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JANICE M. STRALEY, CHRISTINE M. GABRIELE and JOHN R. MORAN

INTERNATIONAL WHALING COMMISSION

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JANICE M. STRALEY[1], CHRISTINE M. GABRIELE[2] & JOHN R. MORAN[3]

[1] University of Alaska Southeast, 1332 Seward Avenue, Sitka, AK 99835
[2] Glacier Bay National Park and Preserve, PO Box 140, Gustavus, AK
[3]Auke Bay Laboratories, National Marine Fisheries Service, 17109 Point Lena Road, Juneau, AK 99801

ABSTRACT
The humpback whales that feed in the waters of Southeast Alaska and northern British Columbia form a genetically distinct feeding aggregation. Most of these whales migrate seasonally in winter to waters near Hawaii, with a small percentage going to Mexican waters, for breeding. This paper summarizes the results from ten analyses where estimates of abundance were calculated for this feeding aggregation. The span of years ranged from 1979 to 2011. One study from northern British Columbia used line transect methods, while the remaining nine analyses used a variety of capture-recapture models to estimate abundance. In these nine models photographs of the distinctive pattern on the ventral surface of an individual whale's flukes was used as the mark. In the 1980s and 1990s surveys were conducted in northern Southeast Alaska, hence these estimates only reflect estimates of abundance for a portion of the population. A North Pacific basin wide study conducted in 2004 and 2005 included the entire range of this feeding aggregation resulting in two estimates: 1) 2,110 (CV=0.073) using a multi-strata model and 2) 3,005 (CV=0.07) using a Lincoln-Peterson model. It should be cautioned that the estimates of abundance presented in this review do not reflect current trends in abundance for this feeding aggregation because in recent years there has been an increase in sightings of 'skinny' whales and significantly fewer calves. The Gulf of Alaska has faced several years of unusually warm conditions with many biological ramifications, care must be exercised in distinguishing long-term population trends from temporary climatic perturbations. The complexity of ecosystem variability under a changing climate highlights the importance of creating monitoring programs capable of reliably detecting population level changes.

KEY WORDS: HUMPBACK WHALES, SOUTHEAST ALASKA, NORTHERN BRITISH COLUMBIA, MARK RECAPTURE, ABUNDANCE, VIOLATION OF ASSUMPTIONS

INTRODUCTION

Humpback whales (*Megaptera novaeangliae*) that feed in the waters of Southeast Alaska and northern British Columbia (SEAK/NBC) (Figure 1) constitute a feeding aggregation that is genetically distinct (Baker et al. 2013). This feeding aggregation migrates seasonally in winter to the waters near Hawaii with a few individuals migrating to the waters of Mexico. These whales exhibit a maternally-directed site fidelity, that is, as a calf your mother brings you to feed in these waters and if female, you will bring your offspring to these waters, as well (Baker et al.1986).

This review summarizes ten analyses that estimated the abundance of humpback whales in Southeast Alaska and northern British Columbia. Not all the analyses were from separate studies. In some cases years were added for a reanalysis or new methods were explored. Most analyses only surveyed part of the range of this feeding aggregation and none are current. Nine analyses used capture recapture models and one study in British Columbia used line transect methods. The focus of this review will be on analyses specific to Southeast Alaska. Overall these analyses show the number of whales has increased from 1979 to 2011. However, it should be cautioned that the estimates of abundance presented in this review may not reflect current trends in abundance for this feeding aggregation. In recent years changes have been observed with an increase in 'skinny' whales and significantly fewer calves sighted in northern Southeast Alaska (Moran et al. 2016, Straley and Moan 2017).

METHODS AND MATERIALS

The study area is located in the eastern North Pacific Ocean from northern British Columbia to Southeast Alaska (51ºN, 130ºW; 60ºN 140ºW) (Figure 1).

All analyses were summarized from peer reviewed publications, dissertations and thesis. Methods are presented in Table 1 and describe the location where the data were collected, span of years and model used to

estimate abundance. The details of the specific models used in each analyses can be found in the reference listed in Table 1.

All capture recapture analyses used photographs to identify individual humpback whales by the black and white pattern on the underside of the flukes (Katona et al. 1979, Jurasz & Palmer, 1981). The whale was considered marked at the first sighting and recaptured in subsequent sightings. To reduce bias in capture probability each analyses incorporated quality coding to the photographs. While studies varied the restrictiveness of the quality coding used on the photographs, all studies recognized this bias can violate assumptions of the model used in the analysis and thus bias the resulting estimate of abundance.

