Appendix 3

ADDITIONAL RESULT ON THE ESTIMATION OF ADDITIONAL VARIANCE

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Paper SC/57/PFI1 showed the estimates of additional variance for western North Pacific Byrde's whales and discussed that the estimated additional variance may include the systematic variation as well as random inter-annual variation. We present an additional result taking such systematic changes in whale distribution between the two survey periods into account.

To express systematic change in distribution between survey periods, we assume a mixed-effect model with interactions as follows:

$$\log \hat{N}_{ay} = \log N_{ay} + \varepsilon_{ay},$$

$$\log N_{ay} = Period + \mu_a + Period * Lat + \rho_{ay},$$

where 'Period' distinguishes survey periods between 1988-96 (as 0) and 1998-2002 (as 1) and 'Lat' means 'Northern blocks' (F,I,L), 'Middle blocks' (G,J,M) and 'Southern blocks' (B,E,H,K).

The estimates of the effects and interaction terms, as well as the additional variance for Case 2 with block K are given below.

Period	Period*middle	Period*north
-1.86 (0.635)	2.40 (0.805)	2.68 (0.780)

The values in parentheses are the standard errors.

σ_A	Total abundance	*CV* (%, nominal)	*CV* (%, with additional variance)
0.508 (0.214, 0.875)	25,852	24.4	34.7

The maximum values of the REML function can be used for the selection of variance components, but cannot be used for the selection of regression variables. Meanwhile, use of AIC with the MLEs contradicts the use of REML for the additional variance. In fact, all the parameters including interaction terms were significant and the result showed the presence of systematic change in distribution between survey periods.

The estimate of the *CV* of the total abundance reduced from around 40% to around 35%. This result suggested that the additional variance reported in SC/57/PFI1 included variation due to such non-random effects. The additional variance shown here is a more appropriate than those reported in SC/57/PFI1.

Appendix 4

STOCK STRUCTURE HYPOTHESES FOR NORTH ATLANTIC FIN WHALES

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In 2003, Iceland proposed that the Scientific Committee should begin the process of an RMP *Implementation* for North Atlantic fin whales (Víkingsson *et al.*, 2003). At last year's meeting, the SC endorsed recommendations from an intersessional group to determine whether there was sufficient information to warrant the initiation of a *pre-Implementation assessment* and recommended to the Commission that the *pre-Implementation assessment* should be initiated (IWC, 2005a, p.11). The Commission subsequently endorsed this recommendation.

According to the guidelines for RMP *pre-Implementation* (IWC, 2005b), the establishment of plausible stock hypotheses that are consistent with the available data is an important part of the *pre-Implementation* process. According to the guidelines, the hypotheses will only need to be broadly specified at this stage and should be 'inclusive enough that it is deemed unlikely that the collection of new data during the *Implementation* process will suggest a major novel hypothesis' (IWC, 2005b, p.85). Hence, the following list of stock hypotheses is long and includes many scenarios that we consider highly unlikely, but can nevertheless not be completely eliminated at this stage (Adjunct I).

According to the IWC Schedule, North Atlantic fin whales are divided into seven management stocks in the following areas:

(1) Nova Scotia;
(2) Newfoundland and Labrador;
(3) West Greenland;
(4) East Greenland, Iceland and Jan Mayen (EGI);
(5) North Norway;
(6) West Norway and Faroe Islands; and
(7) British Isles, Spain and Portugal.

