Thoughts on NA fin RMP implementation, hypothesis IV and research

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General issues concerning Icelandic catch history

Modern whaling started west of Iceland in 1883 and closed in 1915 due to a ban on whaling in Iceland imposed by Icelandic authorities (Sigurjónsson 1988). The operation started by concentrating on blue whales and later humpback whales although fin whales were by then hunted also in considerable numbers. Fin whales comprised about half the total catch (roughly 8,000 fin whales) but in the last years around 80% of the catch and the reminder by then partly sei whales (fig 1). By 1893 the catch was up to 495 and the peak was in 1901 with 1,019 whales caught west of Iceland, when stations started closing down and moved to the East coast. Catches stabilised west of Iceland at around 200 in the period 1905 to 1911. In the last year 52 whales were caught. When the stations moved to the East coast the whalers complained that whales were few and small of the west coast. Catches collapsed quickly at the east coast. The operation thus spanned 43 years and the fin whales being the last major stock to be targeted had all that time to take advantage of the reduced competition by the other species. The stocks of blue and humpback whales were certainly still severely reduced at the start of the more recent operation in 1948, when they were rarely seen, but fin whale catches were then again good so there must still have been a considerable number of young fin whales left in 1915. The latter operation took on average 220 fin whales per year up to 1989. Due to species interaction the total catch of fin whales may therefore by far have exceeded what can realistically be explained in a single species model. The humpback and blue whales around Iceland have been on the increase in recent years (Sigurjónsson and Gunnlaugsson 1990; Gunnlaugsson et al 2004; Pike et al 2009). A single species model hitting recent estimates of around 20,000 (Pike and Gunnlaugsson 2006; Pike et al. 2008), will have to start from a very large initial stock to explain these large cumulated catches, especially given a low msyr, and so the stock will always appear to be severely depleted in that comparison. This may be a similar situation to that in the Southern Ocean where the large catches of fin whales may need to take into account the reduced competition by the stocks depleted first, and there after the demise of fin whales, the minke whale there may also have responded similarly (Mori and Butterworth 2003).

Background

Pre-implementation of North Atlantic fin whales was initiated in 2004 and followed by implementation starting in 2007. As a part of the pre-implementation process seven stock structure hypothesis were developed (IWC 2009). At the last annual meeting (the first annual meeting of the implementation process) the SC agreed unanimously that five of these (I, II, III, V, VI) should be assigned 'high' plausibility and hypothesis VII 'medium' plausibility. While there was disagreement in the Committee regarding hypothesis IV, the SC agreed nevertheless to assign it high plausibility.

At the 2nd intersessional workshop the following six management variants were considered (SC/61/RepX):

- V1 Sub-area WI is a *Small Area*;
- V2 Sub-area (WI+EG) is a *Small Area*. The entire Catch Limit is taken in the WI sub-area;
- V3 Sub-area (WI+EG+EI/F) is a *Small Area*. All of the catch is taken in the WI sub-area;
- V4 Sub-area WI is a *Small Area*. Catch limits will be set based on survey estimates for the WI sub-area north of 60°N (both historic and future surveys). Note: trial NF15 is not applicable for this variant. The same proportions are used in setting future abundance estimates as for trial NF15 (see item F). The catch series is unchanged as all historic catches in the WI sub-area were taken north of 60°N;
- V5 Sub-areas WI and EG are taken to be *Small Areas* and sub-area WI+EG is taken to be a *Combination area*. The catch limits set for the EG Small Area are not taken;

V6 Sub-areas WI, EI/F and EG are taken to be *Small Areas* and sub-area WI+EI/F+EG is taken to be a *Combination area*. The catch limits set for the EG & EI/F Small Areas are not taken.

Based on IST performance, all variants except V2 were classified as 'acceptable without research'. Performance of V2 was 'acceptable' in all but one of the 27 'high' weight trials, the exception (NF-10-2) being ranked as 'borderline' Three 'medium' weight trials were classified as 'unacceptable'. All the four trials mentioned above are based on stock structure hypothesis IV. The proposed research will therefore concentrate on evaluating the assumptions of Hypothesis IV, in particular how they relate to management variant 2.