RESULTS AND DISCUSSION

Estimates of abundance for NSEAK were about 400 to 550 whales in the mid-1980s to early 1990s and increased to nearly 1000 whales in 2000. In 2005 results from the NP basin wide study estimated the abundance at nearly 3,000 to over 6,000 whales for entire range from NBC to SEAK. No variance was calculated for these estimates. Recently, Wade (2017) updated these estimates using two refined models resulting in 2,110 and 3,005 whales estimated for this feeding aggregation. In 2005 in NBC a line transect survey estimated 1,313 whales in NBC. (Table 1 includes estimates and variances if determined for all analyses)

Table 1. Ten analyses are summarized by methods and results. Methods list location of the study area (northern Southeast Alaska=N SEAK, northern British Columbia=N BC, N SEAK & N BC= ALL) span of years (with the year of the estimate in bold) and the model used. Results list the estimate and variance in 95% confidence intervals (CI), coefficient of variation (CV) or 95% central probability interval (CrL). Details for the specific analysis can be found in the reference.

Methods: Area	Years	Model	**Results:** Estimate	Variance	**Reference**
N SEAK	1979-**1986**	closed-Schnabel	547	95% CI: 504-590	Baker et al. 1992
N SEAK	1979-**1988**	open-Jolly-Seber	393	95% CI: 321-455	Straley 1994
N SEAK	1979-**1992**	open-Jolly-Seber	404	95% CI: 350-458	Straley 1995
N SEAK	1994-**2000**	multi strata-Hilborn	961	CV=0.12	Straley et al. 2009
N BC	2004-**2005**	Line Transect	1313	95% CI: 755-2280 CV=0.28	Williams & Thomas 2007
ALL	2004-**2005**	various	2883 to 6414	not calculated	Calambokidis et al. 2008
ALL	2004-**2005**	multi strata-Hilborn Lincoln-Peterson	2110 3005	CV=0.073 CV=0.070	Wade et al. 2017
N SEAK	1994-**2008**	mechanistic movement model within a Bayesian framework	1585	95% CrI: 1455, 1644	Hendrix et al. 2012
Glacier Bay & Icy Strait	1986-**2009**	closed robust design	181	95% CI: 174–192	Saracco et al. 2013
Sitka Sound	1981-**2011**	Hilborn	1044	95% CI: 550-1220	Liddle 2015

Figure 1. The geographic area where humpback whales seasonally migrate to feed that constitutes the Southeast Alaska and northern British Columbia feeding aggregation.

Analyses addressed bias associated with violating the assumptions of the various models (Seber 1982). These bias include 1) recapture probabilities of individual whales may differ depending upon how the individual displays its fluke when making a dive (Straley et al. 2009); (2) whales may emigrate from the study areas and thus not be available for capture in all years (Straley et al. 2009); (4) movement among areas may be influenced by other members of the population; for example, movement to feeding areas may be maternally influenced (Baker et al. 1986); and (5) heterogeneity in movement behavior (Hendrix et al. 2013). The more complex models used by Hendrix, Straley and Wade accounted for the heterogeneity in behavior and reduced the bias for those estimates.

The best estimate for the abundance of humpback whales in SEAK/NBC in 2005 is likely closer to the lower of the Wade (2017) estimates of 2,110 whales. Given that the estimate for northern SEAK in 2008 was 1,585 unique whales (Hendrix et al. 2013) and NBC line estimate in 2005 was 1,313.

In Southeast Alaska a low number of calf sightings (Straley & Moran 2017, Moran et al. 20170 whales with heavy parasite loads (Figures 1 & 2), ‘skinny whales’ (Figure 3), and shifts in

distribution (Straley & Moran 2017), suggest that whales feeding in Southeast Alaska may be ending their period of rapid population growth. In addition, during winter 2015-2016, whale researchers on the Hawaiian wintering grounds reported of a reduction in the number of adults and calves observed.

However, concurrent with these observations, the Gulf of Alaska has faced several years of unusually warm conditions with many biological ramifications, caution must be exercised in distinguishing long-term population trends from temporary climatic perturbations. The complexity of ecosystem variability under a changing climate highlights the importance of creating monitoring programs capable of reliably detecting population level changes.

Figure 1. Humpback whale in Sitka Sound, Alaska covered in cyamids, Feb 4, 2017. M. Kosma

Figure 2. Humpback whale in Sitka Sound, Alaska with unknown skin condition (could be cyamids eating the skin), Feb 4, 2017. M. Kosma photographer

Figure 3. Photographed March 22 2017 feeding on herring in Sitka Sound (J. Straley photographer). Identified as SEAKID 117, nicknamed White Eyes, and a male, seen since the 1970s in the waters of Glacier Bay and Icy Strait (north of Sitka Sound). The scapula is clearly visible in the photograph. NPS biologists noted White Eyes appeared thin during the spring and early summer of 2016 (GBNP unpublished data).

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