieve the above management goals, the MMPA requires that PBR be calculated for each MM stock. PBR is defined as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBR is calculated as follows:

$$PBR = N_{min} * 0.5\ R_{max} * F_r$$

where: N_{min} = minimum population estimate; R_{max} = maximum theoretical or estimated net productivity rate of the stock at a small population size; and F_r = recovery factor (between 0.1 and 1).

Although these terms are defined in the MMPA[1], the procedures to estimate the parameters are found in the Guidelines for Assessing Marine Mammal Stocks (GAMMS) (NMFS, 2005) and are discussed later in this report in Section 2.2 below.

In addition to providing a stock's PBR level and summarizing the estimates that contribute to its calculation, stock assessments, as mandated by the MMPA, must also describe the stock's geographic range and seasonal movements. Current net productivity rate, population trend, and annual human-caused M/SI must be estimated and stock status (strategic or non-strategic) must be determined for each stock. In the case of strategic stocks[2], factors other than human-caused M/SI that may be responsible for the stock's decline or failure to recover also need to be considered. A Stock Assessment must be conducted annually for strategic stocks or those for which significant new information is available, and at least every three years for all other stocks.

Regional Scientific Review Groups (SRGs) review the annual draft Stock Assessment Reports (SARs) prepared by the National Marine Fisheries Service (NMFS) (or the U.S. Fish and Wildlife Service [USFWS] for MM species falling under its jurisdiction) and advise on estimates, uncertainties, habitat issues, and research needs. SARs also are subject to public review and comment.

Commercial fisheries that interact with a stock (i.e. involve marine mammal bycatch) require information on the number of active vessels, the estimated annual M/SI, how M/SI varies seasonally or spatially, and the rate of M/SI based on the fishery fishing effort. In addition, a determination is required on whether total M/SI (all fisheries combined) is "insignificant and is approaching a zero mortality and serious injury rate,"

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[1] "Minimum population estimate" means the number of animals in a stock that—

> (A) is based on the best available scientific information on abundance, incorporating the precision and variability associated with such information; and
>
> (B) provides reasonable assurance that the stock size is equal to or greater than the estimate.

"Net productivity rate" means the annual per capita rate of increase in a stock resulting from additions due to reproduction, less losses due to natural mortality.

[2] A stock for which the direct human caused mortality is above PBR, or a stock that is depleted (abundance determined to be below OSP) or declining and is likely to become listed or is already listed under the Endangered Species Act.

otherwise known as the Zero Mortality Rate Goal (ZMRG), which is set at 10% or less of PBR (FR, 2004).

The List of Fisheries, which classifies fisheries as having frequent, occasional, or remote MM M/SI, must be published at least annually (LOF, 2014). The first step in this 2-tier approach is to determine whether the cumulative fishery-related M/SI (i.e., across all fisheries) exceeds 10% of PBR for a given stock (Figure 1). If it does not exceed 10%, these fisheries are classified as Category III (remote). The second step is to examine M/SI for each individual fishery. If a single fishery causes M/SI ≥ 50% of PBR, it is classified as Category I (frequent), and if it causes 1% PBR < M/SI < 50% of PBR then it is classified as Category II (occasional). Any fishery that causes M/SI ≤ 1% of PBR for each MM stock with which it interacts is classified as Category III (remote). At the discretion of NMFS, fisheries with no reported MM M/SI may also be classified as Category II based on their similarity with other fisheries already classified as Category I or II. Classification by analogy takes into account "[…] fishing techniques, gear used, methods used to deter marine mammals, target species, seasons and areas fished, qualitative data from logbooks or fisher reports, stranding data, and the species and distribution of marine mammals in the area, […]" (LOF, 2014).

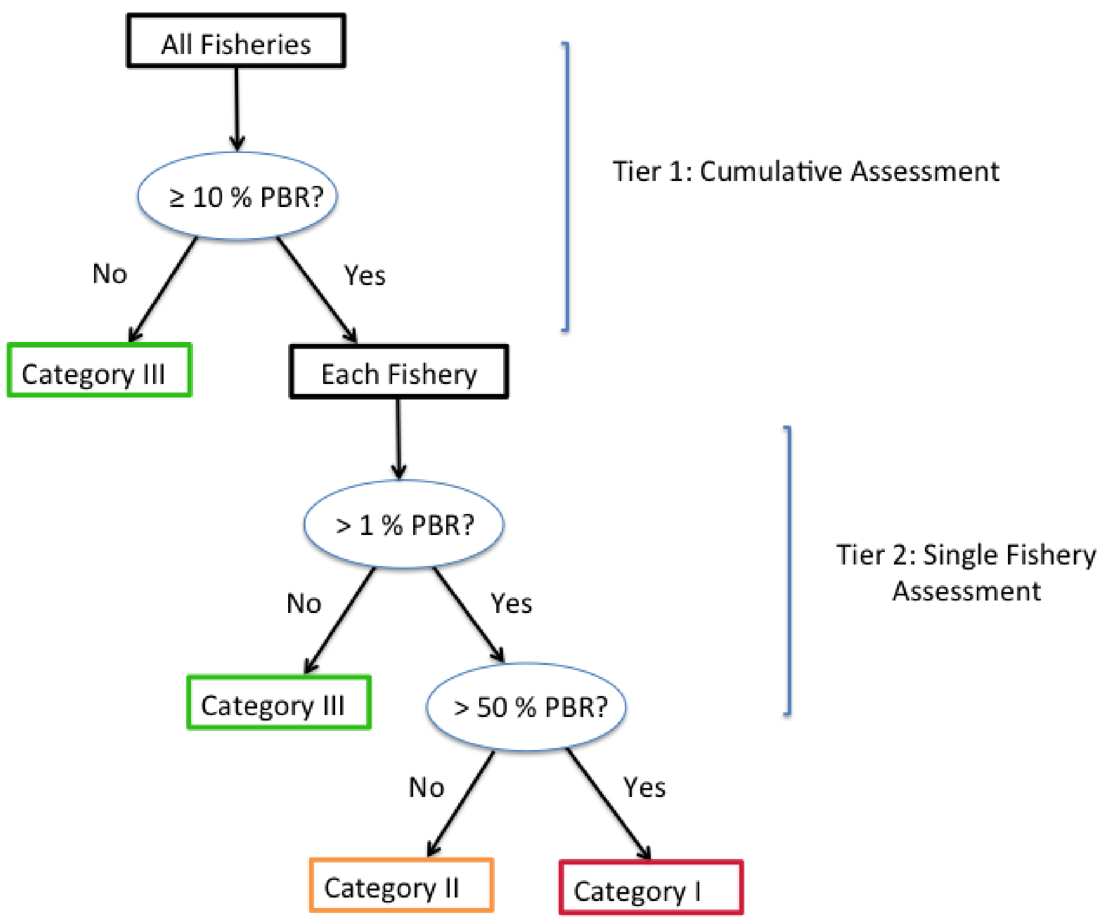

Figure 1 – Decision tree for classification of fisheries based on percent of PBR removed annually.

Take Reduction Teams (TRTs) are established when a stock is strategic and interacts with a Category I or II fishery[3]. TRTs must consist of a balanced representation of resource users and non-users, such as members of State and Federal agencies, Indian tribal entities, scientific bodies, fisheries groups, and environmental organizations. A TRT has the responsibility to draft a Take Reduction Plan (TRP) for submission to NMFS. NMFS either adopts or modifies the draft plan, which is subjected to public comment, revised as needed, and implemented.

The TRP has two primary goals:

a) A short-term goal to reduce M/SI below PBR within 6 months;
b) A long-term goal to reduce M/SI below 10% PBR (ZMRG) within five years, taking into consideration the feasibility of proposed measures (fishery economics, gear availability, etc.) and existing fishery management plans.

Actions proposed to pursue these goals may be regulatory or voluntary. Examples of regulatory measures are mandatory modifications to fishing gear and time-area fishing restrictions. Examples of non-mandatory efforts are research to identify causes of M/SI, and outreach initiatives to encourage fishermen to change how they fish in order to reduce risks to marine mammals. Outreach and education efforts can serve as a way of reminding and reinforcing the need for compliance with mandatory gear modifications and other regulations.

As shown in Figure 2, calculation of PBR and estimation of M/SI are essential to decision-making at various levels, including stock assessment, classification of fisheries, and take reduction planning.

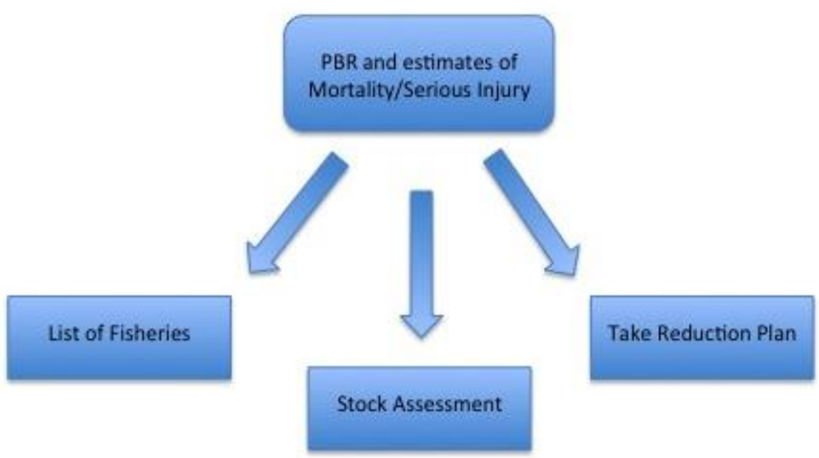

Figure 2 – Management processes that require PBR calculations and estimates of mortality and serious injury.

[3] The Secretary of Commerce may also apply TRPs to Category I or II fisheries that cause high M/SI across several stocks.

It is generally acknowledged that the responsible agencies have fallen far behind in trying to meet the MMPA requirements. As summarized in a letter from the Marine Mammal Commission to the Chief of the Marine Mammal and Sea Turtle Conservation Division of the NMFS Office of Protected Resources (14 November 2012):

> "Many stock assessments lack even the most basic information such as up-to-date minimum abundance estimates, which are necessary to calculate the stocks' potential biological removal (PBR) levels. Estimates of serious injury and mortality rates are lacking for even more stocks. In the absence of such information, managers cannot confidently determine the status of these stocks, the significance of human effects on them, and the effectiveness of management measures intended to protect them. In the end, the lack of information means that managers are likely to err by over- or under-protecting marine mammal species, either of which can be unnecessarily costly."