Hypothesis IV

This hypothesis assumes no interchange between three substocks in the Central North Atlantic (C1, C2 and C3). This assumption seems contradictory to some evidence such as a lack of genetic structure in the North Atlantic (Pampoulie *et al.* 2008) and observed genetic exchange between areas (Skaug *et al*. 2009). The discovery mark-recapture data is fitted in the model and to accomplish the mixing implied by them the animals in the WI area are assumed to come from an isolated breeding stock C2 of which 90% of the animals are in the area each year. The remaining 10% are assumed to be feeding in the areas to the West (EG) and East (EI+F), where the isolated breeding stocks C1 and C3 are mainly assumed to feed but of which 5% are in the WI area each year as "visitors". The word visitor is used here as even though the animals find less competition (more food) within the visited area (e.g. due to a reduction in the stock there), they are assumed to be no more likely to come there the following year. To our knowledge there are no references or data to support such behaviour of permanently fixed proportional site fidelity in large whales. Such behaviour also appears to be contrary to the general understanding of how animals respond to low food availability in an area and would have grave consequences for the species in case of anticipated environmental changes.

A trial was added at the 2nd Intersessional Workshop in Copenhagen in March 2009, where instead of the fixed 5% value, this proportion was estimated in the ISMT model, but came out to be estimated very close to the chosen fixed value and need not be distinguished here. Problems with sustainability only occur in case of assumed 1% MSYR (of mature stock) for which there has been no agreement and is not consistently used in the work of the SC.

The main weaknesses of the hypothesis

1) Trials based on hypothesis IV do fit the mark recoveries poorly, though no worse than some other trials, but are different in that inherently they can not explain why marks placed on the grounds (WI) recover soon after marking (2.7 years excluding same season recoveries) while marks placed in the EG area have recovered later (5 years after marking and including 1 same season recovery, n=8). Hypothesis where there is gradual interchange/dispersal over time do however predict the observed trend with time. Due to the short time that elapsed from the placing of most of the marks till the cessation of whaling this time trend had not gained sufficient statistical strength in the data to reject this hypothesis in the IMS model used.

2) The hypothesis can not explain the recovery of one mark recovered at West Iceland from Canada as no interchange, direct or indirect, is assumed there between. This WI recovery from Canada was 9 years after marking and this fits well in if gradual mixing is assumed between neighboring areas.

3) As same season recoveries are generally not included in mark-recapture analysis, the one same season recovery from East Greenland (found in the catch in Iceland a week later) is not used in the IMS model. Exclusion of same season marks in between area analyses simplifies the analysis but is questionable. The model does also not include the observation that a radiotagged whale in 1980 was followed from west of Iceland to East Greenland in the course of a week. Inclusion of this data would have resulted in a higher estimated proportion of "visitors".

4) A special breeding stock is assumed to feed mainly within the WI area in hypothesis IV. If this breeding component would get exterminated then hypothesis IV predicts that 5% of stocks C1 and C2 would continue to

visit the area but there would be no density response within the area such that it would ever come close to the original density.

The hypothesis was accepted in spite of objections at the 2008 annual meeting, where these points were raised by Gunnlaugsson (IWC, 2009). The SC has thus already chosen to ignore observations that contradict this hypothesis, which is also contrary to general biological understanding of animal foraging behaviour. In addition the SC has rejected that the decline in catch per boat in the early modern whaling period reflects the development in the stock. The 1% MSYR (of mature stock) would be rejected if this cpue trend were accepted. This is of concern when additional research is to be proposed, as results from that research might as well be rejected by the SC. It is worth recalling that historical cpue series were the sole basis for most of the conservation actions recommended by the IWC SC in the past. The IWC SC however did not consider contemporary updates of cpue to be reliable enough as a basis for the setting of quotas, which is another matter. We will still consider here the possibilities of contradicting the hypothesis with research. Not considered here is meta research that would reduce the plausibility of the 1% MSYR case in general.

Observations that would further contradict the hypothesis

1) Breeding does not occur in three discrete areas.

If the animals from the feeding areas breed in the same area they would be expected to interbreed. In light of the numerous cases of hybrids between fin and blue whales, how would animals with no genetic difference avoid interbreeding when breeding in the same area. If the animals interbreed there is no genetic stock to preserve and the 5%/90%/5% behaviour can not be genetically transmitted/sustained. Some statisticians at the 2nd Intersessional meeting still objected to this and stated that the 5%/90%/5% behaviour could be learned as the calves would follow their mothers to the feeding grounds. The calves are likely to follow their mothers only once but would have to learn different rules depending on which breeding grounds they came from. Such learning of proportions by animals is unheard of and hopefully not taken seriously by biologists in the SC.

