Estimating Whaling Catch History

Smith, T.D. and R.R. Reeves

Abstract

Underestimation of historical catches and removals of North Atlantic humpback whales is unlikely to be the explanation for the large differences between estimates of pre-whaling abundance based on genetic variability and those based on estimated levels of historical whaling.

Introduction

The history of whaling has been well described for many regions and for recent centuries, and is known to be complex (*e.g.,* Reeves and Smith, in review). There has long been interest in documenting the historical effects of whaling on whale populations (Tillman and Donovan 1983). More recently, in the context of the IWC Scientific Committee's advisory role for the management of aboriginal and commercial whaling, there has been interest in improving historical estimates of numbers of whales removed by whaling to estimate carrying capacity level as a management reference point, either explicitly as for gray whales (IWC 1993), right whales (IWC 2001), humpback whales (IWC 2002a, 2003) and bowhead whales (IWC 2002b), or implicitly under the RMP as for North Atlantic and Antarctic minke whales (IWC 1994), and more recently for western North Pacific minke whales (IWC 2004). Further, there is increasing interest in assessing the ecological effects of historical whaling removals (Springer et al. 2003; Estes et al. in preparation).

Because of those interests, many types of historical records have been examined for data relevant to estimation of the numbers of whales removed by whaling. The diversity of such sources reflects the fact that they cover many different whaling operations that occurred over hundreds of years and in all oceans of the world. The relevant data can be archeological, anthropological, ethnographic/historical or industrial (e.g., product amounts or value, tallies of individual whales killed) (Reeves and Smith, in review).

Roman and Palumbi (2003) attempted to explain the large differences between their estimates of pre-exploitation whale abundance based on genetic variability data and those of others based on estimated whaling removals, by questioning the reliability of historical whaling records. For example, they stated (p. 508): 'Whaling logbooks provide clues, but may be incomplete, intentionally underreported, or fail to consider whales that were struck and lost'. Subsequently, in response to criticism of their interpretations and analyses, they claimed (Roman and Palumbi 2004): 'No estimate of the number of logbooks that have been lost has been folded into these summations . . .'.

Those and other statements by Roman and Palumbi indicate a fundamental misunderstanding of the nature of sources of historical whaling data and of how such materials have been used to estimate removals. Here, we briefly describe some of the data sources and methods that have been and are being used to reconstruct whaling catch history, particularly that of North Atlantic humpback whales, which were the focus of controversy following the publication of the paper by Roman and Palumbi (2003). We wish to clarify: (a) the nature of the historical sources, (b) the reliability and completeness of catch (removal) estimates derived from those sources and (c) the methodology used to estimate historical abundance from catch data. Further, we comment on the implications of uncertainties surrounding catch (removal) estimates used to generate estimates of pre-exploitation whale abundance.

Nature of the sources and estimates

Estimates of historical whaling removals are based on many sources (e.g. Tillman and Donovan 1983; Mitchell and Reeves 1983; Reeves and Smith, in review). Because of the high value of whaling products, extensive records exist for, e.g. commercial whaling activity, establishment of shore stations, number and duration of voyages, and products landed. In the American ('Yankee') open-boat fishery, vessel departures and arrivals were recorded by customs house officials and were also published in trade newspapers such as the weekly Whalemen's Shipping List (New Bedford), Friend (Honolulu) and Pacific Commercial Advertiser. Nearly complete lists of voyages, including the names of vessels, captains and agents, as well as the characteristics of the vessels, the areas to be whaled and the resulting oil and baleen landings, have been tabulated for the 1800s and early 1900s (e.g. Starbuck 1878; Hegarty 1959; Lund 2001). Similarly, because whale oil was extremely valuable (e.g. Davis et al. 1997), oil export and import records referring to catches at land stations throughout the world were systematically compiled, e.g. by the British Colonial Office (Bluebooks'). In the case of North Atlantic humpback whales, the primary sources of data used for catch

estimation have been published oil returns for individual voyages, logbooks, Bluebooks from British colonies (e.g., West Indies), national industrial catch statistics and reports of individual whales taken (Mitchell and Reeves 1983; Reeves and Smith 2002; Smith and Reeves 2002, 2003a).