This same point has been made repeatedly, including by the agencies themselves. For example, the NOAA Fisheries National Task Force for Improving Marine Mammal and Turtle Stock Assessments acknowledged in the early 2000s that "no information was available on abundance or mortality" for many species and stocks (NMFS, 2004a). The task force concluded that in order "to address and meet its mandates, NOAA Fisheries must improve its research capability and capacity, and significantly enhance the quantity and quality of its protected species stock assessment data and analyses" and that "improvements for most stocks are needed in all five categories: stock identification, abundance, fishery mortality, and assessment frequency and data quality." More recently, the Atlantic SRG (2014) expressed its "general frustration with the assessment of marine mammal stocks, including inter alia the inconsistency of data collected, affecting the ability to estimate abundance and trends therein."

2.2. Guidelines for Assessing Marine Mammal Stocks (GAMMS)

NMFS and USFWS periodically convene workshops to develop, refine, and standardize the elements of and methods used in MM SARs. The guidelines resulting from these workshops become official documents published in the Federal Register.

To date, four workshop reports have been produced. The initial report provided an overall framework for the guidelines (Barlow et al., 1995), and subsequent revisions (Wade and Angliss, 1997; NMFS, 2005; Moore and Merrick, 2011) have reflected advances in science and attempted to address specific challenges (e.g. identification of stocks and estimation of PBR for declining stocks) identified by workshop participants, including representatives from NMFS, MMC, USFWS, and SRGs.

The most recent GAMMS workshop, in February 2011, was intended to address the following objectives, as listed by Moore and Merrick (2011): "Consider methods for assessing stock status (i.e., how to apply the PBR framework) when abundance data are outdated, nonexistent, or only partially available; develop policies on stock identification and application of PBR to small stocks, trans-boundary stocks, and situations where stocks mix; and develop consistent national approaches to a variety of other issues, including application of M/SI information in assessments, and consideration of M/SI from recreational fisheries."

The proposed modifications to guidelines (Moore and Merrick, 2011) were submitted for public comment ending on March 26, 2012. Final regulations have not yet been published, thus the guidelines from 2005 (NMFS, 2005) remain in effect. They aim to: "(1) provide a uniform framework for the consistent application of the amended MMPA throughout the country; (2) ensure that PBR is calculated in a manner that ensures meeting the goals of the MMPA; (3) provide guidelines for evaluating whether fishery takes are insignificant and approaching a zero mortality and serious injury rate; and (4) make the Government's approach clear and transparent to the public." They also call for justification for any departure from the guidelines and an explanation for any deviation from a specific recommendation of the SRG to be given within the relevant SAR.

The following guidelines apply to PBR elements:

- N_{min} is defined as the lower 20th percentile of a log-normal distribution according to $N_{min} = N/\exp(0.842 * (\ln(1+CV(N)^2))^{1/2})$, where CV(N) is the coefficient of variation of the stock's abundance. If eight years have elapsed since the last abundance survey, N_{min} is considered unknown, unless there is strong evidence that the stock has not declined since the last survey. These eight years correspond to a 50% reduction of the stock's initial abundance, assuming the greatest rate of decline (10%) reported for a marine mammal stock in U.S. waters (NMFS, 2005).
- Default values of R_{max} are used when stock-specific values are not available: 0.12 (pinnipeds and sea otters) and 0.04 (cetaceans and manatees).
- F_r is set at 0.1 for endangered species and 0.5 when stocks are depleted, threatened, or of unknown status. When stocks are within OSP or are increasing and incidental mortality has not been increasing, other values may be used up to 1. Adjustments to the default values of F_r may be warranted. For example, a decrease may be applied to account for high variation in estimates of incidental mortality or when a disproportionately larger number of females are taken. Conversely, when mortality estimates are relatively unbiased, default values may be increased.

2.3. Issues Identified and Recommendations Made by Others

In this section, we identify issues raised and recommendations made by other agencies and groups with regard to MM stock assessment. This list of issues and recommendations is not necessarily exhaustive, but rather represents a selection from various sources.

2.3.1. Issues related to abundance estimation and trends

- Incomplete or non-systematic surveys (e.g. with incomplete or inconsistent area and seasonal coverage, at least in some instances due to poor weather conditions, non-availability of ship or aircraft time, or insufficient funding) limit ability to generate accurate estimates of stock abundance, particularly for wide-ranging, migratory species (e.g. most baleen whales) and trans-boundary stocks (e.g. Gulf of Maine/Bay of Fundy harbor porpoises), and may lead to estimates of abundance with low precision (e.g. Joint Scientific Review Group, 2008; Moore and Merrick, 2011).

- Outdated data (older than 8 years) are considered unreliable, making it impossible to use such data to produce abundance estimates suitable for PBR calculation (e.g. Moore and Merrick, 2011).
- Identification of management units and stock structure, and therefore determination of exactly which stock's abundance is being estimated, can be difficult (e.g. NMFS, 2005; Moore and Merrick, 2011).
- Trends in stock abundance are considered by many to be "one of the most important measures" of status (MMC, 2012). This is considered to be the case even if the drivers of the trends are unknown or only partially understood. Data limitations, notably imprecision of abundance estimates and long intervals between surveys (e.g. Waring et al., 2014), preclude assessment of trends for most stocks (71%; Roman et al., 2013).

<u>Recommendations</u>

- If N_{min} is biased, use correction factors or alternative methods to estimate N_{min} (NMFS, 2005).
- When N_{min} is outdated (i.e. 8 years have elapsed since the last survey data were collected), apply a method which takes into account uncertainty. Several methods have been proposed (Moore and Merrick, 2011).
- For trans-boundary stocks, seek to obtain data on abundance and fishery-caused M/SI in both the U.S and non-U.S. parts of the stocks' ranges. For migratory stocks, if only U.S. estimates are available, apportion PBR to U.S fisheries based on the fraction of time spent in U.S. waters. For non-migratory stocks, use the abundance estimate for the fraction of the stock within U.S. waters (NMFS, 2005).
- Consider alternative survey techniques, for example for visually cryptic species (Atlantic Scientific Review Group, 2013).
- Explicit technical guidance should be provided on trend analysis, and for any stock with no trend analysis included in the SAR, an explanation for why such an analysis could not be completed should be provided (MMC, 2012).

2.3.2. Issues related to estimation of human-caused mortality & serious injury (M/SI)

- M/SI estimates are generally limited to fisheries and ship strikes. Other threats may be discussed in the SARs but are generally not quantifiable and their cumulative effects are not estimated. Stranded (beach-cast) carcasses, including from Unusual Mortality Events[4], are often difficult to assign to specific stocks. Also, many carcasses, regardless of whether they come ashore, sink, become scavenged, or simply drift offshore, are not detected (cryptic mortality) (Moore and Merrick, 2011).
- A detailed study conducted by the U.S. Government Accountability Office (GAO, 2008) concluded that "for most stocks, NMFS relies on incomplete, outdated, or imprecise data on stocks' population size or mortality to calculate the extent of incidental take" and that "NMFS does not have a comprehensive strategy for

[4] An Unusual Mortality Event is defined in the MMPA as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response."

assessing the effectiveness of take reduction plans […]" GAO analyzed a sample of 113 stocks from the SARs for 2007 and found that PBR or M/SI was unavailable for 34% of the stocks. Of the remaining 74 stocks, 11 had outdated population size estimates (PBR calculation not reliable) and other stocks had population estimates (48) and fishery-related M/SI estimates (24) that were less precise than the agency's guidelines recommend (CV <30%, Wade and DeMaster, 1999; NMFS, 2004a). For 48 stocks, NMFS was not able to calculate the precision of estimates of fishery-related mortality.
- There are inconsistencies across regions in the reporting of fishery-related mortality in SARs (Moore and Merrick, 2011). For example, not all regions include information regarding M/SI from recreational and foreign fisheries, nor are "unknown or underestimated sources of mortality" reported consistently.
- Common causes of difficulties in estimating fisheries M/SI with acceptable precision and accuracy include: many fisheries have zero or low observer coverage; bycatch, per se, tends to be a rare event (and especially for strategic stocks that are severely depleted or naturally occur in low density); and fisheries tend to be dynamic (e.g. there is considerable variation in effort allocation, gear used and targeted species) (Joint Scientific Review Group, 2008; Moore and Merrick, 2011).

<u>Recommendations</u>

- Consider alternative approaches to existing observer programs for estimating M/SI in fisheries where detection and quantification of M/SI is especially challenging (MMC, 2013).
- The MMC proposed in its Strategic Plan (MMC, 2014a, pp. 14-15) to collaborate with NMFS "to develop methods to estimate accurately the total numbers of human-caused serious injuries and deaths of large whales through workshops focusing on process descriptions and modeling" and "regarding the incorporation of the serious injury and mortality estimates into its stock assessments and into mitigation and conservation actions."
- Include a new section in SARs summarizing the "most important potential human-caused M/SI threats that are unquantifiable" (Moore and Merrick, 2011).
- Include a table in the SARs with U.S. and non-U.S. M/SI from commercial and recreational fisheries (Moore and Merrick, 2011).

2.3.3. Emergent issues

- How does the PBR framework account for (and how is it affected by):
  - Shifts in stock distribution (Joint Scientific Review Group, 2008)
  - Cumulative stressors (human-related or not) (NRC, 2005)
- What approaches, in addition to or instead of PBR, are available (or could be developed) to determine the status of stocks and guide management for conservation (Joint Scientific Review Group, 2008; Moore and Merrick, 2011)?