2) Breeding occurs in discrete areas but there is significant interchange between these areas.

3) Movement across the feeding ground boundary within season or between seasons exceeds 5% (or the value estimated in trial added at 2nd Intersessional meeting).

4) The animals disperse rather than mix on the feeding grounds. That is animals that move from one area to the other are not “visitors” but tend to revisit the area where food is available. This will only be seen after several years and would then likely be captured in the above points, because when compared over some years the proportion that had moved between feeding areas would grow and exceed 5%.

Research proposal

Objective

As mentioned above all trials where V2 failed are related to stock structure hypothesis IV, where no interchange between three substocks in the Central North Atlantic (C1, C2 and C3) is assumed and mixing on the feeding grounds is limited and temporary. The main objective of the research program is to counter this assumption. We propose this be done by genetic studies based on biopsy sampling and sampling of catches at feeding grounds in the three sub-stock areas and through satellite telemetry.

Genetic “mark-recapture” and Relatedness studies.

Previous genetic studies performed with microsatellite loci and mtDNA did not reveal any genetic structure among samples collected at feeding grounds over a period of 20 years (SC/60/PFI11). Therefore, other analytical methods are needed to reveal potential interchange between the areas. Mark-recapture genetic programs enable the unique identification of individuals by using hypervariable genetic markers. A genetic program based on “mark-recapture” analysis will prove more useful to assess potential exchange among the two entities targeted by the research proposal presented here (EG and WI), and to test hypothesis IV, than conventional genetic

analysis. A new method based on identification of close relatives (Skaug *et al.* 2009) is particularly promising and most likely to provide significant data.

The proposal is to collect 100 biopsy samples over the first 5 years in the EG area. In addition to biopsies, potential recaptures will be obtained from the commercial catch in the WI area. The analysis will be based on 15 microsatellite loci and mtDNA sequences of the control region. The sex-determination locus will also be genotyped. Furthermore, power analyses will be carried out to ensure that the genetic markers used have sufficient resolution power to identify individuals unambiguously. Collected samples will be genotyped as described in previous genetic work using the same laboratories (Pampoulie *et al.* 2008).

Mark-recapture
The degree of interchange between the two areas targeted by the research proposal can be directly determined from the number of individuals recaptured during the Icelandic catches. Discovery marks placed in the EG area have had a probability of recovery of about 1 in 10,000 per whale caught of West Iceland within 10 years.

Identification of close relatives
The biopsy samples collected in the EG (East Greenland) and EI+F (East-Iceland Faroes) feeding area will be compared to the new samples from the catch as well as archived samples of 565 whales taken in Icelandic waters and biopsies or samples that may be available from other feeding areas such as Faroes and West-Greenland. There will likely be many more relatedness relations identified between the areas where also existing samples can be used, than direct recaptures (Skaug *et al* 2009). Given hypothesis IV the likelihood of finding two individuals sampled in the same feeding/small area to be closely related is about 9 times higher than if they were sampled in different areas. These data could be directly fitted in the IST model.

Tagging (satellite).
Satellite tracking of large baleen whales is technically challenging and in general the success has been somewhat limited, particularly with respect to long-term (year or more) tracking (Vikingsson and Heide-Jørgensen 2005). Although such long-term tracking would be most useful in our particular case, tracking of shorter durations can potentially reveal important information on stock structure relevant to hypothesis IV such as within season mixing on feeding grounds.
The proposal is to attempt deployment of 50 ARGOS satellite transmitters in the first five years.
If there is substantial movement across the line separating EG and WI during summer feeding season, this would undermine the assumption that all catches are taken from a fixed pool of individuals represented by abundance estimates from the WI area. These studies might also provide better grounds for determining the best location of the boundaries between the three areas. Breeding grounds might be located by tagging in late summer/autum. The tags will be deployed using the ARTS system (air gun) , but the technique will need some improvement in how long the tags last (stay in place in the whale). At present success is low and short and certainly little chance of obtaining between season movements.

Timeline of research programme
Table 1 gives a provisional time schedule for the first 5 years of the research programme. The first year is dedicated to feasibility studies on the sampling methods. It is anticipated that a mid-term review of the research programme will be conducted at the 5-year *Implementation Review* providing a basis for the sampling scheme for the latter 5 year period. The results of the two methods can then be compared and cost evaluated. If tagging is by then more successful, then that component could be augmented while biopsies would still be collected at the same time from the tagged animals. On the other hand, if tagging success is by then still low and short lived the biopsy effort should be increased.