A key source, both in its own right and for interpreting some of the data in other sources, is the whaling voyage logbook (Sherman 1965, 1983). Logbooks were kept at sea as part of standard industry procedures in many nations. Vessel managers and owners used them to account for the results of a voyage. Logbooks were not prepared as governmental reports and did not have to be shared with other whalers. The information provided in them, e.g. on where the captains searched for whales and on when and where whales were seen or taken, was valuable for planning future voyages. Further, the data recorded in the logbook could easily be compared against the gauged amount of oil landed, a procedure that would have revealed inconsistencies or misreporting. Private journals kept by crew members can provide data similar to that found in logbooks (Sherman 1965), and they have been used, when available, to supplement the information obtained from logbooks (hereafter we make no distinction between the two types of sources, referring to both as 'logbooks').

The numbers of whales secured according to logbooks have been shown to be generally consistent with quantities of oil (barrels) landed. Ross (1974) and Best (1987) both reported broad consistency in the 1800s between estimates of numbers of whales caught based on average oil yield per voyage using data extracted from customs house records and those based on average numbers of whales reported per voyage using data from logbooks. On a finer scale, and specifically in the case of North Atlantic humpback whales, Mitchell and Reeves (1983, p188) noted the similarity of the average barrels of oil per whale for a sample of 47 whales reported in logbooks (24 barrels per whale) to the ratio formed by dividing the total oil returns (reported to the customs houses) for 11 voyages by the number of humpback whales landed (reported in logbooks) during those same voyages (25 barrels per whale).

Contrary to the suggestion by Roman and Palumbi (2003; see above), the keepers of logbooks had no incentive and little latitude to underreport catches, and the available evidence indicates that 19th century logbook data were not strategically altered in response to management measures as has been the case with some 20th century catch records (e.g. Yablokov 1994 for Soviet Union; Kasuya 1999 and Kondo 2002 for Japanese shore stations). In fact, the crew's pay was based on the results of the voyage and in some episodes of the British whale fishery; bounties were based on the amounts of oil landed. Therefore, all crew members were presumably interested in ensuring that the catch was not under-reported.

Logbooks ideally include daily records of vessel location and of locations where whales were sighted, chased, struck, landed or lost. Most logbooks routinely include the species of whale encountered (either explicitly or implicitly) and some also include reference to the sex and size of whales taken and/or the barrels of oil and amount of whalebone (baleen) obtained from at least some of the whales secured. Such information has been widely used to estimate rates at which whales were lost after having been struck, the sex and size composition of the catch and the average yield of oil per whale caught (Bannister et al. 1981; Mitchell and Reeves 1983; Hope and Whitehead 1991; Reeves and Cosens 2003). In the case of North Atlantic humpbacks, we used estimates of such quantities from samples of logbooks to estimate numbers of whales removed by sex and size, starting from the 17th century when humpback whaling began in Bermuda (Reeves and Smith 2002; Smith and Reeves 2002, 2003a). Again, contrary to Roman and Palumbi (2003), we were well aware of the inherent shortcomings of the logbook data alone, and therefore used them only to supplement the more extensive and more nearly complete data on total barrels of whale oil landed by pelagic whalers and on oil produced by the many whaling operations across the North Atlantic where logbooks would not be expected to exist (e.g. shore stations).

Precision and bias of estimates of historical catches and removals

The statistical precision and potential bias of estimates of historical catches and removals are ultimately limited by the historical sources. The precision of estimates has been explored to some degree, but more emphasis has been given to minimizing biases. The reason for this emphasis is that biases, especially downward biases, appear to represent a greater source of uncertainty for determining pre-whaling abundance.