2.4. The Atlantic Region

The Atlantic Region was selected by the IAT for its initial focus. This region poses extensive, and in some cases acute, challenges related to MM-fisheries interactions, as demonstrated by the large number of Category I and II fisheries (LOF, 2014) and the relatively large number of TRPs (NMFS, 2004b; Atlantic Scientific Review Group, 2013). The NEFSC is leading a large-scale, multi-year project to assess and monitor protected marine species (AMAPPS—Atlantic Marine Assessment Program for Protected Species). The IAT met with the Protected Species Branch Chief and his staff to initiate discussion on research areas of mutual interest. The team also considered the potential for collaboration with representatives of the fishing industry operating in the Atlantic, who could provide input on the character and dynamics of the fisheries and help identify, and rectify, deficiencies in the available data.

The Atlantic SAR combines information and data from the U.S. Atlantic coast, the Gulf of Mexico, Puerto Rico, and U.S. Virgin Islands. The stocks for these regions currently total 115: 52 in Atlantic waters, 57 in the Gulf of Mexico, and 6 in Puerto Rico and the U.S. Virgin Islands (Waring et al., 2014). The NEFSC is responsible for 25 stocks (all in the Atlantic), while the Southeast Fisheries Science Center (SEFSC) has responsibility for the remaining 90 stocks (including 27 in the Atlantic, representing approximately 52% of the Atlantic stocks). As pointed out in the MMC's Priorities Report to NMFS (MMC, 2014b), very few of the stocks within the Southeast region have "adequate" stock assessments, and "the management challenges associated with such a scarcity of information are plainly evident."

There are 52 marine mammal stocks in the Atlantic region: 42 toothed cetacean, 6 baleen whale, and 4 pinniped stocks. Twenty-one of the 52 are strategic stocks requiring annual assessments. Strategic stocks consist primarily of common bottlenose dolphins (BDs) (66.7% of Atlantic strategic stocks, representing 87.5% of total Atlantic BD stocks) and the remaining are sperm whales and baleen whales (only one of which, common minke whale, is not strategic).

Consistent with our mission, our primary focus to date has been on the issue of scientific uncertainty associated with estimates used to calculate PBR. By characterizing the levels and trends in uncertainty, we have sought to identify areas of SA that would be suitable candidates for research given our team's expertise. However, in this initial phase we did not investigate causes of uncertainty. We compiled the data for this section of the report (2.4) from the 2013 SAR (Waring et al., 2014) with some comparisons made to the 2012 SAR (Waring et al., 2013).

Nation-wide studies have shown that there are similarities in the MM stock assessment challenges, including bycatch estimation, across regions (NMFS, 2004a; GAO, 2008; Moore et al., 2009; Moore and Merrick, 2011; Moore et al., 2013; Roman et al., 2013). Therefore, we hope that research toward improved methods of reducing and managing uncertainty in the Atlantic will have far-reaching benefits beyond this region.

2.4.1. Abundance estimates and calculation of Potential Biological Removal (PBR)

When a reliable abundance estimate is not available for a stock within the last eight years, its abundance is classified as "unknown." Thirty-one percent of the Atlantic stocks have no abundance estimates (Table I). Hence, PBR is undetermined for 31% of the stocks because PBR cannot be calculated in the absence of an abundance estimate (N_{min}). It is fair to note that the 31% includes a number of species that are rarely seen in U.S. Atlantic waters (e.g. killer whales, northern bottlenose whales, pygmy killer whales).

PBR is available for all six baleen whale stocks, for 70% of the toothed cetacean stocks (29 out of 42), and for 25% of the pinniped stocks. These percentages can fluctuate from year to year as abundance estimates become outdated or new estimates are obtained.

Table I

Percentages of Atlantic marine mammal stocks lacking estimates of minimum abundance (N_{min}) and of annual mortality/serious injury (M/SI), with undetermined Potential Biological Removal (PBR), and with R_{max} and F_r set as default values of R_{max} at 0.04 for cetaceans and 0.12 for pinnipeds and of F_r at 0.1 (for endangered/depleted stocks) or 0.5 (for threatened stocks or stocks of undetermined status).

	Unknown or undetermined	Default values
PBR	31%	-
N_{min}	31%	-
Total M/SI	23%	-
R_{max}	-	96%
F_r	-	90%

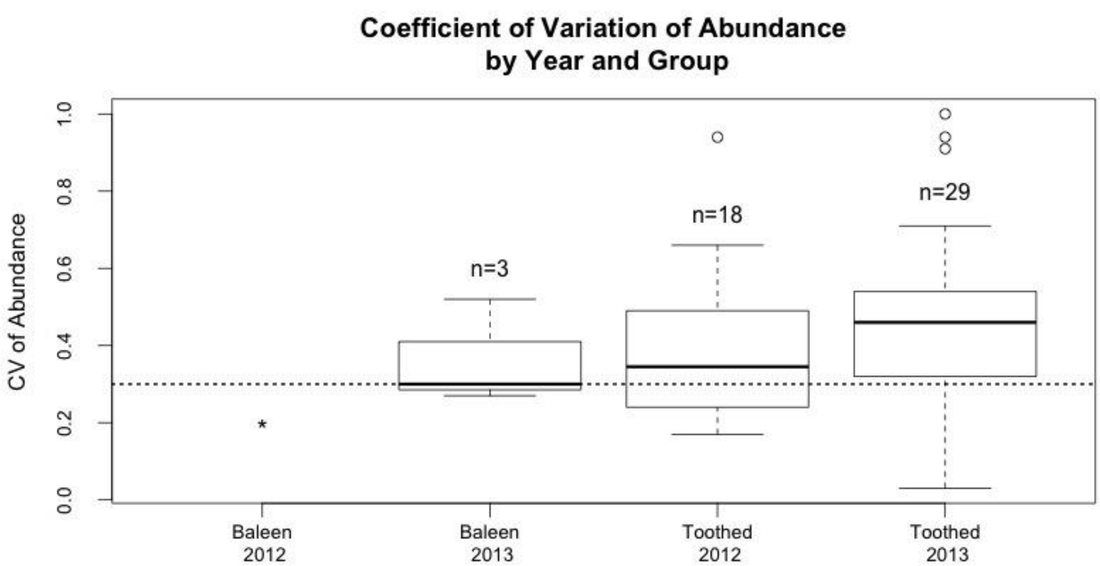

Figure 3 – Coefficients of variation of abundance estimates in 2012 SAR and 2013 SAR for two taxonomic groups in the Atlantic region: Baleen whales and Toothed cetaceans. Number of stocks (n) shown above boxplot. Asterisk (*) indicates no CV available for comparison because only minimum counts of animals seen alive (instead of estimates of population abundance) were reported. Dashed line indicates level of precision considered desirable by NMFS (CV=0.3). Boxplot elements: 1st and 3rd quartiles (box), 2nd quartile (band), range (whiskers) and outliers (open circles).

We compared the coefficients of variation (CVs) of abundance estimates in the 2012 and 2013 SARs for two taxonomic groups (Baleen whales and Toothed cetaceans) in the Atlantic region (Figure 3). In general, the CVs of the 2013 Toothed whale estimates (n=29, median of CV=0.46) were further from NMFS's desired level of precision of 0.3 than the 2012 Toothed whale estimates (n=18, median of CV=0.35) and the 2013 Baleen whale estimates (n=3, median of CV=0.30). This may in part result from the fact that almost twice as many Toothed whales stocks were assessed in the 2013 SAR than in the 2012 SAR. The higher precision of the Baleen whale estimates may be attributable, at least in part, to their higher detection probabilities in line-transect surveys.

In terms of stock status, in general the CVs of the 2013 abundance estimates were closer to the desired level (0.3) for strategic (n=13, median of CV=0.32) than non-strategic stocks (n=19, median of CV=0.47). However, after discounting the three outlier points, the range was wider for the strategic stocks (Figure 4). The various factors discussed above may contribute to these differences.

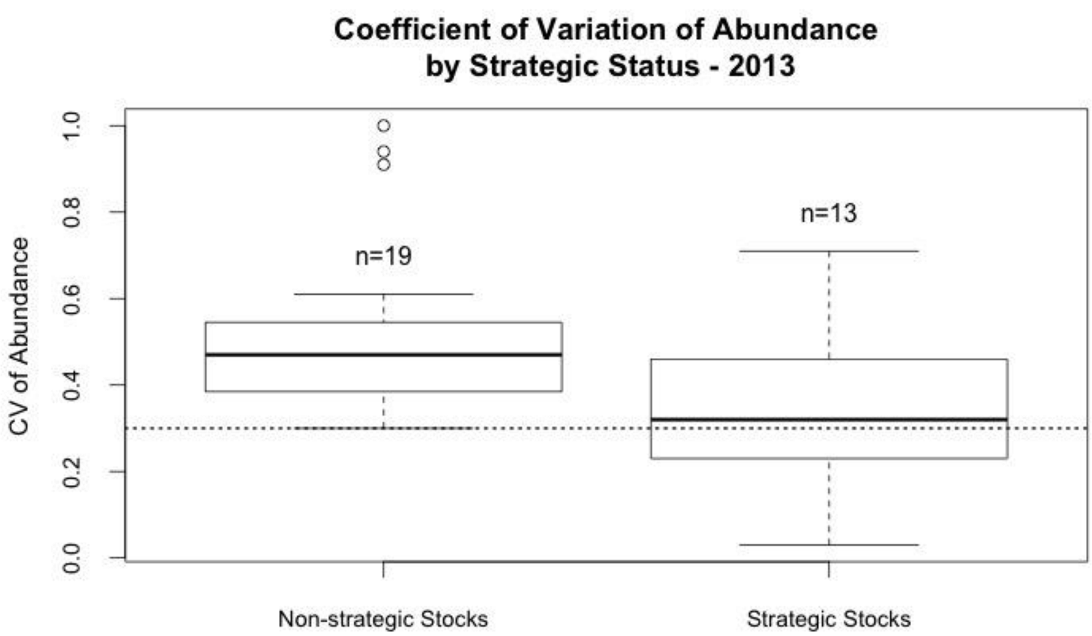

Figure 4 – Coefficients of variation (CVs) of abundance estimates for non-strategic and strategic Atlantic cetacean stocks in 2013 SAR. Number of stocks (n) shown above boxplot. Dashed line indicates level of precision considered desirable by NMFS (CV=0.3). Boxplot elements: 1st and 3rd quartiles (box), 2nd quartile (band), range (whiskers) and outliers (open circles).