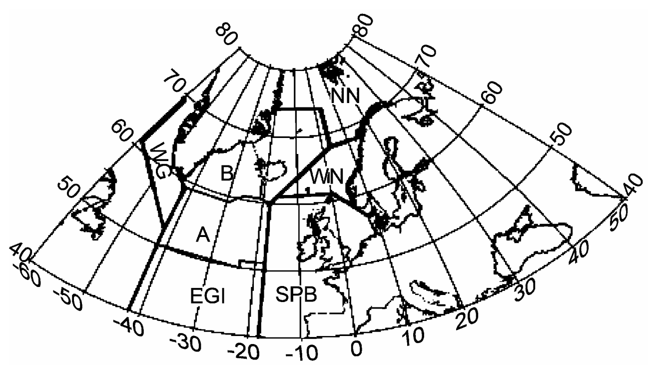

Fig. 1. General block delineations as applied in the NASS surveys. IWC Schedule stock areas are indicated by bold lines. IWC Schedule stock names: WG: West Greenland, EGI: East Greenland - Iceland, NN: North Norway, WN: West Norway and Faroe Islands, SPB: Spain, Portugal-British Isles (NAMMCO, 2000).

Table 1
Summary of North Atlantic fin whale stock structure information.

W-Iceland v/s E-Iceland		
Separate:	Depletion pattern	Risting (1922); Jonsgård (1966); Sergeant (1977)
	Discovery marking E-Iceland (9)	No returns at W-Iceland.
W-Iceland v/s E-Greenland		
Mixing:	Discovery marking E-Greenland	Gunnlaugsson (2004); Sigurjónsson *et al.* (1991)
	Radio tagging (W-Ice. to E-Greenl.)	Watkins *et al.* (1984)
Iceland (EGI) v/s Spain		
Separate:	MtDNA	Daníelsdóttir *et al.* (1991a)
	Allozymes	Árnason & Sigurdsson (1982); Árnason & Jónsdóttir (1987); Árnason *et al.* (1989, 1992); Daníelsdóttir *et al.* (1991b, 1991c, 1992); Daníelsdóttir (1994)
	Microsatellites	Daníelsdóttir *et al.* (2005)
	Morphometrics	Jover (1992); Vikingsson (1992)
	Earplug morphology	Lockyer (1981, 1982)
	Heavy metals	Sanpera *et al.* (1993, 1996)
	Discovery marking Iceland	No returns at Spain
	Discovery marking Spain	No returns at Iceland
Iceland (EGI) v/s Norway		
Separate:	Allozymes	Daníelsdóttir *et al.* (1992)
	Microsatellites	Daníelsdóttir *et al.* (2005)
	Biological parameters	Haug (1981)
	Depletion pattern	Risting (1922); Jonsgård (1966); Sergeant (1977)
	Discovery marking Norway	No returns at W-Iceland. Brown (1977)
Iceland (EGI) v/s Eastern Canada		
Separate:	Allozymes	Daníelsdóttir *et al.* (1992)
	Microsatellites	Daníelsdóttir *et al.* (2005)
	Depletion pattern	Risting (1922); Jonsgård (1966); Sergeant (1977)
	Discovery marking Iceland (few)	No returns at Canada (few catches)
Mixing:	Discovery marking Canada (many)	Only 1 return at W-Iceland
Iceland (EGI) v/s West Greenland		
Separate:	Microsatellites	Daníelsdóttir *et al.* (2005)
	Discovery marking Iceland	No returns at W-Greenland (few catches)
	Discovery marking W-Greenl.(few)	No returns at W-Iceland
W-Greenland v/s E-Canada		
Separate:	Microsatellites	Daníelsdóttir *et al.* (2005)
Faroes v/s Spain		
Mixing:	Satellite telemetry (1 whale)	NAMMCO (2003)
Nova Scotia v/s Labrador-Newfl.		
Separate:	Depletion pattern	Mitchell (1972); Sergeant (1977)
	Organochlorines	Hobbs *et al.* (2001)
Mixing:	Discovery marking (many)	2 &1 returns
Norway v/s Eastern Canada		
Separate:	Allozymes	Daníelsdóttir *et al.* (1992)
	Microsatellites	Daníelsdóttir *et al.* (2005)
Spain v/s Eastern Canada		
Separate:	mtDNA	Bérubé *et al.* (1998)
	Microsatellites	Daníelsdóttir *et al.* (2005)
Bermuda/west Indies v/s Norwegian Sea and UK		
Separate:	Accoustics	Clark (1995); Clark *et al.* (2002)
N-Atlantic v/s Mediterranean (Ligurian Sea)		
Separate:	Microsatellites and mtDNA	Bérubé *et al.* (1998)
	Organochlorines	Marsili and Focardi (1996)
	Ligurian newborns in summer	Notarbartolo di Sciara *et al.* (1996)
	Lack of sightings in Gibraltar strait	Duguy *et al.* (1988)
Mixing:	Stable isotope ratios	Guinet *et al.* (2005)
	Satellite telemetry	Guinet *et al.* (2005)
N-Atlantic v/s Sea of Cortez		
Separate:	Microsatellites and mtDNA	Bérubé *et al.* (1998)