Table 1. Provisional time schedule for a sampling programme.

Year	*Months*	*Area*	*Sample size*		
			Biopsy	*Satellite tagging attempts*	
1	June-August	EG, WI,	20	10	Feasibility study
2	May June	EG, WI, EI+F	40	10	
3	August Sept	WI	10	10	
4	June-Sept.	EG, WI,	30	20	
Total yr 1-5			100	50	

In addition to biopsy sampling genetic samples will be collected from the catch in WI which according to this variant will be in the range of 87 animals annually (SC/61/Rep3). A sample of 565 fin whales from previous commercial and special permit catches has already been genotyped and will be used in the relatedness study.

Progress will be reported to the SC annually. Laboratory analysis will be completed and presented in time for the 5-year *Implementation Review.* Data will be made available to SC members as specified under the DAA.

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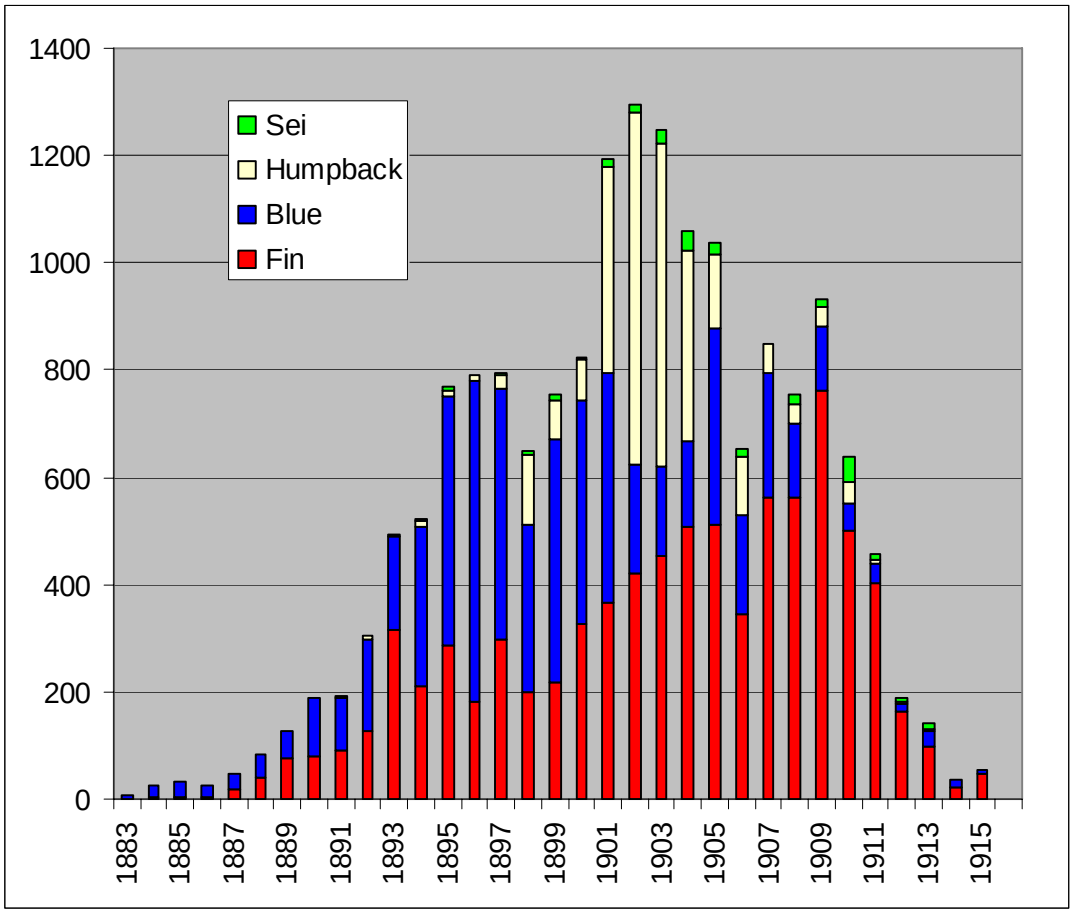

Fig 1. Prorated historical landings of large whales in Iceland 1883-1915.