To examine differences in abundance estimates between two successive years, we compared abundance estimates in 2012 and 2013 (Figure 5). Most of the stocks for which the estimate declined were bottlenose dolphin (BD) stocks. The largest difference was an increase in the estimates for *Kogia* sp. (pygmy and dwarf sperm whales combined), which presumably was owing to changes in survey data used (e.g. an additional survey from North Carolina to central Florida was included in the 2013 SAR) rather than to actual changes in the numbers of animals in these whale populations. The declines in estimates of at least some of the BD stocks may also reflect annual changes in which of the surveys were used to calculate PBR, the requirement to discard survey results older than 8 years, the use of different sampling methods, or differences in the areas surveyed, rather than actual changes in abundance.

For example, the substantial reduction in the best estimate for the Southern North Carolina Estuarine System BD stock (Figure 5, BD-S.NC.est) from 1,614 in the 2012 SAR to 188 in the 2013 SAR is attributable to the use of 2006 mark-recapture surveys in the 2013 SAR in contrast to the use of a summer 2002 aerial line-transect survey in the 2012 SAR. While the 2013 estimate was considered a likely underestimate because the 2006 surveys excluded part of the stock's range (i.e. between 1km and 3km of the shore), the 2012 estimate was considered a likely overestimate due to the probable overlap of the 2002 survey coverage with the range of the Southern Migratory Coastal BD stock.

Conversely, the best estimate for the short-beaked common dolphin stock (Figure 5, SB) increased from 67,191 in the 2012 SAR to 173,486 in the 2013 SAR. The difference is explained by the fact that the 2013 estimate was derived from a Canadian aerial survey of waters from northern Labrador to the Scotian Shelf in July-August 2007 and the 2012 estimate was based on a NMFS aerial and shipboard survey program covering waters between central Virginia and the lower Bay of Fundy in June-August 2011, and the 2007 Canadian survey was considered to have covered a larger proportion of the stock's total range than the 2011 NMFS survey program (Waring et al., 2014).

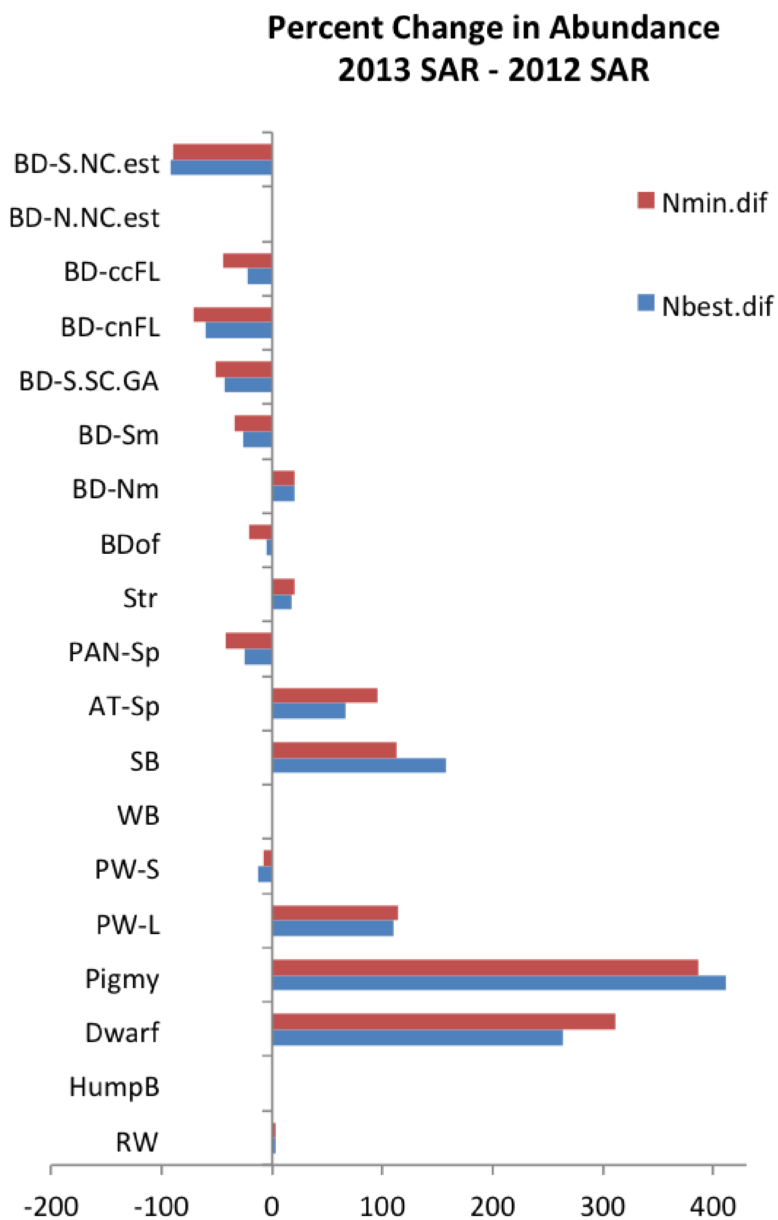

Figure 5 – Comparison of minimum abundance (N_{min}) (red) and point abundance (blue) estimates for Atlantic stocks from 2012 SAR and 2013 SAR. Positive and negative values refer to an increase and a decrease, respectively, in 2013 SAR relative to 2012 SAR. Minimum abundance is calculated as $N_{min} = N/\exp(0.842 * (\ln(1+CV(N)^2))^{1/2})$, where N is the abundance estimate and CV(N) is the coefficient of variation of the abundance estimate.

S=Southern; N=Northern; FL=Florida; GA=Georgia; NC=North Carolina; SC=South Carolina; est=estuarine system; ccFL= central FL coastal; cnFL= northern FL coastal; Sm = Southern migratory coastal; Nm = Northern migratory coastal; of=offshore; BD = Bottlenose dolphin; Str = Striped dolphin; PAN-Sp = Pantropical spotted dolphin; AT-Sp = Atlantic spotted dolphin; SB=Short beaked common dolphin; WB= White beaked dolphin; PW-S = Short-finned pilot whale; PW-L=Long-finned pilot whale; Pygmy=Pygmy sperm whale; Dwarf= Dwarf sperm whale; HumpB= Humpback whale; RW= North Atlantic right whale.

2.4.2. Maximum Productivity Rate (R_{max}) and Recovery Factor (F_r)

For most Atlantic stocks (96%) the Maximum Productivity Rate (R_{max}) is set as a default value depending on whether the stock is cetacean (default=0.04) or pinniped (default=0.12) (Table I). Only two stocks have non-default R_{max} values: the humpback whale (0.065) and the harbor porpoise (0.046) stocks.

Recovery Factor (F_r) values can range between 0.1 and 1.0. Stocks that are classified as endangered or depleted are assigned an F_r of 0.1. Stocks classified as threatened and stocks with unknown status are assigned an F_r of 0.5. Stocks considered to be within OSP can be assigned an F_r of 1.

The F_r is set as a default value for 90% of the Atlantic stocks (Table I). The F_r for all Baleen whale stocks, except the minke whale stock, is set at 0.1. This is because all baleen whale stocks (with the one exception) are listed as endangered or depleted. The F_r for 95% of the Toothed cetacean stocks is set at 0.5. For the four Pinniped stocks, the F_r varies between 0.5 and 1, with half of the stocks set as 1.

2.4.3. Fisheries Classification and Fisheries-Related Mortality and Serious Injury (M/SI)

Currently in the Atlantic, four fisheries are classified as Category I and 19 as Category II, totaling 23 fisheries, including seven classified by analogy (LOF, 2014). Table II lists fisheries with documented M/SI at Category I and II levels and specifies the marine mammal stocks driving their classification, excluding those fisheries classified by analogy. BD stocks are the dominant drivers of Category II classifications and of Category I and II classifications generally.

From 2007 to 2011, the fisheries that interacted with the largest number of small-cetacean stocks were the NE and Mid-Atlantic bottom trawl fisheries (Table III). In terms of mean estimated mortality for cetaceans, which consist primarily of Toothed cetacean stocks, the highest impact fisheries were the NE gillnet (mean=134, S.D.=209.5) and Mid-Atlantic gillnet (mean=72, S.D.=111.2) fisheries (Figure 6). However, it should be noted that observer coverage and the CVs of the estimates of mortality vary markedly among fisheries, between years, and across stocks.

Table II

Category I and II fisheries in the U.S. Atlantic waters and marine mammal stocks driving the fishery classification based on M/SI levels relative to the stock's PBR (LOF, 2014).

Category	Fishery	Stocks driving fishery classification[1]
I	Mid-Atlantic gillnet	4 Bottlenose dolphin stocks: Northern & Southern migratory coastal stocks; Northern & Southern NC est.
I	Northeast sink gillnet	Harbor Porpoise Gulf of Maine/Bay of Fundy
I	Northeast/Mid-Atlantic American lobster trap/pot	North Atlantic Right whale, WNA
I	Atlantic Ocean large pelagics longline	Long-finned and Short-finned pilot whale, WNA
II	Mid-Atlantic mid-water trawl	White-sided dolphin, WNA
II	Northeast mid-water trawl	Long-finned and Short-finned pilot whale, WNA
II	Mid-Atlantic bottom trawl	4 stocks: Common dolphin; Long-finned and Short-finned pilot whale; Risso's dolphin, WNA
II	Northeast bottom trawl	White-sided dolphin, WNA
II	NC inshore gillnet	2 Bottlenose dolphin stocks: Northern & Southern NC est.
II	Southeastern U.S. Atlantic shark gillnet	Bottlenose dolphin, Central FL coastal
II	Southeastern U.S. Atlantic shrimp trawl	Bottlenose dolphin, SC/GA coastal
II	Atlantic blue crab trap/pot	12 Bottlenose dolphin stocks: Northern & Southern migratory coastal stocks; Northern & Southern NC est.; Southern GA est.; Northern GA/Southern SC est.; SC/GA coastal; Northern & Central FL; Charleston est.; Indian Rv. Lagoon est.; Jacksonville est. 1 West Indian manatee stock, FL
II	Mid-Atlantic haul/beach seine	3 Bottlenose dolphin stocks: Northern & Southern Migratory coastal; Northern NC est.
II	NC long haul seine	Bottlenose dolphin, Northern NC est.
II	NC roe mullet stop net	Bottlenose dolphin, Northern Migratory coastal
II	VA pound net	2 Bottlenose dolphin stocks: Southern Migratory coastal; Southern NC est.