The statistical precision of the catch estimates from the American open-boat whaling for North Atlantic humpback whales was explored by Smith and Reeves (2003b) for one period. They estimated that roughly 2,100 humpback whales were landed by American ship-based open-boat whalers in the West Indies and the Cape Verde Islands, the two North Atlantic breeding grounds, during the peak whaling period from 1865 to 1886. Based on a sample of logbooks covering 16% of the voyages during this period, the catch estimate had relatively good precision, with a coefficient of variation of 15%. Additional sampling uncertainty arises in the several

conversion factors. For example, the statistical precision of the estimated number of barrels of oil per whale used to convert oil production to whales landed has not been accounted for. Further, to determine the precision of estimates of total removals one would also have to account for the statistical precision of the estimated rate at which whales were struck but lost. Both factors – oil yield and struck/lost rate – have been estimated from data found in whaling logbooks and, given the consistency of mean values from different samples, the sampling variability is not high.

Biases in estimates of catches and total removals potentially arise in several ways. From a statistical point of view, bias can be induced by the selection of logbooks for reading. For example, Smith and Reeves (2003b) stratified their sample of logbooks by port in order to make it more representative. However, a potentially much greater source of bias lies in the nature of the sources themselves. All sources of historical data are biased to some degree. For example, the Bluebooks, which are often viewed as an authoritative record of British colonial trade, do not necessarily provide continuous, complete or reliable series of data on oil and whalebone production at land stations. As Price (1985:418) pointed out: "The oil export figures [from St. Vincent Bluebooks] are considered to be conservative since they do not include an assessment of the quantity of [humpback] whale oil consumed domestically." Moreover, as Mitchell and Reeves (1983 p 208) noted, there is ambiguity about some of the Bluebook data, such that oil export tallies therein could be positively biased by the inclusion of oil from American pelagic whalers working in nearby waters, as well as by the failure to make a distinction between pilot whale (blackfish) oil and 'whale' oil taken from humpbacks (also see Best 1987 p 414, regarding the latter possibility). Another possibility that cannot be dismissed is that oil exported from one colony to another (e.g. see destinations of oil and whalebone shipped from St. Vincent; Mitchell and Reeves 1983 pp 210-12) was then re-exported, and thus potentially 'double-counted'. Finally, it is readily apparent from the Bluebook data tabulated by Mitchell and Reeves (1983 pp 210-12) for St. Vincent and by Reeves and Smith (2002 p 226) for Barbados that there is substantial year-to-year and place-to-place variability in: the way data were entered (e.g. measurement units); whether whaling catches and/or products were included at all; and whether the Bluebook for a given year is even available in a particular collection. Those of us who have attempted to reconstruct the history of humpback whaling in the North Atlantic have frankly acknowledged that catches from some areas or by the whalers of some nations are only partially known (Mitchell and Reeves 1983; Reeves and Smith 2002), and we have given high priority to overcoming the shortcomings, bearing in mind the intrinsic limitations of our sources.

Stevick *et al.* (2003) expressed a number of relevant concerns, including the possibility of undocumented humpback whale catches by Soviet whaling fleets bound for the Southern Hemisphere from European ports, citing Yablokov *et al.* (1998). However, corrected catch data for Soviet Southern Hemisphere expeditions that sailed in the 1960s from European ports have revealed that no humpback whales were taken in the North Atlantic, and further that while some catches of other species were made in the North Atlantic, this occurred only in a couple of years (Cherry Allison, personal communication).

We recognize that there are several legitimate concerns about representativeness and completeness of the historical sources, but Roman and Palumbi (2003, 2004) have neither addressed those accurately nor acknowledged the 'great lengths' to which IWC scientists have gone to take 'reasonable account' of uncertainties (Holt 2004). We feel that while there is substantial uncertainty about estimates of whaling removals, those uncertainties are not nearly as large as Roman and Palumbi (2003, 2004) imply.