In addition we have considered the Mediterranean Sea area as a separate stock (8) (see Table 1). These areas describe reasonably well the major historic and/or present feeding aggregations in the North Atlantic and recent large scale sightings surveys (NASS) have used these as a basis for block delineation (Fig. 1). We will use these as a basis for discussion, although this does not imply our recognition of these as discrete separate stocks.

SC/57/PFI4 presents new information on the stock structure of North Atlantic fin whales based on analyses of microsatellite DNA data and SC/57/PFI3 summarised the available non-genetic information. In Table 1, the data indicating distinction and/or mixing among different regions within the North Atlantic is summarised. Not shown in Table 1 are limited information from telemetry, showing no large-scale movements (Watkins *et al.*, 1996; Mouillot and

Viale, 2001; Heide-Jorgensen and Víkingsson, 2002; Heide-Jorgensen *et al.*, 2003).

In developing the hypotheses the following assumptions were made (see Table 1 for references).

(1) *More than one breeding stock for the whole North Atlantic.* The results from the genetic analyses clearly showed that more than one breeding stock is likely to exist in the North Atlantic and there is an indication of isolation by distance distribution across the North Atlantic. Evidence for stock structure also comes from various non-genetic methods.
(2) *No significant mixing between eastern and western North Atlantic.* Mixing is unlikely between fin whales living off the East coast of North America and the West coast of Europe, based on genetic and non-genetic studies.
(3) *No significant mixing between Iceland (4) and Spain (British Isles, Spain and Portugal stock (7)).* Both genetic and non-genetic evidence give support for this assumption.
(4) *No significant mixing between the Mediterranean (8) and other North Atlantic stocks.* Both genetic studies and other non-genetic studies indicated separate stocks. The little mixing with Spanish/Portuguese areas that may occur will most likely be carried over from that stock area, but the effects are likely negligible.
(5) *No significant mixing between Iceland (4) and Norway (5+6).* Genetic studies have indicated separation between these areas and this is supported by studies on biological parameters and catch history.

Focus on the EGI area

At last year's meeting the RMP sub-committee 'noted that if the *Implementation* was to focus on one part of the *Region* (in this case the waters near Iceland) the remainder of the *Region* should be designated as *Residual Area* in terms of the RMP' (IWC, 2005b, p.82).

In summary, the available genetic and non-genetic data show a difference between Iceland on one hand, and the eastern North Atlantic (from North Norway to Spain) on the other. Genetics also indicate separation between Iceland and the Western North Atlantic (Canada and West Greenland). The sample size was however low off Greenland and the single Canadian Discovery mark recovered south of Iceland indicates some (but likely very limited) mixing between these two areas.

There are at least two ways to explain the genetic differences found between these areas:

(1) separate breeding stocks in these areas; and
(2) mixing at feeding areas of two or more breeding stocks in different proportions.

Fig. 2 shows a set of stock structure hypotheses that is most compatible with the available data. In Figs 2a and 2b the potential for mixing of breeding stocks in feeding areas is assumed. In Figs 2d and 2e no mixing of breeding stocks occurs in the major feeding areas.

Some thoughts about *Small Areas*

Catches are only expected to be taken off West Iceland and only during the summer, as during the previous whaling operation (1948-85) and continued aboriginal catches off West Greenland.