[1]Category I: M/SI ≥ 50% PBR; Category II: 1% PBR < M/SI < 50% PBR

Table III

Species of small cetaceans reported to have experienced M/SI from 2007 to 2011 in U.S. Atlantic fisheries with observer coverage (2013 SAR). Hp = Harbor porpoise, Ws = Atlantic white-sided dolphin, Sb = Short-beaked common dolphin, Pw L = Long-finned pilot whale, Pw S = Short-finned pilot whale, R = Risso's dolphin, BDoff = Offshore bottlenose dolphin, Mw = Minke whale.

Category	Fishery	Hp	Ws	Sb	Pw L,S	R	BDoff	Mw
I	Pelagic longline			x	Pw S	x	x	
I	Mid-Atlantic gillnet	x		x		x		
I	Northeast gillnet	x	x	x	Pw			
II	Mid-Atlantic mid-water trawl		x	x	Pw LS	x		
II	Northeast mid-water trawl			x	Pw LS			
II	Mid-Atlantic bottom trawl		x	x	Pw LS	x	x	
II	Northeast bottom trawl	x	x	x	Pw LS	x	x	x

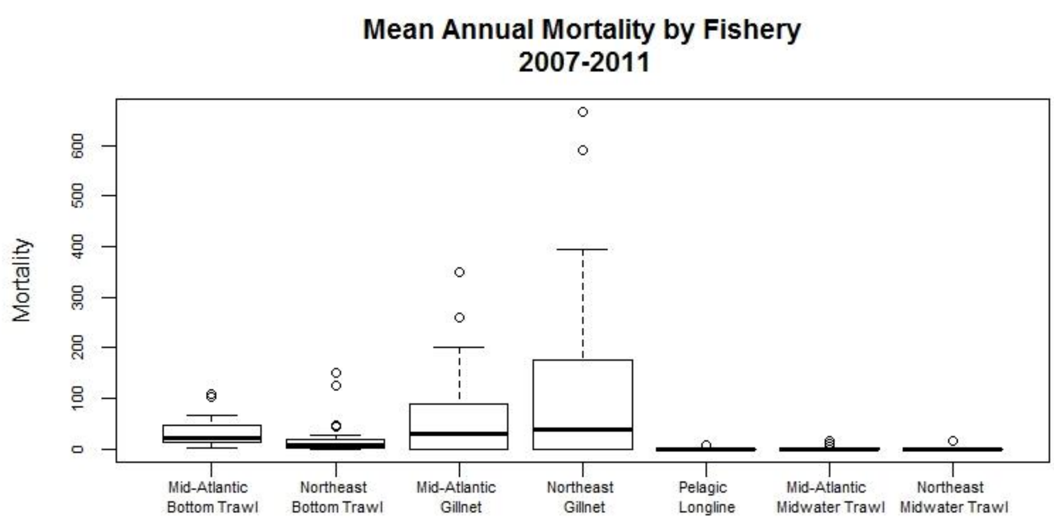

Figure 6 – Estimated mean annual mortality of Atlantic cetaceans from 2007 to 2011 (2013 SAR) by U.S. observed fisheries. Each observation is a species-year mortality estimate. Species composition may vary by fishery.

From 2007 to 2011, the overall mean observer coverage for this group of fisheries was approximately 12% (Figure 7). The fisheries with the highest number of years at or above the overall mean observer coverage were the NE and Mid-Atlantic midwater trawl fisheries. Considering that these two Category II fisheries are of less concern than the Category I longline and gillnet fisheries, but the latter have substantially lower observer coverage, a re-examination of the allocation of observer effort to fisheries in this region may be warranted. However, such a re-examination must take into account that the observer allocation for the New England and mid-Atlantic fisheries is determined primarily by the Standardized Bycatch Reporting Methodology (SBRM) Omnibus Amendment to monitor discards of fish and invertebrate species (Wigley et al., 2014). Marine mammal bycatch monitoring plays no role in the SBRM observer allocation process. Observer coverage dedicated to marine mammals bycatch monitoring is applied solely to the New England and mid-Atlantic gillnet fisheries. For example, in the 2007 fiscal year, NMFS determined that approximately 57,000 sea days were required to achieve a 30% precision in bycatch estimates of several marine mammal species. However, funding only supported 1.4% of the total observer effort (sea days) required (Rossman, 2007).

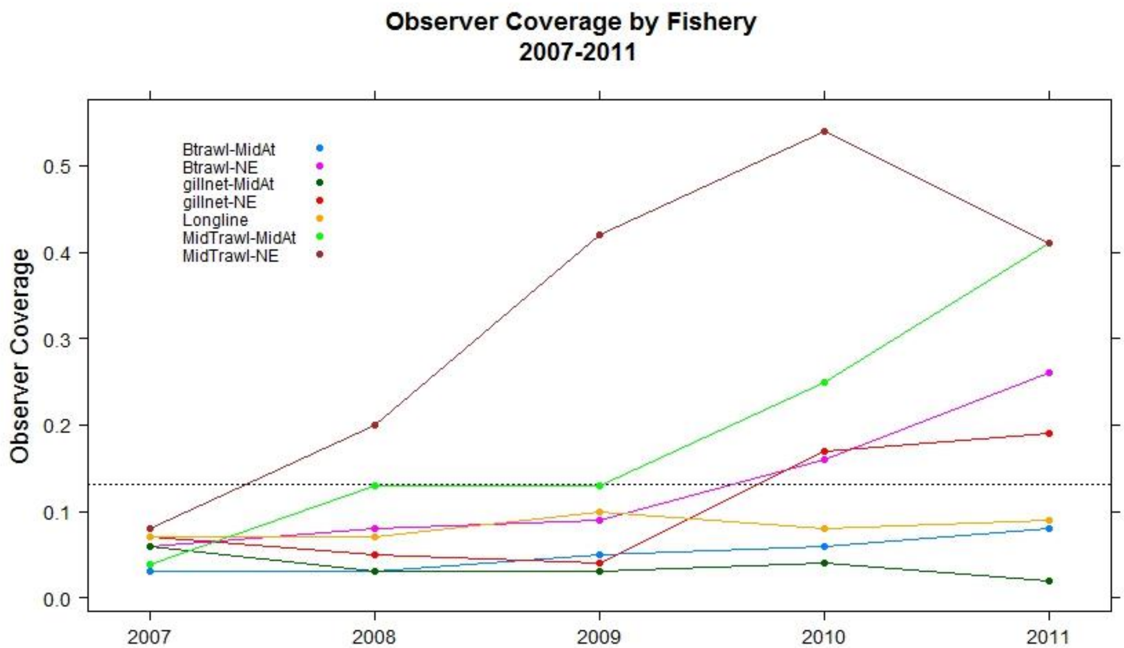

Figure 7 – Observer coverage for observed U.S. fisheries in the Atlantic from 2007 to 2011 (2013 SAR). Dashed line indicates overall mean (0.12). Btrawl=Bottom trawl, MidTrawl=Midwater trawl, MidAt=Mid-Atlantic, NE=Northeast.

For the same period (2007-2011), the mean CV of mortality, computed from yearly CV estimates of bycaught species, varied between 0.32 (Mid-Atlantic bottom trawl) and 1 (longline), and the average of all fisheries was 0.55 (Figure 8). Only the mid-Atlantic bottom trawl (4 estimates with a CV below or equal 0.3), Northeast bottom trawl (4 estimates) and Northeast gillnet (3 estimates) fisheries had any mortality estimates with CVs satisfying NMFS's generally considered desirable level of precision of 0.30 or less (GAO, 2008). The smallest variation in CV occurred in the longline and NE mid-water trawl fisheries, followed by the Mid-Atlantic bottom trawl fisheries. The lack of variation in the longline and NE mid-water trawl fisheries is obviously attributable to the fact that each of these fisheries had only one instance of non-zero mortality during this 5-year period. Gillnet fisheries showed the highest CV variation, ranging between 0.2 and 0.94

in the NE and between 0.41 and 1.03 in the Mid-Atlantic. The higher CVs in some fisheries may be associated with species that are rarely bycaught.

Of all the Toothed cetacean stocks in the Atlantic, the harbor porpoise had the highest estimated mean annual total fishery-related M/SI from 2007 to 2011, by far (709 individuals). It was followed by the short-beaked common dolphin and the short-finned pilot whale (170 and 162 individuals, respectively) (Figure 9). The estimated M/SI levels for harbor porpoise, short-finned pilot whale, and Northern NC bottlenose dolphin stocks exceeded their PBR levels by up to three individuals (Figure 9).

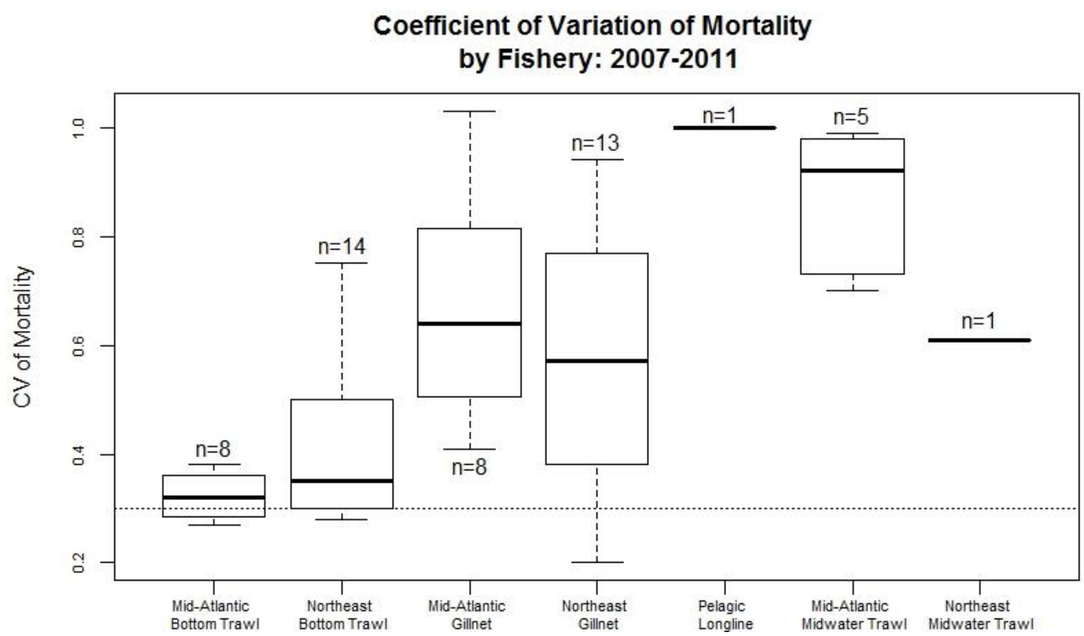

Figure 8 – Coefficients of Variation (CV) of mortality estimates for Atlantic cetacean stocks from 2007 to 2011 (2013 SAR). Dashed line indicates level of precision considered desirable by NMFS (CV=0.3). Sample size (n) indicates number of mortality estimates (species-year estimate) with CV values, where n=1, only one instance of non-zero mortality was recorded.