Estimates of pre-whaling abundance

Roman and Palumbi (2004), in their response to Holt's (2004) critique of their 2003 paper, characterized estimates of pre-whaling abundance as 'logbook estimates', implying that logbook-derived data were the primary, or indeed the only, type of data used for such estimates. Ignoring the fact that back-calculation estimates rely on estimates of present-day abundance as well as estimated historical removals, they continued: 'whale log kills have been added up and this number used as the historic population size for North Atlantic humpbacks.' This is not the method that Holt (2004) described, and their words appear to reflect additional misunderstanding.

More important, though, is Holt's point that under simple density-dependent models, estimates of pre-whaling abundance must be less than the sum of the catches and current abundance. Further, he notes that they could only be that high if there were no density-dependent response whatsoever to the reduction of the population by whaling. Thus accounting for the preferential removal of females with calves (Friday and Smith 2003), a characteristic feature of humpback whaling in areas such as the Cape Verde Islands and West Indies, and the possibility of non-exponential population increases from low levels (Allee effect), would only serve to further reduce any back-calculation estimate of pre-whaling abundance from Holt's 'notional upper limit'.

Further, the effect of removals during the earliest humpback whaling operations in the North Atlantic would likely have been minimal because, as Stevick et al. (2003) point out, "protracted catches at low levels may result in large cumulative catches yet have minimal impact on abundance." Such factors would make the difference between Roman and Palumbi's (2003) genetic variability estimates and the back-calculation estimates produced by more traditional methods even more extreme.

The Scientific Committee attempted to fit a complex population model to estimate pre-whaling abundance for the two North Atlantic breeding populations as well as for the several matrilineal feeding grounds, using estimates of whaling removals and recent abundance (IWC 2002a, 2003). That model accounted not only for the population structure within the North Atlantic, but also to some extent for the sex and age structure of the harvest. Although satisfactory estimates of pre-whaling abundance of humpback whales have not yet been obtained (IWC 2003, p45-6), work is proceeding on this as the Committee recommended (Andre Punt and Nancy Friday, personal communication). In the meantime, following Holt's (2004) discussion of 'notional upper limits' for pre-whaling abundance based on assuming zero net recruitment throughout the period of whaling (i.e., no density dependent response), an upper bound for humpbacks in the North Atlantic would be the sum of current abundance (Smith et al. 1998) and total historical removals from 1664 to 2001 (Smith and Reeves 2003a), or roughly 40,000 animals (11,000 + 29,000). Thus the historical removals would need to be roughly 6 times greater than estimated for the notional upper bound to be consistent with Roman and Palumbi's (2003) estimate of 240,000 humpback whales. The discrepancy would in fact have to be greater than that, because the effects of density dependence (complete lack of which is unrealistic) and sex structure in the harvest (it is known that adult females and calves were taken preferentially in the breeding areas) would be to reduce the estimated pre-whaling abundance below the notional upper bound.

Conclusions

Published estimates of historical removals of North Atlantic humpback whales may be negatively biased, as has been noted repeatedly by those of us involved in the estimation work. However, as we have shown above, it is highly unlikely that the true level of removals could have been high enough to be consistent with Roman and Palumbi's (2003) estimated average abundance of 240,000 animals over evolutionary time. Additional analyses, including those identified by Roman and Palumbi (2003), will be necessary to reconcile the conflicting results of the two approaches.

Shortly after the paper by Roman and Palumbi (2003) was published, Palumbi expressed concern about the reaction by other scientists, noting that "other techniques have not been peer-reviewed or subject to the scrutiny that [this] paper is undergoing" (see Clarke and Knight 2003). Leaving aside the issue of what constitutes adequate peer review, intense scrutiny and critical evaluation are to be expected in fishery management settings when major discrepancies are found between the results obtained with a newly developed method and those obtained using previous methods. A strong and skeptical response should come as even less of a surprise when, as in the present case, the authors advocate the wholesale abandonment of past approaches in favor of their own initial application of a new approach, and that their results, without further testing, should become a basis for the management of whaling (Roman and Palumbi 2003, p. 510, Clarke and Knight 2003, quoting Palumbi).

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