Small Areas should be defined at East Greenland and East Iceland along the lines of NAMMCO (2003). As no abundance estimates exist farther south than 50°N, this would practically be the southern limit. The East Greenland and West and East Iceland *Small Areas* would be a *Medium Area* within the EGI Schedule area. It is reasonable to combine areas farther to the west and east into *Residual Areas* as mixing between stock areas seems limited. More detailed outer areas would have negligible effect for West Iceland, as these would have to blend through the *Small Areas* on both sides. Alternatively, other IWC Schedule areas could serve as *Medium Areas*, though we do not expect that to make a significant difference in this instance.

In any case the Mediterranean could be left out, as genetic and non-genetic studies suggest that it is a separate stock. Although some recent studies indicate limited geographical overlap with Spanish/Portugese waters through the strait of Gibraltar, the evidence for separation between Spanish waters and areas further north and west is so strong that Mediterranean stock influences on those stocks must be negligible.

If more *Medium Areas* are to be included in the assessment, then the possibility of including the Faroe Islands with either the British Isles, Spain and Portugal or the EGI *Medium Area*. Stocks off Canada could be merged due to the high degree of mixing there (from Discovery marks).

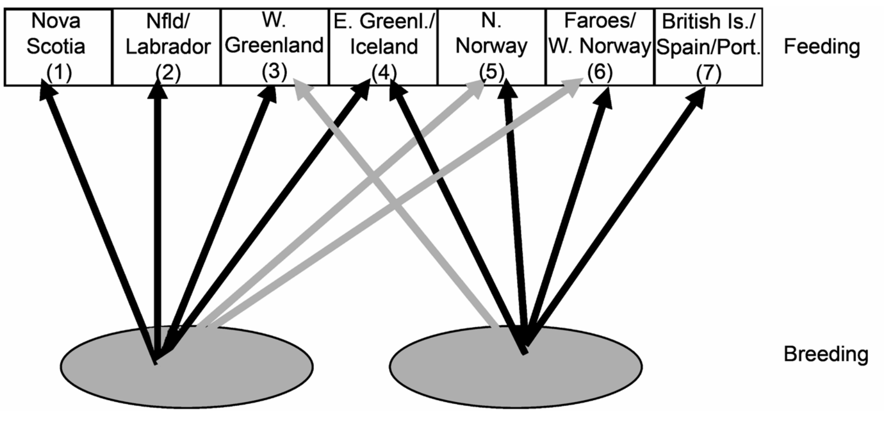

Fig. 2a. Two breeding stocks: Two stocks of fin whales in feeding grounds 1-7 with some possible mixing in feeding grounds 3-6. Grey arrows indicate unlikely events.

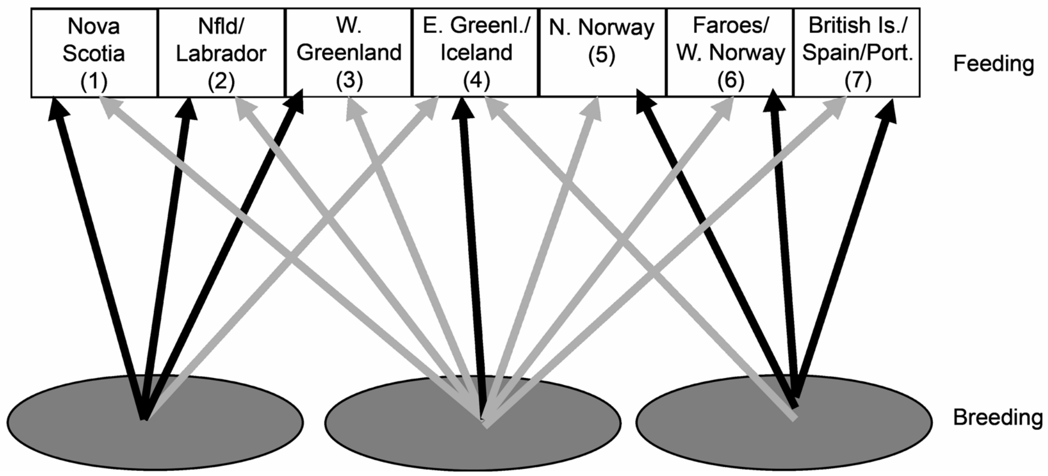

Fig. 2b. Three breeding stocks: Three breeding stocks of fin whales in feeding grounds 1-7 with some possible mixing in feeding grounds. Grey arrows indicate unlikely events.