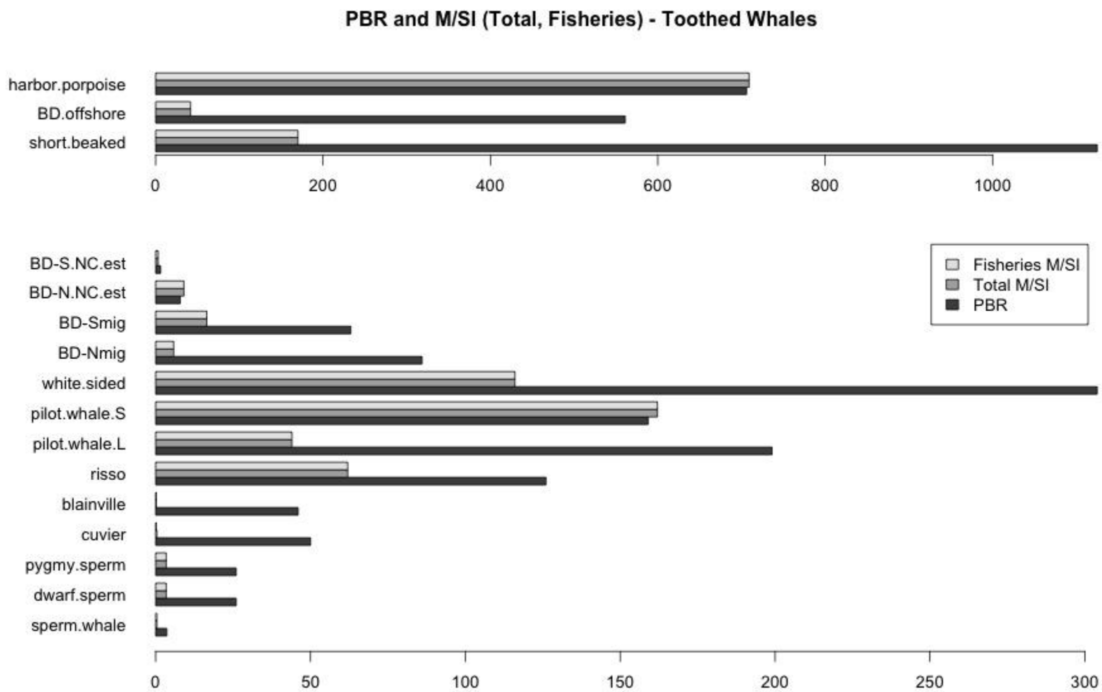

Figure 9 – Total mortality and serious injury (M/SI) and fishery-related M/SI averaged from 2007-2011, and 2013 PBR for Atlantic Toothed cetacean stocks (2013 SAR). For stocks where a M/SI range was provided, only the upper estimate is shown. BD = Bottlenose dolphin, S.NC.est = Southern North Carolina estuarine system, N.NC.est = Northern North Carolina estuarine system, Smig = Southern migratory coastal, Nmig = Northern migratory coastal, Pilot.whale.S = Short-finned pilot whale, Pilot.whale.L = Long-finned pilot whale.

For the Atlantic Baleen whale stocks, the highest fishery-related M/SI value was for the humpback whale (approximately 10 individuals either killed or seriously injured as a result of fishery interactions), followed by the minke whale (6.85 individuals subject to fishery-related M/SI) (Figure 10). The M/SI levels for three out of the five Baleen whale stocks exceeded their PBR levels. Those for minke whales and fin whales did not exceed PBR. It is important to emphasize that the M/SI values for Baleen whale stocks are based on counts of observed animals (injured or dead) and are not estimates of total serious injury and mortality. Cryptic (unobserved) injury and mortality of baleen whales is recognized as an issue that should be addressed in some way (possibly by applying new methodology) rather than continuing to be ignored in assessments.

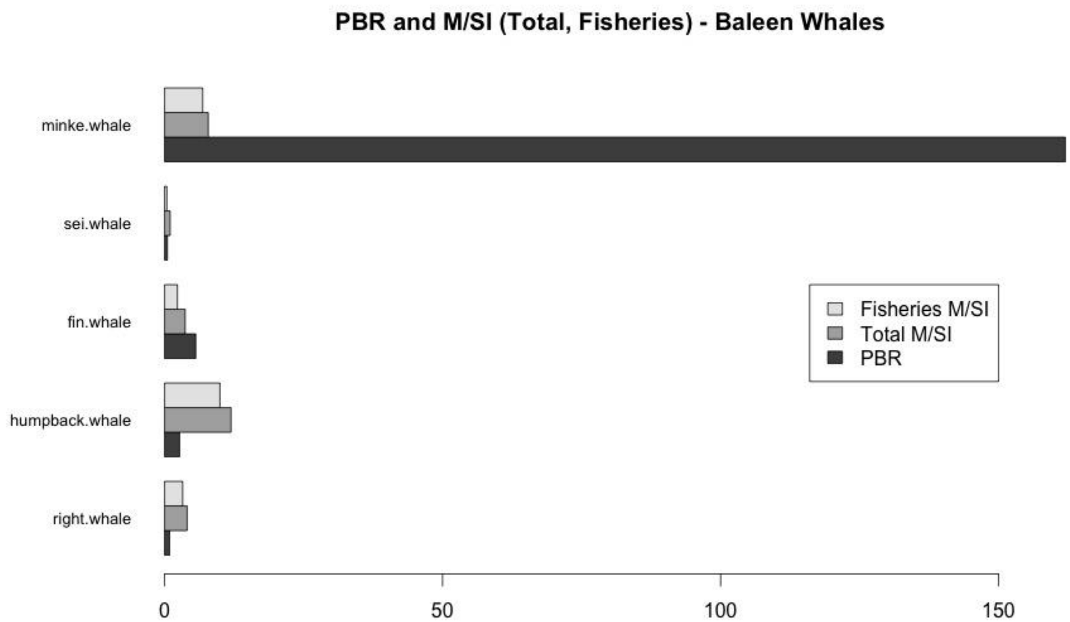

Figure 10 – Mean annual total mortality and serious injury (M/SI) and fishery-related M/SI estimates for Atlantic Baleen whale stocks from 2007 to 2011. The stocks' PBRs in 2013 SAR are also shown. For stocks where a M/SI range was provided, only the upper estimate is shown.

3. Milestones and Timeline

Milestones for Phase 1 (Figure 11) were designed to achieve three main project goals: (1) Establish the IAT; (2) Review and observe the SRG and TRT processes; (3) Develop recommendations to the SCeMFiS's science agenda identifying research/monitoring needs and opportunities. This phase focused on the Atlantic region.

The initial stages of the project involved identifying and reviewing literature related to the assessment of marine mammal populations, including estimation of M/SI caused by human activities, in particular commercial fishing. In addition, a questionnaire was developed and circulated to SCeMFiS members to help prioritize the marine mammal assessment issues of concern to SCeMFiS and to identify the kinds of expertise needed from the IAT. Following NSF IUCRC guidelines, SCeMFiS appointed an industry liaison (Greg DiDomenico, GSSA) for the IAT project.

The IAT was assembled at the end of January 2014. At this time, an introductory letter was circulated to various entities and groups, such as NMFS Headquarters and Science Centers, Atlantic Scientific Review Group, National SRG Coordinator, National TRT Coordinator, and Mid-Atlantic Regional Fisheries Management Council. This letter (see Appendix) described the IAT and its goals, and requested that this information be disseminated to other potentially interested officials and scientists, emphasizing the IAT's desire to address stock assessment challenges in a collaborative manner. The IAT project was also introduced at the Mid-Atlantic Fisheries Council meeting in Annapolis, Maryland (December 10, 2013) and to a wider audience through the Gulf Coast Research Laboratory e-newsletter (http://www.usm.edu/gcrl/public/gcrl.news).

Several members of the IAT attended the Atlantic SRG (ASRG) meeting (February 5-7, Woods Hole) to gain a better understanding of challenges associated with marine mammal assessments in the Atlantic, to introduce the IAT, and to try to foster collaborations. The minutes of the meeting can be found at http://www.nmfs.noaa.gov/pr/sars/pdf/atlantic_srg_feb2014_minutes.pdf. The ASRG offered to advise the IAT on research needs.

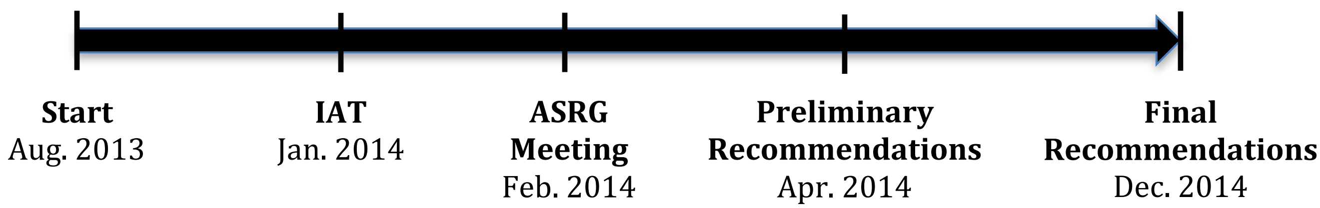

Figure 11 – Milestones in Phase I.

At the IAT's request, NEFSC scientists participated in several small side meetings with the IAT during the ASRG meeting to help identify the technical aspects of stock assessments that the team might investigate, in particular to help prioritize areas of research that would advance the NEFSC's own stock assessment work. Similar meetings, both formal and informal, were held with staff of the MMC, who offered a broad, national-level overview of research and management priorities.

The IAT presented preliminary recommendations to SCeMFiS on April 30, 2014. A proposal aimed at developing a tier PBR system was introduced in preliminary form at the meeting and was developed further afterward. The project will identify scenarios (e.g. data-poor and data-rich stocks) and carry out performance testing within a Management Strategy Evaluation (MSE) framework (see Appendix).

4. Potential Areas for Research

Several potential areas for research with implications for the stock assessment process were identified during Phase I, as summarized briefly below. These are in addition to the MSE/PBR project that was launched during Phase I. During Phase II, the IAT will examine these potential additional areas for research and determine whether and how the team might be able to address them. Some of these topics have undergone preliminary examination during Phase I (as time allowed), and initial descriptions are provided here.

4.1. Stock Identification

Stock identification is a key area of ongoing research. Determining how to define and evaluate "units to conserve" is a major facet of scientific effort within NMFS (e.g.

Taylor, 2005) and also within the International Whaling Commission's Scientific Committee (e.g. IWC, 2014).

In many instances, the currently recognized stock structure is effectively a series of working hypotheses, pending resolution of substantial uncertainty. Everyone involved in stock assessment – scientists, stakeholders, and decision makers – understands that stock identification can have a major bearing on the perceived status of the stocks and hence on management decisions.

The IAT has not attempted to develop any specific projects in this area largely because its primary expertise does not lie in the realm of genetics, but rather marine mammal ecology and the quantitative analysis of population dynamics. However, the MSE framework developed as part of the PBR project (see Appendix) could be extended to address implications of errors in the placement of stock boundaries (e.g. Taylor, 1997; Taylor et al., 2000; Martien et al., 2013). In addition, population-habitat modeling (Hedley et al., 1999; Thomas et al., 2010; Forney et al., 2012) may be a worthwhile approach to complement genetic, morphological, satellite tracking, photo-identification, and other types of studies to assess the ecological scales at which shifts in range occur, potentially leading to changes in stock boundaries. These possibilities may be considered in Phase II.

4.2. Abundance Estimation

Assessments of marine mammal stocks and calculations of Potential Biological Removal levels depend critically on estimates of abundance. Techniques such as shipboard and aerial surveys can be used to obtain data from which to estimate the absolute size of a population. However, the data from these techniques are always subject to uncertainty for various reasons, e.g. small population sizes, patchy distributions, small numbers of observations (sample sizes), and the fact that populations often occur in multiple jurisdictions ("shared stocks"). The IAT has identified the following general areas which could lead to improved abundance estimation and in turn provide a stronger basis for conducting assessments and setting PBR:

- Assessing the feasibility of using data obtained with the benefit of new technologies, such as: imagery from remote sensing devices, data obtained from gliders, drones, etc.
- Adjusting survey designs (e.g. spatial or temporal allocation of effort) such that the resulting information on abundance and trends is of maximum value in setting PBR and hence achieving the goals of the MMPA.

The IAT has not attempted to develop any specific projects in this area. However, the PBR project (see Appendix) will provide a basis to further evaluate management implications related to balancing survey frequency versus survey precision (e.g. many surveys with high CVs versus few surveys with low CVs), as well as the consequences of surveys not covering the full geographic range of a stock. This issue was evaluated previously by Wade (1998).

4.3. Calculating PBR

Calculating the PBR is a key element of the marine mammal conservation framework under the MMPA. The PBR formula depends on three quantities: the minimum population estimate (N_{min}), the maximum theoretical or estimated net productivity rate (R_{max}), and the recovery factor (F_r) (Section 2.1). Each of these parameters is subject to error to varying degrees in any given situation, although default approaches have been provided for setting R_{max} and F_r. The PBR formula was developed to achieve specified management objectives, accounting for several sources of uncertainty. It has not been possible to apply the PBR formula for all marine mammal stocks because required abundance estimates are lacking. Section 2.3 lists some of the uncertainties that hamper setting PBR. The IAT has evaluated these uncertainties and identified the following research areas that could lead to an improved basis for calculating PBR.

1. How can surveys be designed to more precisely estimate abundance, particularly for stocks which have significant interactions with fisheries, such as high rates of M/SI (see Section 4.4 for additional discussion)?
2. Can meta-analysis be used to estimate values of R_{max} for groups of species for which sufficient data are available? The availability of estimates of R_{max} for groups of species would mean that a more fine-scaled array of R_{max} default values could be applied when setting the PBR.
3. Can data sources other than estimates of abundance be used to set PBR? It is very unusual to have estimates of absolute abundance when conducting fishery assessments so fishery assessments and control rules are often based on other quantities, such as indices of trends in relative abundance.
4. How should cases be handled in which there are indices of relative as well as absolute abundance or multiple estimates of absolute abundance? In general, more precise estimates of recent abundance can be obtained by averaging estimates, accounting for trends.
5. How can more of the available data (e.g. on trends in abundance) be used to achieve the conservation goals of the MMPA while at the same time ensuring correct classification of fisheries? In other words, with additional information that has not been used to date, are there solutions that would come closer than the current approach to minimizing the risks of both under-protection and over-protection of marine mammals?
6. How should cases be handled in which data are old (i.e. no estimate of abundance for a number of years)?
7. Could an estimation framework be developed which calculates PBR based on fitting population models, as is common in fisheries management? A precedent for this is the International Whaling Commission's Revised Management Procedure (RMP) which is based on a simple population dynamics model. However, unlike the RMP, model-based estimates in the PBR framework would be designed to achieve the conservation goals of the MMPA rather than the management objectives of the IWC.
8. How should cases be handled in which a marine mammal population is transboundary and anthropogenic removals occur in multiple jurisdictions?
9. Can a case-specific PBR formula be developed?

The IAT prepared a research proposal (see Appendix) for developing a tier system for setting PBR based on four tiers. That proposal forms a basis to address research areas 4, 5, and 6 above and may, with additional funding, also provide an approach for addressing research area 7. The proposed PBR study has been funded by the Western Pacific Regional Fishery Management Council (WPFMC).

The IAT plans to work with NMFS and stakeholder groups during Phase II to examine the feasibility of developing proposals related to research areas 1, 2, 3, and 7. It will develop such proposals if a cost-effective research program can be devised to address these areas. We have begun the process of identifying and evaluating candidate species or species groups for which sufficient data might be available to support a meta-analysis (research area 2). In relation to research area 7, a model-based assessment of false killer whales has been developed by Hilborn and Ishizaki (2013) and presented to the WPFMC, but how this could be used to calculate PBR, and whether PBR calculated from model-based assessments would achieve the goals of the MMPA have yet to be studied. The framework being developed as part of the IAT's currently funded PBR project could be used to evaluate model-based control rules. A proposal to develop a model-based estimation framework for PBR would also start to address research area 9. It is already well known that control rules developed taking account of case-specific uncertainty are likely to outperform generic approaches such as the generic PBR formula. However, whether this will prove true within the MMPA's conservation framework would need to be explored and tested as part of a targeted research project.

In its Priorities Report to NMFS (MMC, 2014b, p. 20), the MMC urged the agency to prioritize stock assessments of MMs starting, for example, with "cases for which there are known or suspected threats, and then focusing on stocks with outdated, little, or no previous abundance and trend data – recognizing and addressing the challenges and expenses of assessing offshore stocks, cryptic species, and those in remote… areas." It is in keeping with this kind of advice that the IAT plans to develop and test a tier system for MM stock assessment.

4.4. Estimation of Fisheries-Related Mortality and Serious Injury

In general, the largest fraction of human-caused MM mortality (herein "mortality" subsumes both deaths and serious injuries) is attributed to incidental mortality caused by fisheries. Estimation of fishery-specific mortality for each MM stock is an essential component of stock assessment. However, the number and intensity of observer programs are limited, bycatch events tend to be rare, species identification is sometimes imprecise, and aspects of fishing operations change within and between years. Thus, obtaining estimates of fishery-specific mortality for MM stocks is challenging, and estimates often exhibit high variance. The IAT identified the following research as beneficial to improving estimation of fishery-specific mortality:

1. What are the best techniques to estimate the mortality caused by a fishery for which observer coverage is low or non-existent?
2. In the case of passive gear such as gillnets, what are the best proxies for fishing effort when the duration of a fishing event (e.g. soak time for gillnets) is not available?

3. For the fisheries with highest incidental mortality, in particular those that cause removals exceeding PBR level, what are the main sources of variability in the estimates of that mortality?
4. Would risk assessment studies be useful when making decisions about how to allocate observer effort?
5. How can spatial modeling be used to improve either estimates of incidental mortality or the allocation of observer effort, or both?

4.5. Stock Assessment Synthesis

The preliminary summary of stock assessment results initiated here for the Atlantic region could be extended to other regions, and retrospectively to 1994, to further understand how the methods applied to MM stock assessment have changed over time and with them, the assessment outcomes. Such a broader synthesis might provide useful insights into: 1) variation in PBR over time, 2) feasibility of trend analysis, and 3) factors responsible for uncertainty associated with estimates of abundance and mortality.