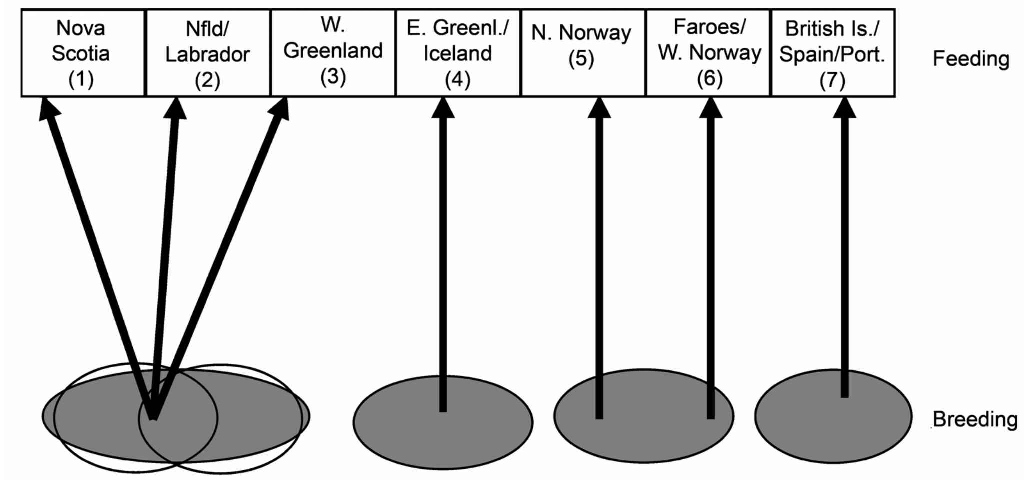

Fig. 2c. Four breeding stocks: Four breeding stocks of fin whales in feeding grounds 1-7 without mixing in feeding grounds.

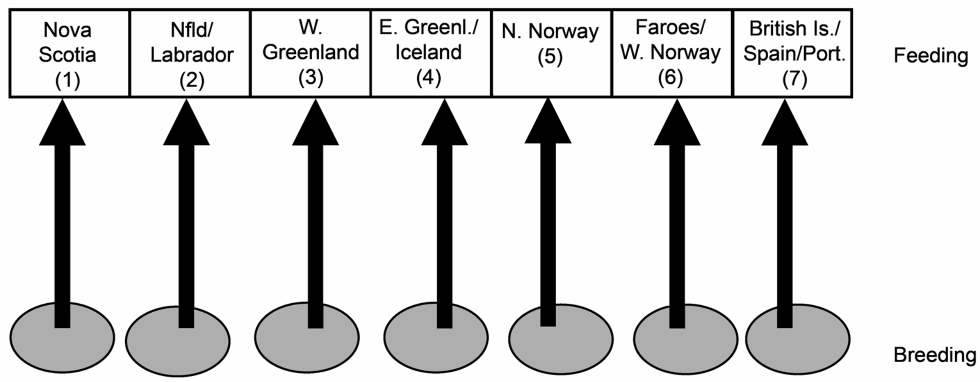

Fig. 2d. One breeding stock of fin whales in each feeding ground with no mixing.