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APPENDIX

Abbreviations and Acronyms

AMAPPS	Atlantic Marine Assessment Program for Protected Species
ASRG	Atlantic Scientific Review Group
BD	Bottlenose dolphins
CV	Coefficient of Variation (a statistical measure of uncertainty)
ESA	Endangered Species Act
GAMMS	Guidelines for Assessing Marine Mammal Stocks
GAO	Government Accountability Office
GSSA	Garden State Seafood Association
IAT	Independent Advisory Team
I/UCRC	Industry and University Cooperative Research program
IWC	International Whaling Commission
LOF	List of Fisheries
MM	Marine Mammal(s)
MMC	Marine Mammal Commission
MMPA	Marine Mammal Protection Act
MSE	Management Strategy Evaluation
M/SI	Mortality/Serious Injury
NEFSC	Northeast Fisheries Science Center
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
OSP	Optimum Sustainable Population

PBR	Potential Biological Removal
RMP	Revised Management Procedure
SAR	Stock Assessment Report
SBRM	Standardized Bycatch Reporting Methodology
SCeMFiS	Science Center for Marine Fisheries
SRG	Scientific Review Group
TRP	Take Reduction Plan
TRT	Take Reduction Team
USFWS	United States Fish and Wildlife Service
WPFMC	Western Pacific Fishery Management Council
ZMRG	Zero Mortality Rate Goal

Mr. Douglas P. Nowacek
Atlantic Scientific Review Group, Chair

January 27, 2014

Dear Dr. Nowacek and Members of the ASRG,

I am pleased to advise you of the recent launch of a new marine mammal research project dedicated to understanding and helping address some of the technical challenges of estimating stock assessment parameters as required under the Marine Mammal Protection Act. This project, along with several other research endeavors, is being conducted through the Science Center for Marine Fisheries (SCeMFiS[1]), which was established recently under a National Science Foundation I/UCRC (Industry/University Cooperative Research Center[2]) initiative to promote research on fisheries sustainability.

The first step was to assemble a group of researchers that combines expertise in marine mammal biology, stock assessment, survey techniques, population and ecological modeling, and approaches to estimation and mitigation of marine mammal interactions with fisheries. This team, called the Independent Advisory Team (IAT) for Marine Mammal Assessments, consists of Dr. André Punt (University of Washington), Dr. Randall Reeves (Okapi Wildlife Associates), Dr. John Brandon, and myself. We have been tasked with formulating research recommendations to SCeMFiS, with an initial focus on marine mammal stocks in northwest Atlantic waters. In developing our recommendations, we will consider state-of-the-art research methods applied to marine mammal populations (and other wild populations) and fisheries worldwide.

Members of our team will attend the Atlantic Scientific Review Group annual meeting scheduled for February 5-7, 2014 in Woods Hole, as we seek to strengthen our understanding of major technical challenges to assessing marine mammal stocks and quantifying interactions with fisheries.

We recognize that despite the many challenges of accurately and precisely estimating the relevant parameters for these highly mobile animals, and despite the fact that fisheries dynamics add another layer of complexity, stock assessment scientists have made significant progress in this area. More and better data are becoming available, and ongoing developments in ecological and population modeling offer possibilities for improved assessments of marine mammal stocks and fisheries interactions. Ultimately, a goal of our research is to inform management decisions that consider the dual objectives of decreasing fishery interactions with marine mammals while maintaining sustainable fishing opportunities.

[1] http://scemfis.org
[2] www.nsf.gov/eng/iucrc

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We welcome any opportunities for collaboration that could enhance our ability to make a modest contribution and help to advance technical aspects of stock assessment and the management of marine mammal-fisheries interactions. We would appreciate your help in disseminating this information to your colleagues involved in related work. We are available to participate in relevant activities, such as conferences, workshops, and meetings, particularly with regard to stock assessment of marine mammals in the U.S. Atlantic.

I'm available to assist with any questions or comments you may have for our team.

Sincerely,

Paula Moreno

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Project Overview:

DEVELOPMENT AND TESTING OF A TIER SYSTEM FOR APPLICATION TO PBR

Paula Moreno, André Punt, John Brandon, Randall Reeves
Independent Advisory Team for Marine Mammal Assessments

Background:

Interaction with fisheries is the primary human-related source of serious injury or mortality (SI/M) identified for marine mammal (MM) stocks in U.S. waters. Determination of Potential Biological Removal (PBR) levels and estimation of SI/M levels are central to the MM conservation framework established under the MMPA. PBR determines the maximum allowable human-caused removals from a stock. PBR, combined with estimated SI/M, is used to classify MM stocks as strategic or nonstrategic, and fisheries as Category I, II, etc. Take Reduction Plans to reduce bycatch through modification of fishing practices are required when Category I and II fisheries interact with stocks classified as strategic. In 2008, the Government Accountability Office concluded that data limitations "make it difficult for NMFS to accurately determine which marine mammal stocks meet the statutory requirements for establishing take reduction teams". The PBR formulation was designed to achieve specified conservation targets with high probability. For a given stock, PBR is expected to decrease as the uncertainty associated with abundance increases, all else being equal. The current guidelines to estimate parameters for determining the PBR (NMFS, 2005) do not provide a basis for incorporating multiple measures of abundance (including relative and absolute estimates obtained from different survey types) in stock assessment, and in that sense there may be cases where the full use of available data and information is lacking. Recently, some alternative approaches have been proposed (e.g., Moore & Merrick, 2011), and some approaches are in place such as averaging abundance estimates and SI/M over time (NMFS, 2005). Nevertheless, there has been no formal, comprehensive or comparative evaluation of these methodologies and their alternatives. The lack of such an evaluation precludes or delays the implementation of standardized methodologies to improve accuracy and precision of estimates used to determine the PBR. We propose to conduct a formal evaluation of the robustness of alternative approaches. Robustness is defined as achieving the objectives for MM stocks in the U.S. by maximizing the use of available data and reducing uncertainty. For this evaluation, we will develop a tiered PBR system and test it using a Management Strategy Evaluation (MSE). A tiered system should make better use of existing information by incorporating the best available information for each stock, which could mean drawing on more data than are currently used to set PBR for data-rich cases, and exploiting novel alternative sources and analytical approaches to set PBR for data-poor stocks.

Methods:

The Tiered System

The MSE approach is widely used within the U.S. and elsewhere to evaluate the robustness of management strategies given scientific uncertainties (e.g. Punt *et al.*, 2012). Also common in fisheries management is the use of tiered systems of Harvest Control Rules (HCRs), analogous to PBR in terms of setting a limit on removals, where each tier reflects the amount of information available for the stock in question (e.g., NPFMC, 2008; PFMC 2011). The tiered system to be developed and tested within this project would consist of four tiers: Tier 1, where trends in abundance can be estimated; Tier 2, where multiple abundance estimates are available but trends cannot be estimated reliably; Tier 3, where a single estimate of abundance is available; Tier 4, where only data on relative abundance are available. The performance of this framework, consisting of different estimation techniques to cope with data-poor, -moderate and -rich stocks, would be compared to that of the current approach for calculating PBR.

Testing Framework

MSE involves three key steps: (a) development of a model (referred to as the operating model) which represents the system being managed, (b) identification of candidate management strategies (in this case features of the proposed tiered system such as how historical abundance estimates are weighted, how trends are estimated, and whether abundance data older than 8 years are used), and (c) evaluation, using simulation, of the candidate management strategies. A more diverse set of scenarios would be explored than previously (Wade, 1998), consistent with more recent applications of MSE to marine mammals and other long-lived species subject to human-caused mortality (e.g. Curtis and Moore, 2013; IWC 2014a,b). Scenarios would be developed to represent the likely actual situations for several stocks of large and small cetaceans. Selection of case-studies will be achieved by convening scoping meetings with Western Pacific Regional Fishery Management Council staff, National Marine Fisheries Service scientists, and other marine mammal or stock assessment scientists. In selecting case-studies, the primary geographic focus will be on stocks from Hawaiian and Atlantic waters. Other stocks will be considered, if and as necessary to fulfill the requirements of covering a broad range of uncertainty within the MSE operating model.

The operating model would be used to generate the data, given key uncertainties in the observation process. Data generation would include scenarios with incomplete survey coverage, and bias effects due to small sample size when estimating bycatch due to low observer coverage (e.g. Moore, 2011). The values of the parameters for each tier (such as those which define how past abundance estimates are weighted for Tier 2) would be selected to meet management objectives under the MMPA (Wade, 1998; Taylor *et al.* 2000). Other performance metrics suggested by stakeholder groups could also be considered, e.g. minimizing “false positive” error rates that result in classifying stocks as strategic when they are not. Results would be presented for a reference set of specifications for selecting the parameters of the tiered system. In addition, alternative specifications for the operating model could be used to explore the performance of the tiered system when the assumptions on which it is based are violated.

The Team

The team consists of experts with extensive experience in conservation, assessment and management of MM and fish stocks, as well as fisheries-MMs interactions at both the national and international levels. Some members of the team participate in the Scientific Committee of the International Whaling Commission. Drawing upon advanced modeling approaches for fisheries and protected species, the team is well qualified to design and develop a framework that would support science-based decision-making by MM and fisheries managers. The team scientists are: Paula Moreno (University of Southern Mississippi), André Punt (University of Washington), John Brandon (Greeneridge Sciences), and Randall Reeves (Okapi Wildlife Associates).

Significance and Broader Impacts:

The key benefit of using a tiered system is that it would make clearer how the available data can be used to compute PBR. By its nature, a tiered system allows PBR to increase with more and better information, all things being equal, subject to the constraint that the risk associated with human-caused mortality remains constant.

The proposed tiered system would make it possible to evaluate the degree to which increased data collection and expanded monitoring effort can be expected to lead to higher PBRs for the same level of risk, thereby providing a basis to evaluate allocation of resources. For example, the results of the simulations could be used to assess the relative benefits of more frequent but less precise surveys vs less frequent but more precise surveys, as well as the relative benefits of increased on-board observer coverage (and hence lower CVs for bycatch) vs more precise surveys. Given the perpetual limitation on resources to carry out MM surveys, it is imperative to design survey and monitoring schemes that optimize management outcomes.

The MSE framework would be made available as open-source software, thereby allowing a broader group of researchers, including those supported by NOAA (e.g., Regional Fisheries Management Councils), industry, and NGOs, to evaluate alternative tiered systems. This will provide additional transparency and could result in possibly identifying tiered systems that better achieve the goals of managing bycatch while also minimizing adverse impacts on fisheries, as required by the MMPA and NOAA's National Bycatch Strategy. A similar approach was taken in the recent MSE for the northern subpopulation of Pacific sardines where software was made available publicly and several groups, including industry, NGOs, and government advisers, were able to evaluate their own management strategies.

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