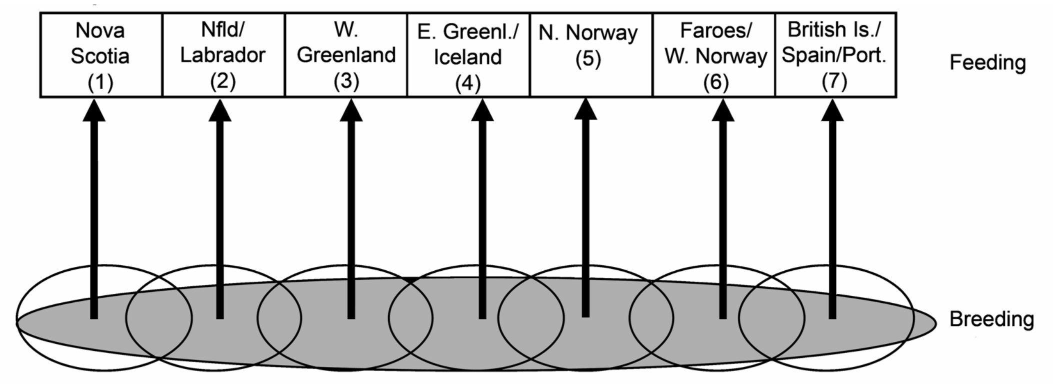

Fig. 2e. Isolation by distance. Breeding sub-stocks with limited and/or overlapping ranges.

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Adjunct 1. Set of stock structure hypotheses for North Atlantic fin whales

As noted in the text, we consider the different hypotheses highly variable in plausibility and have grouped them into three classes of plausibility based on the available evidence. **Bold**: most plausible; *italics*: least plausible; 'normal' font: intermediate plausibility.

1. Two breeding stocks (W and E)	
1.1:	**1+2+3, 5+6+ 7 and overlap in 4 (See Fig. 2-1)**
1.2:	*1+2+3+4, 5+6+7*
2. Three breeding stocks (W, C, E)	
2.1	**1+2+3, 4, 5+6+7 (See Fig. 2-2)**
2.2:	*1+2, 3+4, 5+6+7*
2.3:	*1+2+4, 3, 5+6+7*
2.4:	*1+2+3+4, 5, 6+7*
2.5:	*1+2+3+4, 5+6, 7*
3. Four breeding stocks	
3.1:	**1+2+3, 4, 5+6, 7 (See Fig. 2-3)**
3.2:	1+2+3, 4, 5, 6+7
3.3:	1+2, 3, 4, 5+6+7
3.4:	*1+2+4, 3, 5+6, 7*
3.5:	1+2, 3+4, 5+6, 7
3.6:	1+2, 3+4, 5, 6+7
3.10:	*1+4, 2+3, 5+6, 7*
3.11:	*1+4, 2+3, 5, 6+7*
4. Five breeding stocks	
4.1:	**1+2, 3, 4, 5+6, 7**
4.2:	1+2, 3, 4, 5, 6+7
4.3:	1+2, 3+4, 5, 6, 7
4.4:	1+2+3, 4, 5, 6, 7
4.5:	1+2+4, 3, 5, 6, 7
4.6:	**1, 2+3, 4, 5+6, 7**
4.7:	1, 2+3, 4, 5, 6+7
4.8:	1, 2, 3+4, 5+6, 7
4.9:	1, 2, 3+4, 5, 6+7
4.10:	*1, 2+4, 3, 5+6, 7*
4.11:	*1, 2+4, 3, 5, 6+7*
4.12:	*1+4, 2, 3, 5+6, 7*
4.13:	*1+4, 2, 3, 5, 6+7*
5. Six breeding stocks	
5.1:	**1+2, 3, 4, 5, 6, 7**
5.2:	**1, 2, 3, 4, 5+6, 7**
5.2:	1, 2+3, 4, 5, 6, 7
5.3:	1, 2, 3+4, 5, 6, 7
5.4:	*1+4, 2, 3, 5, 6, 7*
5.5:	*1, 2+4, 3, 5, 6, 7*
6. Seven breeding stocks	
6.1:	**1, 2, 3, 4, 5, 6, 7 (See Fig. 2-4)**